BSEE
Bureau of Safety and Environmental Enforcement

FINAL REPORT

Suitability of Source Control and Containment Equipment versus Same Season Relief Well in the Alaska Outer Continental Shelf Region

October 1, 2018

prepared by

BCE Bratslavsky
CONSULTING ENGINEERS INC

And

SOLSTENXP

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Suitability of Source Control and Containment Equipment versus Same Season Relief Well in the Alaska Outer Continental Shelf Region

Prepared for

Bureau of Safety and Environmental Enforcement

Prepared by

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List of Acronyms

AAC	Alaska Administrative Code
ABS	American Bureau of Shipping
ADEC	Alaska Department of Environmental Conservation
ADNR	Alaska Department of Natural Resources
AHC	Active Heave Compensation
AHTS	Anchor-Handling Tug and Supply (vessel)
AK	Alaska
AOGCC	Alaska Oil and Gas Conservation Commission
APD	Application for Permit to Drill (US Government/BSEE)
API	American Petroleum Institute
AQI	Air Quality Index
AWKS	Alternative Well Kill System
Bbl	Barrel
BMP	Bureau of Minerals and Petroleum (Government of Greenland)
BOD	Biological Oxygen Demand
BOEM	Bureau of Ocean Energy Management
BOP	Blowout Preventer
BSEE	Bureau of Safety and Environment Enforcement
BV	Bureau Veritas
C	Celsius
CFD	Computational Fluid Dynamics
CFR	Code of Federal Regulations
CIDS	Concrete Island Drilling System
CO	Carbon Monoxide

CO_2	Carbon Dioxide
DNV	Det Norske Veritas
DOI	Department of Interior
DP	Dynamic Positioning
EN	European Standards
EPA	Environmental Protection Agency
F	Fahrenheit
FR	Federal Regulation
GEBCO	General Bathymetric Chart of the Oceans
GHG	Greenhouse Gas
GPS	Global Positioning System
HAP	Hazardous Air Pollutant
HT	Hazard Time
IADC	International Association of Drilling Contractors
IPAA	Independent Petroleum Association of America
ISO	International Organization for Standardization
LEL	Lower Explosive Limit
LMRP	Lower Marine Riser Package
LR	Lloyd’s Register
MACONDO	Mississippi Canyon Block 252, an oil and gas prospect in the US Exclusive Economic Zone of the Gulf of Mexico where the Deepwater Horizon Oil Spill Occurred
MARPOL	Marine Pollution (Stands for The International Convention for the Prevention of Pollution from Ships)
MMS	Minerals Management Service
MODU	Mobile Offshore Drilling Unit
MT	Move-Off Time

NAD	North American Datum
NCEI	National Centers for Environmental Information
NEB	National Energy Board (Government of Canada)
NIC	(US) National Ice Center
NM	Nautical Mile
NDBC	National Data Buoy Center
NOAA	National Oceanic and Atmospheric Administration
NOIA	National Ocean Industries Association (US)
NORSOK	Norsk Sokkels Konkurranseposisjon (Translates to Norwegian Shelf's Competitive Position) (Norwegian Government Standards)
NO_x	Nitrogen Oxides
NPDES	National Pollutant Discharge Elimination System
NRDC	Natural Resources Defense Council
OCS	Outer Continental Shelf
ODPCP	Oil Discharge Prevention and Contingency Plan
OPD	Official Protraction Diagram
OPRC	Oil Pollution Prevention Response and Cooperation (UN Convention)
OSR	Oil Spill Response
OSRL	Oil Spill Response Limited
PDF	Portable Document Format (electronic file format)
PM_{10}	Particulate Matter 10 Micrometers or Less in Diameter
$PM_{2.5}$	Particulate Matter 2.5 Micrometers or Less in Diameter
RAR	Remote Anchor Release
RFQ	Request for Quotation
ROV	Remotely Operated Vehicle
RP	Recommended Practice (API Term)

SCCE	Source Control and Containment Equipment
SDC	Steel Drilling Caisson
SID	Subsea Isolation Device
SIMOPS	Simultaneous Operations
SO_x	Sulfur Oxides
SSRW	Same-Season Relief Well (Canadian Regulatory Term)
ST	Secure Time
TSS	Total Suspended Solids
U.S.	United States
UAS	Unmanned Aircraft System
UAV	Unmanned Aerial Vehicle
UK	United Kingdom
UN	United Nations
US	United States
USA	United States of America
USCG	United States Coast Guard
USOGA	US Oil and Gas Association
VA	Virginia
VOC	Volatile Organic Compound
WMO	World Meteorological Organization

Definitions

Cap and Flow System: Cap and flow system means an integrated suite of equipment and vessels, including a capping stack and associated flow lines, that, when installed or positioned, is used to control the flow of fluids escaping from the well by conveying the fluids to the surface to a vessel or facility equipped to process the flow of oil, gas, and water. A cap and flow system is a high pressure system that includes the capping stack and piping necessary to convey the flowing fluids through the choke manifold to the surface equipment.

Capping Stack: A capping stack is a mechanical device, including one that is pre-positioned, that can be installed on top of a subsea wellhead or blowout preventer to stop the uncontrolled flow of fluids into the environment.

Containment Dome: A containment dome is a non-pressurized container that can be used to collect fluids escaping from a well, equipment below the sea surface, or from seeps. The device is suspended over the discharge. The containment dome includes all of the equipment necessary to capture and convey fluids to the surface.

Relief Well: A relief well is a secondary well that is drilled with the intent of intersecting the target well at some pre-determined depth below the seabed. The purpose of the relief well is to permanently kill the incident well by pumping salt water, mud, and cement into the incident well as needed. Aside from the precision directional (angled) drilling techniques and associated additional time required to drill a relief well, the drilling operations are similar for drilling a relief well and a regular well.

SCCE: Source Control and Containment Equipment (SCCE) means the collective purpose of capping stack, cap and flow system, containment dome, and/or other subsea and surface devices, equipment, and vessels is to control a spill source and stop the flow of fluids into the environment or to contain fluids escaping into the environment. "*Surface devices*" refers to equipment mounted or staged on a barge, vessel, or facility to separate, treat, store and/or dispose of fluids conveyed to the surface by the cap and flow system or the containment dome. "*Subsea devices*" includes, but is not limited to, remotely operated vehicles, anchors, buoyancy equipment, connectors, cameras, controls and other subsea equipment necessary to facilitate the deployment, operation, and retrieval of the SCCE. The *SCCE does not include a blowout preventer*.

Significant Wave Height (H_s) is the mean wave height (trough to crest) of the highest third of the waves.

Wave height (H) is the difference between the elevation of the crest at the top of a wave and the elevation at the bottom, or trough of the neighboring wave.

Wave period (T) is the time in seconds required for two successive wave crests to pass a fixed point.

Executive Summary and Conclusions

This Study Report on the *Suitability of Source Control and Containment Equipment (SCCE) versus Same Season Relief Well in the Alaska Arctic OCS Region* was prepared by Bratslavsky Consulting Engineers, Inc. for the Bureau of Safety and Environmental Enforcement (BSEE) to assess the metocean conditions for the period of 2012 to 2016 that could impact the safe deployment of SCCE or a relief well in response to a loss of well control situation. The Arctic OCS includes the Chukchi Sea and Beaufort Sea planning areas, both of which combined cover nearly 200,000 square miles.

The scope of work for this project included ten tasks. Tasks 1 through 5 are covered outside of the main body of this report and are listed below:

Task 1: Conduct a post award Kickoff meeting. This activity was conducted on September 11, 2017 with a summary report of the meeting provided to BSEE.

Task 2: Conduct a comprehensive review of current U.S. and international regulations, standards, recommended practices, specifications, technical reports, and common industry methods regarding the safe deployment of SCCE in response to a loss of well situation in Arctic conditions. This work task is contained in appendix D, Gap Analysis and Matrix of Regulations, Standards and Guidance at the end of this report.

Task 3: Conduct a comprehensive review, similarly to task 2 above, regarding the safe deployment of a relief well in response to a loss of well situation in Arctic conditions. This work task is contained in appendix D, Gap Analysis and Matrix of Regulations, Standards and Guidance at the end of this report.

Task 4: Conduct a comprehensive review of the current 30 CFR 250 regarding the deployment of SCCE and relief wells in response to a loss of well situation in Arctic conditions. This work task is contained in appendix D, Gap Analysis and Matrix of Regulations, Standards and Guidance at the end of this report.

Task 5: Provide a gap analysis of the data obtained from tasks 2, 3 and 4 above. The Gap Analysis is contained in appendix D at the end of this report.

BSEE also specified that a deployment analysis be conducted to cover the following five tasks which are contained in the main body of this report.

Task 6: Conduct a historical statistical analysis of the metocean conditions during the Alaska OCS drilling seasons over the past 5 years with an assessment of when – and for what duration – operational conditions would have supported the safe deployment of SCCE alone in response to a loss of well situation in Arctic conditions.

Task 7: Conduct a historical statistical analysis, similarly to task 6 above, for the safe deployment of a relief well alone in response to a loss of well situation in Arctic conditions.

Task 8: Conduct a historical statistical analysis, similarly to task 6 above, for the safe deployment of either SCCE or a relief well in response to a loss of well situation in Arctic conditions.

Task 9: Conduct a historical statistical analysis, similarly to task 6 above, for the safe deployment of neither SCCE nor a relief well in response to a loss of well situation in Arctic conditions.

Task 10: Conduct a historical statistical analysis, similarly to task 6 above, for the safe deployment of one method of response to a loss of well situation in Arctic conditions but preclude the other.

In developing the metocean analysis, criteria were set for wind speed, wave height, wave period, temperature and sea ice coverage. These criteria were determined to potentially have an impact on the safe deployment of SCCE and relief wells. Bathymetry was also identified as a key metocean parameter that could impact the safe deployment of SCCE and relief wells. Publicly available metocean data was analyzed against the criteria and probabilities for safe deployment of SCCE and a relief well were calculated for the tasks listed above. Collectively, these data are presented in 10- day periods for the months of June through December, resulting in 21 consecutive 10-day periods for the data analysis.

Several different scenarios were developed to support the analysis. Four scenarios were identified for the Chukchi Sea; one each for SCCE and relief well deployment in open water conditions and one each for SCCE and relief well deployment in sea ice conditions. Similarly for the Beaufort Sea, two open water and two sea ice scenarios were considered. These four base operating scenarios were then applied to the five analysis tasks specified by BSEE above resulting in 20 total scenarios analyzed.

The Report also addresses the types of SCCE and relief well drilling vessels available for deployment as well as support vessels and ancillary equipment for SCCE and relief well deployment in Arctic waters.

Publicly available data for the period 2012 to 2016 were used for this analysis including:

- Bathymetry data from the General Bathymetric Chart of the Oceans (GEBCO) were plotted as bathymetry isobaths across the Chukchi Sea and Beaufort Sea planning areas.
- Temperature and wind data from coastal Arctic stations were utilized; then analyzed to determine the probabilities as to when the conditions exceeded the deployment criteria.
- Wave height and wave period data were obtained from published studies for the wave characteristics in the Chukchi and Beaufort seas.
- Sea ice data from the National Ice Center was obtained and analyzed in accordance with the developed criteria to determine the probability of safe deployment of SCCE or a relief well in varying sea ice conditions.

The analysis techniques used for this Study can be considered standard in the industry to analyze the available data. Furthermore, the results described in the Report led the team to make the following conclusions regarding safe deployment of SCCE and relief wells in the Chukchi Sea and Beaufort Sea planning areas:

- The available open water operating season in the Chukchi Sea ranges from 60 to 90 days in the historically active exploration area of the Chukchi Sea planning area.
- The available open water operating season in the Beaufort Sea is limited to approximately 50 to 60 days across the historically active exploration area of the Beaufort Sea planning area.
- The existing available ice class Arctic floating drilling fleet is very limited and does not have the capability to operate in water depths shallower than 984 feet (300 meters) unless outfitted with a turret mooring modification that could reduce the minimum operating water depth to approximately 328 feet (100 meters).
- Deployment of SCCE is likely to be impaired in water depths shallower than 984 feet (300 meters), which are potentially subject to a gas boil at the surface from a subsea blowing well. This situation will likely require offset installation equipment in water depths shallower than 984 feet (300 meters). Modeling analysis of the blowout plume in the water column may provide a better estimate of the maximum depth that would be necessary for offset installation equipment in the Chukchi Sea and Beaufort Sea planning areas.
- SCCE, including offset installation equipment for SCCE deployment in shallow waters, will need to be fit for purpose due to the bathymetry limitations and logistical requirements of the Chukchi Sea and Beaufort Sea planning areas where rapid deployment of response equipment from worldwide staging areas such as the Gulf of Mexico or Europe is not feasible.
- Subsea Isolation Devices (SIDs) are a practical means of mitigating a substantial portion of the risk associated with loss of well control within a very short timeframe. As a preinstalled form of SCCE, SIDs can be deployed under adverse sea states and weather conditions.
- Prestaging of SCCE, including offset installation equipment, in wet storage on the seafloor will likely reduce response time and reduce deployment downtime due to sea state conditions.
- Late season SCCE deployment in sea ice conditions is a viable option if open water relief well drilling operations are not able to be completed before the open water season ends.

1.0 Introduction

1.1 Request for Quotes (RFQ) Language for the Statistical Analysis and Final Report on BSEE Suitability of Source Control and Containment Equipment versus Same Season Relief Well in the Alaska OCS Region

Purpose: The purpose of this Study is to provide a description of the Alaska Arctic Outer Continental Shelf (OCS) meteorological/oceanography (metocean) and operational conditions which, in the event of a loss-of-well-control situation, may preclude the safe deployment of Source Control and Containment Equipment (SCCE); or may preclude the operator from safely drilling a relief well; or, allow one method, but preclude the other. This report will also provide historical statistical analysis of the Alaska Arctic OCS drilling season, over the past 5 years, in which metocean and operational conditions would support either method.

Background: The Bureau of Safety and Environmental Enforcement (BSEE) issued the final Arctic Rule, adding to and revising existing regulations in Code of Federal Regulations (CFR) Title 30 (Mineral Resources), Part 250 Oil and Gas and Sulphur Operations in the Outer Continental Shelf (30 CFR 250).

As per the requirements in 30 CFR 250.471, for exploration wells drilled on the Arctic OCS, operators using a Mobile Offshore Drilling Unit (MODU) for drilling below or working below the surface casing must have access to the following SCCE capable of stopping or capturing the flow of an out-of-control well:

- A capping stack which can arrive at the well location within 24-hours after a loss of well control and can be deployed by direction of the Regional Supervisor.
- A cap and flow system must be positioned to ensure its arrival at the well location within 7-days after a loss of well control and can be deployed by direction of the Regional Supervisor.
- A containment dome must be positioned to ensure that it will arrive at the well location within 7-days after a loss of well control.

As per the 30 CFR 250.472 relief well rig requirements for the Arctic OCS are as follows:

> In the event of a loss of well control, operators may be directed to drill a relief well using the relief well drilling rig described in the approved Application for Permit to Drill (APD). The relief well drilling rig must be staged in a location such that it can arrive on site, drill a relief well, kill and abandon the original well, and abandon the

relief well prior to expected seasonal ice encroachments at the drill site, but no later than 45 days after the loss of well control.

The oil and gas industry has argued that current regulatory and/or permit requirements for a same season relief well do not recognize the more effective and lower environmental impact capabilities of capping and containment solutions. Additionally, they have stated that current well control regulations do not account for the technological advancements made in capping and containment post-Macondo. Industry contends that the use of advanced control and containment technologies could prevent or significantly reduce the spill volume, when compared to a relief well, which could take more than 30-days to be effective.

Industry has estimated that under moderate weather conditions, a successful relief well may take 30-days to 90-days, plus deployment time. In comparison, a capping stack could be implemented significantly sooner, and a subsea shut-in device could be activated within minutes.

Therefore, the BSEE Alaska Region requested a comprehensive review and gap analysis of United States (U.S.) and international regulations, standards, recommended practices, specifications, technical reports and common industry methods regarding the safe employment of SCCE versus a relief well in Arctic conditions, and a historical statistical analysis of the Alaska Arctic OCS drilling seasons, over the past 5 years, in which metocean and operational conditions would support either or both methods. These work products are described in the BSEE Statement of Work under the following tasks.

Task 1: Conduct a post award Kickoff meeting. This activity was conducted on September 11, 2017 with a summary report of the meeting provided to BSEE.

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1.2 Safe Deployment Analysis Approach

All offshore activities, including relief well drilling and SCCE deployment, depend on the use of marine vessels which are subject to operational limitations related to metocean conditions. To determine the safe metocean conditions for these activities, we refer to the operating capabilities and limitations that have been established for the associated deployment vessels and their onboard equipment. These operating limitations however, generally exceed the safe conditions for critical operations that typically occur during deployment activities. Critical operations in relief well drilling include BOP handling, mudline cellar drilling, anchor handling and other operations that require moderate winds and sea states to be safely performed. Likewise, deployment of SCCE has critical operational periods that include crane operations to deploy equipment and materials to the seafloor such as a containment dome, capping stack, flow lines, and other ancillary subsea equipment for the SCCE response. Suitable and safe metocean conditions for these activities are discussed below in section 6 of this report.

Sea ice coverage also is paramount to the safe deployment of SCCE and relief wells as seasonal ice coverage will determine the beginning and end of the useful operating window for the deployment of SCCE and relief wells. Criteria for sea ice coverage are also discussed in section 6 below.

1.3 Report Structure

This report is structured to discuss the intersections between operational requirements for the safe deployment of relief well drilling rigs and SCCE, including support vessels and station keeping in sea ice, and the key metocean conditions which dictate when deployment can be conducted. The report then proceeds to define the deployment analysis methodology and results of the analysis. Several appendices have been included at the end of the report to provide additional detail and supporting information.

1.4 General Background on Offshore Drilling Operations in the Alaska Arctic OCS

The Alaska Arctic OCS is comprised of the Chukchi Sea and Beaufort Sea planning areas that are shown in figures 1-1 and 1-2, respectively.

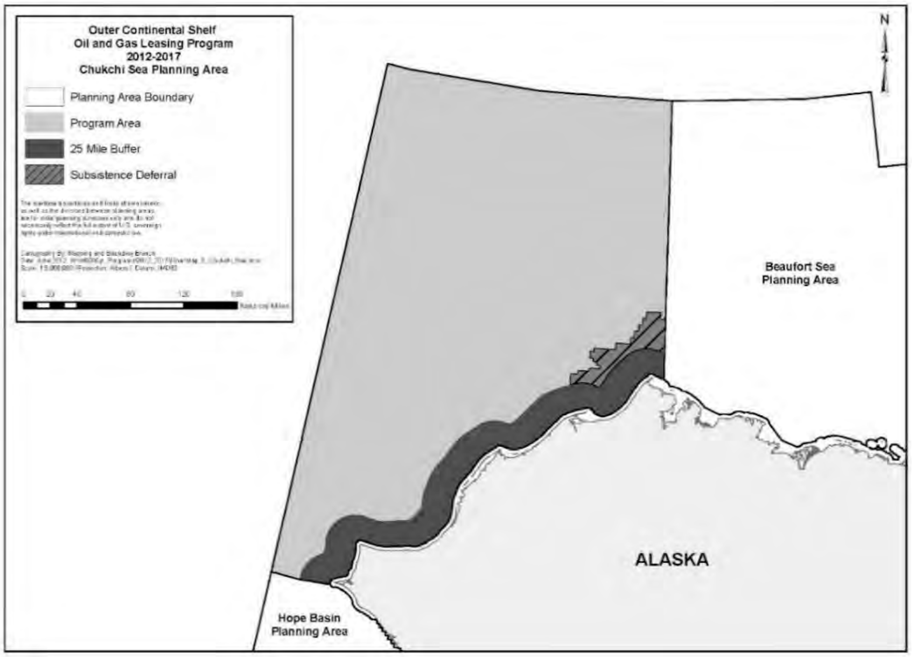


Figure 1-1. Chukchi Sea planning area (US BSEE, 2018).

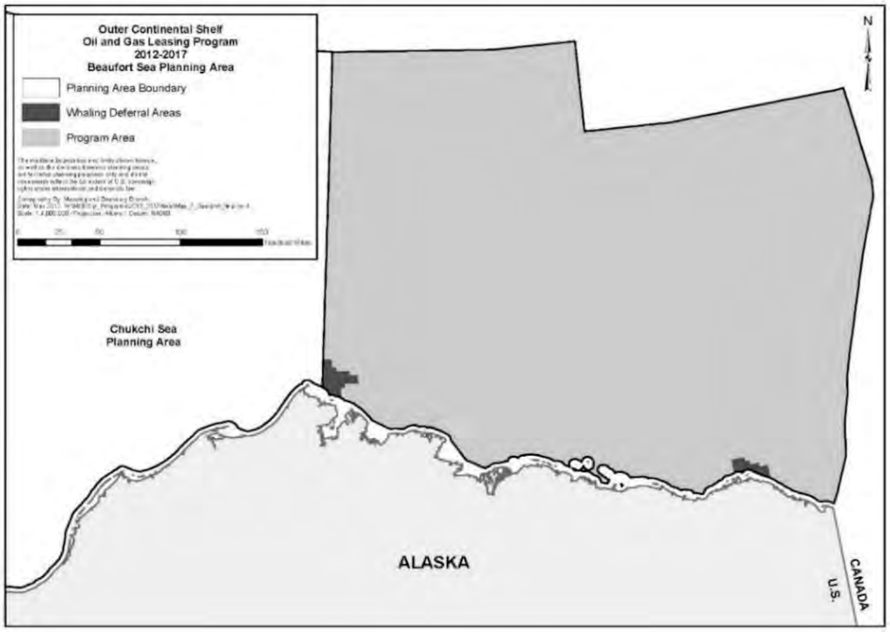


Figure 1-2. Beaufort Sea planning area (US BSEE, 2018).

Historically, the prospective area of the Beaufort Sea planning area has been along the geologic feature known as the Barrow Arch. This subsurface feature trends northwesterly from the Canadian border and generally follows the Alaska Arctic coast past Utqiagvik (Barrow). The vast majority of discovered petroleum reserves on the North Slope lie along the Barrow Arch which continues out into the Chukchi Sea beyond Utqiagvik (Barrow). The southern part of the Chukchi Sea planning area below the 72nd parallel is considered an extension of the North Slope petroleum system into the OCS. Located here are similar associated large geological structures that could hold large petroleum reserves with potential economics to support such remote development.

Moving northward from the Barrow Arch (and perpendicularly away) in the Beaufort Sea planning area, the continental shelf deepens to 328 feet (100 meters), and, where it rapidly falls off, to over 11,480 feet (3,500 meters) deep into the Canada Basin. This deep area is not considered geologically prospective at this time (Casarta, 2018). The relatively narrow shelf of the Beaufort Sea planning area combined with other factors (such as severe sea ice conditions, limited seismic coverage, generally smaller exploration structures, and project economics that require very large oil reserves) have prevented offshore exploration in the Beaufort Sea planning area beyond approximately 35 miles north of the Alaska Arctic coast, an area where the maximum water depth of exploration drilling has been 167 feet (51 meters) (US BOEM, 2018).

Offshore drilling operations in the Alaska Arctic OCS have been conducted during all seasons. The type of equipment used in a drilling operation depends both on the time of the year and on the water depth at the drilling site. In the summer and fall seasons (July to

November), drilling is usually conducted using ice class floating drilling vessels, whereas during the winter and spring seasons, drilling is conducted using bottom-founded submersible drilling vessels or man-made gravel or ice islands.

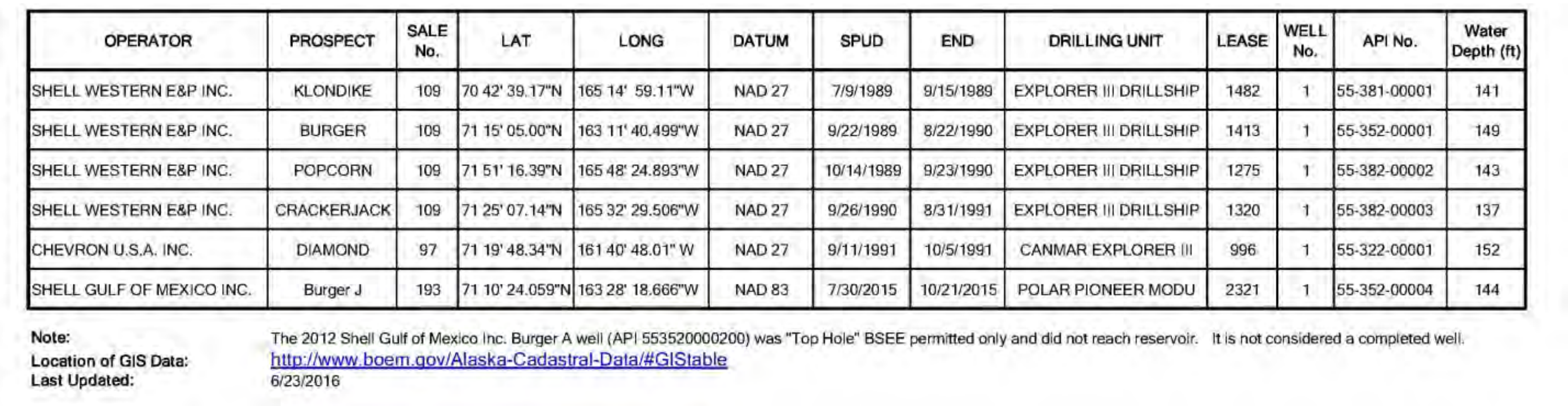
Historically, water depths for wells drilled within the planning areas have ranged from 18 to 167 feet (6 to 51 meters) in the Beaufort Sea and 137 to 149 feet (42 to 46 meters) in the Chukchi Sea (US BOEM, 2018). In water depths shallower than 79 feet (24 meters), bottom-founded submersible drilling caissons, gravel islands or ice islands have been used – to date this has only occurred in the Beaufort Sea. In water depths deeper than 79 feet (24 meters), which is both the upper limit of the submersible drilling fleet and beyond the practical depth of man-made exploration islands, drilling requires floating drilling vessels such as a semi-submersible drilling vessel or a drillship. To date, all drilling in the Chukchi Sea has used floating drilling vessels and these operations have occurred, as mentioned above, between 137 and 152 feet (42 and 46 meters) (US BOEM, 2018). In the Beaufort Sea, floating drilling vessels have been used in water depths of 87 to 167 feet (27 to 51 meters). In some cases, in the Chukchi Sea, a jackup rig has also been considered for use but never deployed.

A listing of the historical wells drilled in the Chukchi Sea and Beaufort Sea planning areas are presented in tables 1-1 and 1-2 respectively. Note that all the wells that have been drilled, as listed in these tables, have been exploration wells. The only oil or gas field to be developed on the Alaska Arctic OCS to date is the Northstar Unit. The Northstar oilfield was developed from a man-made gravel island placed in 39 feet (12 meters) of water in the Beaufort Sea. Approximately 20 initial production wells were drilled using a conventional land drilling rig. The field has produced over 170,000,000 bbl of oil since production began in 2001 and continues to produce oil today (AOGCC).

Drilling operations in the Chukchi Sea have been conducted during the open water season with conventional anchor-moored MODUs including the Explorer III (6 wells) drillship and the Polar Pioneer (1 well) semi-submersible drilling vessel. Due to the relatively shallow water depths of 200 feet (61 meters) or less in the Chukchi Sea historical exploration area, conventional anchor-mooring systems are necessary to maintain close radius position over the well. Dynamically positioned (DP) MODUs require deeper water to operate in as they require more tolerance in station keeping and are generally limited to water depths of about 984 feet (300 meters) and deeper.

Drilling in ice conditions in both the Chukchi Sea and Beaufort Sea OCS areas requires drilling vessels suited for icy waters although ice conditions in the Chukchi Sea area are less severe than in the Beaufort Sea. Jackup vessels and semi-submersible rigs have not been used in the Beaufort Sea for two primary reasons. They are not well suited for working in icy waters, as their structure exposes the drilling riser to ice impacts and potential damage from floating ice and they have not typically of sufficient ice class to allow transit through sea ice laden water which can be a necessary to reach the selected drilling location in the Beaufort

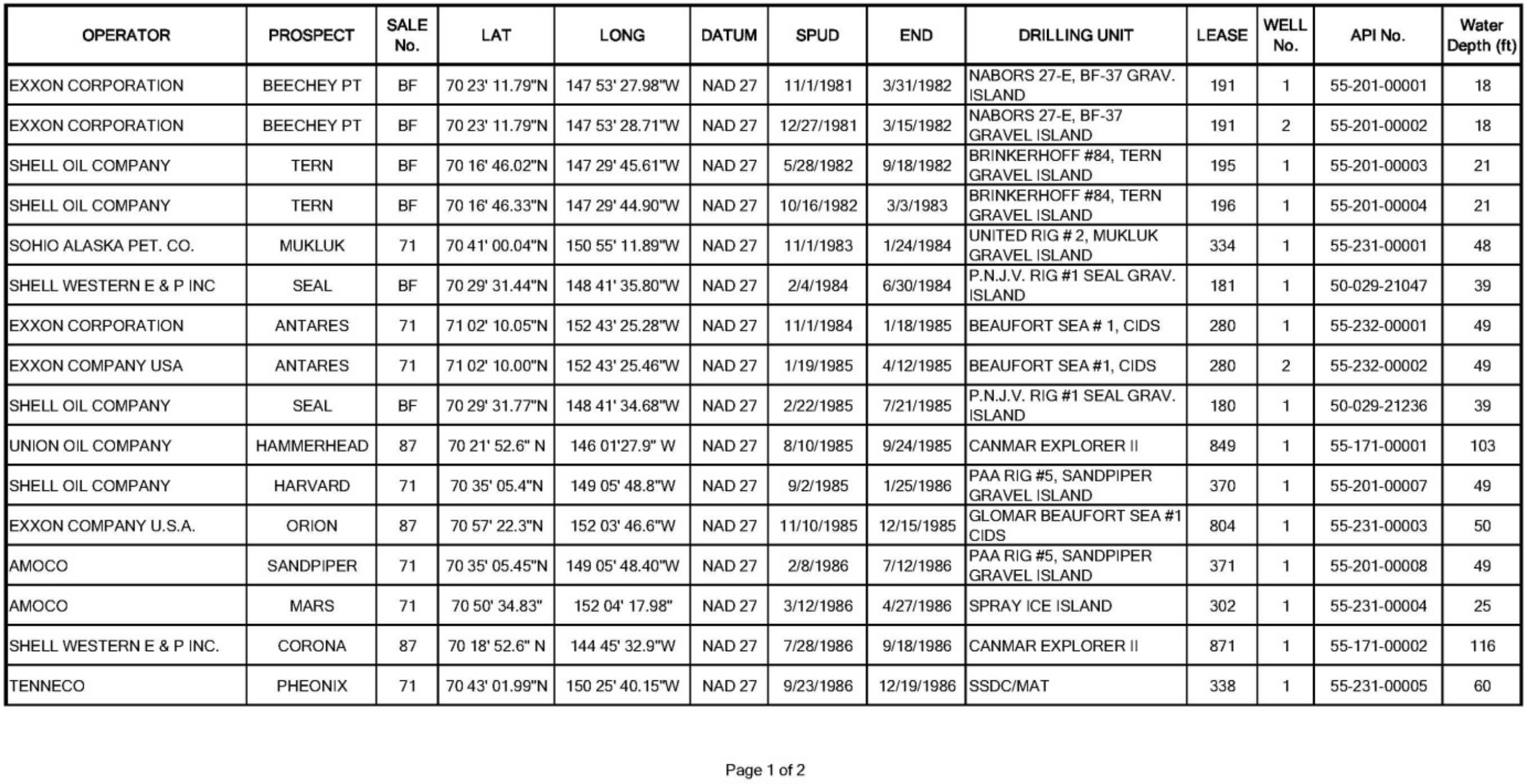
Table 1-1. Chukchi Sea OCS exploration wells (US BOEM, 2018).



OPERATOR	PROSPECT	SALE No.	LAT	LONG	DATUM	SPUD	END	DRILLING UNIT	LEASE	WELL No.	API No.	Water Depth (ft)
SHELL WESTERN E&P INC.	KLONDIKE	109	70 42' 39.17"N	165 14' 59.11"W	NAD 27	7/9/1989	9/15/1989	EXPLORER III DRILLSHIP	1482	1	55-381-00001	141
SHELL WESTERN E&P INC.	BURGER	109	71 15' 05.00"N	163 11' 40.499"W	NAD 27	9/22/1989	8/22/1990	EXPLORER III DRILLSHIP	1413	1	55-352-00001	149
SHELL WESTERN E&P INC.	POPCORN	109	71 51' 16.39"N	165 48' 24.893"W	NAD 27	10/14/1989	9/23/1990	EXPLORER III DRILLSHIP	1275	1	55-382-00002	143
SHELL WESTERN E&P INC.	CRACKERJACK	109	71 25' 07.14"N	165 32' 29.506"W	NAD 27	9/26/1990	8/31/1991	EXPLORER III DRILLSHIP	1320	1	55-382-00003	137
CHEVRON U.S.A. INC.	DIAMOND	97	71 19' 48.34"N	161 40' 48.01" W	NAD 27	9/11/1991	10/5/1991	CANMAR EXPLORER III	996	1	55-322-00001	152
SHELL GULF OF MEXICO INC.	Burger J	193	71 10' 24.059"N	163 28' 18.666"W	NAD 83	7/30/2015	10/21/2015	POLAR PIONEER MODU	2321	1	55-352-00004	144

Note:	The 2012 Shell Gulf of Mexico Inc. Burger A well (API 553520000200) was "Top Hole" BSEE permitted only and did not reach reservoir. It is not considered a completed well.
Location of GIS Data:	http://www.boem.gov/Alaska-Cadastral-Data/#GIStable
Last Updated:	6/23/2016

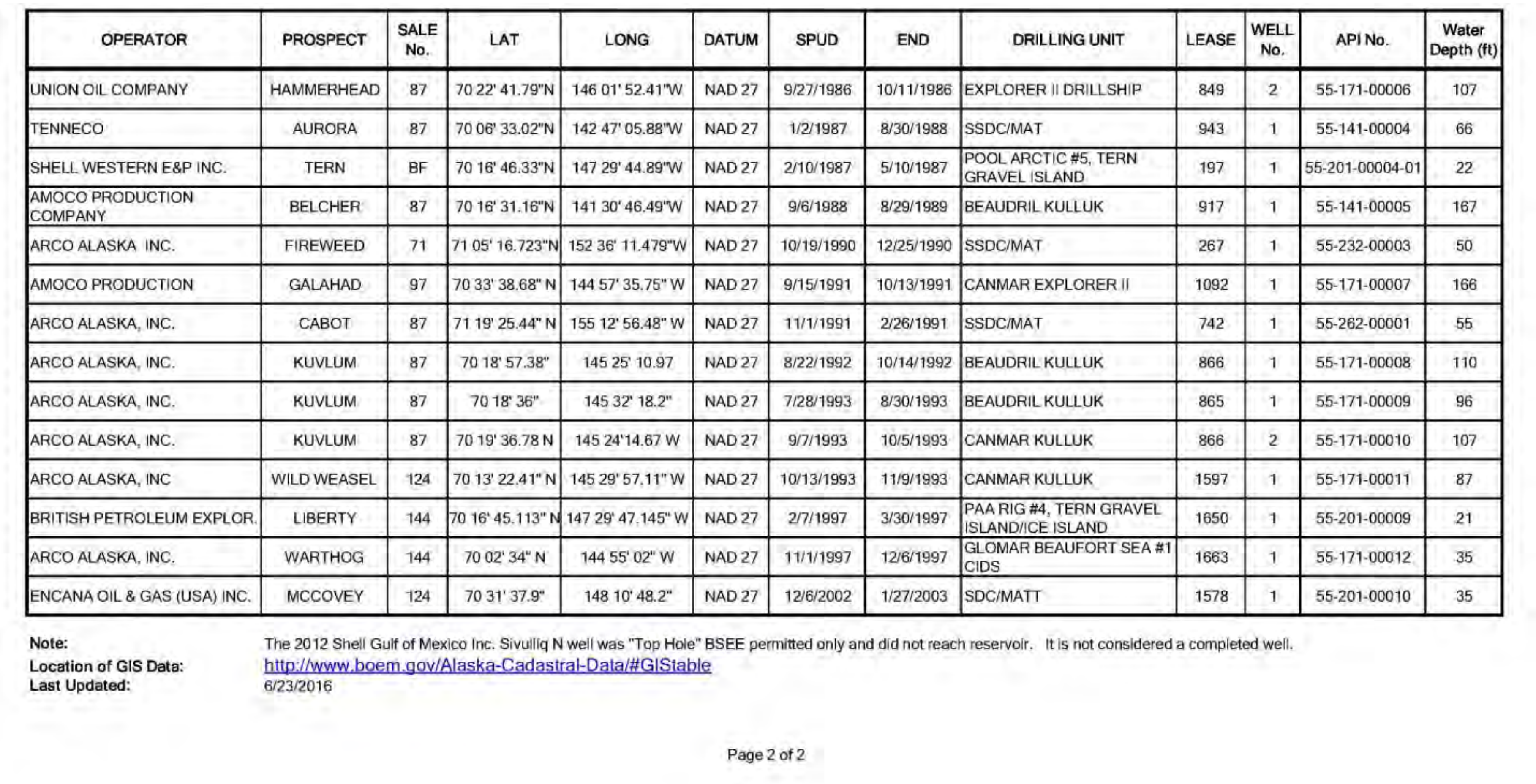
Table 1-2. Beaufort Sea OCS exploration wells (US BOEM, 2018).



OPERATOR	PROSPECT	SALE No.	LAT	LONG	DATUM	SPUD	END	DRILLING UNIT	LEASE	WELL No.	API No.	Water Depth (ft)
EXXON CORPORATION	BEECHEY PT	BF	70 23' 11.79"N	147 53' 27.98"W	NAD 27	11/1/1981	3/31/1982	NABORS 27-E, BF-37 GRAV. ISLAND	191	1	55-201-00001	18
EXXON CORPORATION	BEECHEY PT	BF	70 23' 11.79"N	147 53' 28.71"W	NAD 27	12/27/1981	3/15/1982	NABORS 27-E, BF-37 GRAVEL ISLAND	191	2	55-201-00002	18
SHELL OIL COMPANY	TERN	BF	70 16' 46.02"N	147 29' 45.61"W	NAD 27	5/28/1982	9/18/1982	BRINKERHOFF #84, TERN GRAVEL ISLAND	195	1	55-201-00003	21
SHELL OIL COMPANY	TERN	BF	70 16' 46.33"N	147 29' 44.90"W	NAD 27	10/16/1982	3/3/1983	BRINKERHOFF #84, TERN GRAVEL ISLAND	196	1	55-201-00004	21
SOHIO ALASKA PET. CO.	MUKLUK	71	70 41' 00.04"N	150 55' 11.89"W	NAD 27	11/1/1983	1/24/1984	UNITED RIG # 2, MUKLUK GRAVEL ISLAND	334	1	55-231-00001	48
SHELL WESTERN E & P INC	SEAL	BF	70 29' 31.44"N	148 41' 35.80"W	NAD 27	2/4/1984	6/30/1984	P.N.J.V. RIG #1 SEAL GRAV. ISLAND	181	1	50-029-21047	39
EXXON CORPORATION	ANTARES	71	71 02' 10.05"N	152 43' 25.28"W	NAD 27	11/1/1984	1/18/1985	BEAUFORT SEA # 1, CIDS	280	1	55-232-00001	49
EXXON COMPANY USA	ANTARES	71	71 02' 10.00"N	152 43' 25.46"W	NAD 27	1/19/1985	4/12/1985	BEAUFORT SEA #1, CIDS	280	2	55-232-00002	49
SHELL OIL COMPANY	SEAL	BF	70 29' 31.77"N	148 41' 34.68"W	NAD 27	2/22/1985	7/21/1985	P.N.J.V. RIG #1 SEAL GRAV. ISLAND	180	1	50-029-21236	39
UNION OIL COMPANY	HAMMERHEAD	87	70 21' 52.6" N	146 01'27.9" W	NAD 27	8/10/1985	9/24/1985	CANMAR EXPLORER II	849	1	55-171-00001	103
SHELL OIL COMPANY	HARVARD	71	70 35' 05.4"N	149 05' 48.8"W	NAD 27	9/2/1985	1/25/1986	PAA RIG #5, SANDPIPER GRAVEL ISLAND	370	1	55-201-00007	49
EXXON COMPANY U.S.A.	ORION	87	70 57' 22.3"N	152 03' 46.6"W	NAD 27	11/10/1985	12/15/1985	GLOMAR BEAUFORT SEA #1 CIDS	804	1	55-231-00003	50
AMOCO	SANDPIPER	71	70 35' 05.45"N	149 05' 48.40"W	NAD 27	2/8/1986	7/12/1986	PAA RIG #5, SANDPIPER GRAVEL ISLAND	371	1	55-201-00008	49
AMOCO	MARS	71	70 50' 34.83"	152 04' 17.98"	NAD 27	3/12/1986	4/27/1986	SPRAY ICE ISLAND	302	1	55-231-00004	25
SHELL WESTERN E & P INC.	CORONA	87	70 18' 52.6" N	144 45' 32.9"W	NAD 27	7/28/1986	9/18/1986	CANMAR EXPLORER II	871	1	55-171-00002	116
TENNECO	PHEONIX	71	70 43' 01.99"N	150 25' 40.15"W	NAD 27	9/23/1986	12/19/1986	SSDC/MAT	338	1	55-231-00005	60

Page 1 of 2

Table 1-2. Beaufort Sea OCS exploration wells (US BOEM, 2018) (continued).



OPERATOR	PROSPECT	SALE No.	LAT	LONG	DATUM	SPUD	END	DRILLING UNIT	LEASE	WELL No.	API No.	Water Depth (ft)
UNION OIL COMPANY	HAMMERHEAD	87	70 22' 41.79"N	146 01' 52.41"W	NAD 27	9/27/1986	10/11/1986	EXPLORER II DRILLSHIP	849	2	55-171-00006	107
TENNECO	AURORA	87	70 06' 33.02"N	142 47' 05.88"W	NAD 27	1/2/1987	8/30/1988	SSDC/MAT	943	1	55-141-00004	66
SHELL WESTERN E&P INC.	TERN	BF	70 16' 46.33"N	147 29' 44.89"W	NAD 27	2/10/1987	5/10/1987	POOL ARCTIC #5, TERN GRAVEL ISLAND	197	1	55-201-00004-01	22
AMOCO PRODUCTION COMPANY	BELCHER	87	70 16' 31.16"N	141 30' 46.49"W	NAD 27	9/6/1988	8/29/1989	BEAUDRIL KULLUK	917	1	55-141-00005	167
ARCO ALASKA INC.	FIREWEED	71	71 05' 16.723"N	152 36' 11.479"W	NAD 27	10/19/1990	12/25/1990	SSDC/MAT	267	1	55-232-00003	50
AMOCO PRODUCTION	GALAHAD	97	70 33' 38.68" N	144 57' 35.75" W	NAD 27	9/15/1991	10/13/1991	CANMAR EXPLORER II	1092	1	55-171-00007	166
ARCO ALASKA, INC.	CABOT	87	71 19' 25.44" N	155 12' 56.48" W	NAD 27	11/1/1991	2/26/1991	SSDC/MAT	742	1	55-262-00001	55
ARCO ALASKA, INC.	KUVLUM	87	70 18' 57.38"	145 25' 10.97	NAD 27	8/22/1992	10/14/1992	BEAUDRIL KULLUK	866	1	55-171-00008	110
ARCO ALASKA, INC.	KUVLUM	87	70 18' 36"	145 32' 18.2"	NAD 27	7/28/1993	8/30/1993	BEAUDRIL KULLUK	865	1	55-171-00009	96
ARCO ALASKA, INC.	KUVLUM	87	70 19' 36.78 N	145 24'14.67 W	NAD 27	9/7/1993	10/5/1993	CANMAR KULLUK	866	2	55-171-00010	107
ARCO ALASKA, INC	WILD WEASEL	124	70 13' 22.41" N	145 29' 57.11" W	NAD 27	10/13/1993	11/9/1993	CANMAR KULLUK	1597	1	55-171-00011	87
BRITISH PETROLEUM EXPLOR.	LIBERTY	144	70 16' 45.113" N	147 29' 47.145" W	NAD 27	2/7/1997	3/30/1997	PAA RIG #4, TERN GRAVEL ISLAND/ICE ISLAND	1650	1	55-201-00009	21
ARCO ALASKA, INC.	WARTHOG	144	70 02' 34" N	144 55' 02" W	NAD 27	11/1/1997	12/6/1997	GLOMAR BEAUFORT SEA #1 CIDS	1663	1	55-171-00012	35
ENCANA OIL & GAS (USA) INC.	MCCOVEY	124	70 31' 37.9"	148 10' 48.2"	NAD 27	12/6/2002	1/27/2003	SDC/MATT	1578	1	55-201-00010	35

Note:	The 2012 Shell Gulf of Mexico Inc. Sivulliq N well was "Top Hole" BSEE permitted only and did not reach reservoir. It is not considered a completed well.
Location of GIS Data:	http://www.boem.gov/Alaska-Cadastral-Data/#GIStable
Last Updated:	6/23/2016

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Sea. However, the Polar Pioneer operated by Shell in the Chukchi Sea in 2015 was an exception to this situation where it was classed for transit through ice laden waters.

All operations in the Chukchi and Beaufort seas have also included a support fleet of ice management vessels because even when drilling in open water, it is prudent to utilize two or more ice class support vessels to manage any drifting ice and provide safe escort of the drilling vessel into and out of the area.

As discussed above, the bathymetry of the Chukchi Sea and Beaufort Sea shelf areas is relatively shallow (GEBCO, 2018), on the order of 328 feet (100 meters) or less throughout the historically prospective acreage. Historically, vessels such as the Kulluk drilling barge, and the drillships Explorer II and Explorer III were built to accommodate these depths, but those vessels are no longer available as they have been retired from service and scrapped or, in the case of the Explorer III, it has been converted to a dynamically positioned (DP) vessel and no longer has a conventional anchor-mooring system. This is problematic for new floating drilling operations in the Beaufort Sea because the existing ice class drilling-vessel fleet is geared toward worldwide deep-water capability with minimum operating water depths of 984 feet (300 meters) or 328 feet (100 meters), with anchor-mooring modifications. The limitations presented by the shallow bathymetry are a significant challenge for further offshore-operations with floating drilling vessels in the Alaska Beaufort and Chukchi Seas where likely near- to mid-term future exploration operating water depths will continue to be shallower than 200 feet (61 meters).

While it is unlikely in the current economy that new ice class drilling vessels will be built to support oil and gas operations in the Beaufort and Chukchi seas for the near- to mid-term timeframe, there are new concepts under development as shown in appendix A of this report. With adequate industry interest and funding, additional shallow-water-capable ice class vessels could be built in the future. Existing commercial vessels could also be modified for ice class drilling operations in shallow waters as was done by Canadian Marine Drilling (CANMAR) in the 1970s (Connelly, 2018).

This report discusses the metocean challenges to operating and responding to well blowouts in the Alaska Arctic OCS and the ability and limitations of current equipment and technology to meet those challenges.

2.0 Metocean Conditions and Their Relation to SCCE and Relief Well Deployment

2.1 Key Metocean Conditions Included in the Deployment Analysis

Several metocean factors including wind speed, wave height, wave period, current speed, bathymetry and ice coverage, comprise the critical operating conditions that affect the safe deployment of SCCE and relief wells in the Alaska Arctic OCS. Bathymetry and ice management concerns also place strong limitations on where, when, and with what equipment drilling and support vessels can operate. For bathymetry and sea ice coverage, the stationary characteristic of bathymetry and the seasonal predictability of ice coverage are useful for accessible locations and general timing and duration for safe deployment of SCCE and relief well drilling vessels in both open water and sea ice scenarios. Additional metocean conditions that have negligible impact on safe deployment of SCCE or relief wells are also discussed in this section.

2.1.1 Sea State

Rough sea states, including high waves and longer wave periods, can affect the safety and operating limits of relief well and SCCE deployment in the Chukchi and Beaufort seas. They are most likely to occur during the open water season when there is no ice present to dampen wind-driven waves and fetch distances are at their greatest. These areas can experience gale or storm-force winds resulting in a rough sea state during the typical summer and fall operating seasons (Scully). Sea states have also been increasing in the Chukchi and Beaufort seas in recent years due to the recession of sea ice coverage and larger open water areas that can lead to increased wave heights and swell (Thomson and Fan, 2016). As sea ice coverage increases in the fall and early winter, sea states are dampened by the reduced open water area. As a result, sea state is less likely to affect ice class vessels operating in sea ice than vessels operating in open water deployment scenarios.

The support vessel fleet and the relief well drilling rig can be adversely affected by sea state and these vessels have published limits for acceptable sea state conditions for conducting critical and routine operations (Transocean 2018, Connelly 2018, Edison Chouest, 2018). Generally, critical operations have a reduced tolerance of sea state conditions. A relief well drilling rig may suspend deployment operations such as BOP deployment, if necessary, during a high sea state condition. Similarly, SCCE deployment would likely be suspended under similar conditions as the resulting heave action on the deck of a vessel may negatively impact the ability to safely deploy SCCE equipment. Capping stacks and containment domes are usually deployed using a deck crane or A-frame located on the stern of the deployment vessel. If the vessel is experiencing too much heave due to wave action, the capping stack or other SCCE device could unintentionally hit the wellhead with great downward force during deployment causing damage to the SCCE itself and/or to the wellhead. Safe deployment of the capping stack or containment dome would require heave conditions on the order of 1.5 feet (0.5 meter) or less unless the vessel is equipped with heave-compensating technology. If a vessel has a heave-compensated crane or A-frame to deploy a capping stack, deployment can occur in maximum wave heights (H_{max}) 9.8 feet (3 meters) or more with modest wave periods such as those found in the Beaufort and Chukchi seas. While most modern intervention vessels with high capacity deck cranes have heave-compensating capabilities in this range of metocean conditions, there is only one ice class intervention vessel of this type in service today (Fox, 2018).

2.1.2 Wind Speed

High winds can affect both relief well drilling operations and support-vessel operations for both intervention vessels and the ice management fleet. Drilling vessels have wind ratings for routine and critical operations, above which, operations may be suspended. Likewise, the support-vessel fleet will have wind-rating limitations for safe operations in addition to general industry operating guidelines. In most cases, wind ratings are combined with the sea state and current speed to determine acceptable safe-operating conditions. High wind speeds will tend to increase wave heights in open water conditions which can limit operations. In ice-laden seas, high winds can increase the drift speed of ice; this can make ice management operations more difficult and trigger higher alert levels in the ice alert system.

2.1.3 Air Temperature

Arctic offshore drilling from floating vessels generally occurs during the summer and fall shoulder season when air temperatures are less extreme. Conversely, drilling from ice islands, or submersible vessels is usually conducted during the winter season. Throughout both seasons cold air temperatures will be encountered.

Arctic floating drilling vessels and associated support vessels are designed to withstand cold temperatures. The Stena IceMAX is certified to DNV Winterized Cold (-4 F/-20 C, -22 F/-30 C). The temperature -4 F (-20 C) stands for material design temperature and -22 F (-30 C) for extreme design temperature. However, cold temperatures that may occur during winter operations may also cause superstructure icing particularly when vessels are underway and generating bow spray. Atmospheric icing may also occur on stationary vessels because of fog and/or precipitation, especially during winter storms. Ice accretion, which is frozen sea water, can present safety concerns, affect equipment (valves, winches, pipes, etc.) and/or slow productivity.

Air temperature is not a significant contributing factor in the deployment analysis, because ice class drilling vessels are designed to operate in cold weather and vessel icing is not considered to be a major issue during summer and fall drilling operations, when floating drilling and support vessels are required for relief well drilling and SCCE deployment. Winter drilling operations are conducted from submersible vessels or man-made islands with conventional land-type rigs; in both cases, the critical equipment is designed to operate in very cold temperatures and winter conditions. During extreme winter conditions when temperatures may dip below -22 F (-30 C); in almost all cases, ice conditions would have already reached concentrations that are prohibitive for the operation of ice class floating drilling and support vessels. Vessel operations would be suspended for the season, making the cold temperatures a moot point. For this reason, air temperature has minimal impact on operations as discussed in section 7 below.

2.1.4 Bathymetry

As discussed in section 1.4 above, water depths in the majority of the U.S. Chukchi Sea and Beaufort Sea historically prospective areas are relatively shallow on the order of 328 feet (100 meters) or less. This water depth range limits the fleet of available drilling vessels that can be used and it presents significant safety concerns for the intervention and support vessels which can be used for the deployment of SCCE. Vessels involved in the deployment of SCCE in shallow waters could be impaired by a surface gas boil as discussed below in section 2.1.1.5. For these reasons, water depth is considered a major limiting factor for the relief well drilling rig and SCCE deployment vessels; water depth is therefore included in the deployment analysis scenarios presented in this report. Figure 2-1 shows the bathymetry isobaths across the Beaufort Sea and Chukchi Sea planning areas.

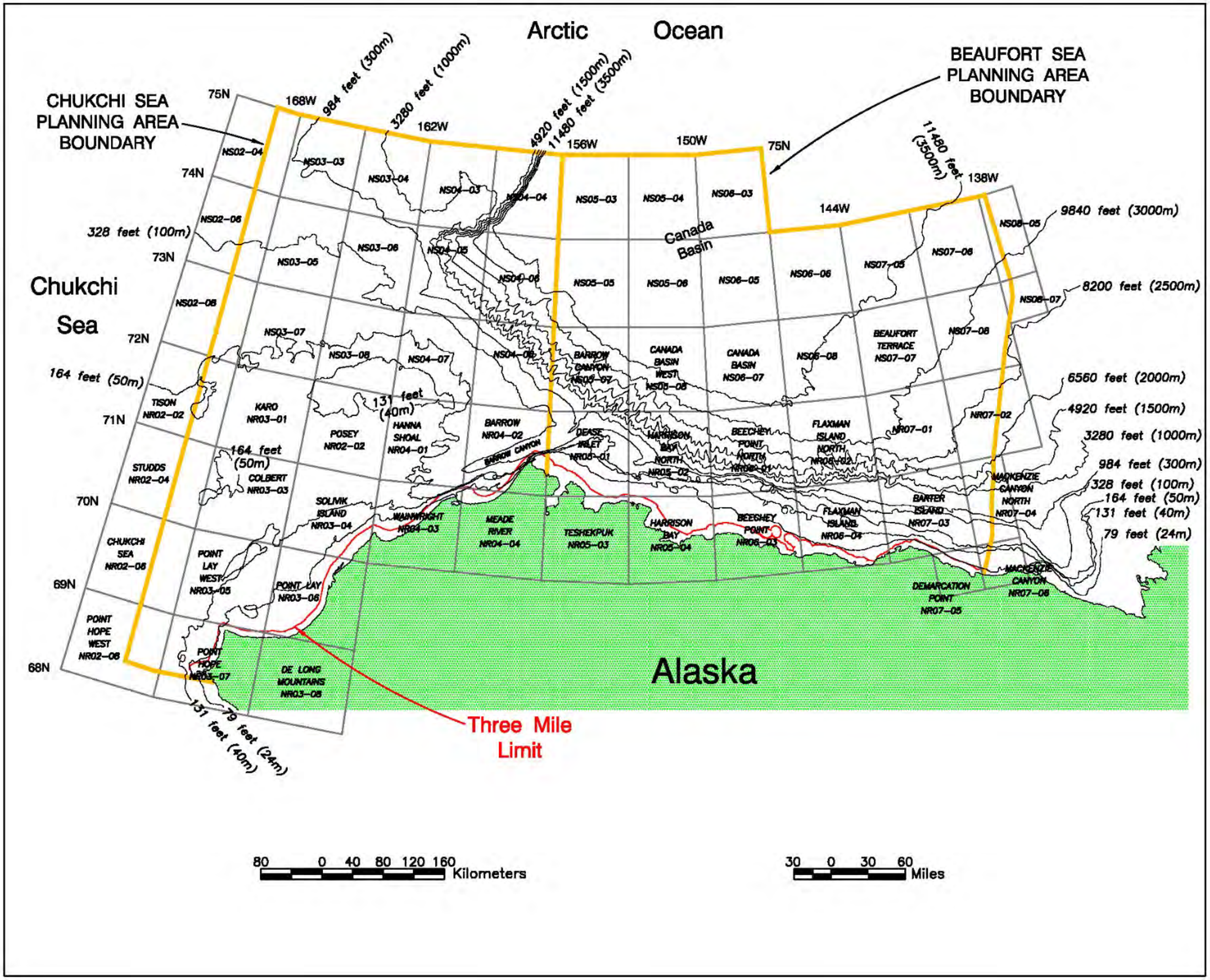


Figure 2-1. Bathymetry of Chukchi Sea and Beaufort Sea planning areas.

2.1.4.1 Equipment Use is Limited in Various Water Depth Ranges of the Chukchi and Beaufort Seas

Nearshore Water Depths – Gravel Islands, Ice Islands, and Submersible Drilling Caissons

Beaufort Sea planning area exploration and development drilling operations have been conducted in water depths as deep as 26 feet (8 meters) from ice islands, 49 feet (15 meters) from gravel islands, and 66 feet (20 meters) from submersible drilling caissons (US BOEM, 2018). For these wells, land-type drilling rigs were utilized for the drilling operations. In the Chukchi Sea, no wells have been drilled with these types of drilling structures and equipment.

The practice of conducting exploration drilling from gravel islands in the nearshore waters of the Beaufort Sea has generally been discontinued since the late 1980s due to cost and environmental reasons. However, gravel islands remain a viable development platform for nearshore fields such as the planned development at Liberty. Ice islands also continue to be a viable exploration option in the nearshore waters of the Beaufort Sea planning area at water depths shallower than 26 feet (8 meters). However, ice islands are generally not considered for use in the Chukchi Sea planning area where water depths are deeper than 26 feet (8 meters) and variable sea ice conditions preclude the practicality of this approach.

Of the three submersible drilling caissons that could be used in nearshore waters, only the SDC, with a depth range of 26 to 79 feet (8 to 24 meters), is still available for use in the Beaufort and Chukchi seas. The other similarly capable vessels, the Molikpak and the Concrete Island Drilling System (CIDS), have been transferred to the Sea of Okhotsk and are utilized as development structures offshore of Sakhalin Island.

Nearshore areas of the Chukchi Sea and Beaufort Sea planning areas can also be accessed through extended-reach drilling (ERD). Significant technological advancements in ERD technology in recent years has led to wells being drilled with horizontal displacement in excess of 7 miles. Examples in the Beaufort Sea planning area for ERD applications include Eni's current drilling activities at North Nikaitchuq, which are planned to reach the exploration target in Harrison Bay Block 6423 from their Spy Island drilling facility (man-made gravel island) located in State of Alaska waters 3.8 miles from the Federal OCS (US BOEM). In addition, BP had planned to develop the Liberty field on the OCS with ERD techniques, but that plan has been cancelled in favor of gravel-island development under the new operator, Hilcorp Alaska. However, it is important to note that ERD drilling techniques are not considered a reliable method for drilling relief wells because their level of subsurface precision is not sufficient for guidance to intercept a blowing well (Shursen and Carden, 2018).

Water Depths 79 feet (24 meters) to 131 feet (40 meters) - Not currently Serviceable with the Existing Drilling Fleet
With nearshore operating water-depth limitations of a maximum of 79 feet (24 meters) for portions of the Chukchi Sea and Beaufort Sea planning areas, drilling locations between 79 feet (24 Meters) and 131 feet(40 Meters) will have minimal options for relief well deployment due to the limitations of the current floating drilling fleet. Previously, this gap in operating depth was filled by the Kulluk which has drilled wells in water depths as shallow as 87 feet (27 meters). However, the Kulluk has since been retired from service and scrapped.

Water Depths 131 feet (40 meters) to 328 feet (100 meters) - Serviceable with the Existing Open Water Drilling Fleet
In water depths ranging from 131 feet (40 Meters) to 328 feet (100 meters), existing open water drilling vessels such as the anchor moored semi-submersible Polar Pioneer can safely drill relief wells. If operations were required in sea ice conditions, currently there are no ice class drilling vessels that can drill in this water depth range.

Water Depths Above 328 feet (100 meters) – Floating Drilling Vessels
For water depths deeper than 328 feet (100 meters), both open water and sea ice drilling conditions are possible. The open water anchor moored semi-submersible fleet can operate in water depths of 1,500 feet (457 meters) or more. For sea ice conditions, a vessel such as the Stena IceMAX can be fitted with a turret anchor mooring system (see section 2.1.1.4 below) to drill in water depths deeper than 328 feet (100 meters) (Stena, 2018).

The above conditions area discussed as a rationale for water depth being a key metocean criterion due to the limitations on equipment availability for SCCE deployment and relief well drilling at various depth ranges.

2.1.4.2 Drilling Vessel Transit

Water depth is an important factor for relief well operations, as it affects the type of drilling vessels that can access a well site. While draft is generally not a limiting factor for mobilizing a drilling vessel to the subject areas, it could be a limiting factor for bringing in a relief well drilling rig on short and unexpected notice. Limitations are mostly based on where the relief well drilling rig is located, and the route required to transit to the work area. The draft of support vessels is generally less of a concern than the draft of the larger drilling vessels.

Transiting to the Beaufort and Chukchi Seas from the Pacific provides adequate draft for large vessels. However, bringing ships or support equipment in from the

Atlantic through the Northwest Passage is more limited. The most common route is Victoria Strait where occasional shallow water depths of 31 feet (9.5 meters) will not accommodate large ice class drillships like the Stena IceMAX (Connelly, Stena). Prince of Wales Strait is deeper and may allow transit in early spring, but will likely require icebreaker support. Smaller, shallower draft ice class drilling vessels do not currently exist. This makes the ability of bringing in relief well drilling rigs and/or support vessels from the Atlantic a problematic response strategy. Figure 2-2 shows the Northwest Passage mobilization routes.

Figure 2-2. Northwest Passage routes (geology.com, 2018).

This concern is mentioned as a rationale for water depth being a key metocean criterion due to the limitations vessel draft may impose in bringing in response vessels from the east.

2.1.4.3 Rig Collapse and/or Debris Interfering with Well Response

In the unlikely event of a drill rig collapsing or sinking during a well blowout, it is more advantageous to be in deeper water where there is less potential for the rig and or other debris to fall on top of the wellhead. Also in deeper water, it takes longer for an object to sink; this would allow the currents more time to move the vessel and any associated debris away from the well site. For example, the Macondo well had a dynamically-positioned drilling rig located in 5,000 feet of water. When the rig sank, it drifted away from the well and landed 1,200 feet from the wellhead; this allowed response operations to proceed without interference from the rig.

However, in shallow-water depths, it takes less time for an object to sink, and there is little opportunity for the ocean currents to carry the rig/debris very far away. If the rig sinks, it may fall on the wellhead and blowout preventer (BOP) causing further damage and obstructing access to the blowing well. Mooring lines that remain anchored to the seafloor could also cause a rig to fall on the well. If the well is covered by the rig and/or debris, there is no way to install a capping stack or other SCCE until the rig has been removed from the immediate well area. Moored rigs and bottom-founded rigs such as a jackup or submersible present similar problems for removal from the site. In any of these situations, specialized equipment will be required to conduct removal of the rig structure and associated debris.

This concern is mentioned as another rationale for including water depth in the deployment analysis because in the event of a blowout, it influences the likelihood of the need to bring in vessels and equipment to remove debris from the immediate wellhead area when drilling in shallow waters.

2.1.4.4 Mooring and Dynamic Positioning Requirements for Floating Vessels

Water depth at the drill site must also be compatible with the mooring and positioning systems in the drillships and support vessels. Modern drilling vessels have transitioned from fixed anchors to computerized dynamic positioning (DP) systems for station keeping (Wang 2016, Weingarth, 2006). The advantages of DP systems include the ability to work in deep waters without anchors, faster deployment onsite, and the ability to maneuver the vessel heading while maintaining the station above the well head (weathervaning).

Another advantage of operating at greater depth is that depth provides tolerance for more play in the surface position of the vessel. In floating drilling operations, it is vital for the vessel to keep stationary over the well so that the marine riser connecting the vessel to the wellhead is nearly upright and vertical. A certain amount of offset distance in the vessel location is unavoidable, but with deeper water depth, the riser deflection angle from the seafloor wellhead equipment to the vessel is lessened, thus reducing strain on the riser connection to the wellhead.

For operations in icy seas, several companies have developed turret mooring systems for their drillship designs that will provide additional station keeping ability during operations in ice-laden waters. To date, these systems have only been tested in the lab for the new generation drillships and have not been commercially produced for field application. The turret system allows the drilling vessel to be anchored to the seafloor while utilizing the DP system to provide additional station keeping support and maintaining an optimal heading for given weather and ice conditions (Efraimsson, 2016). This minimizes ice forces on the vessel including the avoidance of ice pressure building against the beam of the vessel. Turret mooring has been used on some early drillships built in the mid-1970s and earlier, but none have been built since then.

The Stena IceMAX (Stena Drilling) is one of only three active ice class drilling vessels in existence today along with the Bully I and Bully II, which are operated by Noble Drilling. These vessels require minimum water depths of 984 feet (300 meters) or more for DP operations and 328 feet (100 meters) for turret moored operations with DP assist. Stena's concept for turret mooring of the IceMAX is shown below in figure 2-3.

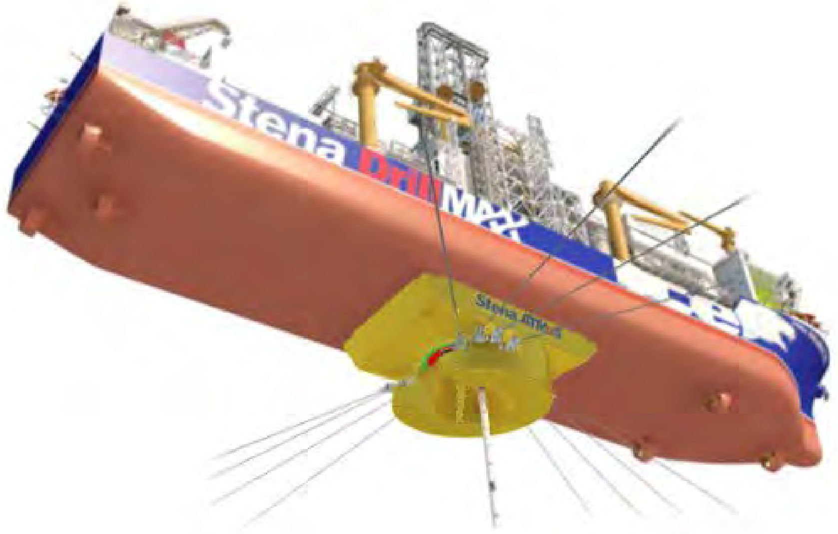


Figure 2-3. Stena IceMAX turret mooring system (Stena, 2018).

While it is possible that an ice class drillship could be built (or an existing vessel modified) to be capable of operating in water depths shallower than 328 feet (100 meters) versus the existing ice-capable drilling vessels, it does not seem likely in the foreseeable drilling rig market. The current economic model for Arctic-capable offshore-drilling vessels is to build an ice class drilling vessel with the flexibility to operate in icy waters, as well as in the more active deep-water markets worldwide. Drilling contractors must utilize their vessels in areas besides the Arctic OCS so that they can follow the asset demand and maximize their return on capital investment through year-round operations. Offshore-drilling contractors and designers such as Gusto MSC, Aker and LMG Marin, and others, also have designs for ice-capable turret-moored drilling rigs. However, these vessels are generally designed to operate in deep water such as offshore northeast Greenland and other markets where water depths are significantly deeper than the historically prospective areas in the US Chukchi and Beaufort seas.

Based on these water-depth limitations for the ice class drilling vessels, and when sea ice conditions are present, it would not be possible to deploy a relief well in the majority of the historically prospective operating regions of the Beaufort Sea and the Chukchi Sea planning areas and significant portions of the entire planning areas. Therefore, bathymetry has been included as a key criterion in analyzing safe deployment analysis for relief well drilling rigs in the deployment analysis scenarios presented in this report.

2.1.4.5 Gas-Boil Hazard

In a blowout scenario, an oil and gas stream exits the wellhead on the seafloor with the vast majority of the fluid volume exiting the well as gas (Ross). The gas rapidly expands as it rises up the well and enters the water column traveling to the sea surface at estimated velocities of 5 to 10 m/s or higher. The migrating gas can create a sea-surface boil or gas boil; a forceful release of hazardous gases which can present human-health hazards to workers, fire hazards to the drilling rig and support vessels, potential stability problems for the vessels, as well as create significant turbulence in the water. Figures 2-4 and 2-5 show examples of gas boil hazards in shallow water.

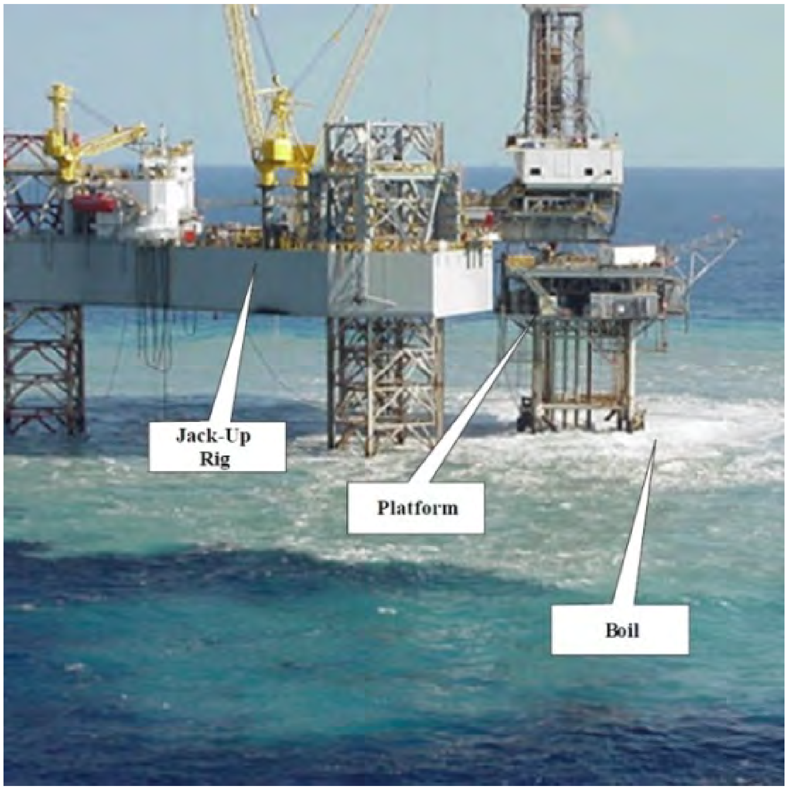


Figure 2-4. Gas boil at High Island Block A-368 Gulf of Mexico in water depth of 315 feet (96 meters) (US BSEE, 2018).

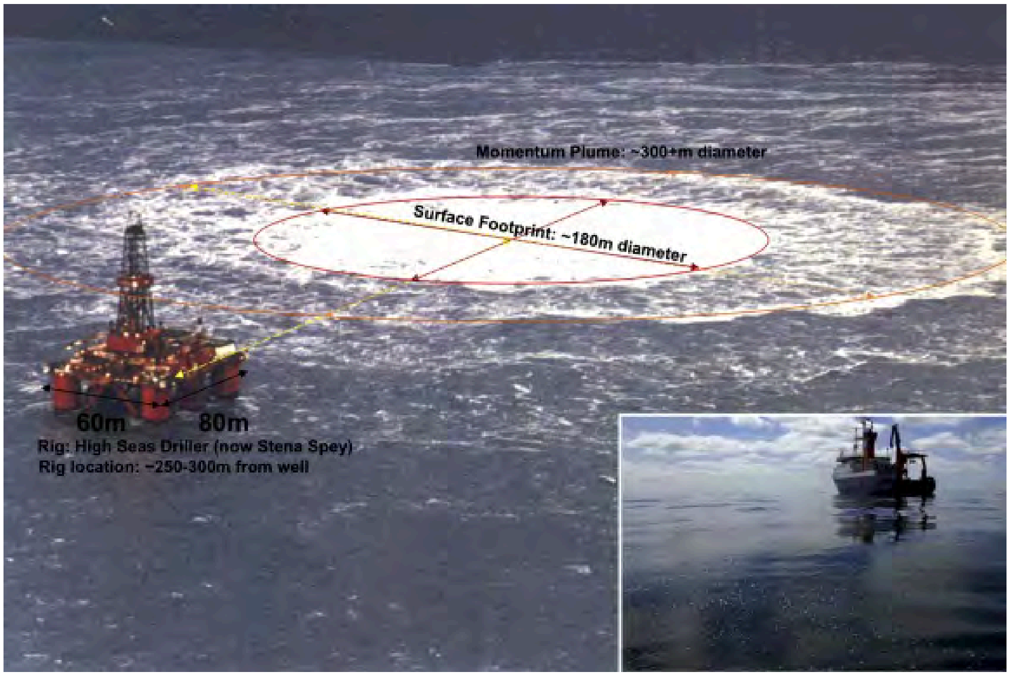


Figure 2-5. SB-04 well shallow gas blowout in water depth of 312 feet (95 meters), North Sea (Liefer, 2015).

The potential for a gas boil depends on whether the blowout occurs at an adequate depth to allow the gas to be entrained into the water column before reaching the surface, and/or whether the combination of depth and current speed will carry the gas away from the immediate area above the well before it reaches the surface. While in some scenarios the upward migration of a gas plume can be retarded by thermal stratification of the water column (Liefer and Judd, 2015), this phenomenon is not known to be sufficient to prevent a sea-surface gas boil from a blowout at depths of 984 feet (300 meters) or shallower in the Beaufort or Chukchi seas.

There is no set safe distance for operating above a blowing well as it is dependent on well flow rate, gas to oil ratio, site-specific currents, water column characteristics and water depth. Modeling may be used to help determine the direction and distance the plume will travel before reaching the surface for site-specific scenarios (Olsen). However, in shallow water with depths of less than 984 feet (300 meters) such as in much of the Beaufort Sea and Chukchi Sea planning areas, a gas boil is likely to be a concern during a blowout response. In stationary water, the upward velocity of a gas bubble is only about 0.82 feet/s (0.25 m/s), but this increases in the center of a blowout plume where velocities can reach 16 to 33 feet/s (5 to 10 meters/s) due to the pumping effect of the rising gas in the bulk liquid (Ross, 1997). Mean current velocities in the Chukchi Sea range of 0.39 feet/s to 0.92 feet/s (12 cm/s to 28 cm/s) and from 0.16 feet/s to 0.33 feet/s (5 cm/s to 10 cm/s) in the Beaufort Sea (Francis, 2016). These current velocities are too slow to provide significant horizontal displacement of the gas plume as it rises in the water column.

Using the most conservative of each of these parameters, for water depth of 984 feet (300 meters), rising gas velocity of 16 feet/s (5 meters/s) and a current speed of 0.92 feet/s (28 cm/s), it is estimated that the surface displacement of the center of a gas boil would be within 58 feet (17.6 meters) of the well center.

This minimal offset from the well will likely prohibit an intervention vessel from safely positioning itself above the blowing well, which in turn will prohibit safe vertical deployment of SCCE equipment from the vessel. Additionally, in the event of a gas boil, the gas and oil vapors that are released will likely exceed regulatory lower explosive limits (LEL) making it necessary to move the drilling rig and associated vessels away from the well to avoid fire and human-health hazards, if possible.

A possible solution to enable SCCE deployment in the presence of a gas boil is to use an offset-deployment technology to remotely position SCCE over the blowing well in shallow water. Leading up to Shell's exploration program in the 2015 Chukchi Sea open water season, Shell designed and built a fit for purpose containment dome that incorporated an offset installation system into the dome itself. This system included a series of eight winches on the exterior of the dome and connecting cables to prepositioned seafloor anchors that allowed the dome to be remotely maneuvered and positioned over the well.

For deployment of heavier SCCE components such as a capping stack, an offset installation system has been designed, built and field tested by Oil Spill Response Limited (OSRL), which is a consortium of over 40 worldwide offshore operators. (see appendix A for additional information on current and developing technology). The OSRL system is limited to open water deployment and a minimum operating water depth of 148 feet (45 meters) (131 feet (40 meters) with the use of recessed wellhead cellar, as is typical in the Chukchi Sea and Beaufort Sea floating drilling practices). The system is housed in Trieste, Italy and requires a total of seven Boeing 747 cargo aircraft loads to deploy to a well control incident and a minimum of five vessels working at the deployment location. Given these limitations and the remote logistical requirements of the Chukchi and Beaufort seas, it is likely that an offset capping stack installation system for the Alaska Arctic OCS would need to be fit for purpose built and pre-staged nearby and/or on the seafloor near the well location to be able to be rapidly deployed. For construction of a fit for purpose offset installation system, it should be possible to adapt the OSRL type system for use in Arctic waters and shallower deployment depths through selective design changes. It should also be noted that while OSRL has constructed and tested one offset-installation system, they have no current plans to construct any additional systems.

Pre-installed subsea isolation devices (SIDs) designed to be activated by remote control is another available and proven SCCE technology for deployment in shallow-water depths where gas boil hazards are a concern (Trendsetter). If the well has been designed for the use of a pre-installed SID, this is an additional safety system to be considered for well containment. It should be noted however, that in the unlikely event that loss of well control occurs outside of the main well bore, then other containment and mitigation measures will be required.

Based on the inherent dangers that a gas boil presents for SCCE deployment in shallow waters, it is likely that direct-vertical-deployment of a capping stack, cap and flow system, or containment dome will be problematic in the shallow waters of the Beaufort and Chukchi seas without use of an offset-installation system or other specialized deployment equipment that is yet to be developed. Therefore, water depth has been included as a key criterion in analyzing safe deployment of SCCE and relief well drilling rigs in the deployment analysis presented in this report.

2.1.5 Sea Ice Concentration

Sea ice has a major effect on all Arctic offshore operations. These impacts depend on ice concentration or lack thereof, ice properties, ice drift and ice forces encountered in a prospective area. There are different types of ice, i.e. first-year, second-year, multi-year, shelf or glacial ice. The occurrence and geometry of ice features also varies, such as ice islands, level ice, rafted ice, rubble fields, leads or polynya, pressure and shear ridges, stamukhi, land-fast ice and pack ice (US NIC, 2018, Appel, 2018).

Recent trends in the reduction of sea ice cooncentration during the open water season have resulted in significantly greater areas of open water that has in turn increased the sea states encountered in the Chukchi and Beaufort seas. These effects can impact offshore operations through decreased operating efficiency up to and including suspension of operations.

Navigational and operational hazards of sea ice to drilling vessels and other support vessels are primarily caused by increasing concentration and thickness of ice. As ice concentrations increase, the vessels efficiency decreases. All ice class vessels have limits to their ability to push through ice floes and to withstand ice pressure. The vessel's capabilities are determined by the ice classification for the vessel that is provided by various marine classification societies such as the American Bureau of Shipping (ABS), DNV GL, and others (Connelly, 2018).

Non ice class vessels can operate safely in limited ice conditions with sea ice concentrations below 2 or 3 tenths coverage but will be chased from the area as sea ice conditions increase beyond this level (Connelly, 2018).

In addition to creating navigational obstacles, ice floes and other ice features have the potential to push against a drilling vessel and move it off center from the wellhead, thereby straining the riser system and possibly requiring suspension of well operations and disconnecting the riser from the subsea BOP stack to allow the rig to move off location (Wang 2016, Efraimsson 2016). To manage this situation during drilling operations, a comprehensive ice alert and ice management system is utilized to forecast and manage the drifting ice with ice breakers to reduce its size as it approaches the drilling unit such that the smaller ice floes and ice features can pass by the drilling vessel without producing excessive global loading on the mooring system and drilling vessel. Open water drilling operations also require an active ice alert and management system to ensure that the rig is not impacted by ice conditions approaching the drilling location.

SCCE deployment is also affected by ice conditions. Deployment is limited by the capability of the deployment vessels to operate in icy seas and by the type of SCCE equipment. Ideally, the SCCE equipment would be vertically deployed through a vessel's moonpool. In icy conditions, this method of deployment prevents sea ice impacts to the crane lines holding the SCCE equipment and to the SCCE equipment itself. However, other methods of deployment including over-the-side or stern of a support vessel, or underwater offset installation, can also be used with varying levels of deployment efficiency.

Ice conditions also ultimately determine the beginning and the end of the drilling season for both open water and sea ice drilling operations including the required minimum of 45 days to accommodate relief well operations before the end of the drilling season. As such, ice conditions also represent a major controlling factor in determining the ability to perform safe deployment of a relief well. Depending upon the ice capability of the drilling and support vessels and the drilling location, the season may extend into November for a given year.

Because ice conditions determine the ability of vessels to operate, define the drilling season, and affect the efficiency of safe deployment of SCCE and relief wells, ice conditions were selected as a key criterion in the deployment analysis presented in this report.

2.2 Rationale for Not Including Other Metocean Conditions in the Deployment Analysis

To determine safe conditions for deploying SCCE and drilling relief wells, additional metocean factors were considered besides those identified in section 2.1 above. While many of these factors require evaluation for safety planning and/or their potential to decrease operational efficiency, none of them are critical factors for deciding when and how to safely deploy SCCE or drill relief wells. In general, these additional metocean factors are addressed through vessel and equipment design and through operating protocols. For these reasons, the following factors are not included in the deployment analysis.

2.2.1 Ocean Currents

Ocean currents can affect the speed and frequency with which ice interacts with a vessel. Currents also affect the dispersal of gas from gas boils, and how far a collapsed rig or other debris will be transported away from a well site because of drift. Mean velocities for currents in the Beaufort are generally in the range of 0.16 feet/s to 0.33 feet/s (5 cm/s to 10 cm/s) with slightly higher mean velocities in the Barrow Canyon area where they range from 13 cm/s to 24 cm/s (NOAA ERL PMEL-90, 1989 and Francis, 2016). For the Chukchi Sea, current velocities are higher but still modest with mean current velocities ranging from 0.4 feet/s to 0.9 feet/s (12 cm/s to 28 cm/s) (Francis, 2016). Currents above the 99th percentile for the Beaufort Sea and Chukchi Sea are approximately 1.74 feet/s (53 cm/s) and 2.62 feet/s (80 cm/s), respectively. These modest currents have minimal impact on SCCE deployment, support-vessel operations or relief-drilling rig operations unless combined with high winds and associated high sea states which are already limiting criteria in the deployment analysis. For these reasons, current is not viewed as a limiting factor to operations and was not included in the deployment analysis.

2.2.2 Visibility

During times of reduced visibility, offshore operations rely on modern technology to compensate for lack of visibility whether from daylight hours which can range from 0 to 24 hours/day depending on the season, from foggy conditions which particularly occur in the transition region between open water and ice-covered seas, or from blowing snow. Powerful forward search lighting, ice radar systems, and real time satellite systems all provide operational support information to mitigate hazards to safe navigation, monitoring of ice hazards, and operation of both drilling activity and ice management activity under reduced visibility conditions. While reduced visibility can increase risks for vessel collisions while conducting physical ice management operations, reduce ice management efficiency and impact aviation operations, it is not likely to prevent SCCE or relief well deployment activities. For this reason, visibility is not viewed as a limiting factor and was not included in the deployment analysis.

2.2.3 Precipitation

Precipitation in the Alaska Arctic falls both as rain and snow. It can contribute to superstructure icing, but it does not present any substantial obstacles to relief well drilling rig operations or to SCCE deployment. Research for this paper yield no results of drilling and drilling vessel support operations in the Beaufort or Chukchi Sea being adversely affected by superstructure icing. Thus, precipitation is not viewed as a limiting factor and was not included in the deployment analysis.

2.2.4 Humidity

Humidity levels in the Alaska Arctic offshore are significantly higher than over the semi-arid Arctic landmass but it does not present any obstacles to relief well drilling rig operations or to SCCE deployment (Appel). For this reason, humidity is not viewed as a limiting factor and was not included in the deployment analysis.

2.2.5 Water Temperature

Water temperature has indirect impacts upon relief well drilling rig operations and SCCE deployment, primarily as it impacts sea ice formation. Sea ice is already listed as a key limiting criterion. Therefore, water temperatures are not specifically included in the deployment analysis.

3.0 Station Keeping

3.1 Open Water Station Keeping

Station keeping in open water conditions for the drilling rig or support vessels is dependent upon the operating limits set for the drilling rig and support vessels. MODUs such as the Polar Pioneer have published operating limits that provide the anticipated station keeping capability under set conditions such as water depth, wind speed, wave height, wave period and current. Typically, one set of parameters is set for normal operations and a second is set for survival status under severe weather. The operating parameters are set to limit the riser angle deflection to typically 3 to 4 degrees or less during drilling. These parameters can also be adjusted for water depths that fall outside the typical operating depths for the vessel as is the case in much of the Chukchi and Beaufort seas where shallow water drilling is the norm.

Modern support vessels such as ice management vessels and other supply vessels that would typically support an open water relief well drilling program or SCCE deployment in the Alaska Arctic OCS also have published station keeping limits that are set by the same parameters as for the MODU example above. These vessels are critical to maintaining operations on site and they are typically operated in DP mode. A DP vessel's station keeping capability is determined by the DP capability analysis for the vessel. The DP system allows the vessel to maintain position for activities such as material and fuel transfers, anchor handling, ice management, SCCE deployment, personnel transfers and other necessary functions.

3.2 Station Keeping in Sea Ice

Setting required conditions for safe deployment of a relief well rig and/or SCCE deployment in the Arctic OCS includes understanding and addressing not only the drilling rig's ability to function in ice, but also the conditions required to enable ice management and other support vessels to create and maintain safe ice conditions in the well-site vicinity.

Remote location, lack of onshore infrastructure, cold temperatures, and hazards associated with ice floes require an offshore Arctic drilling program to have a self-sufficient marine support fleet that can provide most if not all drilling services in the field, including ice management and ice escort, SCCE deployment, subsea injection of dispersants, rescue and evacuation, and oil spill response. Arctic drilling operations in high concentrations of sea ice require assurance that ice interaction will not lead to costly, unanticipated emergency disconnections of the rig from the well, cause damage that may lead to a spill, interfere with the safe deployment of SCCE if needed, or preclude the ability to bring in and initiate drilling with a relief well drilling rig. Station keeping involves both the capacity of the drilling vessel to withstand ice pressure and the involvement of the ice management vessels to break and move ice. This includes reducing large ice floes on the order of 131 to 328 feet (40 to 100 meters) in diameter into smaller pieces on the order of 9.8 feet (3 meters) in size such that they flow by the drilling vessel with minimal impact as well as moving larger ice floes away from the drilling rig.

In the case of an ice class drillship, the rig's ability to withstand and minimize ice pressure is highly influenced by its ability to maintain its heading (weathervaning) to face oncoming sea ice. This minimizes ice forces and offsets, including when there may be changes in the ice drift direction. Heading bow first into the direction of ice drift allows managed ice floes to float past the ship with minimal impact. The direction of ice movement changes in response to variations in wind and ocean current conditions. If the vessel cannot weathervane in response to these changes in ice movement direction, the beam of the vessel may be exposed to ice impacts and ice-pressure build-up. This can pose a risk of excessive ice forces that may limit the vessel's station keeping ability and require a suspension of operations. The majority of today's mooring designs for ice class drillships employ dynamic positioning and turret mooring systems to optimize station keeping capability.

Besides ice class drillships, the other primary new design for an ice class drilling vessel is the round semi-submersible design that is similar to the former Kulluk barge which was known as a conical drilling unit. This design uses a multi-anchor mooring system and can be augmented with DP for transport and mooring assistance. It does not require the weathervaning capability of the drillship case discussed above due to its circular hull and can work in very high ice concentrations up to 10 tenths managed ice coverage. See appendix A for new ice class drilling vessel designs.

Ice management operations also include support vessels that can produce a managed ice zone up-drift and around the drilling rig where ice conditions are limited to suitably small broken ice floes, typically 9.8 feet (3 meters) in diameter, passing the rig. Support ice-breaking vessels conduct physical ice management by breaking, pushing, washing, towing, or providing ice reconnaissance. Different transit patterns - linear, circular, or arc-shaped may be used. Vessel numbers and deployment strategies depend on site-specific circumstances but often include the following deployment pattern for operations in sea ice:

- Far-field surveillance to detect potentially unmanageable ice features.
- Mid-field ice breaker scouting to confirm ice breakability.
- Near-field systematic floe break up using one or more ice breakers. These are usually smaller vessels with higher maneuverability to minimize risk of collision with the drilling rig.

This ice management fleet of Polar class 3 and 4 ice breakers is typical for operations in the Beaufort Sea. Operations in the less severe ice conditions of the Chukchi Sea require less icebreaking/management support for typically planned operations.

3.2.1 Ice Drift Forecasting and Methods to Inform Ice Management Practices

Accurate monitoring of ice drift direction is one of the preeminent aspects of an ice alert and ice management system. Early detection and continuous monitoring of a potentially hazardous ice event is necessary to conduct an overall risk-management plan and to manage the plan through an ice alert system.

Ice management vessels must be continuously repositioned to effectively control the ice through complex changes in ice drift direction and speed. The vessels are positioned based on ice drift forecasts, crew judgment and/or site-specific algorithms that incorporate real time measurements of ice drift direction and velocity.

Ice drift forecasting may use several types of technologies including satellite sensors with associated real time satellite imagery, seafloor fiber-optic sensors, wave gliders, passive/active gates with upward looking sonar, aerial surveillance (helicopter, fixed wing airplanes, kites, drones), marine vessels and onboard radar systems. Newer sensor technologies enable better data collection to occur during extreme weather events as well as in the dark or other low-visibility conditions. These imaging and remote-sensing technologies also remove much of the subjectivity in producing ice analysis and forecasting to support the ice alert and ice management systems.

ExxonMobil, in association with the Norwegian University of Science and Technology's Odin Arctic Technology Research Cruise, has developed a systematic ice management command-and-control tactic that eliminates the need for ice drift forecasting for near-field operations (Hamilton). Their tactic uses an algorithm based on measured ice drift direction and velocity, no other data or forecast is required. Ice drift data were collected during test trials for this method using a variety of on-ice beacons, and at times by marine radar. It is recommended however, that in application ice drift tracking, data may be better collected using ice-enhanced marine radar and Ice Profiling Sonar/Acoustic Doppler Current Profiler instruments deployed around the drilling rig on the seabed. ExxonMobil maintains their algorithm/ice drift data ice management method is more effective and accurate for managing near-field operations than ice management using more conventional forecasting. However, far-field ice surveillance would still require drift forecasting.

3.2.2 Ice Alert Systems

An ice alert system compares ice conditions with operations and vessel capabilities to determine associated risk levels; this includes regular drilling operations, and also applies to SCCE deployment and relief well drilling operations (Connelly, 2015). Using site-specific information, the alert system determines the following:

- Hazard Time (HT) – time for a potentially hazardous ice event to arrive at the operation.

- Secure Time (ST) (also known as T-Time) – time required to stop well operation and secure the well.
- Move-Off Time (MT) – time required to safely secure mooring systems and evacuate the site.
- Clear Deck Time – time required to anchor handling vessels brought to the rig and to clear decks for mooring recovery.

The alert system sets risk levels using the equation of Hazard Time minus the sum of Secure Time and Move-off Time (HT-(ST+MT)= X); the number of hours represented by X determines a required action that will range from normal operations to operate with caution, operate with restrictions, secure well operations, remove anchor and finally moving the rig. This system ensures that the stop-work process will allow safe disconnection from the well if conditions approach a critical hazardous ice event.

Hazardous ice events are any ice condition that exceeds the capability for the work process to safely operate. These include:

- An unmanaged ice feature approaching the site that exceeds the capabilities of the equipment and vessels.
- Physically managed ice that cannot be successfully managed before it is forecasted to arrive at site.
- High drift rates that exceed the support vessels' ability to keep the ice away from the site.
- Inability to manage ice due to mechanical failure in an ice management vessel, or due to an inexperienced crew that falls behind in the ice management process.

3.2.3 Managed Ice Conditions

Using modern technology and a fleet of four or more ice management vessels, operations can be sustained under ice conditions with an average of 8 tenths ice concentration. However, because ice concentration is not a homogenous condition, it is managed at 7 tenths to 9 tenths ice concentration. Managed ice is assumed to typically consist of floe sizes ranging from 10 to 15 feet (3 to 5 meters), with a uniform thickness of 1 meter, and typically moving at a steady velocity of 1.6 feet/s (0.5 meters/s) (Connelly, 2015).

3.2.4 Ice Management Vessel Availability

Ice management vessels are available with advanced planning for operations in the Chukchi and Beaufort seas. These include the Baltic Sea based vessels such as the Fennica and Nordica, the Aiviq and the MPV Everest. Several capable vessels are also available in the Russian market. There is only one existing ice class support vessel (the

MPV Everest) that is equipped with a suitable moonpool and heave compensated crane for well intervention and SCCE deployment activities in sea ice conditions.

Under the current and anticipated Arctic offshore market, new-builds for suitable ice class marine support vessels for use in Arctic waters will be limited in the near- to mid-term future. The combination of high construction costs and limited opportunities for more lucrative day rates in the Beaufort and Chukchi Seas and other Arctic markets is anticipated to deter new construction of ice class support vessels. Thus, for the purposes of the deployment analysis, the capabilities of currently available ice class marine vessels are being used to determine suitable conditions for safe deployment of relief well drilling rigs and SCCE.

4.0 Equipment Assumptions Based on Currently Available Technology

This section provides summary information on the currently available technologies addressed in the deployment analyses for SCCE, drilling rigs and support vessels. Additional information on these technologies along with developing technologies are provided in appendix A.

4.1 SCCE

Equipment assumptions for SCCE include an integrated suite of containment domes, capping stacks, cap and flow systems, SIDs and ancillary equipment necessary to deploy these systems as defined by BSEE.

4.1.1 Containment Dome

Containment domes (also referred to as a top hat) initially were large structures that can be placed over a blowing well to funnel and transport the oil, gas and other fluids being expelled from a blowout to a surface processing and containment system on a vessel stationed near the well. More recent designs for containment domes are smaller and designed to be used during the initial stages of a well capping or cap and flow situation (Trendsetter, 2018).

To date, they have limited field application to prove their capabilities. Two containment domes were deployed at the Macondo blowout in 2010. The first containment dome deployed filled with ice (methane hydrates) which caused it to float back up to the surface creating a potential hazard to the nearby vessels (DeMarben, 2016). This type of phenomenon could be of concern in the Alaska Arctic OCS. Hydrates are formed by methane frozen in the ground in a water and methane matrix and are known to occur at shallow depths in cold climates. If these hydrates melt, they can release gas or potentially impair the containment dome system. The presence of hydrates may complicate deployment of SCCE as they did at Macondo and consideration for hydrates should be included in the front end planning and design of an SCCE deployment scenario. The second containment dome deployed at Macondo was successful and aided spill response to the blowout.

Shell conducted two test deployments of containment dome prototypes near Bellingham, Washington. The first test occurred in 2012 and resulted in damage to the dome which became unhooked from the winch lines on the first day. On the fifth day, Shell experienced a more severe incident when the dome shot to the surface and then sank more than 120 feet (37 meters) before its downward fall was controlled by its safety buoy (DeMarben, 2016). The dome was repaired and subsequently certified by the United States Coast Guard (USCG) and American Bureau of Shipping (Bradner, 2013). A second test in 2015 was more successful and demonstrated better promise for the technology (Dlouhy, 2015). Their use in Arctic waters remains untested.

Figure 4-1. Examples of containment domes for Shell Arctic and the Macondo response.

Transport of a containment dome similar to those shown in figure 4-1 will require an ocean-going vessel, which may have limited access to the Chukchi and Beaufort seas in the late season due to higher concentrations of ice. This would necessitate trans-loading of the equipment in a location such as Dutch Harbor, Alaska. Therefore, prepositioning and storage in the Arctic would be required for rapid deployment to a blowout event.

Advantages

- Can be staged and/or transported to site from a regional hub.
- Recent designs are reduced in size which simplifies deployment.
- Can be used during preparations for installation of a capping stack or drilling of relief well.
- Can provide injection of dispersants and hydrate inhibitors.

Limitations

- The use of a containment dome may also be constrained by the drilling unit itself. Drilling rigs, such as jackups and submersible drilling vessels, are unlikely to provide adequate structural clearance for deployment of a containment dome without moving the rig off the drill site.
- Transport to site may be limited by ice conditions.
- Likely to capture only a portion of the hydrocarbon flow due to non-sealing design.

Availability

- Containment domes are readily available from response consortiums and industry suppliers.

4.1.2 Subsea Capping Stack/Cap and Flow

A subsea capping stack is a large piece of equipment (75-140 tons or more) that is installed on a blowout well's BOP stack or wellhead to stop or redirect the flow of hydrocarbons and control the flow. After capping stack installation, the well intervention team can work to permanently seal the well. The cap provides a dual barrier for containment – a combination of rams, chokes, and valves to stop the flow, and a containment cap to capture lost fluids. The stack's valves can be closed to cap the well (cap only), or, if necessary, the flow can be redirected to surface vessels through flexible flow lines (cap and flow). The cap can also be used to inject dispersants into the well to mitigate the impact of oil released into the environment. Similarly, methanol or glycol can be injected into the well to minimize the formation of hydrates and/or kill fluids such as mud or cement may be pumped down the stack to kill and seal the well.

Deployment can occur through the floor of the drilling rig moon pool using drill pipe, on a wire of an intervention vessel using a heave-compensated crane, or on a wire from the stern of an anchor-handling vessel with an A-frame. In the presence of a gas boil or in situations where direct-vertical deployment is otherwise obstructed, the use of offset-installation equipment may be required as discussed above in section 2.1.1.5. Additional information on offset-installation equipment is contained in appendix A.

Utilizing the capping stack in a cap-and-flow system requires the addition of several support vessels oil and gas processing, hydrocarbon storage and transfer, dispersant injection, hydrate inhibitor injection and other SCCE deployment related tasks. This fleet will likely need to be assembled fit for purpose fleet suited to the Alaska Arctic OCS due to the difficult operating logistics for the area.

Transport of a capping stack and related equipment to the Alaska Arctic OCS on emergency notice will require flying the components to Prudhoe Bay or Cold Bay for assembly and transport via barge and supply/intervention vessel to the well location. Prudhoe Bay has shallow draft at the dock face and requires lightering of the equipment to the supply vessels in deeper water which may not be possible during icy conditions in Prudhoe Bay. Cold Bay is an alternative landing location but is further away from the Arctic OCS and will increase response time. The logistical difficulties and time required for flying capping stack equipment into Alaska will likely require pre-staging of the equipment to be able to meet the desired rapid-response time that a capping stack offers. For the Alaska OCS, pre-staging may involve wet storage of the equipment on the seafloor near the drilling location. The same support vessels that would deploy the capping stack would handle the pre-staging activities.

Advantages

- Field tested and successfully deployed on multiple practice drills.
- Can be staged and/or transported to site from a regional hub.

- Can provide multiple well services including injection of dispersants and hydrate inhibitors.

Limitations

- Transport to site may be limited by ice conditions.
- Prestaging of equipment will likely be necessary for an immediate response.
- Capping stacks would not be effective in a case where the blowout has breached the well casing and is exiting the seafloor outside the well casing.

Availability

- Capping stacks are a thoroughly tested technology that have been aggressively developed since the Macondo incident and are available globally throughout the offshore oil industry.
- Specialized subsea service companies have built a variety of capping stack models modified for specific environmental conditions, including Arctic waters. In the Arctic, the capping stack must be designed to provide fast closure at applicable water depth for the main bore and diversion outlets with metallic and non-metallic components constructed from materials designated for the extreme cold temperatures that occur in the Arctic.

4.1.3 Subsea Intervention Device

A subsea intervention device (SID) is also known as prepositioned-capping device (PCD) that allows remote controlled intervention into subsea wells for a variety of well-maintenance services. If the well is designed to accommodate a full shut-in of the last casing string set, it can temporarily cap and control a well and facilitate plug and abandonment of the well, if desired. SID’s are pre-installed with the rig during initial well development. Remote controlled operation ensures that the SID can be deployed in instances where site hazards make it unsafe or inaccessible to deploy other types of SCCE. These instances may include a blowout with pressurized fluids coming up solely through the well bore, situations where the rig catches fire or collapses on top of the well, or operations that are constrained due to shallow waters.

Advantages

- Can be preinstalled avoiding concerns about deployment and metocean conditions.
- Remote control allows offsite control during dangerous conditions.
- The use of a preinstalled SID could provide a faster and safer additional line of defense for a blowout than a relief well or deployment of a capping stack or containment dome resulting in smaller discharges to the environment.

Limitations

- SIDs would not be effective in a case where the blowout has breached the well casing and is exiting the seafloor outside the well casing.
- Could increase minimum operating water-depth for shallow floating drilling operations.

Availability

- Readily available on an as-needed basis from industry suppliers.

4.2 Drilling Rigs/Relief Well Drilling Rigs

Relief well drilling rigs in the Chukchi Sea planning area can include non-ice class drilling vessels such as a semi-submersible rig, a jackup vessel or an ice class drillship. For the Beaufort Sea, drilling rigs could include an ice class drillship or an Arctic submersible in nearshore waters. An ice island could also be deployed in certain nearshore Beaufort Sea environments where water depth and seasonal conditions allow. It is also conceivable that a relief well could be drilled from an existing gravel island assuming the island was within the necessary proximity for executing a relief well.

4.2.1 Man-Made Islands

In the past, man-made islands have been constructed in the Beaufort Sea using ice or gravel for both oil well exploration and development. Gravel exploration islands were constructed in the 1970s and 1980s but are now limited to development islands such as at Northstar and the planned Liberty development on the OCS (US BOEM, 2018). Gravel development islands have also been utilized in State of Alaska waters at the Endicott, Spy Island/Nikaitchuq and Oooguruk oilfield developments.

Ice islands have been utilized for exploration operations and are a potential relief well structure in water depths shallower than 50 feet (15 meters) and located inside the shear zone between the landfast and floating pack ice (C-Core, 2005). Ice islands have not been constructed in the Chukchi Sea where the applicable water depths and available landfast ice areas for ice-island construction are very limited.

The time required to construct an ice island is dependent on several factors including water depth, ambient temperatures, grounded and land-fast ice formation and construction methods.

Figure 4-2. Man-made gravel island, Northstar oilfield development facility (Wikimedia, 2010).

Figure 4-3. Man-made ice island, Canadian Beaufort Sea (Connelly, 2018).

Advantages

- Drilling rig is not exposed to floating ice.

Limitations

- Only suitable for nearshore waters.
- Extended construction time and seasonal constraints.
- If not pre-constructed, it is unlikely to be able to construct a man-made island in time to comply with the 45 day limit for relief well operation and completion.

Availability

- Use of an ice island for a relief well drilling rig will likely require construction concurrent with the primary drilling operations to ensure a well-response scenario that meets the current 45 day response requirement.
- Arctic capable land rigs applicable for island use are available.

4.2.2 Jackup Drilling Vessel

A jackup drilling rig is a fixed structure platform with steel legs that are anchored to the seabed by gravity. The legs support a barge deck with an integrated drilling rig and housing for the crew. Jackups are generally used in water depths shallower than 500 feet (≈150 meters) with open water where the presence of sea ice is unlikely or minimal. ConocoPhillips planned to use a jackup drilling vessel to drill their Devil's Paw Chukchi Sea prospect in 2014 but cancelled the project during the permitting phase.

Advantages

- Drilling rig and other equipment stored on deck are elevated above impacts from wave action.

Limitations

- Generally applicable in water depths shallower than 500 feet (≈150 meters) and in open water.
- The riser that connects the drilling rig to the well is exposed to open surface waters on a jackup vessel. This exposure leaves the riser vulnerable to damage from floating ice.
- In the event of a blowout, it can be from difficult to impossible to access the wellbore for deployment of SCCE or other well-killing techniques due to the rig structure surrounding and over the wellbore.

Figure 4-4. Example of a jackup drilling rig with SID on seafloor (Faust, 2012).

- If a fire occurs, there is a good chance the rig will collapse and crush or distort the riser so that well intervention would be difficult.
- Jackups usually require transport by a heavy-lift vessel for long-distance rig moves.

Availability

- Jackup drilling vessels are readily available in the global market.

4.2.3 Semi-Submersible Drilling Vessel

A semi-submersible drilling vessel uses ballasted, watertight pontoons located below the ocean surface to dampen the impacts of wave action and provide a stable drilling platform in a wide range of water depths from 131 feet (40 meters) with a conventional anchor mooring system up to 10,000 feet (3,048 meters) with DP. Structural columns extend from the pontoons to the platform elevating the deck above the water line. Semi-submersible drilling rigs are not suitable for use in sea ice conditions due to the exposed marine-riser system which could be subject to damage from ice impacts. Furthermore, anchor moored semi-submersible vessels typically have structural cross members that extend below the water line which could become fouled with drifting ice and create excessive forces on the structure which would require discontinuance of drilling operations and emergency move off of the location.

Figure 4-5. Example of a semi-submersible drilling vessel, Polar Pioneer (US BSEE, 2018).

Advantages

- The riser can be disconnected from the BOPs and the rig moved off location in a well-control or ice-incursion event.
- In most blowout cases, with the rig pulled off location, it will not interfere with SCCE deployment.
- Can be used for SCCE deployment or relief well drilling, if it is not damaged by the blowout event.
- Can operate in water depths as shallow as 131 feet (40 meters) with conventional anchor mooring system.
- Drilling platform is elevated above the impacts of most wave action.

Limitations

- Similar to a jackup rig, the riser is not protected, leaving it vulnerable to ice impact and damage.
- Only capable of operating in open water.

Availability

- Conventionally moored semi-submersibles still exist on the market (such as the Polar Pioneer which Shell used in 2015 for the Burger J well in the Chukchi Sea).

4.2.4 Gravity–Based, Caisson Structures/Submersible Vessels

- Three gravity-based MODU structures were built for exploration drilling in the Beaufort Sea. These are the Molikpak, Concrete Island Drilling System (CIDS) and the SDC. Both the Molikpak and CIDS have been repurposed as development structures in the Sea of Okhotsk offshore Sakhalin Island and are not available for use. The SDC is the only remaining gravity-based Arctic drilling structure that is available to work in the Alaska Arctic OCS. It has a caisson that provides a protected moonpool to conduct drilling operations in open water and all ice conditions. The work deck that contains the drilling rig, camp housing and support facilities sits on top of the structure. The rig is a land-type rig with conventional land BOPs contained in the rig substructure.
- Due to the caisson design of the SDC, deployment of SCCE would be limited to more traditional surface based intervention and capping techniques where the well could be capped from the surface by direct injection of kill fluids from the surface or installation of a BOP over the top of the well. Installation of a pre-installed SID on the wellhead below the rig BOPs is also an option to minimize the potential for loss of well control.

Figure 4-6. Example of a submersible vessel, the SDC (Connelly, 2018).

Advantages

- Can drill year-round in the Beaufort Sea and selected areas of the Chukchi Sea.
- Can serve as a relief well rig within its water-depth range.

Limitations

- Limited to water depths that range from 26 to 79 feet (8 to 24 meters).
- Requires two ice class towing vessels to be moved on location.
- Requires a geotechnical program at the well location prior to set down.
- Requires specific seabed soil conditions and uniform bathymetry to structurally support the unit at the set-down location.

Availability

- The SDC remains cold stacked in the Canadian Beaufort Sea and is available for use.

4.2.5 Drillships

All previous drillship operations in the Chukchi and Beaufort seas have been conducted with conventionally moored drillships that utilized a traditional anchor and cable and chain system. The conventional mooring system allowed the vessels to operate is shallow depths on the order of 100 feet (30 meters) These vessels were all built in the 1970s and there are no viable cable/chain and anchor moored Arctic ice class drilling vessels in existence today as discussed above in section 1.4.

Based on research for this report, the Aban Ice which operates in Indian waters and is the oldest drillship in operation, is the only anchor moored drillship left in worldwide service. While the vessel has “Ice” in its name, it has never had any classification for working in ice laden waters (Aban, 2018). The Aban Ice was built in 1959 and converted to a drillship in 1975. It is likely nearing the end of its service life

Modern drillships use dynamic positioning (DP) and are designed to work in water depths as deep as 10,000 feet (3,048 meters) or more.

Figure 4-7. Stena IceMAX drillship (Stena, 2018).

The Stena IceMAX is one of only three existing ice class drillships currently available. The others are the Noble Bully I and Bully II. The IceMAX was built in 2012 and it has been constructed and certified to Polar class 4 (PC4). This classification enables the vessel to work in temperatures of -30 C and of 8 tenths ice coverage and can be fitted with a supplemental turret mooring system for additional station keeping capability that is necessary for shallow water operations in depths less than 984 feet (300 meters). Turret mooring systems allow the ship to maintain its position while altering the vessel heading (weathervaning) so that the bow can be maintained facing into the approaching managed ice drift. The ice moves around the bow of the vessel and past the ship instead of building up ice pressure along the ship's beam.

The riser on a drillship is also protected from ice impacts because the drilling riser is deployed through the moonpool and turret which are surrounded by the ship's hull. The Stena moonpool and turret mooring system extend to a depth of 39 feet (12 meters) below the water's surface, providing protection to the riser from the top of the deck to 39 feet (12 meters) below the sea surface, well below the depth where managed ice could cause any damage to the riser.

Advantages

- Designed for Arctic conditions.
- Designed to allow weathervaning to minimize ice forces.
- Moonpool protects the riser from floating ice.
- Can operate in water depth as shallow as 328 feet (100 meter) with turret mooring system modification.
- Can operate in 8 tenths ice coverage.

- Capable of rapid riser disconnect from the wellhead to move out of the well area.

Limitations

- The Stena IceMAX, when fitted with the turret mooring system, has a minimum operating depth of 328 feet (100 meters). Therefore, it is not capable of operations throughout most of the Chukchi Sea planning area and all the historically prospective areas of both the Chukchi Sea and Beaufort Sea planning areas.

Availability

- Ice class drillships are currently available but only for drilling in 984 feet (300 meters) water depth or deeper without anchor mooring modifications.

4.3 Support Vessels

The support vessel fleet for exploration drilling operations on the Arctic OCS varies significantly between the Chukchi Sea and Beaufort Sea planning areas. In general, the Chukchi Sea experiences a significantly longer open water operating season and therefore, support-vessel requirements can include non-ice class vessels to maintain operations during the anticipated open water operating window. Historically, operations below the 72nd parallel in the Chukchi Sea (see figure 2-1 above), have been conducted with two, and occasionally three, ice management (icebreaker) vessels while the Beaufort Sea, with its more demanding ice management conditions typically requires additional ice class support and supply vessels for operations in ice-laden waters. Any potential future operations in the northern areas of the Chukchi Sea planning area above the 72nd parallel may also require a more robust ice class support fleet similar to what historically has been used in the Beaufort Sea.

The number and type of vessels that comprise an Arctic marine-support fleet is based on the operating area and capabilities of the available vessels, most of which can conduct multiple functions to support operations. Depending upon the location of planned activities, ice-strengthened marine-support vessels may include general support vessels, anchor-handling tug and supply (AHTS) vessels, fuel tankers (may vary from a single large tanker to multiple small tankers or a combination of both) shallow-draft resupply vessels, and a supply ship.

The support fleet needs to be nearly self-sufficient and able to accomplish the following tasks (see section 3 Station keeping for more details):

- Escort of the drilling vessel in and out of the drilling site at the beginning of the season and to enable a safe exit out of the area at the end of the season, as well as to ensure access for fuel and material supply ships throughout the drilling season.
- Breaking, pushing and washing to maintain a positive alert level and safe operating zone around the drilling unit.

- Storing and supplying fuel and supplies to the drilling vessel and to other marine-support vessels.
- Storage and shipment of waste materials from the drilling rig.
- Provide a location to conduct maintenance work for the drilling rig and other support vessels.
- Carrying, deploying and retrieving anchors (not necessary if the drilling vessel uses DP only).
- Deploying and retrieving ROVs to support well-work operations.
- Carrying and refueling helicopters for personnel transfers and ice reconnaissance.
- Emergency response for the drilling unit including firefighting and facility evacuation.
- Oil spill response and cleanup.
- Blowout response and well intervention.

Vessel complements for floating drilling operations in the lower Chukchi Sea planning area have typically included:

- Two each polar ice class ice-breaking and AHTS vessels.
- Fuel resupply vessel.
- Supply ship.
- Oil-spill-response vessel for skimming and recovery.
- Additional spill response vessels including an oil-storage tanker, boom boats, and small watercraft for nearshore activities in shallow water.
- Cap and flow hydrocarbon processing vessel (in 2015).

Vessel complements for floating drilling operations in the Beaufort Sea have typically included:

- Four each polar ice class ice-breaking and AHTS vessels.
- Ice class fuel resupply vessel.
- Supply ship.
- Ice class oil-spill-response vessel for skimming and recovery.
- Additional spill-response vessels including an oil-storage tanker, boom boats, and small watercraft for nearshore activities in shallow water.

A suite of support vessels is selected for each project during project planning and development to fully support the operations. In the event of a blowout and the need for rapid deployment of SCCE or commencement of relief well drilling, additional vessels would likely be immediately mobilized. These may include available ice class vessels to continue operations as necessary during increasing ice conditions in both the Chukchi and Beaufort seas as the open water season progresses into the fall. Furthermore, for an extended emergency response, additional marine-support activity will be required as the response operations are implemented.

If safe deployment of SCCE requires additional vessels to be brought to site, ice management and intervention vessels can be brought in from Russia and the Baltic Sea to assist as needed. International conventions are in place to facilitate the sharing of response vessels amongst international communities. Likewise, operating companies also typically have emergency equipment sharing agreements for operations worldwide.

Table 4-1 lists selected currently available ice management and AHTS vessels that would be either already dedicated to an Alaska Arctic OCS project or could be mobilized upon an emergency need.

These types of vessels would be critical to enable safe deployment of SCCE and to support relief well operations during ice conditions that may be encountered after a blowout incident begins. They would be the primary vessels for managing ice, deploying SCCE, and supplying the relief well rig during drilling. Examples of additional support vessels including ice capable fuel tankers, spill response, hydrocarbon processing and other support vessels are included in appendix A.

It is important to note that only one ice class vessel listed above is equipped with a moonpool, the recently constructed MPV Everest. Deployment of SCCE and subsea support operations, such as ROVs or divers in icy seas, will usually require a moonpool. Deployment of these operations through over-the-side or off-the-stern of a non-moonpool equipped vessel increases the risk of an unsuccessful deployment or damage to equipment in icy conditions.

The type of deck equipment installed on the vessels in table 4-1 is also a critical factor in the deployment of SCCE. Very few of the vessels have deck cranes that are actively heave compensated (AHC) or have adequate lifting capacity for heavy SCCE, such as a capping stack. As an alternative to a deck crane, an A-frame can be installed off the stern of the vessel. This arrangement would also likely require installation of a heave compensation system into the A-frame hoisting-and-deployment system to effectively deploy SCCE. The crane systems on the vessels in table 4-1 and other likely non-ice class support vessels from locations such as the Gulf of Mexico are not likely to be de-rated for colder weather operations. Derating of crane equipment for cold temperatures generally begins when ambient temperatures approach -30 F (-34 C) by which time sea ice conditions will have caused a suspension in operations.

The recently constructed MPV Everest is the only vessel listed in table 4-1 that is outfitted with high-capacity AHC cranes and a moonpool for the deployment of SCCE components including ROVs, a capping stack and other well-intervention equipment. It is also the only ice class vessel in existence that has been specifically designed to support well-intervention activities.

Table 4-1. Selected Ice Management and AHTS vessels.

Vessel:	Fennica	Nordica	Polaris	Otso	Aiviq	Everest
						
Project Duties	Ice Management, AHTS	Ice Management, AHTS	Ice Management, Emergency Towing, Spill Response	Ice Management, Emergency Towing	Ice Management, AHTS, Spill Reponse	Well Intervention, Ice Mannagement, ROV & Diving
Mob / Demob / Port	From/To Helsinki Finland	From/To Helsinki Finland	From/To Helsinki Finland	From/To Helsinki Finland	From/To Gulf of Mexico	From/To Singapore or Worldwide
Vessel General Description						
Year Built	1993	1994	2016	1986 (Upgraded 2015)	2012	2017
Lengh Over All	381 feet (116 meters)	381 feet (116 meters)	361 feet (110 meters)	325 feet (99 meters)	361 feet (110 meters)	465 feet (142 meters)
Horse Power	29,000 HP	29,000 HP	29,000 HP	29,000 HP	21,760 HP	33,800 HP
Propulsion	2 x Aquamaster	2 x Aquamaster	3 x ABB Azipods	2 x Variable pitch propeller, 2 ea Rudders with 30 deg offset	Variable Pitch / Twin Screw	2 x Azimuth
Thrusters	Three x 1,100 kW	Three x 1,100 kW	See above	1 x ABB Bow Thruster 1,720 kW	3 x Bow (one being a fold down azimuthing type) and 1 x Stern thruster	2 x Fwd tunnel 2,700 kW, 1 x tunnel 600 kW, 1 x retractable azimuth 3,000 kW
Ice Class	DNV Polar 10	DNV Polar 10	LR PC 4	DNV 1A Super	ABS A3	BV Ice Class IA Super
Ice Class Common	PC 3	PC 3	PC 4	PC 4	PC 4	PC 4
Bollard Pull	232 ton	230 ton	214 ton	160 ton	200 ton	120 ton
Flag State	Finnish	Finnish	Finnish	Finnish	USA	Bahamas
Classification	DNV	DNV	DNV	DNV	ABS	BV
Helideck	Approved for Super Puma	Approved for Super Puma	Winch only	Weight limit 2.9 ton	Sikorsky S92	Sikorski S92A & 61N
Accommodation	Total 77 personnel, 21 crew	Total 77 personnel, 21 crew	Total 80 personnel, 16 crew	Total 35 personnel, 21 crew	Total 92 personnel, 28 crew	Total 140 personnel, 24 crew
DP	Yes	Yes	Yes	No	Yes	Yes
Cranes	30 ton, 5 ton	160 ton AHC, 5 ton	2 each < 30 ton	No	15 ton, 2 each 5 ton	250 ton AHC, 50 ton AHC
Moonpool	No	No	No	No	No	Main 7.2m x 7.2m, Dive 4m x 4m, ROV 5.6m x 4m

Advantages

- Numerous support vessels on site provide immediate response capability for the deployment of SCCE (depending on the availability of the SCCE equipment).
- Vessels can perform multiple functions for versatility and operational efficiency.
- Selected support vessels have ice-strengthened hulls for safe use in the Arctic OCS during ice conditions.

Limitations

- There is only one ice class vessel that has a moonpool for vertical deployment of SCCE, ROV and diving support.

Availability

- Ice management vessels are available on the market, however, the fleet of available vessels is has been further limited by the recent sale in 2018 of the Tor Viking II, Balder Viking and Vidar Viking ice breakers to the Canadian Coast Guard.
- Ice class supply and support vessels are available on the market.

5.0 Geographic Extent of Study

The geographic extent of this study is comprised of the Chukchi Sea and Beaufort Sea OCS planning areas (see figures 1-1 and 1-2 in section 1 above). This area is a vast range of Arctic waters roughly bounded by the Alaska Coast north of Point Hope, the 169th west meridian, the 75th parallel to the north and the 138th west meridian to the east. The total area of these two planning areas is nearly 200,000 square miles.

5.1 Important Differences Between the Planning Areas

The safe deployment of relief wells or SCCE in the Chukchi Sea and Beaufort Sea planning areas can be affected by several factors including the bathymetry of the planning area, seasonal ice conditions and sea state conditions. These factors vary across both planning areas.

5.1.1 Sea Ice Conditions

Sea ice conditions in the Chukchi Sea planning area are less severe than in the Beaufort Sea planning area. The southern half of the Chukchi Sea planning area, below the 72nd parallel, generally has extended areas of open water or moderate sea ice conditions (<3/10 coverage) starting around the end of May or early June with ice coverage further decreasing as the summer progresses (US NIC, accessed 2018). This area is also less likely to encounter multi-year ice conditions during the typically-preferred operating timeframe of mid-July through October. Multi-year ice conditions require more robust ice management resources for conducting operations (Connelly). The northern half of the Chukchi planning area, above the 72nd parallel, is subject to more severe ice conditions with ice coverage and the presence of multi-year ice generally increasing to the northern extent of the planning area during much of the summer season. Freeze-up (> 7/10 ice coverage) of the entire Chukchi Sea planning area usually occurs by early to mid-December of a given year (US NIC).

The Beaufort Sea planning area has more severe sea ice conditions than the Chukchi Sea due to its more northerly position and lack of southern sea exposure. Sea ice usually begins to break up in July with open water present 100 to 500 or more miles offshore from land during August and September (US NIC). Depending upon the year, large ice floes can occur throughout the Beaufort Sea planning area during the entire summer season, although this phenomenon is less common in recent years (Coastal Frontiers, 2017). This possibility has historically required that Beaufort Sea exploration operations maintain a higher level of ice management and icy-sea support capability than is required for operations in the Chukchi Sea planning area (Connelly). Freeze-up (> 7/10 ice coverage) of the entire Beaufort Sea planning area usually occurs in early to mid-November of a given year which is about a month earlier than in the Chukchi Sea planning area (US NIC).

5.1.2 Bathymetry

The bathymetry of the Chukchi Sea and Beaufort Sea planning areas is also significantly different for the two areas (see figure 2-1 in section 2 above). Most of the Chukchi Sea shelf is relatively shallow with approximately 65 percent of the planning area having water depths of 328 feet (100 meters) or shallower (GEBCO, 2018). In the northeastern portion of the planning area, the shelf falls off rapidly to water depths deeper than 11,480 feet (3500 meters). To date, all Chukchi Sea exploration wells have been drilled below the 72nd parallel and in water depths ranging from 137 to 152 feet (42 to 46 meters) (US BOEM, 2018).

For the Beaufort Sea planning area, the continental shelf is much smaller. A 40 to 60 nautical mile wide shelf trends northwest from the eastern extent of the planning area to the Barrow Canyon bathymetric feature which lies just north of Utqiagvik (Barrow) and continues into the Chukchi Sea planning area (GEBCO, 2018). At the northern extent of the Beaufort Sea shelf, water depths rapidly deepen into the Canada Basin to deeper than 11,480 feet (3,500 meters).

5.1.3 Sea State Conditions

Sea state conditions also vary between the Chukchi and Beaufort seas with the Chukchi Sea generally subject to higher wave heights and longer wave periods due to greater open water extent which leads to greater fetch and higher waves than in the Beaufort Sea. However, depending upon the pattern of ice recession during a specific year open water season, the Beaufort Sea can experience similar open water distances to the Chukchi Sea.

5.2 Official Protraction Diagrams

The project team determined that the most effective method to evaluate and display the probability for safe SCCE and relief well deployment for the Beaufort Sea and Chukchi Sea planning areas is to use the official protraction diagrams (OPD) from each planning area. The OPDs for the Chukchi Sea and Beaufort Sea planning areas are presented in figures 5-1 and 5-2, respectively. They are also available at the online link: https://www.boem.gov/Oil-and-Gas-Energy-Program/Mapping-and-Data/Alaska.aspx.

The OPDs divide the Chukchi Sea and Beaufort Sea planning areas into rectangular shapes that are approximately 3 degrees longitude by 1- degree latitude. The OPDs have been further subdivided into four quadrants (approximately 30 miles by 30 miles each) for statistical analysis of the ice coverage data. OPDs that contain partial quadrants exist on the western extent of the Chukchi Sea planning area and the eastern extent of the Beaufort Sea planning area as well as along the coastline. For these cases, the ice data has been analyzed for the entire quadrant versus subdividing the quadrant into irregular shapes. Figures 5-3 and 5-4 present the quadrant subdivisions of the OPDs for the Chukchi Sea and Beaufort Sea planning areas, respectively. This approach yields 103 quadrants in the Chukchi Sea planning area and 104 quadrants in the Beaufort Sea planning area that were included in the ice analysis. Individual quadrants that did not include waters beyond the three-mile limit were not included in the ice analysis because areas inside the three -mile limit are State of Alaska waters and tidelands. Thus, only Federal OCS waters are included in the nearshore OPD quadrant selections discussed above. The individual OPDs and quadrant subdivision boundaries for each planning area are tabulated in tables 5-1 and 5-2 below.

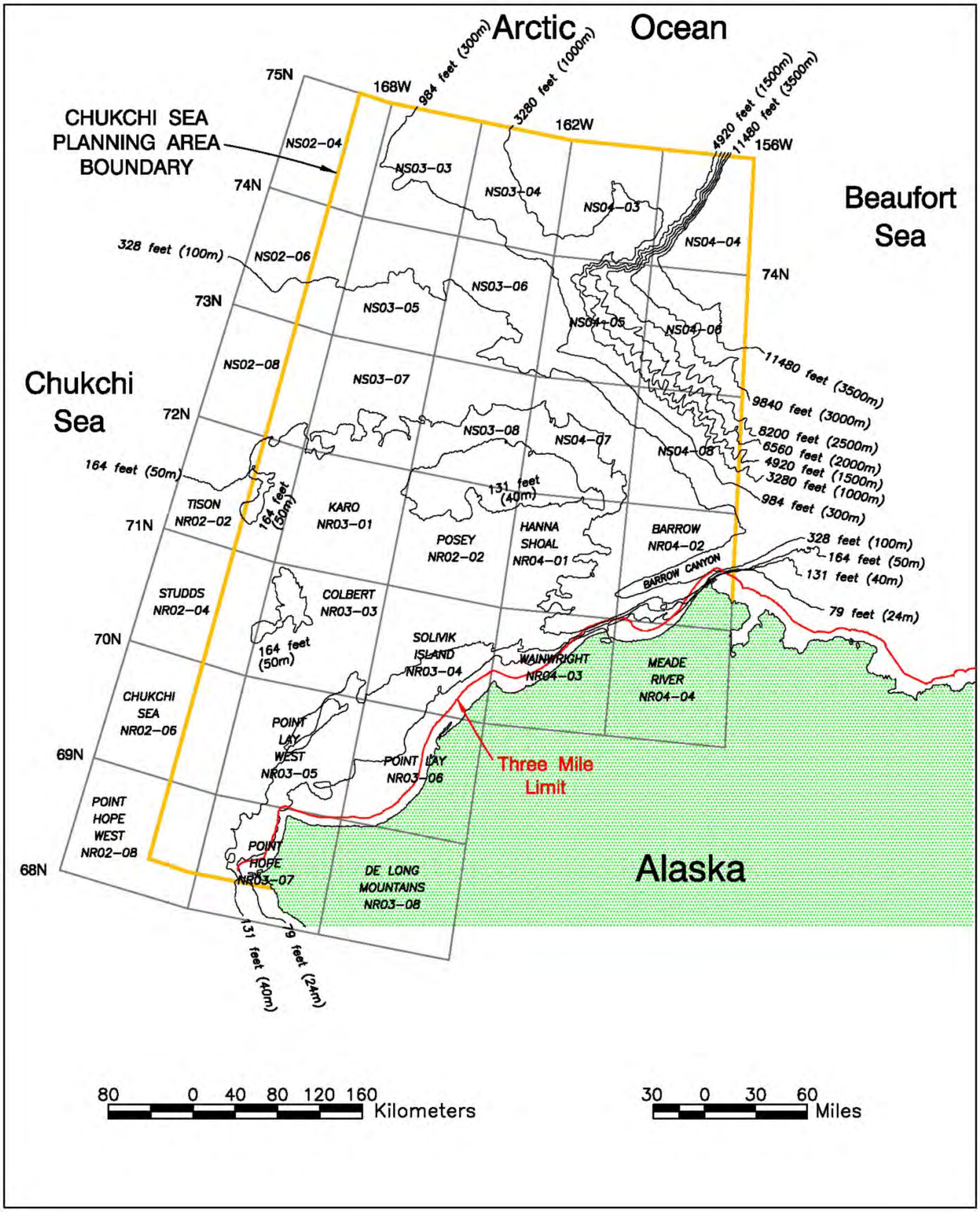


Figure 5-1. Chukchi Sea planning area with OPDs.

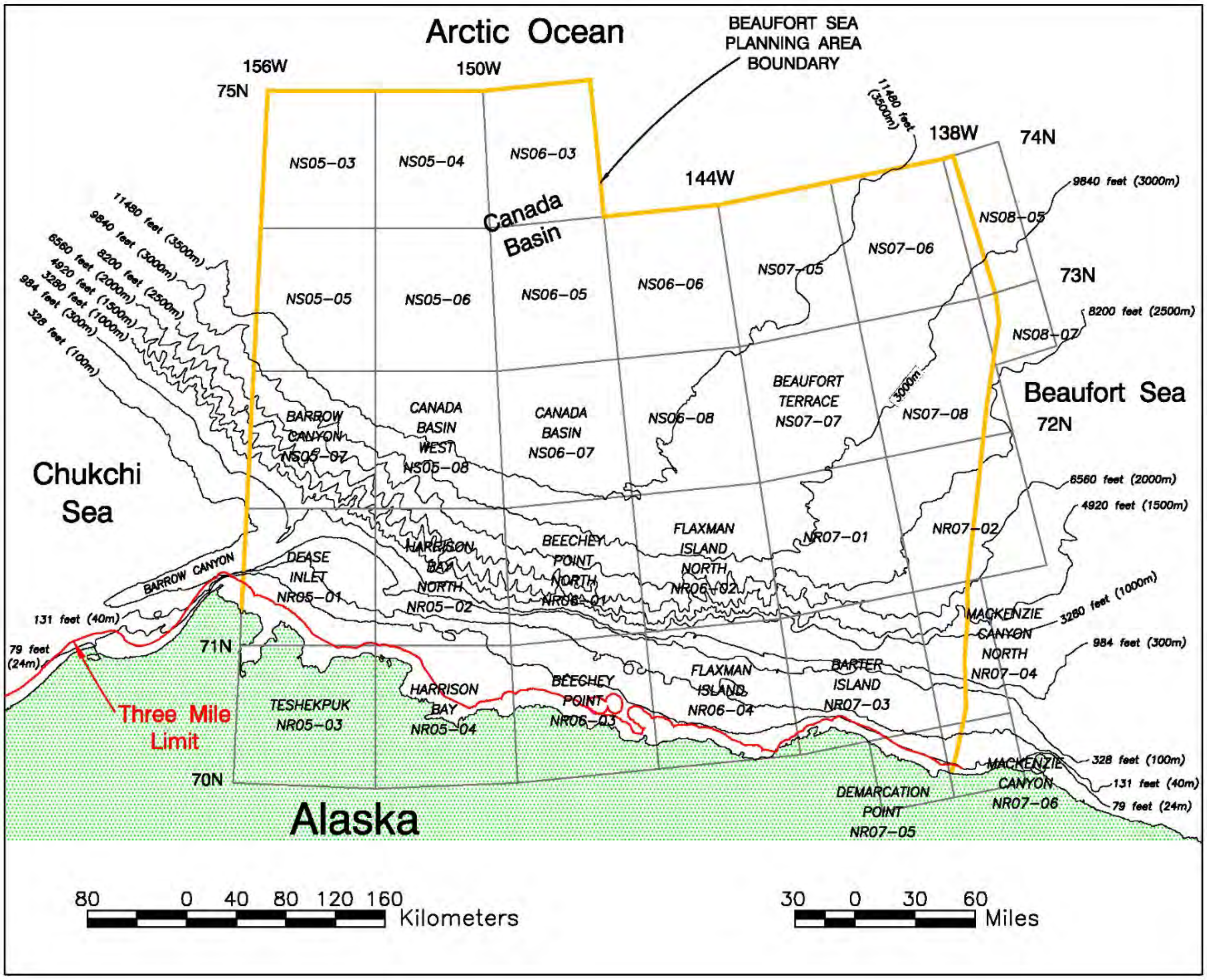


Figure 5-2. Beaufort Sea planning area with OPDs.

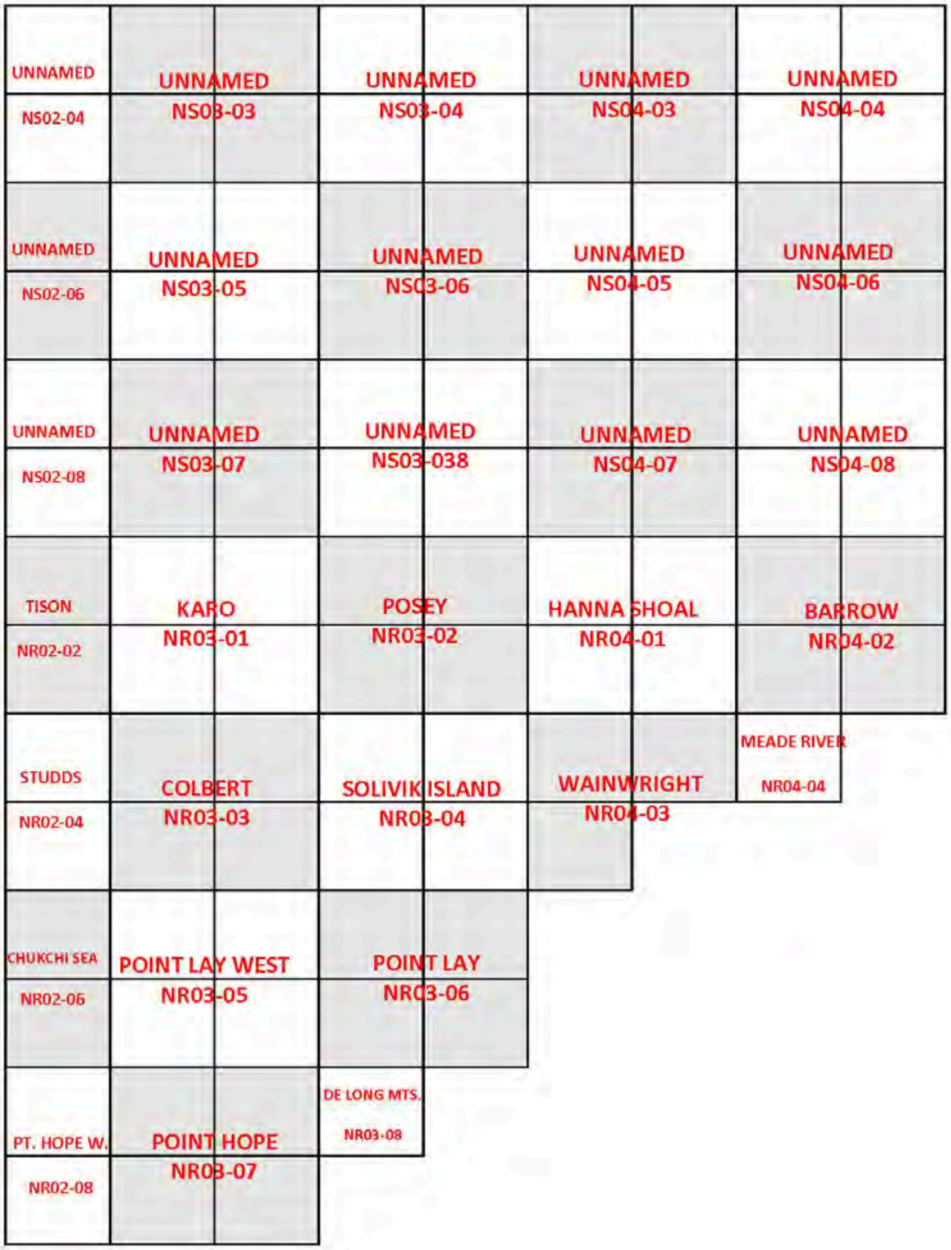


Figure 5-3. Chukchi Sea planning area OPD quadrant subdivisions.

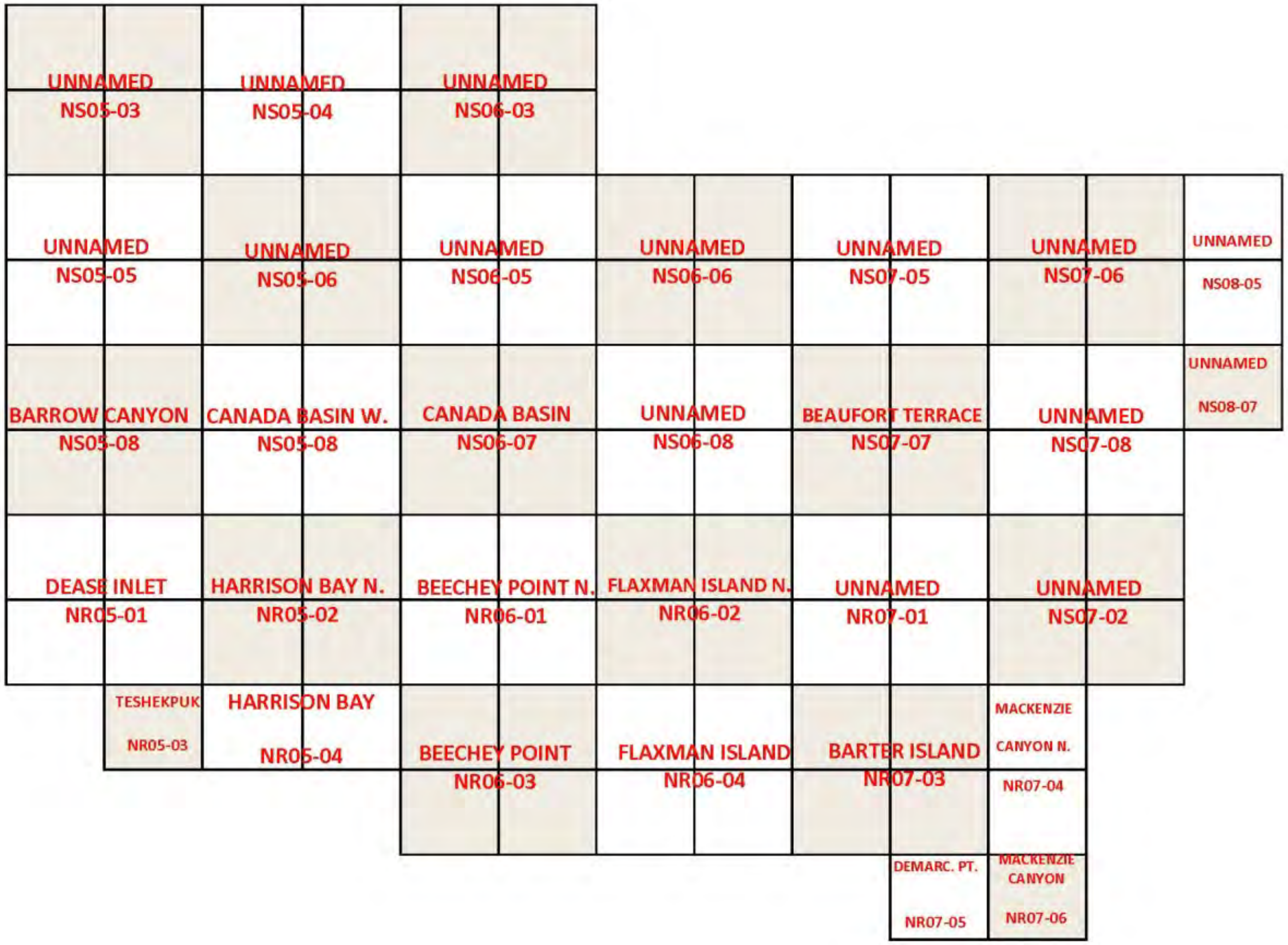


Figure 5-4. Beaufort Sea planning area OPD quadrant subdivisions.

Table 5-1. Chukchi Sea planning area OPDs and quadrant subdivision boundaries.

Protraction Diagram	Diagram Name	Protraction Diagram Boundaries				NW Quadrant Boundaries				NE Quadrant Boundaries				SW Quadrant Boundaries				SE Quadrant Boundaries			
		Lat		Long		Lat		Long		Lat		Long		Lat		Long		Lat		Long	
		North	South	East	West	North	South	East	West	North	South	East	West	North	South	East	West	North	South	East	West
NS02-04	UNNAMED	75	74	168	168 58'37"	NA	NA	NA	NA	75	74.5	168	168 58'37"	NA	NA	NA	NA	74.5	74	168	168 58'37"
NS03-03	UNNAMED	75	74	165	168	75	74.5	166.5	168	75	74.5	165	166.5	74.5	74	166.5	168	74.5	74	165	166.5
NS03-04	UNNAMED	75	74	162	165	75	74.5	163.5	165	75	74.5	162	163.5	74.5	74	163.5	165	74.5	74	162	163.5
NS04-03	UNNAMED	75	74	159	162	75	74.5	160.5	162	75	74.5	159	160.5	74.5	74	160.5	162	74.5	74	159	160.5
NS04-04	UNNAMED	75	74	156	159	75	74.5	157.5	159	75	74.5	156	157.5	74.5	74	157.5	159	74.5	74	156	157.5
NS02-06	UNNAMED	74	73	168	168 58'37"	NA	NA	NA	NA	74	73.5	168	168 58'37"	NA	NA	NA	NA	73.5	73	168	168 58'37"
NS03-05	UNNAMED	74	73	165	168	74	73.5	166.5	168	74	73.5	165	166.5	73.5	73	166.5	168	73.5	73	165	166.5
NS03-06	UNNAMED	74	73	162	165	74	73.5	163.5	165	74	73.5	162	163.5	73.5	73	163.5	165	73.5	73	162	163.5
NS04-05	UNNAMED	74	73	159	162	74	73.5	160.5	162	74	73.5	159	160.5	73.5	73	160.5	162	73.5	73	159	160.5
NS04-06	UNNAMED	74	73	156	159	74	73.5	157.5	159	74	73.5	156	157.5	73.5	73	157.5	159	73.5	73	156	157.5
NS02-08	UNNAMED	73	72	168	168 58'37"	NA	NA	NA	NA	73	72.5	168	168 58'37"	NA	NA	NA	NA	72.5	72	168	168 58'37"
NS03-07	UNNAMED	73	72	165	168	73	72.5	166.5	168	73	72.5	165	166.5	72.5	72	166.5	168	72.5	72	165	166.5
NS03-08	UNNAMED	73	72	162	165	73	72.5	163.5	165	73	72.5	162	163.5	72.5	72	163.5	165	72.5	72	162	163.5
NS04-07	UNNAMED	73	72	159	162	73	72.5	160.5	162	73	72.5	159	160.5	72.5	72	160.5	162	72.5	72	159	160.5
NS04-08	UNNAMED	73	72	156	159	73	72.5	157.5	159	73	72.5	156	157.5	72.5	72	157.5	159	72.5	72	156	157.5
NR02-02	TISON	72	71	168	168 58'37"	NA	NA	NA	NA	72	71.5	168	168 58'37"	NA	NA	NA	NA	71.5	71	168	168 58'37"
NR03-01	KARO	72	71	165	168	72	71.5	166.5	168	72	71.5	165	166.5	71.5	71	166.5	168	71.5	71	165	166.5
NR03-02	POSEY	72	71	162	165	72	71.5	163.5	165	72	71.5	162	163.5	71.5	71	163.5	165	71.5	71	162	163.5
NR04-01	HANNA SHOAL	72	71	159	162	72	71.5	160.5	162	72	71.5	159	160.5	71.5	71	160.5	162	71.5	71	159	160.5
NR04-02	BARROW	72	71	156	159	72	71.5	157.5	159	72	71.5	156	157.5	71.5	71	157.5	159	71.5	71	156	157.5
NR02-04	STUDDS	71	70	168	168 58'37"	NA	NA	NA	NA	71	70.5	168	168 58'37"	NA	NA	NA	NA	70.5	70	168	168 58'37"
NR03-03	COLBERT	71	70	165	168	71	70.5	166.5	168	71	70.5	165	166.5	70.5	70	166.5	168	70.5	70	165	166.5
NR-03-04	SOLIVIK ISLAND	71	70	162	165	71	70.5	163.5	165	71	70.5	162	163.5	70.5	70	163.5	165	70.5	70	162	163.5
NR04-03	WAINWRIGHT	71	70	159	162	71	70.5	160.5	162	71	70.5	159	160.5	70.5	70	160.5	162	NA	NA	NA	NA
NR04-04	MEADE RIVER	71	70	156	159	71	70.5	157.5	159	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NR02-06	CHUKCHI SEA	70	69	168	168 58'37"	NA	NA	NA	NA	70	69.5	168	168 58'37"	NA	NA	NA	NA	69.5	69	168	168 58'37"
NR-03-05	POINT LAY WEST	70	69	165	168	70	69.5	166.5	168	70	69.5	165	166.5	69.5	69	166.5	168	69.5	69	165	166.5
NR-03-06	POINT LAY	70	69	162	165	70	69.5	163.5	165	70	69.5	162	163.5	69.5	69	163.5	165	69.5	69	162	163.5
NR02-08	POINT HOPE WEST	69	68	168	168 58'37"	NA	NA	NA	NA	69	68 18'	168	168 58'37"	NA	NA	NA	NA	NA	NA	NA	NA
NR03-07	POINT HOPE	69	68	165	168	69	68.5	166.5	168	69	68.5	165	166.5	68.5	68	166.5	168	68.5	68	165	166.5
NR03-08	DELONG MOUNTAINS	69	NA	162	165	69	68.5	163.5	165	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Note: Please refer to the individual protraction diagrams for exact latitude boundaries which vary slightly from the presentation above.

Table 5-2. Beaufort Sea planning area OPDs and quadrant subdivision boundaries.

Protraction Diagram	Diagram Name	Protraction Diagram Boundaries				NW Quadrant Boundaries				NE Quadrant Boundaries				SW Quadrant Boundaries				SE Quadrant Boundaries			
		Lat		Long		Lat		Long		Lat		Long		Lat		Long		Lat		Long	
		North	South	East	West	North	South	East	West	North	South	East	West	North	South	East	West	North	South	East	West
NS05-03	UNNAMED	75	74	153	156	75	74.5	154.5	156	75	74.5	153	154.5	74.5	74	154.5	156	74.5	74	153	154.5
NS05-04	UNNAMED	75	74	150	153	75	74.5	151.5	153	75	74.5	150	151.5	74.5	74	151.5	153	74.5	74	150	151.5
NS06-03	UNNAMED	75	74	147	150	75	74.5	148.5	150	75	74.5	147	148.5	74.5	74	148.5	150	74.5	74	147	148.5
NS05-05	UNNAMED	74	73	153	156	74	73.5	154.5	156	74	73.5	153	154.5	73.5	73	154.5	156	73.5	73	153	154.5
NS05-06	UNNAMED	74	73	150	153	74	73.5	151.5	153	74	73.5	150	151.5	73.5	73	151.5	153	73.5	73	150	151.5
NS06-05	UNNAMED	74	73	147	150	74	73.5	148.5	150	74	73.5	147	148.5	73.5	73	148.5	150	73.5	73	147	148.5
NS06-06	UNNAMED	74	73	144	147	74	73.5	145.5	147	74	73.5	144	145.5	73.5	73	145.5	147	73.5	73	144	145.5
NS07-05	UNNAMED	74	73	141	144	74	73.5	142.5	144	74	73.5	141	142.5	73.5	73	142.5	144	73.5	73	141	142.5
NS07-06	UNNAMED	74	73	138	141	74	73.5	139.5	141	74	73.5	138	139.5	73.5	73	139.5	141	73.5	73	138	139.5
NS08-05	UNNAMED	74	73	135	138	74	73.5	136.5	138	NA	NA	NA	NA	73.5	73	136.5	138	NA	NA	NA	NA
NS05-07	BARROW CANYON	73	72	153	156	73	72.5	154.5	156	73	72.5	153	154.5	72.5	72	154.5	156	72.5	72	153	154.5
NS05-08	CANADA BASIN WEST	73	72	150	153	73	72.5	151.5	153	73	72.5	150	151.5	72.5	72	151.5	153	72.5	72	150	151.5
NS06-07	CANADA BASIN	73	72	147	150	73	72.5	148.5	150	73	72.5	147	148.5	72.5	72	148.5	150	72.5	72	147	148.5
NS06-08	UNNAMED	73	72	144	147	73	72.5	145.5	147	73	72.5	144	145.5	72.5	72	145.5	147	72.5	72	144	145.5
NS07-07	BEAUFORT TERRACE	73	72	141	144	73	72.5	142.5	144	73	72.5	141	142.5	72.5	72	142.5	144	72.5	72	141	142.5
NS07-08	UNNAMED	73	72	138	141	73	72.5	139.5	141	73	72.5	138	139.5	72.5	72	139.5	141	72.5	72	138	139.5
NS08-07	UNNAMED	73	72	137 45'	138	73	72.5	136.5	138	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NR05-01	DEASE INLET	72	71	153	156	72	71.5	154.5	156	72	71.5	153	154.5	71.5	71	154.5	156	71.5	71	153	154.5
NR05-02	HARRISON BAY NORTH	72	71	150	153	72	71.5	151.5	153	72	71.5	150	151.5	71.5	71	151.5	153	71.5	71	150	151.5
NR06-01	BEECHEY POINT NORTH	72	71	147	150	72	71.5	148.5	150	72	71.5	147	148.5	71.5	71	148.5	150	71.5	71	147	148.5
NR06-02	FLAXMAN ISLAND N.	72	71	144	147	72	71.5	145.5	147	72	71.5	144	145.5	71.5	71	145.5	147	71.5	71	144	145.5
NR07-01	UNNAMED	72	71	141	144	72	71.5	142.5	144	72	71.5	141	142.5	71.5	71	142.5	144	71.5	71	141	142.5
NR07-02	UNNAMED	72	71	138	141	72	71.5	139.5	141	72	71.5	138	139.5	71.5	71	139.5	141	71.5	71	138	139.5
NR05-03	TESHEKPUK	71	70	153	156	NA	NA	NA	NA	71	70.5	153	154.5	NA	NA	NA	NA	NA	NA	NA	NA
NR05-04	HARRISON BAY	71	70	150	153	71	70.5	151.5	153	71	70.5	150	151.5	NA	NA	NA	NA	NA	NA	NA	NA
NR06-03	BEECHEY POINT	71	70	147	150	71	70.5	148.5	150	71	70.5	147	148.5	NA	NA	NA	NA	70.5	70	147	148.5
NR06-04	FLAXMAN ISLAND	71	70	144	147	71	70.5	145.5	147	71	70.5	144	145.5	70.5	70	145.5	147	70.5	70	144	145.5
NR07-03	BARTER ISLAND	71	70	141	144	71	70.5	142.5	144	71	70.5	141	142.5	70.5	70	142.5	144	70.5	70	141	142.5
NR07-04	MACKENZIE CANYON N.	71	70	138	141	71	70.5	139.5	141	NA	NA	NA	NA	70.5	70	139.5	141	NA	NA	NA	NA
NR06-06	MT. MICKELSON	70	69	144	147	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NR07-05	DEMARCATION POINT	70	69	141	144	NA	NA	NA	NA	70	69.5	141	142.5	NA	NA	NA	NA	NA	NA	NA	NA
NR07-06	MACKENZIE CANYON	70	69	138	141	70	69.5	139.5	141	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Note: Please refer to the individual protraction diagrams for exact latitude boundaries which vary slightly from the presentation above.																				

6.0 Methods of Deployment Analysis

6.1 Premise of Deployment Analysis

Safe deployment of SCCE and relief wells on the Alaska Arctic OCS is dependent on several factors including water depth, sea ice conditions, sea states and wind speeds during deployment activities. Bathymetry and metocean conditions that affect safe deployment of these response activities and reduce the probability for safe deployment are addressed in the deployment analysis for both open water and sea ice scenarios in the Chukchi and Beaufort Sea planning areas.

Shallow water depths require that the relief well rig is capable of operating at such depths which have historically been on the order of 167 feet (51 meters) or shallower. This bathymetry regime restricts the type and availability of drilling vessels that can be used in an open water scenario and they preclude all vessels on the worldwide market for drilling in sea ice conditions except for water depths shallower than 79 feet (24 meters). The risk associated with a surface gas boil in shallow water is also greatly increased and will likely require the use of offset installation equipment for SCCE deployment in a blowout scenario.

Other operational limiting factors such as sea state, winds and sea ice are not static as is bathymetry and vary throughout the operating season. Therefore, depth constraints, based on the capabilities of currently available drilling vessels and the potential need for offset installation equipment are presented as an independent set of figures and discussion in section 7 below.

The time periods for when drilling can occur, or when SCCE can be deployed, are a seasonal matter that is ultimately dependent on ice concentration for operations in sea ice and sea state conditions during the open water drilling season. There is a predictable beginning in most years to the open water season that generally varies with latitude and the retreat of sea ice during July and August in a typical year. When ice concentrations have abated sufficiently for the operating scenario, drilling operations can commence. Similarly, there is an end to the useful season, when it is no longer practical or safe for drilling or SCCE deployment to occur. Ice concentration can be reasonably predicted for planning purposes and can also be very accurately monitored to determine when activities are actually initiated and then concluded for the season. This data can also be utilized for spill response and relief well planning to estimate when these operations would need to be started or discontinued at a given location to meet operational and regulatory requirements. Ice concentration probabilities in the OPDs are presented in time increments indicating when relief well drilling and deployment of SCCE can generally begin and end for each OPD under open water and sea ice operating scenarios.

Delays in relief well drilling and SCCE deployment operations are usually related to sea state and wind speed, or the occurrence of an ice incursion event in the vicinity of operations that cannot be mitigated by ice management vessels and requires a suspension of deployment activities and move off from the location. However, these operating delays do not define when and where response activities can occur (unless it is the end of the useful season) but rather slow the response or temporarily lower the efficiency of the response. While sea state concerns are more likely to occur during open water periods, and large ice features are more likely to be present during periods of higher ice concentration, neither condition is totally predictable for planning purposes.

6.1.1 Deployment Efficiency

Deployment of SCCE and relief wells will experience a drop in efficiency during elevated sea states and wind speeds in an open water scenario. Sea state is less likely to reduce efficiency in a sea ice scenario due to the damping effect of sea ice on waves but high winds combined with increasing ice coverage can lead to decreased efficiency in the management of ice approaching the location. Higher ice concentrations also lessen efficiency because ice management takes more resources and ice management vessels need to be refueled more often (Connelly).

6.1.2 Assumptions

Assumptions that apply to both open water and sea ice operating scenarios are the following:

- SCCE includes capping stacks, cap and flow systems, containment domes, offset installation equipment and all other equipment listed under SCCE in the Definitions section at the beginning of this report.
- SCCE, including the deployment vessels, will be a fit for purpose suite of equipment that is dedicated to the operations for the season.
- Offset-installation equipment is based on OSRL or similar technology.
- An ice management and ice alert system will be in place for the season.
- The deployment analysis does not apply to SIDs or other pre-installed wellbore SCCE which do not require vessel deployment at the time of the event.

6.1.2.1 Open Water Scenario Assumptions

Additional assumptions for the deployment analysis for open water operations are the following:

- A minimum of two ice management vessels (see table 4-1 above) will support operations while other support vessels may not have ice classification.
- SCCE and relief well deployment operations require a 30 nautical mile open water radius for safe operations.

6.1.2.2 Sea Ice Scenario Assumptions

- Assumptions for the deployment analysis for sea ice operations are the following: relief well drilling vessels will be classed for drilling operations in sea ice.
- Ice class drilling vessel access/operations in water depths from 82 feet to 328 feet (25 to 100 meters) and deeper depths is based on a hypothetical MODU that does not exist in the current drilling rig market. This MODU will be capable of operations in sea ice concentrations up to 8 tenths managed ice coverage.
- Ice class drillship access/operations in over 328 feet (100 meters) are based on the Stena IceMAX with turret mooring modification.
- A minimum of four ice management vessels (see table 4-1 above) will support operations and other support vessels will have ice classification for operations in sea ice sufficient for the anticipated ice regime.
- Well-intervention vessel access/operations will be based on the MPV Everest (see table 4-1 above).

6.2 Metocean Conditions Used in This Analysis

Metocean conditions utilized in the deployment analysis include bathymetry, sea ice coverage, wind speed, wave height and wave period. Other metocean parameters that are not included in the analysis due to minimal or no impact on the deployment of SCCE and relief wells are discussed above in section 2.2.

6.2.1 Bathymetry

Bathymetry data for the Chukchi Sea and Beaufort Sea planning areas for this study was downloaded from the General Bathymetric Chart of the Oceans (GEBCO) which is a publicly available database on the GEBCO website (GEBCO, 2018). The bathymetry data was then processed with Blue Marble Global Mapper software to generate bathymetry contours across the planning areas. Selected key isobaths for presentation include the following:

- 79 foot (24 meter) isobath which is the maximum operating water depth of the SDC submersible drilling vessel.
- 131 foot (40 meter) isobath which is the minimum operating depth for available SCCE offset installation equipment (with a 30 to 35 foot (9 to 11 meter) recessed seafloor mudline cellar). It is also the approximate lower operating limit for an anchor moored semisubmersible MODU.
- 328 foot (100 meter) isobath which is the minimum operating water depth for a turret-moored drillship such as the Stena IceMAX.

- 984 foot (300 meter) isobath which is the minimum operating water depth for the Stena IceMAX in DP mode and it is the likely safe depth where offset installation equipment would not be necessary for SCCE deployment.

6.2.2 Ice Coverage

6.2.2.1 US National Ice Center Data Source for Sea Ice Information

The US National Ice Center (US NIC) provided two types of weekly/bi-weekly sea ice charts: hemispheric sea ice analyses and regional sea ice analyses for the Chukchi and Beaufort seas for the period of 2012 to 2016.

The hemispheric ice charts of the Arctic are created using near-real time different satellite data and some additional meteorological and oceanographic information. This product provides observed sea ice concentration (figures 6-1 and 6-2) and the stage of development (figure 6-3) and is available as shapefiles.

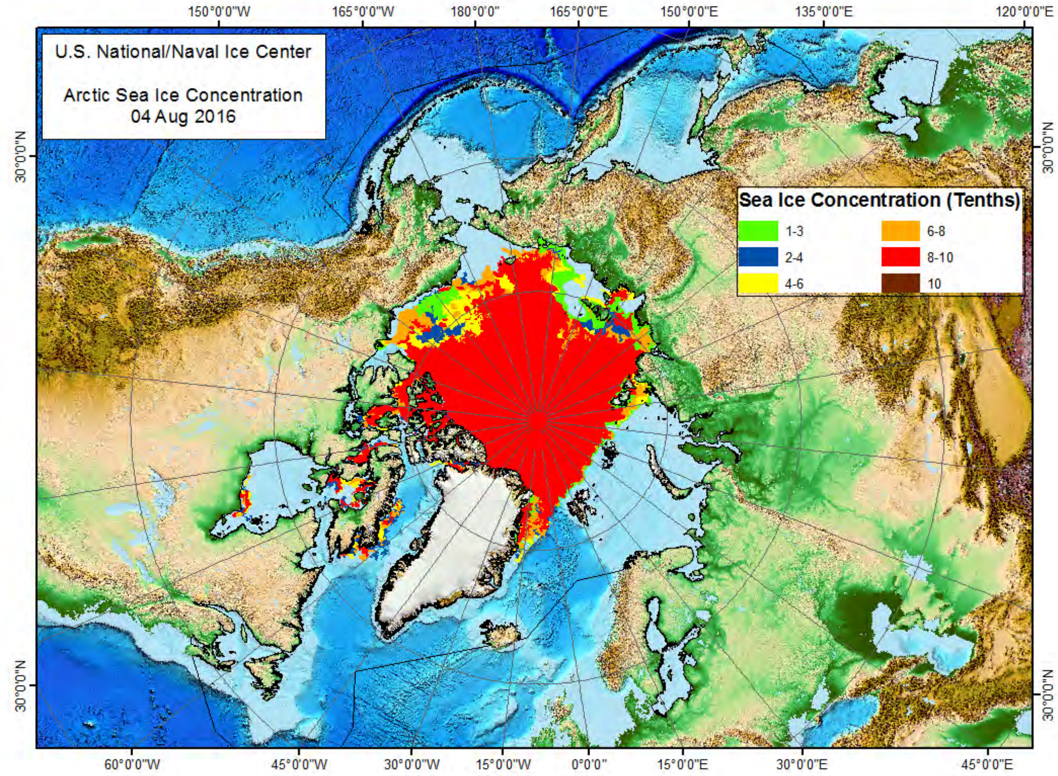


Figure 6-1. NIC hemispheric chart of observed sea ice concentration for the Arctic.

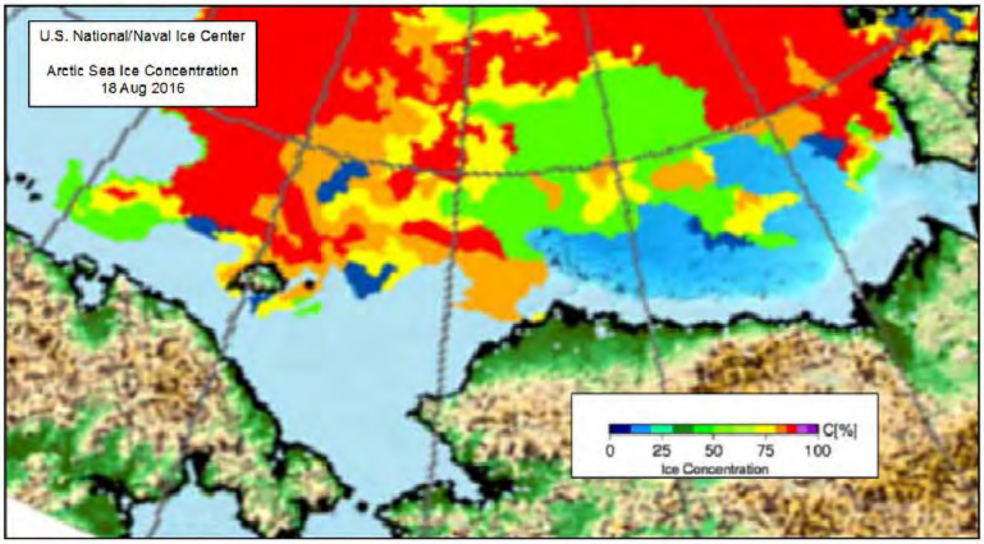


Figure 6-2. NIC hemispheric chart showing a zoom-in of sea ice distribution detail.

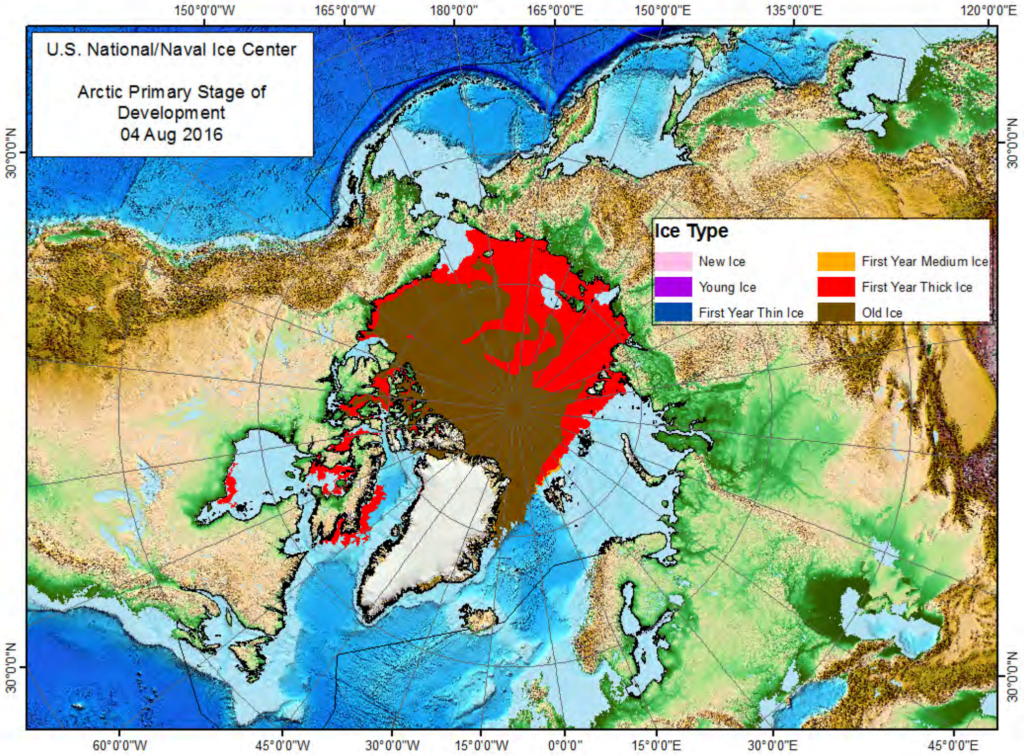


Figure 6-3. NIC hemispheric chart showing stage of sea ice development in the Arctic.

Examples of similarly generated regional sea ice analyses on 18-Aug-2016 are presented below for the Chukchi Sea (figure 6-4) and the Beaufort Sea (figure 6-5).

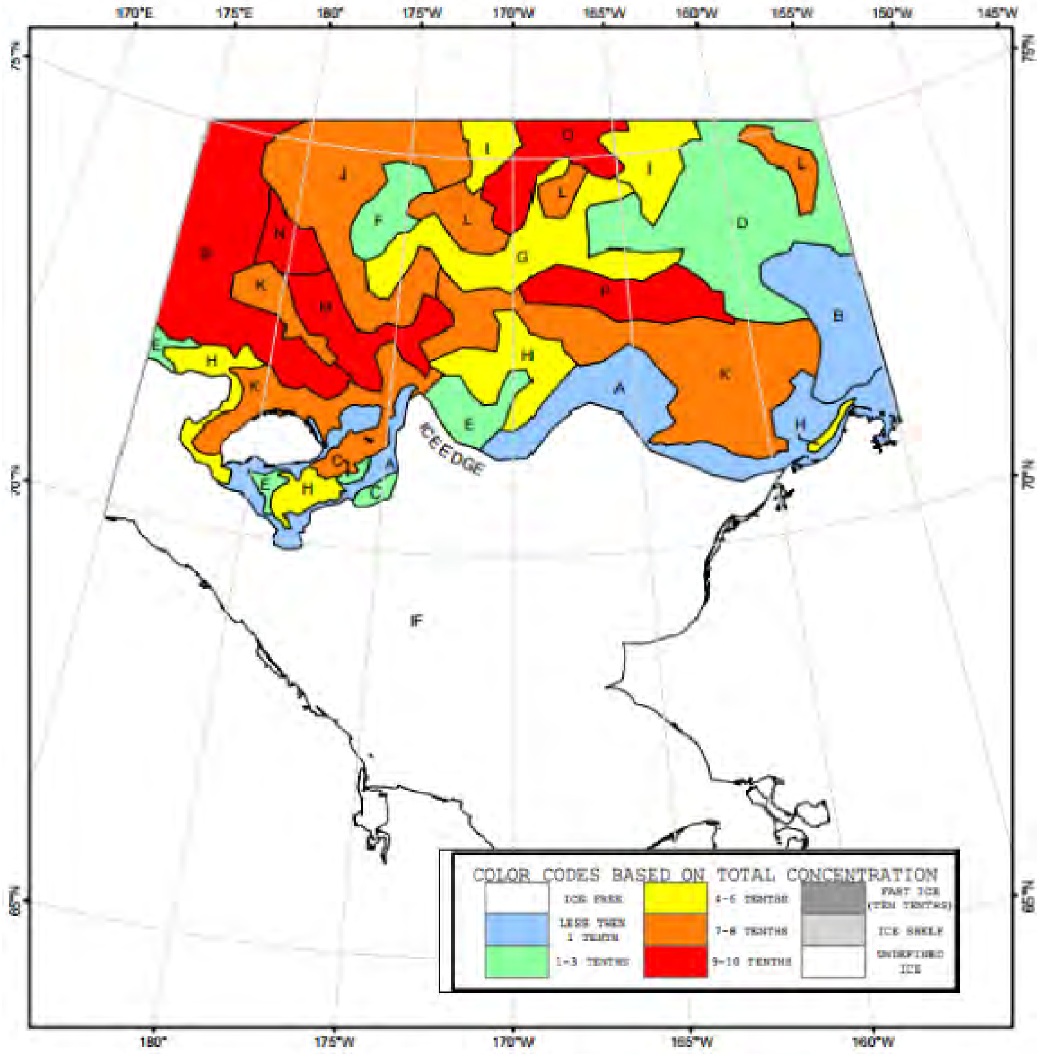


Figure 6-4. NIC regional chart showing sea ice analysis for the Chukchi Sea, 18-Aug-2016.

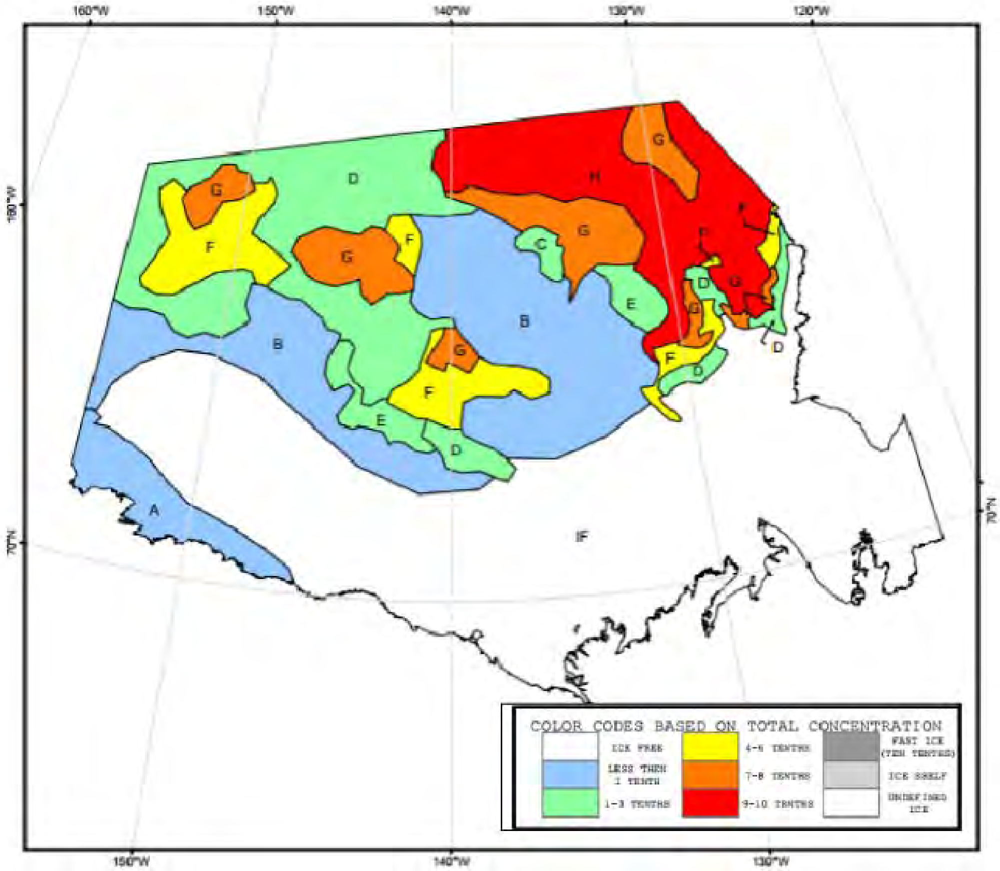


Figure 6-5. NIC regional chart showing sea ice analysis for the Beaufort Sea, 18-Aug-2016.

A very significant feature of NIC sea ice analyses is the availability of shapefiles saved in archives for all years of observations. The shapefiles can be used to get historical digitized information on sea ice distribution in the regions of interest.

6.2.2.2 Analysis of Sea Ice Concentration from the NIC

The use of NIC sea ice data was conducted using the following methodologies.

NIC Archive of Ice Concentration

Data was collected from the archives of sea ice charts in the NIC. These archives include PDF maps of sea ice distribution and corresponding digitized shapefiles. Both the sea ice charts and shapefiles include information on several ice parameters including thickness, stage of development, age and other parameters that are described in accordance with the official sea ice nomenclature approved by the World Meteorological Organization (WMO).

Selection of Temporal Resolution

In most cases, the information (ice charts and shapefiles) on sea ice distribution was available weekly. The days on which the sea ice charts in the archives had been prepared for NIC varied from month-to-month. As a result, it was not quite clear how to prepare systematic observations for predetermined weekly periods within each month for the 5 years to be analyzed (2012 - 2016). An additional difficulty in processing weekly observation data was related to the number of periods within a month. Four weekly observations do not cover the total duration of a month. Therefore, it was decided to conduct our deployment analysis using 10-day periods that nicely fit into a month in creating three each 10-day periods within each month: Days 1 - 10, 11 - 20, 21 - 30 (31).

Historically, offshore operations have not been conducted in the Chukchi and Beaufort seas prior to June of a given year and have only lasted into early winter in the most favorable ice conditions. Based on this, data was only analyzed for the months of June through December which yielded a total number of 21 each 10-day periods subject to analysis; three per month from June through December.

Selection Spatial Resolution and Grid

The choice of spatial resolution for sea ice analysis was based on an optimal compromise between very high resolution with a large number of observations and low resolution with a small number of observations. For practical purposes, it is desirable to use latitude and longitude coordinates with close to square cells to fit well with the OPDs that are oriented by latitude and longitude as well. The decision was made to use 0.5-degree latitude by 1.5-degrees longitude cells for the deployment analysis. These cells are equal to ¼ (or one quadrant) of a full-sized OPD that measures approximately 1-degree latitude by 3-degrees longitude.

Extraction of Sea ice Concentration from NIC Archive

The shapefiles were used to extract total sea ice concentration for a regular 0.25-degree latitude/longitude grid covering all areas of Alaska OCS region.

Sea ice concentration in the NIC charts is identified by a range of changes in each individual ice zone within standard limits that can vary from time to time. The range of concentration was transformed into a single percentage of sea ice concentration based on averaging the limiting concentrations. All concentration ranges are in tenths and corresponding magnitudes of the concentration used to analyze sea ice concentration are presented in table 6-1.

Table 6-1. Concentration range for zones in sea ice charts and assigned concentration for sea ice analysis.

Concentration range in NIC ice charts (tenths)	Concentration magnitude used to analyze sea ice (percent)
10	100
9-10	95
8-10	90
7-9	80
6-8	70
5-7	60
4-6	50
3-5	40
2-4	30
1-3	20
Ice Free	0

Estimation of Average Ice Concentration in Quadrants

The gridded information was further used to estimate sea ice concentration within each quadrant defined above. The concentration in each quadrant was calculated as an average from up to 12 observation values corresponding to the grids within a quadrant. Figures 6-6 and 6-7 show the average number of observations for the quadrants in each 10-day period for the Chukchi Sea and Beaufort Sea planning areas, respectively.

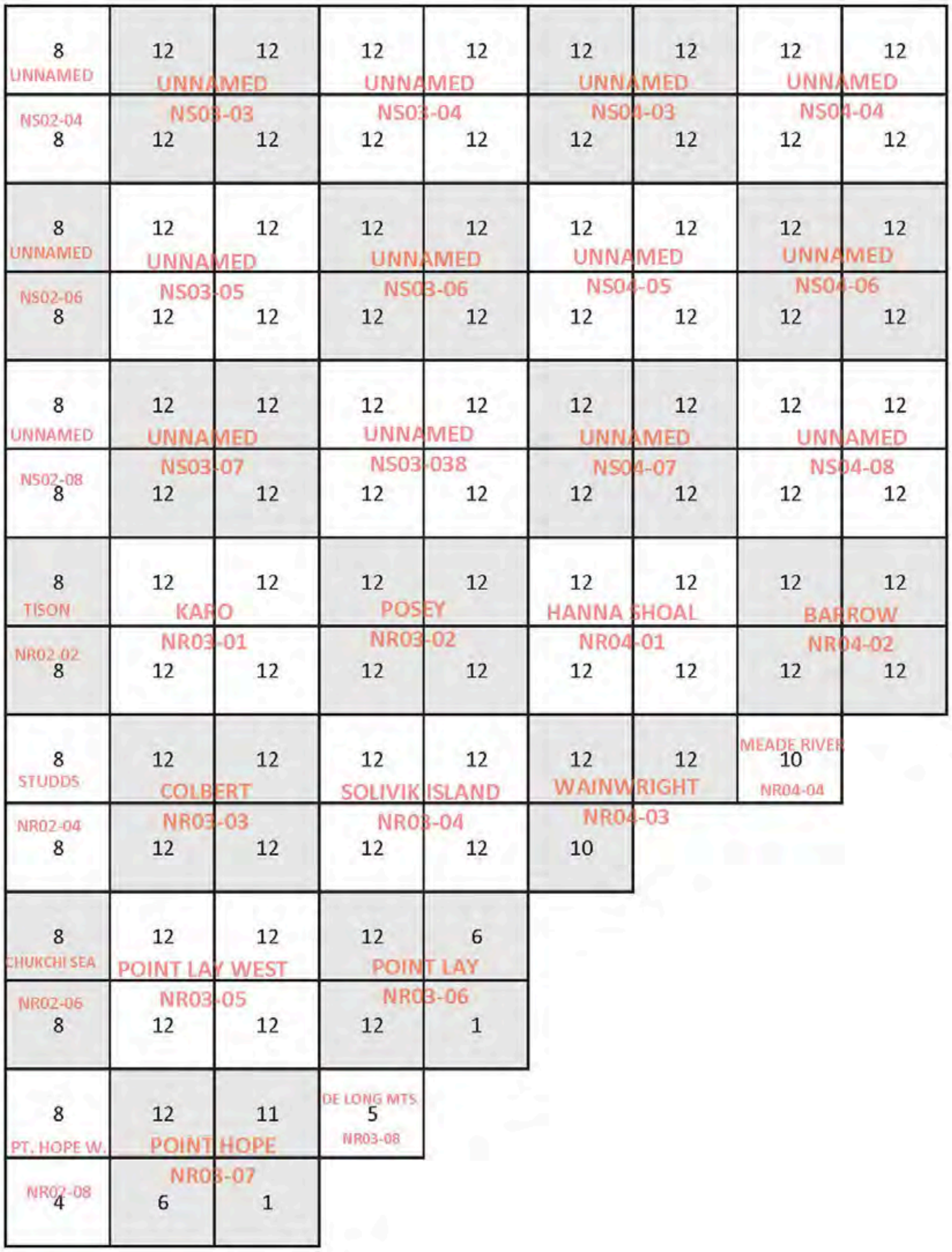


Figure 6-6. Average number of sea ice observations per 10-day period for quadrants in the Chukchi Sea planning area, June to December, 2012 to 2016.

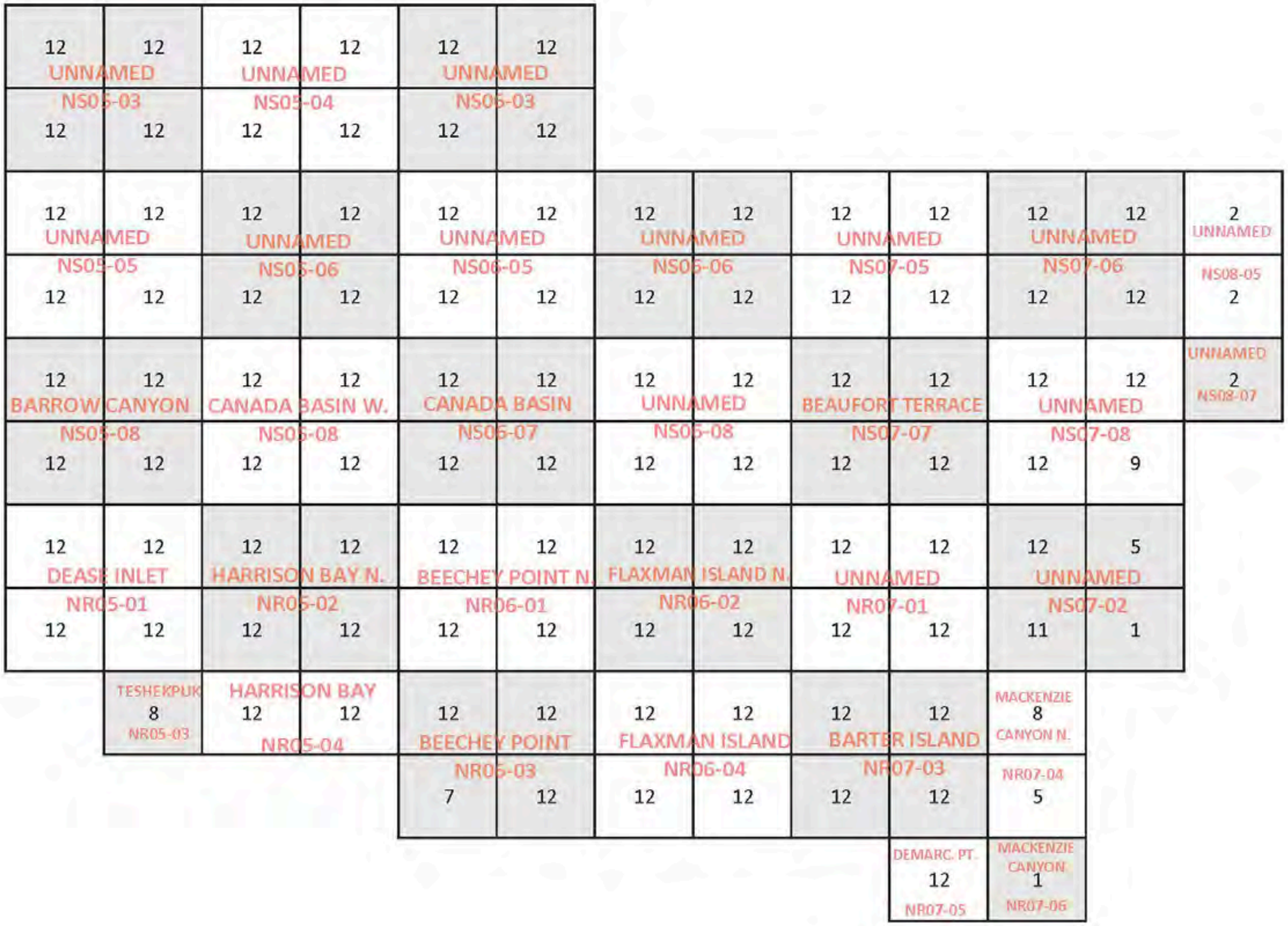


Figure 6-7. Average number of sea ice observations per 10-day period for quadrants in the Beaufort Sea planning area, June to December, 2012-2016.

Final Sea Ice Coverage Analysis

The concentration of sea ice coverage in each quadrant was then applied to the limiting criteria for sea ice coverage that was established for each SCCE and relief well deployment scenario (scenarios and associated metocean criteria are presented in section 6.3 below). The results of the application of sea ice concentration data in each quadrant to the scenario criteria yielded the percent probability of the desired deployment action for each scenario. These deployment probabilities were then plotted in each OPD quadrant for all 10-day analysis periods for all base operating scenarios. Individual data sheets for each of these outputs are presented in appendix B. Figures 6-8 and 6-9 show the quadrant probabilities for selected scenarios during the June 1 to June 10 analysis period in the Chukchi Sea and Beaufort Sea planning areas, respectively.

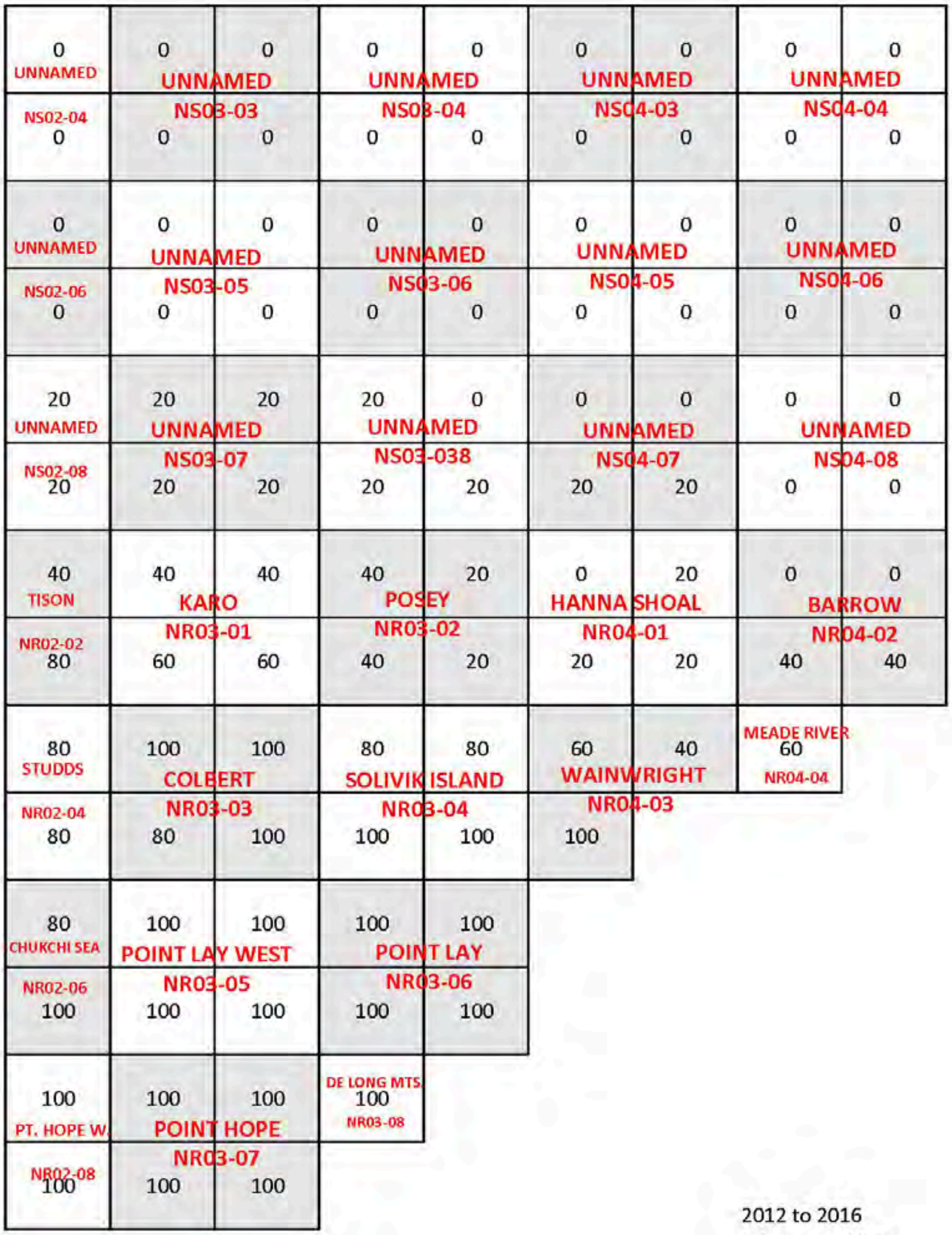


Figure 6-8. Percent probability of open water with 30 NM ice free radius in the Chukchi Sea, scenario 6.1.

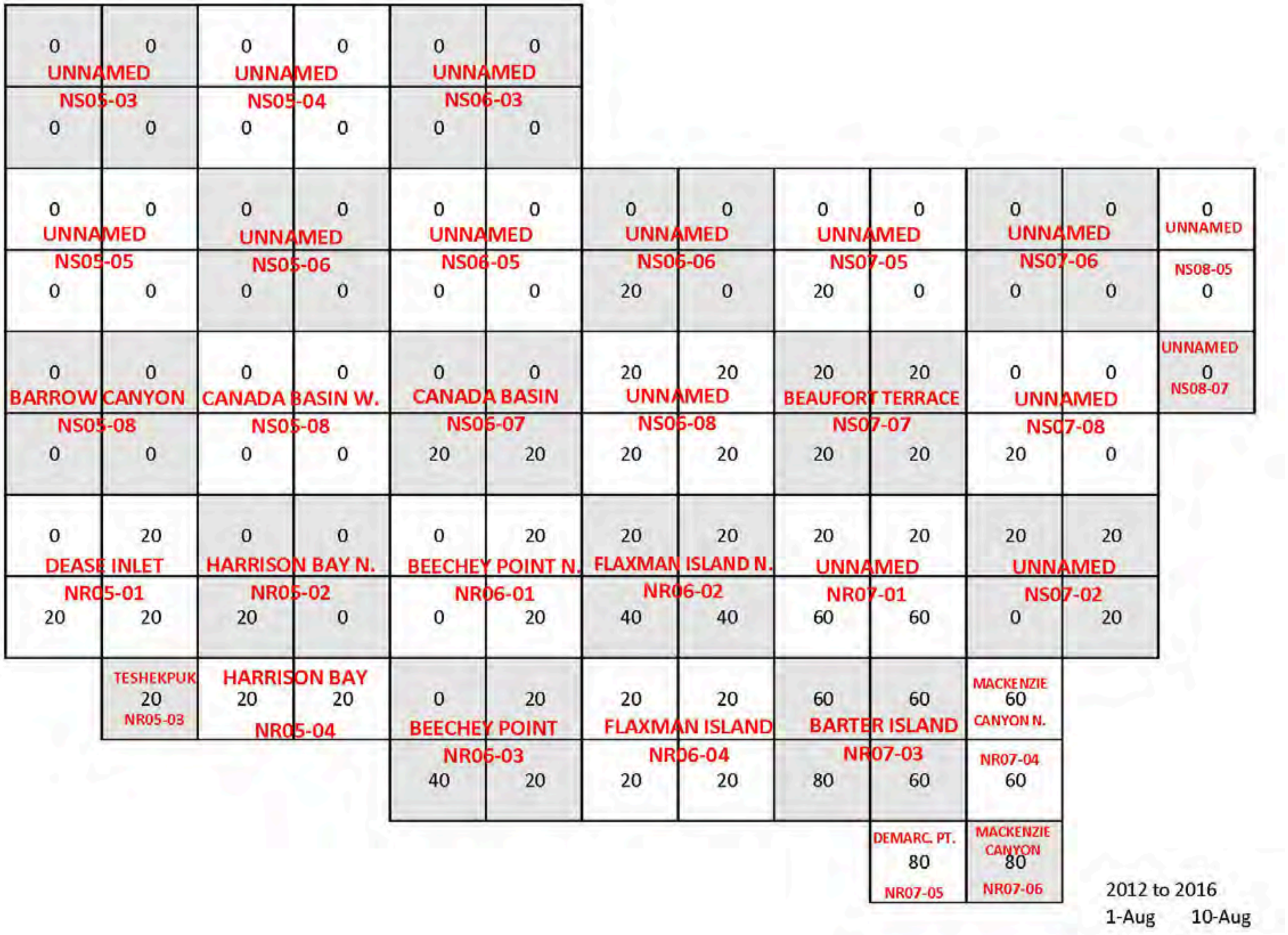


Figure 6-9. Percent probability of open water with 30 NM ice free radius in the Beaufort Sea, scenario 6.3.

6.2.2.3 Wind Speed, Wave Height and Wave Period

Wind and sea state conditions, namely wind speed, wave height and wave period have the potential to impact offshore activities in the Chukchi Sea and Beaufort Sea planning areas if the combination of these conditions exceed the operating limits of the drilling vessel and support fleet. Adverse sea state conditions will not prevent the continuation of offshore operations but may temporarily reduce operations efficiency during unfavorable conditions. Therefore, the probability of these metocean parameters exceeding the deployment operating limitations specified in table 6-2 below was assessed on a monthly basis. For a shorter period, the estimate of the probability would not be representative; however, calculations for a longer period could miss features characteristic of seasonal changes that vary across the operating season.

Wind Speed

There are two major sources of information on surface wind: data from atmospheric modeling and direct instrumental observations. Despite continuing improvement of atmospheric models, the models tend to underestimate surface wind speed, especially for cases with strong winds and storm conditions (Appel). Therefore, hourly direct surface wind speed measurements at 33 foot (10 meter) height were collected from six weather stations located along the coast line of the Chukchi and Beaufort seas over the period of June through December for the years 2012 to 2016. These stations include Point Hope, Point Lay, Wainwright, Utqiagvik (Barrow), Prudhoe Bay and Barter Island. Wind speed data is also available from historical buoy data and other sources in the Chukchi Sea for the period of 1989 to 2013 and other stations in the Beaufort Sea from 1999 to 2014 (Francis, 2016), however, these data sets were collected at significantly varying elevations that can significantly affect the measurements. Thus, 33 foot (10 meter) collection height, which is the standard elevation for collection of wind speed data, was used for the analysis in section 7 below.

Wave Height and Period

Wave height and period data for the Chukchi Sea is available from buoy measurements that were collected in 2010, 2011 and 2012 (Francis, 2016). The 2012 data is the only Chukchi Sea wave data within the BSEE specified 2010 to 2016 review timeframe and consists of wave height and wave period data from three buoys located in the Chukchi Sea in the Colbert, Posey and Hanna Shoal OPD areas. These three data sets from 2012 have been combined for comparison with the 2010 to 2012 data in the analysis for the Chukchi Sea wave height and wave period analysis in section 7 below.

A single buoy data set for the Beaufort Sea was identified from the year 2013. This data is also included in the Beaufort Sea analysis. In general, the quantity of field measurements of waves is insufficient in the Beaufort Sea planning area for analyzing the wave characteristics in the area. Therefore, the limited data can be augmented with remote sensing methods to collect and study the wave characteristics that can influence offshore deployment of SCCE and relief wells. In this case, numerical modeling simulations and remote-sensing altimeter observations are utilized as sources for analyzing the sea state in the Beaufort Sea. Primary data sources for the sea state assessment herein are two sea state studies (Thomson and Fan, 2016, and Liu, 2016) that utilize sea state modeling in the Chukchi and Beaufort seas. The studies include two significantly different years, 2012 and 2014 with average and light ice cover conditions, respectively, as well as other data prior to 2016. The studies were used to provide estimates for wave characteristics in the Beaufort Sea planning area.

The two significant factors that influence the wave regime in the Chukchi Sea and Beaufort Sea planning areas are wind vectors and the seasonally varying location of the sea ice edge that delineates the spatial extent and configuration of open water. The magnitude of the waves that are generated is directly related to the intensity of the wind vectors and the fetch distance between the coast line and sea ice edge.

The propagation of waves within the sea ice zone is a less studied process; although, all available investigations overwhelmingly indicate that sea ice cover significantly suppresses the kinetic energy of waves which in turn affects wave speed, height and period. In addition, the sea ice edge zone where waves transform and become dampened by sea ice is much smaller than the typical size of the open water region. For these reasons, the analysis of waves was limited to the areas of open water in the Beaufort Sea and Chukchi Sea planning areas. Open water periods begin in May in the Chukchi Sea planning area and in May or June in the Beaufort Sea planning area. These conditions continue into October or November depending upon the temperatures encountered during freeze-up in late fall.

The two characteristics required to estimate the probability of sea state having an impact on the deployment of SCCE and relief wells in the subject areas are significant wave height and wave period. The output of the sea state models provided a source for these data as well as the buoy data discussed above.

These model outputs were then compared against satellite altimeter measurements from available sources including the Envisat records and CRYOSAT data from the NOAA Laboratory for Satellite Altimetry.

6.2.2.4 Air Temperature

The potential for temperature to impact safe deployment of SCCE or relief wells is determined by the limits of the operating vessels for offshore operations. Critical vessels, including relief well drilling rigs and support vessels for ice management and

SCCE deployment have operating-temperature limits in accordance with the classification of the vessel.

The example considered for an open water relief well drilling vessel was the Transocean Polar Pioneer utilized by Shell in 2015. This vessel has a minimum operating temperature of – 4 F (-20 C) and is classified by DNV for escorted transit only in sea ice and not for drilling operations in sea ice. Support vessels for the open water drilling operations would have temperature limitations in a similar range for normal operations. For operations in sea ice, drilling and support vessels need to have more robust winterization and temperature ratings. The Stena IceMAX drillship, ice management vessels (see table 4-1 above) and other potential support vessels for sea ice conditions have minimum operating temperature ratings of -22 F (-30 C) to accommodate late season operations in reduced temperatures.

Temporal changes in air temperature are characterized by a larger time scale than wind variability making it acceptable to consider changes in air temperature on a daily basis. Daily temperature data was obtained for available Chukchi Sea and Beaufort Sea coastal stations from the monthly weather observation summaries collected by NOAA's National Centers for Environmental Information (US NCEI) and published on their Climate Data Online website.

The analysis used data from stations at Barter Island, Prudhoe Bay, Utqiagvik (Barrow), Wainwright, Point Lay and Point Hope. All these stations are located in close proximity to the coast (< 1 mile) except for Prudhoe Bay; the station for Prudhoe Bay is located at the Deadhorse Airport seven miles inland and may be less affected by the warming influence of the coastal ocean waters than the other stations. None-the-less, Prudhoe Bay data was included as a worst-case representation of potential low temperature limitations to ice class drilling and support vessels.

These records of daily meteorological data were used to analyze air temperature in 10-day periods similar to the periods used for the ice analysis discussed above. Data was selected for the months of October through December as this time period is when temperatures begin to decline to the critical vessel-operating limits mentioned above. From this data, the frequencies of the daily maximum and minimum air temperatures that were below operating limits for each 10-day period were assessed.

6.3 Operating Scenario Format for Presentation of Results

During the process of establishing criteria for the safe deployment of SCCE and relief wells and to address the BSEE's scope of work for tasks 6 through 10, the project team developed four base operating-scenarios which apply to when deployment activities can safely occur as defined under each of the five tasks (for a total of 20 scenarios). These four operating scenarios include both open water and sea ice operating conditions for both the Chukchi and Beaufort seas and are based on the premise that the concentration of ice coverage largely determines when operations can safely occur; key metocean parameters such as wind speed, wave height and wave period contribute an additional reduction in the probability of safe deployment of SCCE and relief wells when these criteria parameters are exceeded.

The Chukchi Sea has sufficient open water in the middle of the operating season to conduct open water drilling operations with a smaller ice management support fleet and non-ice class drilling vessels as evinced by Shell's operations in 2015 with the Polar Pioneer. However, as the season progresses with an increase in sea ice concentration, any relief well operations in icy seas would require additional ice management vessels and an ice class relief well rig. While no ice class drilling vessels currently exist in the worldwide market that could also accommodate the typical exploration water depths which range from 131 to 164 feet (40 to 50 meters) in the Chukchi Sea, this scenario is presented as an example of the when and where a relief well could be deployed with a drilling vessel and support fleet capable of operating in sea ice conditions. Similarly for SCCE deployment, increased ice class vessel support would be required for all SCCE deployment tasks in sea ice conditions. These periods which occur during spring break-up and fall freeze-up are often referred to as the shoulder season of the operating window.

In the Beaufort Sea, ice conditions are more severe and have historically required ice class drilling vessels and a generally greater complement of ice management vessels. However, in recent years, including the period of 2012 to 2016, greater aerial extent and duration of open water conditions has developed which could result in an open water drilling program in ice free conditions. Thus, both open water and sea ice scenarios were developed for the Beaufort Sea similarly to the scenarios above for the Chukchi Sea.

Tasks 8, 9 and 10 require comparisons of the base operating scenarios and their limiting criteria described above and result in an additional four each scenarios for each of these three tasks. In total, 20 scenarios were developed (four for each of tasks 6 – 10), 10 for the Chukchi Sea and 10 for the Beaufort Sea. Table 6-2 summarizes the scenarios and the critical deployment criteria associated with each scenario.

Table 6-2. Criteria for safe deployment of SCCE and relief wells in the Chukchi and Beaufort Seas.

Task Description	Scenario	Deployment Scenario Description	Location	Criteria Parameter	Deployment Criteria Limit	Comment
6. Safe deployment of SCCE possible.	6.1	Open water SCCE deployment	Chukchi	Ice concentration	Open water, minimum 30 NM radius without ice	30 NM buffer to provide sufficient time to secure operations and move off location
				Wave height	≤6.6 feet (2 meters) significant wave height	Survey of industry practices, moderate sea state conditions
				Wave period	≤10 seconds	Published vessel limits when combined with high waves and wind speed
				Wind speed	≤30 kts (15 meters/s)	Survey of industry practices, crane and over the side deployment operating limits
				Air temperature	≥ -4 F (-20 C)	Published vessel limits for typical AHTS support fleet in open water
	6.2	SCCE deployment with sea ice operating capability	Chukchi	Ice concentration	0 to 7 tenths, first year ice, ≤10% old ice	Assumes minimum 4 each Polar class ice management vessels, moonpool capability required
				Wave height	≤6.6 feet (2 meters) significant wave height	Survey of industry practices, moderate sea state conditions in open water
				Wave period	≤10 seconds	Published vessel limits when combined with high waves and wind speed
				Wind speed	≤30 kts (15.5 meters/s)	Combined with current driven ice drift, can limit ice management operations
				Air temperature	≥ -22 F, (-30 C)	Published vessel limits for typical ice management AHTS support fleet in sea ice
	6.3	Open water SCCE deployment	Beaufort	Ice concentration	Open water, minimum 30 NM radius without ice	30 NM buffer to provide sufficient time to secure operations and move off location
				Wave height	≤6.6 feet (2 meters) significant wave height	Survey of industry practices, moderate sea state conditions
				Wave period	≤10 seconds	Published vessel limits when combined with high waves and wind speed
				Wind speed	≤30 kts (15 meters/s)	Survey of industry practices, crane and over the side deployment operating limits
				Air temperature	≥ -4 F (-20 C)	Published vessel limits for typical AHTS support fleet
	6.4	SCCE deployment with sea ice operating capability	Beaufort	Ice concentration	0 to 7 tenths, first year ice, ≤10% old ice	Assumes minimum 4 each Polar class ice management vessels, moonpool capability required
				Wave height	≤6.6 feet (2 meters) significant wave height	Survey of industry practices, moderate sea state conditions in open water
				Wave period	≤10 seconds	Published vessel limits when combined with high waves and wind speed
				Wind speed	≤30 kts (15.5 meters/s)	Combined with current driven ice drift, can limit ice management operations, crane operations
				Air temperature	≥ -22 F, (-30 C)	Published vessel limits for typical ice management AHTS support fleet in sea ice
7. Safe deployment of relief well possible.	7.1	Open water relief well deployment	Chukchi	Ice concentration	Open water, minimum 30 NM radius without ice	30 NM buffer to provide sufficient time to secure operations and move off location
				Wave height	≤9.8 feet (3 meters) significant wave height	Limits for heave/roll in critical operations such as mudline cellar drilling, BOP handling and anchor handling in open water
				Wave period	≤10 seconds	Published vessel limits when combined with high waves and wind speed
				Wind speed	≤30 kts (15 meters/s)	Survey of industry practices, anchor handling, associated elevated sea states
				Air temperature	≥ -4 F (-20 C)	Published vessel limits for typical AHTS support fleet and Polar Pioneer example MODU
	7.2	Relief well deployment with sea ice operating capability	Chukchi	Ice concentration	0 to 8 tenths, first year ice, ≤10% old ice	Assumes minimum 4 each Polar class ice management vessels
				Wave height	≤9.8 feet (3 meters) significant wave height	Limits for heave/roll in critical operations such as mudline cellar drilling, BOP handling and anchor handling in open water
				Wave period	≤10 seconds	Published vessel and MODU limits when combined with high waves and wind speed in open water
				Wind speed	≤30 kts (15.5 meters/s)	Combined with current driven drift, can limit ice management operations
				Air temperature	≥-22 F, (-30 C)	Published vessel and MODU limits for sea ice operations
	7.3	Open water relief well deployment	Beaufort	Ice concentration	Open water, minimum 30 NM radius without ice	30 NM buffer to provide sufficient time to secure operations and move off location
				Wave height	≤9.8 feet (3 meters) significant wave height	Limits for heave/roll in critical operations such as mudline cellar drilling, BOP handling and anchor handling in open water
				Wave period	≤10 seconds	Published vessel and MODU limits when combined with high waves and wind speed in open water
				Wind speed	≤30 kts (15.5 meters/s)	Survey of industry practices, anchor handling, associated elevated sea states
				Air temperature	≥ -4 F (-20 C)	Published vessel limits for typical AHTS support fleet and assumed MODU
	7.4	Relief well deployment with sea ice operating capability	Beaufort	Ice concentration	0 to 8 tenths, first year ice, ≤10% old ice	Assumes minimum 4 each Polar class ice management vessels
				Wave height	≤9.8 feet (3 meters) significant wave height	Limits for heave/roll in critical operations such as mudline cellar drilling, BOP handling and anchor handling in open water
				Wave period	≤10 seconds	Published vessel and MODU limits when combined with high waves and wind speed
				Wind speed	≤30 kts (15.5 meters/s)	Combined with current driven ice drift, can limit ice management operations
				Air temperature	≥ -22 F, (-30 C)	Published vessel and MODU limits for sea ice operations

Table 6.2 Criteria for safe deployment of SCCE and relief wells in the Chukchi and Beaufort Seas (continued).

Task Description	Scenario	Deployment Scenario Description	Location	Criteria Parameter	Deployment Criteria Limit	Comment
8. Safe deployment of SCCE or relief well possible.	8.1	Open water SCCE or relief well deployment	Chukchi	See 6.1 vs 7.1 above	≤6.6 feet (2 meters) significant wave height for SCCE deployment	Both SCCE and relief well deployable with ≤6.6 feet (2 meters) significant wave height
	8.2	SCCE or relief well deployment with sea ice operating capability		See 6.2 vs 7.2 above	0 to 7 tenths, first year ice, ≤10% old ice and ≤6.6 feet (2 meters) significant wave height for SCCE deployment	Both SCCE and relief well deployable in 0-7 tenths, first year ice, ≤10% old ice and ≤6.6 feet (2 meters) significant wave height
	8.3	Open water SCCE or relief well deployment	Beaufort	See 6.3 vs 7.3 above	≤6.6 feet (2 meters) significant wave height for SCCE deployment	Both SCCE and relief well deployable with ≤6.6 feet (2 meters) significant wave height
	8.4	SCCE or relief well deployment with sea ice operating capability.		See 6.4 vs 7.4 above	0 to 7 tenths, first year ice, ≤10% old ice and ≤6.6 feet (2 meters) significant wave height for SCCE deployment	Both SCCE and relief well deployable in 0-7 tenths, first year ice, ≤10% old ice and ≤6.6 feet (2 meters) significant wave height
9. Safe deployment of neither SCCE or relief well is possible.	9.1	Neither open water SCCE nor relief well are deployable	Chukchi	See 6.1 vs 7.1 above	≤9.8 feet (3 meters) significant wave height	Neither SCCE nor relief well deployable when >9.8 feet (3 meters) significant wave height
	9.2	Neither SCCE nor relief well are deployable with sea ice operating capability		See 6.2 vs 7.2 above	0 to 8 tenths, first year ice, ≤10% old ice and ≤9.8 feet (3 meters) significant wave height	Neither deployable when >8 tenths ice concentration or >9.8 feet (3 meters) significant wave height
	9.3	Neither open water SCCE nor relief well are deployable	Beaufort	See 6.3 vs 7.3 above	≤9.8 feet (3 meters) significant wave height	Neither SCCE nor relief well deployable when >9.8 feet (3 meters) significant wave height
	9.4	Neither SCCE nor relief well are deployable with sea ice operating capability		See 6.4 vs 7.4 above	0 to 8 tenths, first year ice, ≤10% old ice and ≤9.8 feet (3 meters) significant wave height	Neither deployable when >8 tenths ice concentration or >9.8 feet (3 meters) significant wave height
10. Safe deployment of one method possible but not the other.	10.1	Open water relief well deployable but not SCCE	Chukchi	See 6.1 vs 7.1 above	≤9.8 feet (3 meters) significant wave height	Relief well deployable in ≤9.8 feet (3 meters) significant wave height but not SCCE
	10.2	Relief well deployable but not SCCE with sea ice operating capability		See 6.2 vs 7.2 above	0 to 8 tenths ice concentration and ≤9.8 feet (3 meters) significant wave height	Relief well deployable in 0 to 8 tenths ice concentration and ≤9.8 feet (3 meters) significant wave height but not SCCE
	10.3	Open water relief well deployable but not SCCE	Beaufort	See 6.3 vs 7.3 above	≤9.8 feet (3 meters) significant wave height	Relief well deployable in ≤9.8 feet (3 meters) significant wave height but not SCCE
	10.4	Relief well deployable but not SCCE with sea ice operating capability		See 6.4 vs 7.4 above	0 to 8 tenths ice concentration and ≤9.8 feet (3 meters) significant wave height	Relief well deployable in 0 to 8 tenths ice concentration and ≤9.8 feet (3 meters) significant wave height but not SCCE

Criteria associated with sea state (wave height and wave period) and wind speed have been developed from a survey of industry practices, technical expert input, and vessel operating parameters. Temperature limits included in table 6-2 coincide with published operating limitations for the assumed fleet of drilling and support vessels for a given scenario. These scenarios do not account for bathymetry limitations within the existing fleet of ice class drilling vessels and SCCE deployment equipment. Bathymetry limitations are discussed separately in section 7.

The criteria selected for each scenario in table 6-2 are described in the following paragraphs.

Ice Concentration

A 30 nautical mile buffer of open water has been set for ice conditions in open water scenarios. This distance is based on an anticipated ice drift rate of approximately 1 knot (0.5 meters/s) current and the estimated time to secure operations and move off location. This radius could vary depending on the specific operations and the time to secure operations and move to a safe location for a specific operating scenario.

For sea ice operating scenarios, two separate ice concentration criteria have been set. For deployment of SCCE, an ice concentration range of 0 to 7 tenths managed ice coverage has been established. For an ice class MODU relief well operating scenario, the ice concentration criterion has been set at 0 to 8 tenths concentration. These criteria limits are based on historical operating results for sea ice operations in the Chukchi and Beaufort seas.

Wave Height

The wave height criterion for safe SCCE deployment is set at ≤6.6 feet (2 meters) significant wave height (H_s). This criterion limit reflects moderate wave conditions and takes into account the operating limits related to deployment of equipment from vessels to the seafloor, personnel working on the decks of vessels during deployment and the precision handling that the specialized SCCE equipment requires. This criterion limit was also developed in part from a survey of industry practices.

For drilling operations, the wave height criteria limit is ≤9.8 feet (3 meters) H_s. This criterion limit reflects the critical operating condition limits for operations such as anchor handling, mudline cellar drilling, BOP handling and other activities that have reduced tolerance for the effects of high waves. This value is partly based on the Polar Pioneer open water MODU that Shell utilized in the Chukchi Sea in 2015 for drilling of the Burger J well.

Wave Period

Wave period is part of the overall sea state along with wave height. A wave period criterion limit of >10 seconds has been set based on the wave period tolerances of the anticipated drilling rig and AHTS support vessel fleet. This value applies to both SCCE and relief well deployment. These vessels have published wave period limits in their station keeping capability analysis. It should be noted that for the aforementioned vessel fleet, wave period does not generally have a significant impact on operating performance unless combined with winds greater than 30 knots (15.5 meters/s) and significant wave heights in excess of 16 feet (5 meters).

Wind Speed
The limiting wind speed criterion is set at 30 knots (15.5 meters/s) for both SCCE and relief well deployment. This value reflects limitations during critical operations such as vessel crane operations during SCCE deployment and the previously mentioned critical operations for drilling operations. Wind speed and wave height are closely related as waves in the Chukchi and Beaufort seas are predominantly wind generated. Sustained wind speeds of 30 knots (15.5 meters/s) will quickly build wave heights that exceed the wave height criteria specified in table 6-2.

Temperature
Criteria for limiting temperature are based on published operating limits of the anticipated drilling rig and AHTS support vessel fleet. For the open water scenarios, vessel operating temperature limits are set at -4 F (-20 C). For sea ice operations, offshore vessels require more robust winterization for colder temperatures and the temperature criterion for sea ice operating capability is -22 F (-30 C).

6.3.1 Chukchi Sea - Rationale for Open Water and Sea Ice Base Operating Scenarios

Drilling in the Chukchi Sea has been conducted with both ice class and non-ice class drilling vessels. Shell operated the Transocean Polar Pioneer in the Chukchi Sea during the 2015 open water season for the Burger J well. Prior to this well, five other wells were drilled in the Chukchi Sea with the ice class CANMAR Explorer III drillship (US BOEM, 2018). ConocoPhillips also planned to use a jackup drilling vessel (non-ice class) for their Devils Paw prospect in the Chukchi Sea but cancelled the project in the permitting phase (Faust, 2012).

Two base operating scenarios were developed for the Chukchi Sea for SCCE deployment; one for open water operations (scenario 6.1) and the second for operations in sea ice (scenario 6.2).

Similarly, two base operating scenarios were developed for relief well drilling deployment in the Chukchi Sea; one for open water conditions (scenario 7.1) and the second for sea ice operating conditions (scenario 7.2). It is important to note that for relief well drilling in sea ice, there are no ice class drilling vessels available that can operate in water depths shallower than 984 feet (300 meters) or 328 feet (100 meters) with a turret mooring modification as shown above in section 2.1.4.4.

The typical ice management vessel complement for open water operating conditions in the Chukchi Sea has been a minimum of two polar class (PC3 and/or PC4) ice management vessels (see table 4-1 above). In the potential scenario of extended relief well or SCCE deployment activities due to a blowout, additional ice class management and support vessels would likely be brought in on an emergency basis as required by BSEE's Arctic Rule requirements to provide additional ice management capability as the sea ice season set in. Ice management vessels could be mobilized from the Baltic states or Russian waters within 14 to 21 days under prearranged emergency response agreements that follow international agreements such as the International Law of the Arctic for sharing of resources and aid in emergencies such as an oil spill.

6.3.2 Beaufort Sea – Rationale for Open Water and Sea Ice Base Operating Scenarios

Offshore drilling in the Beaufort Sea planning area has historically been conducted with ice class drilling vessels, except for nearshore operations that have utilized ice or gravel islands. With sea ice recession trending upwards and greater open water areas in the Beaufort Sea (Thomson and Fan, 2016), it is conceivable that drilling operations could be conducted during the open water drilling window in the Beaufort Sea.

As with the Chukchi Sea above, two base operating scenarios were developed for SCCE deployment in the Beaufort Sea; one for open water (scenario 6.3) and one for operating in sea ice conditions (scenario 6.4).

Likewise, two base operating scenarios were developed for relief well deployment in the Beaufort Sea; one for open water (scenario 7.3) and another for potential sea ice conditions (scenario 7.4).

Similar to the Chukchi Sea response discussion above, additional ice management and support vessels would be brought in as needed to assist with a relief well and SCCE deployment response.

6.3.3 Comparison Scenarios 8.1 to 8.4, 9.1 to 9.4 and 10.1 to 10.4

Scenarios 8.1 to 8.4, 9.1 to 9.4 and 10.1 to 10.4 have been created to address tasks 8, 9 and 10 of the scope of work (see section 1.1 above for a description of tasks 8, 9 and 10). Each of the scenarios in this group requires comparison with the base operating scenarios described above and listed in table 6-2.

Scenarios 8.1 to 8.4 require the comparison of base operating scenarios 6.1 with 7.1, 6.2 with 7.2, 6.3 with 7.3 and 6.4 with 7.4 as shown in table 6-2. For each of these comparisons, the limiting criteria are identified in table 6-2 to determine the conditions when both SCCE and a relief well can be deployed. Since SCCE has lower criteria limits for significant wave height and sea ice concentration than relief well drilling, the criteria for SCCE deployment determine the conditions for which both SCCE and a relief well can be deployed in scenarios 8.1 to 8.4.

Scenarios 9.1 to 9.4 also require comparison of base operating scenarios 6.1 with 7.1, 6.2 with 7.2, 6.3 with 7.3 and 6.4 with 7.4 as shown in table 6-2. For each of these comparisons, the limiting criteria are identified in table 6-2 to determine the conditions when neither SCCE nor a relief well can be deployed. Since the relief well scenario has higher criteria limits for sea ice concentration and significant wave height than SCCE deployment, the criteria for relief well deployment determine the conditions for which neither SCCE nor a relief well can be deployed in scenarios 9.1 to 9.4.

Scenarios 9.1 to 9.4 also require comparison of base operating scenarios 6.1 with 7.1, 6.2 with 7.2, 6.3 with 7.3 and 6.4 with 7.4 as shown in table 6-2. For each of these comparisons, the limiting criteria are identified in table 6-2 to determine the conditions when neither SCCE nor a relief well can be deployed. Since the relief well scenario has higher criteria limits for sea ice concentration and significant wave height than SCCE deployment, the criteria for relief well deployment determine the conditions for which neither SCCE nor a relief well can be deployed in scenarios 9.1 to 9.4.

For scenarios 10.1 to 10.4, the same base operating scenario comparisons are required as for scenarios 8.1 to 8.4 above to determine the conditions when SCCE or a relief well (one or the other) can be safely deployed. Since the relief well scenario has higher criteria limits for sea ice concentration and significant wave height than SCCE deployment, the criteria for relief well deployment determine the conditions for which a relief well can be deployed but not SCCE in scenarios 10.1 to 10.4.

6.3.4 SCCE and Relief Well Operations After Deployment

Deployment of SCCE and a relief well are both subject to critical operating limits as discussed above and presented in table 6-2. Critical operations during deployment require reduced sea state and wind speed limits due to the nature of deployment operations which for SCCE deployment include handling of equipment on deck, deploying equipment overboard or through a vessel moonpool, crane operations, hooking up flow lines, and other activities requiring moderate sea states. Likewise for relief well drilling operations, critical deployment activities include anchor handling, mudline cellar drilling and BOP handling that have criteria limits below those of normal routine operations. Once equipment is deployed and operational, ongoing operations such as cap and flow and relief well drilling should be able to continue operations at higher sea state limits as long as they are within the vessel fleet station keeping and other related operating limits. These higher operating sea state and wind speed limits are discussed below in section 7.

6.4 RFQ – Task Approach - Scenarios, based on Period of 2012 to 2016 of Alaska Arctic Data

The following sections list the tasks as described in the RFQ and the operating scenarios within each task. This is also the format in which the results are presented in section 7.

Data within the period from 2012 to 2016 was used when available to develop the scenarios; Chukchi Sea and Beaufort Sea operational experience was also used to frame the different scenarios that can be anticipated on the Alaska Arctic OCS. In some cases, data outside the 2012 to 2016 timeframe was used to provide representative information for use in the analysis. For example, buoy data for wave height and period in the Chukchi Sea covers years 2010, 2011 and 2012 (Francis, 2016). Given that wave height is a critical parameter, this data was also incorporated into the analysis. All sea ice, temperature, and wind speed data collected and analyzed for this report is from the years 2012 to 2016.

The sea ice data is measured and analyzed based on tenths of concentration which is an international standard for reporting sea ice concentration. Sea ice concentration is a critical operating parameter from open water conditions to potential response operations in managed ice coverage. It also defines the beginning and end of the open water season and thus determines the duration possible for each scenario presented below. Deployment criteria for sea ice concentration (see table 6-2 above) were set based on historical sea ice operating conditions in the Chukchi Sea and Beaufort Sea.

6.4.1 Task 6: When, and for what duration, metocean conditions over the past 5-years, would have supported safe deployment of SCCE alone in response to a loss-of-well situation in Arctic conditions

6.4.1.1 Task 6, Scenario 6.1: Open Water SCCE Deployment in the Chukchi Sea

Scenario 6.1 for the Chukchi Sea covers the deployment of SCCE when operations are being conducted in open water. This scenario assumes that two ice management vessels would be part of the project fleet to provide any ice management or escort support in the event the need for such support materialized.

6.4.1.2 Task 6, Scenario 6.2: SCCE Deployment with Sea Ice Operating Capability in the Chukchi Sea

Scenario 6.2 for the Chukchi Sea covers deployment of SCCE with the capability for conducting operations in sea ice. This situation could occur later in the operating season as sea ice moves southward in the Chukchi Sea or during the early part of the spring/summer if SCCE were to be deployed during the season following a blowout. Scenario 6.2 assumes a minimum of four Polar class ice management vessels to allow operations to be conducted in sea ice from 0 to 7 tenths concentration.

6.4.1.3 Task 6, Scenario 6.3: Open Water SCCE Deployment in the Beaufort Sea

Scenario 6.3 for the Beaufort Sea covers SCCE deployment in open water. This scenario has similar assumptions to scenario 6.1 above.

6.4.1.4 Task 6, Scenario 6.4: SCCE Deployment with Sea Ice Operating Capability in the Beaufort Sea

Scenario 6.4 for the Beaufort Sea covers SCCE deployment with the capability for conducting operations in sea ice. This assumes a minimum of four Polar class ice management vessels would be available to allow operations to be conducted in sea ice from 0 to 7 tenths concentration.

6.4.2 Task 7: When, and for what duration, metocean conditions over the past 5-years, would have supported safe deployment of a relief well alone in response to a loss-of-well situation in Arctic conditions

6.4.2.1 Task 7, Scenario 7.1: Open Water Relief Well Deployment in the Chukchi Sea

Scenario 7.1 represents the situation where a relief well is drilled following a blowout in open water conditions. This scenario would be supported by the same support vessel fleet as used for drilling the incident well.

6.4.2.2 Task 7, Scenario 7.2: Relief Well Deployment with Sea Ice Operating Capability in the Chukchi Sea

Scenario 7.2 covers relief well drilling operations with an ice class MODU capable of operating in sea in ice conditions from 0 to 8 tenths concentration in the Chukchi Sea. These conditions appear in the fall and early winter across the Chukchi Sea planning area and could also be encountered during the spring of the following season. A minimum of four Polar class ice management vessels are assumed for this scenario. It is important to note that there are currently no ice class MODUs available that can operate in water depths shallower than 984 feet (300 meters) or 328 feet (100 meters) with turret mooring modification as shown above in section 2.1.1.4. This scenario represents what can be done in ice conditions for relief well drilling with a MODU that is properly equipped and has ice classification for drilling in ice laden waters.

6.4.2.3 Task 7, Scenario 7.3: Open Water Relief Well Deployment in the Beaufort Sea

Scenario 7.3 represents the situation where a relief well is drilled following a blowout in open water conditions. This scenario would be supported by the same support vessel fleet as used for drilling the incident well.

6.4.2.4 Task 7, Scenario 7.4: Relief Well Deployment with Sea Ice Operating Capability in the Beaufort Sea

Scenario 7.4 covers relief well drilling operations with an ice class MODU in ice conditions from 0 to 8 tenths concentration for the Beaufort Sea. A minimum of four Polar class ice management vessels are assumed for this scenario. As stated above for scenario 7.2, there are no MODUs currently available that can conduct this activity in water depths shallower than 984 feet (300 meters).

6.4.3 Task 8: When, and for what duration, metocean conditions over the past 5-years, would have supported safe deployment of either SCCE or a relief well alone in response to a loss-of-well situation in Arctic conditions

6.4.3.1 Task 8, Scenario 8.1: Open Water Deployment of SCCE or Relief Well in the Chukchi Sea

Scenario 8.1 represents the situation where both SCCE and a relief well are deployable in the Chukchi Sea open water season. For this scenario SCCE deployment has lower sea state tolerance (see table 6-2) than the relief well and therefore, the SCCE deployment scenario is the lower deployment probability of the two.

6.4.3.2 Task 8, Scenario 8.2: SCCE or Relief Well Deployment with Sea Ice Operating Capability in the Chukchi Sea

Scenario 8.2 covers Chukchi Sea operations where a relief well or SCCE is deployed with sea ice operating capability. SCCE deployment has the lower deployment probability for this scenario with lower sea state tolerance and 0 to 7 tenths ice concentration limit versus 0 to 8 tenths for relief well drilling (see table 6-2).

6.4.3.3 Task 8, Scenario 8.3: Open Water Deployment of SCCE or Relief Well in the Beaufort Sea

Scenario 8.3 represents the situation where both SCCE and a relief well are deployable in the Beaufort Sea open water season. For this scenario, SCCE deployment has lower sea state tolerance (see table 6-2) than the relief well and therefore, the SCCE deployment scenario has the lower deployment probability of the two.

6.4.3.4 Task 8, Scenario 8.4: SCCE or Relief Well Deployment with Sea Ice Operating Capability in the Beaufort Sea

Scenario 8.4 covers Beaufort Sea operations where SCCE and relief well deployment are conducted with sea ice operating capability. SCCE deployment has the lower deployment probability for this scenario due to lower sea state tolerance and 0 to 7 tenths sea ice concentration limit versus 0 to 8 tenths for relief well drilling (see table 6-2).

6.4.4 Task 9: When, and for what duration, metocean conditions over the past 5-years, would have supported safe deployment of neither SCCE nor a relief well alone in response to a loss-of-well situation in Arctic conditions

6.4.4.1 Task 9, Scenario 9.1: Neither Open Water SCCE nor Relief Well are Deployable in the Chukchi Sea

For Scenario 9.1, both SCCE and a relief well are unable to be deployed in open water in the Chukchi Sea. Because the relief well has higher sea state tolerance (see table 6-2) than SCCE deployment, the relief well deployment criteria are the limiting factors for this scenario, above which neither activity can be deployed.

6.4.4.2 Task 9, Scenario 9.2: Neither SCCE nor Relief Well are Deployable with Sea Ice Operating Capability in the Chukchi Sea

Scenario 9.2 represents the situation where neither SCCE nor relief well deployment are conducted with sea ice operating capability in the Chukchi Sea. The relief well operation has greater sea state limits of 10 foot (3 meter) significant wave height for open water and higher ice concentration tolerance at 0 to 8 tenths (see table 6-2) and these are the limiting criteria for this scenario, above which neither activity can be deployed.

6.4.4.3 Task 9, Scenario 9.3: Neither Open Water SCCE nor Relief Well are Deployable in the Beaufort Sea

For scenario 9.3, both SCCE and a relief well are unable to be deployed in open water in the Beaufort Sea. Because the relief well has higher sea state tolerance (see table 6-2) than SCCE deployment, the relief well deployment criteria are the limiting factors for this scenario, above which neither activity can be deployed.

6.4.4.4 Task 9, Scenario 9.4: Neither SCCE nor Relief Well are Deployable with Sea Ice Operating Capability in the Beaufort Sea

Scenario 9.4 covers the situation where neither a relief well nor SCCE can be deployed with sea ice operating capability in the Beaufort Sea. The relief well MODU has higher ice concentration and sea state tolerance (see table 6-2) than SCCE deployment and therefore the relief well has a higher deployment probability, above which neither method can be deployed.

6.4.5 Task 10: When, and for what duration, metocean conditions over the past 5-years, would have supported safe deployment of one method of response to a loss-of-well situation in Arctic conditions, but would have precluded the other method.

6.4.5.1 Task 10, Scenario 10.1: Open Water Relief Well Deployable but not SCCE in the Chukchi Sea

Scenario 10.1 covers the situation in the Chukchi Sea where a relief well is deployable in open water but SCCE is unable to be deployed. Because the relief well has higher sea state limits than SCCE (see table 6-2), the relief well deployment probability will be higher for this scenario.

6.4.5.2 Task 10, Scenario 10.2: Relief Well Deployable but not SCCE with Sea Ice Operating Capability in the Chukchi Sea

For this scenario in the Chukchi Sea, the relief well MODU has higher sea state and ice concentration operating capability (see table 6-2). Therefore, the relief well deployment probability will be greater than that of SCCE.

6.4.5.3 Task 10, Scenario 10.3: Open Water Relief Well Deployable but not SCCE in the Beaufort Sea

Scenario 10.3 covers the situation in the Beaufort Sea where a relief well is deployable in open water but SCCE is unable to be deployed. The relief well MODU, with its better sea state tolerance (see table 6-2), has a higher deployment probability for this scenario.

6.4.5.4 Task 10, Scenario 10.4: Relief Well Deployable but not SCCE with Sea Ice Operating Capability in the Beaufort Sea

Similar to scenario 10.2 above, scenario 10.4 covers the situation in the Beaufort Sea where the relief well MODU has higher sea state and ice concentration operating capability (see table 6-2). Therefore, the relief well deployment probability will be greater than that of SCCE for this scenario.

7.0 Deployment Analysis Results (All Scenarios)

The results from the analysis of the key criteria affecting safe SCCE and relief well drilling rig deployment are presented below. For the purposes of this analysis, SCCE refers to capping stacks, cap and flow systems, containment domes, and the ancillary equipment and vessels necessary to deploy and operate the equipment. SIDs are an additional and important form of SCCE but as a pre-installed technology there is no need to conduct a deployment analysis for SIDs. Also, for the purposes of this analysis, deployment of relief well drilling rigs refers to drilling vessels such as a jackup or semisubmersible MODU (open water scenarios 7.1, 7.3, 8.1, 8.3, 9.1, 9.3 and 10.1, 10.3) and ice class MODUs such as the Stena IceMAX or other to-be-built MODUs capable of working in the typically shallow waters of the Chukchi Sea and Beaufort Sea historical exploration areas (sea ice scenarios 7.2, 7.4, 8.2, 8.4, 9.2, 9.4, 10.2, and 10.4).

These analyses address criteria that may affect deployment including sea ice coverage, wave height, wave period, wind speed, temperature and bathymetry. Results are presented in sections that address each RFQ task, within each task there are four separate analyses for the four base operating scenarios. The base operating scenarios are 6.1 through 6.4 and 7.1 through 7.4. The remaining scenarios in tasks 8, 9 and 10 are calculated from the results of the base operating scenarios.

The results show, on a 10-day basis, for each OPD, the percent probability of safe deployment of SCCE or a relief well within the task descriptions provided by BSEE. These data are presented in separate tables for each task/operating scenario.

The above referenced analysis for safe deployment does not address limits to equipment based on water-depth; bathymetric maps are presented separately to graphically depict where shallow-water bathymetric conditions may be a significant impediment to the deployment of a relief well drilling rig due to a lack of drilling vessels that can operate below specified water depths. SCCE deployment is also affected by shallow water conditions which may be susceptible to gas boil hazards at the sea surface and require alternative offset installation equipment for SCCE deployment. Isobaths for additional key water-depths are also depicted to include consideration of water depth limitations on SCCE deployment operations.

Presentation of the results includes results for analysis of sea ice concentration, sea state, wind speed and temperature against the deployment criteria specified in section 6.3 above followed by analysis results for each scenario in similar order to section 6.4 above.

7.1 Sea State and Wind Speed Results

7.1.1 Wind Speed Results

For the months of June to December in the years of 2012 to 2016, the total number of daily wind speed observations for the Chukchi Sea and Beaufort Sea coastal stations are presented in table 7-1. Table 7-2 presents the probability for wind speeds equal to or exceeding the 30 knot wind speed deployment criterion set in section 6.3 above.

Table 7-1. Total number of wind speed observations, 2012 to 2016.

Station	June	July	August	September	October	November	December	Total
Barter Island	1,143	1,137	1,445	1,870	2,006	1,566	1,763	10,930
Prudhoe Bay	3,591	3,648	3,191	3,311	3,666	3,397	3,669	24,473
Barrow	4,459	4,540	4,486	4,476	4,578	4,410	4,441	31,390
Wainwright	6,183	6,831	6,895	7,059	6,945	6,845	6,510	47,268
Point Lay	3,604	3,489	3,646	3,620	3,634	3,597	3,499	25,089
Point Hope	2,516	3,003	2,930	3,150	2,625	2,837	3,263	20,324
Total	21,496	22,648	22,593	23,486	23,454	22,652	23,145	159,474

Table 7-2. Percent probability of wind speed above 30 knots (15.5 meters/s), 2012 to 2016.

Station	June	July	August	September	October	November	December	Average
Barter Island	1.3	2.3	2.6	8.8	14.2	8.4	5.8	6.2
Prudhoe Bay	3.0	3.2	6.0	10.3	9.9	6.7	4.3	6.2
Barrow	0.1	0.0	0.8	0.7	1.3	2.5	2.1	1.1
Wainwright	0.0	0.2	0.4	0.3	0.6	2.4	3.0	1.0
Point Lay	0.5	0.8	1.6	0.7	1.5	3.7	4.1	1.8
Point Hope	2.2	2.1	4.4	8.1	13.3	11.2	20.9	8.9
Average	1.2	1.4	2.6	4.8	6.8	5.8	6.7	4.2

The probability that wind speed will exceed 30 knots (15.5 meters/s) is relatively low throughout the Chukchi Sea and Beaufort Sea areas. Wind speeds of this magnitude are considered moderate gale to near gale winds and have the ability to generate wind driven waves in excess of 13 feet (4 meters). The probability for wind speeds in excess of 30 knots generally changes smoothly within a seasonal cycle with a minimum monthly average of 1.2 percent probability for wind speeds greater than 30 knots in June and then gradually increases to averages of 6.8, 5.8 and 6.7 percent probability in October, November and December, respectively. It should be noted that Point Hope in the southern extent of the Chukchi Sea planning area has the highest wind speeds on an average basis compared to all other data source locations.

Winds along the Alaska Arctic coast are typically stronger than offshore winds; this is due to a difference in heating and air pressure over land that results in a higher pressure gradient along the coastline with higher wind speeds (Appel, 2018). Thus, it can be inferred that the probability of offshore wind speeds greater than 30 knots (15.5

meters/s) may be slightly less than what is shown in table 7-2; therefore, the data in table 7-2 can be considered a conservative estimate for the probability of offshore winds exceeding 30 knots.

A similar wind speed data analysis was done for wind speeds over 40 knots (20.6 meters/s). Wind speeds of this magnitude are considered gale force winds and have the ability to generate wind driven waves in excess of 20 feet (6 meters). Table 7-3 presents these results.

Table 7-3. Percent probability of wind speed above 40 knots (20.6 meters/s), 2012-2016.

Station	June	July	August	September	October	November	December	Average
Barter Island	0.2	0.0	0.0	0.3	2.0	2.3	0.9	0.8
Prudhoe Bay	0.9	0.1	0.4	2.0	1.9	1.4	1.1	1.1
Barrow	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Wainwright	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Point Lay	0.0	0.0	0.1	0.3	0.0	0.1	1.1	0.2
Point Hope	0.0	0.0	0.5	0.4	1.7	1.9	5.5	1.4
Average	0.2	0.0	0.2	0.5	0.9	1.0	1.5	0.6

The average probability that wind speed will exceed 40 knots (20.6 meters/s) is less than 1% (99th percentile) from June through December for the entire Chukchi Sea and Beaufort Sea areas. During the primary operating season of August through October, Barter Island (October) and Prudhoe Bay (September, October) in the eastern Alaska Beaufort Sea have percent probabilities above 1% (98th percentile) for wind speed greater than 40 knots. Likewise, Point Hope in the far south of the Chukchi Sea planning area has 40 knot wind speeds nearly 2% of the time (98th percentile) in October.

7.1.2 Wave Height and Wave Period Results

7.1.2.1 Chukchi Sea Wave Height and Wave Period Results

The sea state results obtained from buoy data, hindcasting and altimetry measurements for the Chukchi Sea planning area wave characteristics are summarized in tables 7-4 and 7-5. Data utilized in the analysis for Chukchi Sea wave heights is from buoy data that was gathered by Shell during the period of 2010 to 2012 and from remote sensing studies done by Thomson and Fan and Liu. Buoy data available for wave studies is very limited and it was determined that utilization of the 2010 to 2012 data set in the BSEE TAP 717 paper (Francis, 2016) was necessary to provide a multi-year estimate of the seasonal wave conditions in the Chukchi Sea.

Table 7-4. Chukchi Sea significant wave height summary data and sources.

	2012 Buoy Data, 3 Buoys in Colbert, Posey and Hanna Shoal OPDs			BSEE TAP 717 Paper Buoy Data 2010-2012 (Francis, 2016)			Remote Sensing Data							
							(Liu, 2016)						(Thomson & Fan, 2016)	
	Aug	Sep	Oct	Aug	Sep	Oct	2010	2011	2012	2013	2014	2015	2012	2014
Deployment Criteria	Probability Above Critera													
≤ 6.6 feet (2 m) SCCE	4%	24%	13%	13%	23%	13%							22%	20%
≤ 9.8 feet (3 m) relief well	0%	7%	4%	1%	5%	3%							3%	3%
	Percentile Distribution													
90th percentile		9.2 feet (2.8 m)	7.2 feet (2.2 m)	7.2 feet (2.2 m)	8.2 feet (2.5 m)	7.2 feet (2.2 m)	8.5 feet (2.6 m)	6.9 feet (2.1 m)	9.2 feet (2.8 m)	7.5 feet (2.3 m)	8.2 feet (2.5 m)	8.5 feet (2.6 m)	8.2 feet (2.5 m)	8.2 feet (2.5 m)
95th percentile		10.5 feet (3.2 m)	9.2 feet (2.8 m)	7.9 feet (2.4 m)	9.8 feet (3 m)	9.2 feet (2.8 m)							9.2 feet (2.8 m)	9.2 feet (2.8 m)
99th percentile		12.5 feet (3.8 m)	10.8 feet (3.3 m)	9.8 feet (3.0)	12.5 feet (3.8 m)	11.2 feet (3.4 m)	11.5 feet (3.5 m)	8.9 feet (2.7 m)	11.2 feet (3.4 m)	9.5 feet (2.9 m)	9.5 feet (2.9 m)	11.5 feet (3.5 m)	11.8 feet (3.6 m)	11.8 feet (3.6 m)

Table 7-5. Chukchi Sea peak wave period summary data and sources.

	2012 Buoy Data, 3 Buoys in Colbert, Posey and Hanna Shoal OPDs			Buoy Data 2010-2012 (Francis, 2016)			Remote Sensing Data (Thomson & Fan, 2016)	
	Aug	Sep	Oct	Aug	Sep	Oct	2012	2014
Deployment Criteria	**Probability Above Criteria**							
≤ 10 seconds (s)	0%	2%	0%	0%	2%	0	1%	0.2%
	Percentile Distribution							
90th percentile	6.6 s	9.3 s	7.9 s				8.5 s	8.2 s
95th percentile	7.1 s	9.6 s	8.2 s	7.7 s	9.5 s	8.3 s	9.3 s	8.9 s
99th percentile	8.3 s	10.2 s	8.6 s	8.5 s	11.1 s	9.1 s	10.0 s	9.7 s

It should be noted that the combined 2012 data from the three buoys presented in table 7-4 are a subset of the data used in the analysis results of the TAP 717 paper; the combined data from these three buoys are presented separately for comparison with the 2010 to 2012 wave height and wave period data as they are within the 2012 to 2016 BSEE specified analysis timeframe. The 2012 buoy data represent a year that had higher sea states than average due to lower sea ice coverage and large fetch distances in the Chukchi Sea.

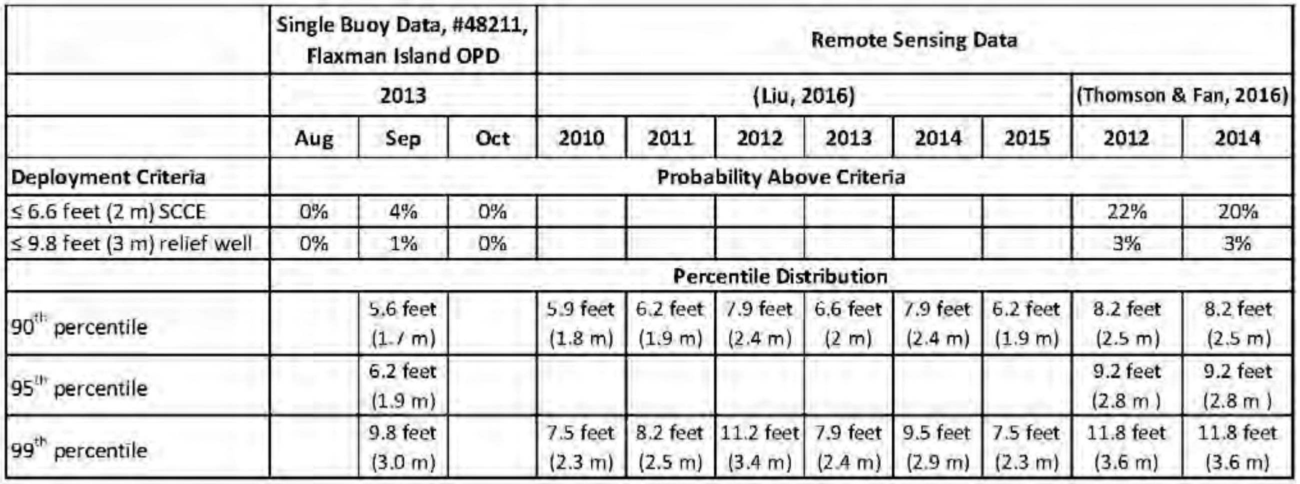
The significant wave height results shown in table 7-4 above for the Chukchi Sea show that September typically has the highest significant wave heights with approximately 23% of the significant wave heights exceeding the 6.6 foot (2 meter) criterion for SCCE deployment and 5% of the significant wave heights exceeding the 9.8 foot (3 meter) criterion for relief well drilling based on the 2010 to 2012 TAP 717 data. The remote sensing data from Liu and Thomson and Fan also generally agree with the percentile distributions of the buoy data; this is an important result when trying to estimate wave heights in areas that have limited buoy data. The Liu data in table 7-4 is specific to the Chukchi Sea while the Thomson and Fan data is composite data for both the Chukchi Sea and Beaufort Sea during the years 2012 and 2014.

The Chukchi Sea dominant wave period data presented in table 7-5 above is gathered from the aforementioned buoy data and Thomson and Fan's remote sensing study. The results show that wave periods rarely exceed 10 seconds and that wave periods below this level are unlikely to significantly impact offshore operations. Wave periods exceeding 10 seconds in the Chukchi Sea are associated with high wave heights, however, waves will typically reach heights that negatively impact SCCE or relief well deployment operations before wave periods exceed 10 seconds.

7.1.2.2 Beaufort Sea Wave Height and Wave Period Results

Table 7-6 presents the significant wave height data for the Beaufort Sea. One buoy data source for the Beaufort Sea was located for the year 2013 from the National Data Buoy Center (NDBC). Other private data sets dating back to 2008 and 2009 were not analyzed. With the limited data available, the remote sensing data can be used to supplement the buoy data to better estimate the significant wave height regime in the Beaufort Sea. The buoy data and remote sensing data from Liu indicate that 90th percentile wave heights in the Beaufort Sea are approximately 20 percent lower on average than in the Chukchi Sea. These typically lower wave heights are the result of less open water and reduced fetch distances in the Beaufort Sea versus the Chukchi Sea.

Table 7-6. Beaufort Sea significant wave height summary data and sources.



	Single Buoy Data, #48211, Flaxman Island OPD			Remote Sensing Data							
	2013			(Liu, 2016)						(Thomson & Fan, 2016)	
	Aug	Sep	Oct	2010	2011	2012	2013	2014	2015	2012	2014
Deployment Criteria	Probability Above Criteria										
≤ 6.6 feet (2 m) SCCE	0%	4%	0%							22%	20%
≤ 9.8 feet (3 m) relief well	0%	1%	0%							3%	3%
	Percentile Distribution										
90th percentile		5.6 feet (1.7 m)		5.9 feet (1.8 m)	6.2 feet (1.9 m)	7.9 feet (2.4 m)	6.6 feet (2 m)	7.9 feet (2.4 m)	6.2 feet (1.9 m)	8.2 feet (2.5 m)	8.2 feet (2.5 m)
95th percentile		6.2 feet (1.9 m)								9.2 feet (2.8 m)	9.2 feet (2.8 m)
99th percentile		9.8 feet (3.0 m)		7.5 feet (2.3 m)	8.2 feet (2.5 m)	11.2 feet (3.4 m)	7.9 feet (2.4 m)	9.5 feet (2.9 m)	7.5 feet (2.3 m)	11.8 feet (3.6 m)	11.8 feet (3.6 m)

Beaufort Sea dominant wave period data is presented in table 7-7. As with the wave height data, the data set is very limited. The remote sensing data from Thomson and Fan does not correlate well either as this data set is a composite for both the Chukchi Sea and Beaufort Sea and tends to overestimate wave characteristics in the Beaufort Sea. Even with the limited data, it is evident that wave periods in the Beaufort Sea are unlikely to impact SCCE or relief well deployment operations.

Table 7-7. Beaufort Sea peak wave period summary data and sources.

	2013 Buoy Data #48211, Single Bouy in Flaxman Island OPD			**Remote Sensing Data (Thomson & Fan, 2016)**	
	Aug	**Sep**	**Oct**	**2012**	**2014**
Deployment Criteria	**Percent Above Criteria**				
≤10 seconds	0%	0%	0%	1%	0.2%
	Percentile Distribution				
90th percentile	6.7 s	7.0 s	6.2 s	8.5 s	8.2 s
95th percentile	7.1 s	7.5 s	6.3 s	9.3 s	8.9 s
99th percentile	8.5 s	8.4 s	6.4 s	10.0 s	9.7 s

7.2 Air Temperature Results

The results of the air-temperature analysis for the five-year period 2012 to 2016 for the months of October through December are presented in table 7-8 and table 7-9. As can be expected in late fall and winter, the average probability of daily minimum and maximum temperatures dipping below -4 F and -22 F (-20 C and -30 C) systematically increases through the seasonal cycle. It should be mentioned that, while not represented in the five-year-average probability data shown in tables 7-8 and 7-9, in some years the frequency of low temperatures in November exceeds the frequency in December.

For the Chukchi Sea and Beaufort Sea open water relief well drilling rig scenarios (7.1, 8.1, 9.1 and 10.1), the data in table 7-8 can be considered for potential drilling vessel operating limitations due to low temperatures. The average probability of minimum daily temperatures reaching -4 F (-20 C) ranges from zero percent in October to over 70 percent by mid to late December. The average probability of maximum daily temperatures remaining at or below -4 F (-20 C) during this time frame ranges from zero percent in October and early November to 27 percent by mid to late December indicating that on most days the temperature rises above -4 F (-20 C) for part of the day.

Table 7-8. Percent probability of air temperature below -4 F (-20 C), 2012-2016.

	Minimum Daily									Maximum Daily								
	October			November			December			October			November			December		
Stations	1 - 10	11 - 20	21 - 31	1 - 10	11-20	21-30	1 - 10	11 - 20	21 - 31	1 - 10	11 - 20	21 - 31	1 - 10	11 - 20	21 - 30	1 - 10	11 - 20	21 - 31
Barter Island	0	0	2	13	28	40	78	82	89	0	0	0	0	0	2	42	36	36
Prudhoe Bay	0	2	4	34	40	68	80	88	83	0	0	0	2	6	8	58	56	41
Barrow	0	0	2	18	28	62	74	86	85	0	0	0	0	0	4	8	18	13
Wainwright	0	0	0	16	31	66	66	79	79	0	0	0	0	9	12	32	35	26
Point Lay	0	0	0	13	34	69	68	90	77	0	0	0	0	12	15	24	48	36
Point Hope	0	0	0	0	4	2	26	42	42	0	0	0	0	0	0	0	8	15
Average	0	0	1	16	28	51	65	78	76	0	0	0	0	5	7	27	34	28
	Note: The -4 F (-20 C) temperature criteria applies to Chukchi Sea and Beaufort Sea open water scenarios.																	

Table 7-9. Percent probability of air temperature below -22 F (-30 C), 2012-2016.

	Minimum Daily									Maximum Daily								
	October			November			December			October			November			December		
Stations	1 - 10	11 - 20	21 - 31	1 - 10	11-20	21-30	1 - 10	11 - 20	21 - 31	1 - 10	11 - 20	21 - 31	1 - 10	11 - 20	21 - 30	1 - 10	11 - 20	21 - 31
Barter Island	0	0	0	0	0	2	28	44	13	0	0	0	0	0	0	0	8	0
Prudhoe Bay	0	0	2	2	12	12	42	40	36	0	0	0	0	2	0	12	14	4
Barrow	0	0	0	0	4	2	8	28	15	0	0	0	0	0	0	0	2	0
Wainwright	0	0	0	0	9	0	15	31	15	0	0	0	0	0	0	0	0	0
Point Lay	0	0	0	0	8	4	15	32	25	0	0	0	0	0	0	2	0	2
Point Hope	0	0	0	0	0	0	0	2	5	0	0	0	0	0	0	0	0	0
Average	0	0	0	0	6	3	18	30	18	0	0	0	0	0	0	2	4	1
	Note: The -22 F (-30 C) temperature criteria applies to Chukchi Sea and Beaufort sea scenarios with sea ice operating capabilty.																	

For scenarios with sea ice operating capability, ice class MODUs such as the Stena IceMAX and the ice management support-vessel fleet have -22 F (-30 C) operating limitations. This temperature limit applies to all scenarios that have sea ice operating capability. The analysis of temperatures in table 7-9 shows that probabilities for minimum and maximum daily temperatures dipping to -22 F (-30 C) are very low across all stations in October and November. By December, the eastern Beaufort Sea stations have the highest individual probabilities for days with minimum temperature of -22 F (-30 C) or less. The average probabilities for the maximum daily temperature to remain at -22 F (-30 C) or less is low across all months with Prudhoe Bay having 12 to 14 percent probability of such an occurrence during early to mid-December. However, the Prudhoe Bay results may overstate these cold temperature probabilities due to the inland location of the weather station.

It is necessary to emphasize that offshore air temperatures, over regions of open water or thin newly-formed ice, in the period of autumn cooling, systematically remain above the temperature at the coast line along the Chukchi Sea and Beaufort Sea planning areas (Appel). Therefore, the probabilities of low temperatures in tables 7-8 and 7-9 represent maximum possible probabilities and an overestimation of the frequency of critically low temperatures potentially influencing offshore relief well and SCCE deployment operations.

When the probabilities for critically low temperatures shown in tables 7-8 and 7-9 are compared with the probability results for sea ice concentration shown in appendix B, it becomes apparent that for all scenarios the probability of safe deployment operations is significantly reduced by ice conditions prior to the onset of critically low temperatures. Thus, notwithstanding the potential for a medium-to-high probability of critically low air temperatures of -4 F (-20 C) in November for open water scenarios, and December for all nearly all scenarios, the influence of low temperatures on offshore activities should have minimal effect on the deployment of SCCE and relief wells. Sea ice conditions, driven by temperatures above these limits, are the critical limiting criteria when compared with temperature for safe deployment of SCCE and relief wells in the Chukchi Sea and Beaufort Sea planning areas.

7.3 Metocean Efficiency Reduction Factor

The reduction in deployment capability that is caused by metocean factors such as wind speed, wave height and period, and temperature can be defined as an estimated metocean efficiency reduction factor (MERF). The factor is estimated to apply the limiting criterion that is most likely to reduce efficiency while not applying factors that have much lower probability or are typically an accompanying factor to the critical criterion such as high wind speed driving wave generation to heights that exceed the deployment criteria. For example, crane operations may be able to be conducted safely at 30 knots (15.5 meters/s) wind speed; however, if these wind speeds are sustained for a sufficient period of time they are capable of generating significant wave heights in excess of 13 feet (4 meters) which will exceed the significant wave height critical deployment criterion for both relief well drilling and SCCE deployment.

Table 7-10 summarizes the probability that deployment efficiency of SCCE and relief wells will be reduced by limiting deployment criteria due to open water metocean factors including wind speed, wave height and period, and temperature in the Chukchi Sea. The estimated MERF for SCCE and relief well deployment are also included in table 7-10.

For the Chukchi Sea, the dominant critical deployment factor is significant wave height for open water and therefore the percent probability for this criterion is applied to the MERFs for both SCCE and relief well deployment. The probability for the significant wave height is taken from table 7-4 above. At the end of the open water season, wave heights are not the major issue but instead it will become cold temperatures and the oncoming ice concentration that ends the open water season.

To apply the MERF to the overall deployment analysis, it is necessary to combine this factor with the ice analysis results for open water areas for each scenario contained in appendix B. The MERF does not apply to areas with sea ice concentration greater than zero as wave action is damped by ice coverage and the resultant limiting criterion is the sea ice concentration itself. The resulting deployment probabilities are summarized below in section 7.4.

The probability for open water deployment efficiency reduction due to critical deployment metocean parameters in the Beaufort Sea is presented in table 7-11. The estimated MERFs for SCCE and relief well deployment are also included in table 7-11.

For the Beaufort Sea, the significant wave height contribution to the MERF had to be estimated based on the relative wave heights between the Chukchi Sea and Beaufort Sea in addition to a statistical analysis to estimate the relationship between the 90th and 99th percentiles for significant wave heights above 6.6 feet (2 meters) and 9.8 feet (3 meters). The relationships were approximated by linear functions characterized by correlation coefficients above 97%. These statistical relationships were used to estimate the probability of significant wave height above 6.6 feet (2 meters) and 9.8 feet (3 meters) using known 90th and 99th percentiles from the Chukchi Sea from which the significant wave height factors in table 7-11 could be estimated.

Table 7-10. Chukchi Sea SCCE and relief well deployment MERF summary.

	Probability Criteria Exceeded						
Deployment Criteria	**June**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
≤ 6.6 feet (2 meters) significant wave height (Hs) for SCCE	0%	0%	13%	23%	13%	7%	0%
≤ 9.8 feet (3 meters) significant wave height (Hs) for relief well	0%	0%	1%	5%	3%	2%	0%
Wave period ≤ 10 seconds	0%	0%	0%	2%	0%	0%	0%
Wind speed ≤ 30 knots (15.5 meters/second)	1%	1%	2%	2%	4%	5%	8%
Temperature ≥ -4 F (-20 C)	0%	0%	0%	0%	0%	16%	45%
Estimated SCCE MERF	1%	1%	13%	23%	13%	16%	45%
Estimated relief well MERF	1%	1%	1%	5%	4%	16%	45%

Table 7-11. Beaufort Sea SCCE and relief well deployment MERF summary.

	Probability Criteria Exceeded						
Deployment Criteria	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
≤ 6.6 feet (2 meter) significant wave height (Hs) for SCCE	0%	0%	5%	10%	5%	3%	0%
≤ 9.8 feet (3 meters) significant wave height (Hs) for relief well	0%	0%	0%	2%	0.3%	0%	0%
Wave period ≤ 10 seconds	0%	0%	0%	1%	0%	0%	0%
Wind speed ≤ 30 knots (15.5 meters/second)	1%	2%	3%	7%	8%	6%	4%
Temperature ≥ -4 F (-20 C)	0%	0%	0%	0%	0%	20%	59%
Estimated SCCE MERF	1%	2%	5%	10%	8%	20%	59%
Estimated relief well MERF	1%	2%	3%	7%	8%	20%	59%

7.4 Task 6 Results: When, and for what duration, metocean conditions over the past 5-years, would have supported safe deployment of SCCE alone in response to a loss-of-well situation in Arctic conditions.

The results for all scenarios presented in the following sections 7.4 through 7.8, are derived by utilizing the ice concentration data in appendix B and combining this data with the applicable MERF determined above in section 7.3. The sea ice concentration data is averaged for each OPD in the following deployment tables for each 10 day period of sea ice data. Then, the MERF is applied to all open water scenarios by multiplying the averaged probability for open water by the MERF. This correction factor for the open water portion of the OPD is then subtracted from the average ice concentration component of the deployment probability to determine the total deployment probability. This results in an estimated deployment probability for a given OPD in time. For example, if an OPD has 100 percent probability of open water deployment, and a MERF of 10 percent, the resulting deployment probability with the MERF applied is 90 percent.

7.4.1 Scenario 6.1 Results

Scenario 6.1 covers the situation where SCCE is deployed in the Chukchi Sea in response to a blowout well during the open water season typically from late July or early-August and into October, depending on the location. Table 7-12 shows the percent probability of safe deployment for scenario 6.1 in the Chukchi Sea planning area over the period of June through December for the years 2012 to 2016.

The results in table 7-12 show that safe SCCE deployment conditions for scenario 6.1 are generally suitable (greater than 75 percent probability) in the southern extent of the planning area OPDs during the period of July 15 through the month of October. In the historically common exploration areas above the 71st parallel of the Posey, Hanna Shoal and Karo OPDs, safe open water SCCE deployment can be anticipated at 75 percent or greater probability from late-September through October. Moving north above the 72nd parallel, the percent probability for safe deployment of SCCE decreases rapidly as would be expected with closer proximity to the Arctic ice pack and colder temperatures.

Table 7-12. Scenario 6.1: Percent probability of safe SCCE deployment in open water in the Chukchi Sea, 2012 to 2016.

OPD #	OPD Name	June			July			Aug			September			October			November			December		
		1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
NS02-04	UNNAMED	0	0	0	0	0	0	0	0	0	23	39	39	70	35	17	0	0	0	0	0	0
NS03-03	UNNAMED	0	0	0	0	0	0	0	0	4	23	39	39	65	17	17	0	0	0	0	0	0
NS03-04	UNNAMED	0	0	0	0	0	0	0	0	26	23	35	35	57	17	4	0	0	0	0	0	0
NS04-03	UNNAMED	0	0	0	0	0	0	0	0	22	19	50	42	44	22	17	0	0	0	0	0	0
NS04-04	UNNAMED	0	0	0	0	0	0	0	0	17	15	46	27	35	17	9	0	0	0	0	0	0
74 Degrees North Latitude																						
NS02-06	UNNAMED	0	0	0	0	0	0	0	9	9	23	54	69	61	44	9	0	0	0	0	0	0
NS03-05	UNNAMED	0	0	0	0	0	0	0	4	17	23	50	65	70	52	13	0	0	0	0	0	0
NS03-06	UNNAMED	0	0	0	0	0	0	0	0	26	54	46	58	83	61	26	0	0	0	0	0	0
NS04-05	UNNAMED	0	0	0	0	0	0	0	0	52	46	65	50	87	44	35	0	0	0	0	0	0
NS04-06	UNNAMED	0	0	0	0	0	0	0	0	35	23	62	46	39	35	35	0	0	0	0	0	0
73 Degrees North Latitude																						
NS02-08	UNNAMED	0	0	0	0	0	20	17	26	44	46	46	69	78	70	61	34	0	8	6	6	6
NS03-07	UNNAMED	0	0	0	0	0	15	17	17	39	35	54	69	87	78	52	25	13	8	3	6	0
NS03-08	UNNAMED	0	0	0	0	0	5	13	13	26	39	50	65	87	78	57	0	4	0	0	0	0
NS04-07	UNNAMED	0	0	0	0	0	0	9	9	22	58	58	62	74	78	52	4	0	0	0	0	0
NS04-08	UNNAMED	0	0	0	0	0	0	0	9	78	62	73	62	87	61	39	0	0	0	0	0	0
72 Degrees North Latitude																						
NR02-02	TISON	0	0	0	0	20	30	52	52	78	77	77	77	87	87	87	59	34	50	11	6	11
NR03-01	KARO	0	0	0	5	25	20	44	61	65	62	73	77	87	87	87	55	34	25	6	0	0
NR03-02	POSEY	0	0	0	10	5	5	26	17	39	35	54	77	87	87	87	34	13	0	0	0	0
NR04-01	HANNA SHOAL	0	0	0	0	0	5	13	22	35	62	54	69	87	87	74	13	0	0	0	0	0
NR04-02	BARROW	0	0	0	5	5	5	17	39	74	69	69	73	87	83	61	0	0	0	0	0	0
71 Degrees North Latitude																						
NR02-04	STUDDS	0	0	0	0	40	40	70	87	87	77	77	77	87	87	87	84	59	50	6	0	0
NR03-03	COLBERT	5	10	15	15	54	74	83	87	87	77	77	77	87	87	87	67	50	42	6	0	0
NR-03-04	SOLIVIK ISLAND	0	5	30	25	50	79	78	87	78	77	73	77	87	87	83	59	29	17	3	0	0
NR04-03	WAINWRIGHT	0	0	20	26	40	33	58	58	81	67	72	77	87	81	58	22	11	6	0	0	0
NR04-04	MEADE RIVER	0	0	0	20	20	40	52	70	87	77	77	77	87	87	70	0	0	0	0	0	0
70 Degrees North Latitude																						
NR02-06	CHUKCHI SEA	0	10	50	50	79	79	78	87	87	77	77	77	87	87	87	84	67	50	17	0	0
NR-03-05	POINT LAY WEST	0	15	40	59	99	94	87	87	87	77	77	77	87	87	87	76	46	25	3	0	0
NR-03-06	POINT LAY	30	15	40	50	99	99	87	87	87	77	73	73	83	65	39	17	8	0	0	0	0
69 Degrees North Latitude																						
NR02-08	POINT HOPE WEST	0	40	69	69	99	99	87	87	87	77	77	77	87	87	87	84	59	34	22	0	0
NR03-07	POINT HOPE	0	30	54	64	94	99	87	87	87	77	77	77	87	87	87	55	34	17	0	0	0
NR03-08	DELONG MOUNTAINS	40	20	20	40	79	99	87	87	87	77	77	77	87	87	52	0	0	0	0	0	0

7.4.2 Scenario 6.2 Results

Scenario 6.2 covers the situation where SCCE is deployed in response to a blowout well in the Chukchi Sea with the capability of operating in sea ice conditions. These operations are assumed to be supported by four Polar class ice management vessels. Safe deployment of SCCE for this equipment spread can be conducted in 0 to 7 tenths ice concentration.

Table 7-13 shows the percent probability of safe deployment for scenario 6.2 with varying seasonal sea ice coverage in the Chukchi Sea planning area over the period of June through December for the years 2012 to 2016.

The results in table 7-13 show that safe SCCE deployment ice conditions are suitable (75 percent or greater probability) in scenario 6.2 for up to 6 months in the southwestern extent of the planning area. In the historically active exploration area between the 71st and 72nd parallels, SCCE can be safely deployed from August through October. Safe SCCE deployment decreases as the analysis moves north with no periods of safe deployment exceeding 10 days above the 74th parallel.

Table 7-13. Scenario 6.2, Percent probability of safe SCCE deployment with sea ice operating capability in the Chukchi Sea, 2012-2016.

OPD #	OPD Name	June			July			Aug			September			October			November			December		
		1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
NS02-04	UNNAMED	0	0	0	0	0	10	20	30	20	33	59	49	90	75	37	0	0	0	0	0	0
NS03-03	UNNAMED	0	0	0	0	0	5	5	10	19	33	49	49	85	72	37	0	0	0	0	0	0
NS03-04	UNNAMED	0	0	0	0	0	0	10	5	41	43	45	45	72	37	24	0	0	0	0	0	0
NS04-03	UNNAMED	0	0	0	0	0	0	30	15	37	29	55	47	84	42	37	0	0	0	0	0	0
NS04-04	UNNAMED	0	0	0	0	10	0	15	10	42	35	51	32	60	27	29	0	0	0	0	0	0
74 Degrees North Latitude																						
NS02-06	UNNAMED	0	0	0	0	0	20	10	9	39	43	54	69	81	84	39	10	0	0	0	0	0
NS03-05	UNNAMED	0	0	0	0	0	10	15	29	37	48	55	70	80	82	43	5	0	0	0	0	0
NS03-06	UNNAMED	0	0	0	0	0	0	15	40	51	54	46	63	83	91	51	0	0	0	0	0	0
NS04-05	UNNAMED	0	0	0	0	0	0	15	30	67	56	75	60	87	69	35	0	0	0	0	0	0
NS04-06	UNNAMED	0	0	0	0	0	10	20	35	60	48	72	56	84	45	35	0	0	0	0	0	0
73 Degrees North Latitude																						
NS02-08	UNNAMED	0	0	0	20	20	30	57	76	54	56	56	69	78	90	71	44	50	38	6	6	16
NS03-07	UNNAMED	0	0	0	20	25	30	32	47	59	70	59	79	87	88	77	35	43	23	8	11	10
NS03-08	UNNAMED	0	0	0	20	35	20	23	28	56	74	50	70	87	88	82	25	19	15	0	5	0
NS04-07	UNNAMED	0	0	0	5	0	5	44	59	67	68	58	72	74	78	67	19	0	5	0	0	0
NS04-08	UNNAMED	0	0	0	5	0	0	30	54	78	62	78	62	87	91	49	15	10	0	0	0	0
72 Degrees North Latitude																						
NR02-02	TISON	0	0	0	20	70	70	82	82	88	77	77	77	87	87	87	79	74	50	11	16	11
NR03-01	KARO	0	5	15	35	65	80	79	81	80	82	73	77	87	87	87	75	54	45	16	20	20
NR03-02	POSEY	0	0	15	20	25	70	71	77	84	75	54	77	87	87	87	44	38	25	5	0	0
NR04-01	HANNA SHOAL	5	5	0	15	10	45	73	72	90	82	59	74	87	87	89	33	10	0	0	0	0
NR04-02	BARROW	20	5	5	15	45	45	52	79	89	79	74	73	87	88	86	30	20	10	0	0	0
71 Degrees North Latitude																						
NR02-04	STUDDS	0	0	30	20	80	60	70	87	87	77	77	77	87	87	87	84	69	50	26	20	20
NR03-03	COLBERT	30	35	40	65	84	99	88	87	87	77	77	77	87	87	87	82	70	52	26	20	10
NR-03-04	SOLIVIK ISLAND	30	50	50	55	75	99	88	87	83	77	73	77	87	87	88	79	49	37	23	0	0
NR04-03	WAINWRIGHT	40	53	53	46	80	93	85	91	88	80	72	77	87	88	91	89	38	19	13	0	0
NR04-04	MEADE RIVER	80	40	20	20	100	80	92	90	87	77	77	77	87	87	90	80	40	20	0	0	0
70 Degrees North Latitude																						
NR02-06	CHUKCHI SEA	10	30	80	90	89	89	88	87	87	77	77	77	87	87	87	84	67	70	37	20	20
NR-03-05	POINT LAY WEST	50	65	90	94	99	99	87	87	87	77	77	77	87	87	87	86	76	50	33	0	0
NR-03-06	POINT LAY	65	75	90	90	99	99	87	87	87	77	78	78	88	90	89	62	38	5	0	0	0
69 Degrees North Latitude																						
NR02-08	POINT HOPE WEST	70	100	99	99	99	99	87	87	87	77	77	77	87	87	87	84	69	74	42	0	0
NR03-07	POINT HOPE	75	85	99	99	94	99	87	87	87	77	77	77	87	87	87	90	79	42	20	5	0
NR03-08	DELONG MOUNTAINS	60	80	100	100	79	99	87	87	87	77	77	77	87	87	72	20	20	0	20	0	0

7.4.3 Scenario 6.3 Results

Scenario 6.3 covers the situation where SCCE is deployed in the Beaufort Sea in response to a blowout well during the open water season typically from late-August to mid-October in the historically active exploration areas and depending on the location.

Table 7-14 shows the percent probability of safe deployment for scenario 6.3 in the Beaufort Sea planning area over the period of June through December for the years 2012 to 2016.

The results in table 7-14 show that safe SCCE deployment conditions for scenario 6.3 are generally suitable (greater than 75 percent probability) in the southern extent of the planning area OPDs during the period of late August into early October. Moving north above the 72nd parallel, the Dease Inlet OPD at the western extent of the planning area near the Chukchi Sea has greater than 75 percent probability of safe deployment of SCCE from late August into early- to mid-October. Otherwise, the probability for safe deployment of SCCE decreases rapidly in October and in more northerly OPDs as would be expected with closer proximity to the Arctic ice pack and colder temperatures.

Table 7-14. Scenario 6.3: Percent probability of safe SCCE deployment in open water in the Beaufort Sea, 2012 to 2016.

OPD	OPD Name	June			July			Aug			September			October			November			December		
		1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
NS05-03	UNNAMED	0	0	0	0	0	0	0	0	19	36	32	32	41	23	23	0	0	0	0	0	0
NS05-04	UNNAMED	0	0	0	0	0	0	0	0	19	36	45	54	55	28	18	0	0	0	0	0	0
NS06-03	UNNAMED	0	0	0	0	0	0	0	5	33	45	54	54	55	23	14	0	0	0	0	0	0
74Degrees North Latitude																						
NS05-05	UNNAMED	0	0	0	0	0	0	0	0	33	32	54	54	46	37	37	0	0	0	0	0	0
NS05-06	UNNAMED	0	0	0	0	0	0	0	0	38	41	54	63	64	37	37	0	0	0	0	0	0
NS06-05	UNNAMED	0	0	0	0	0	0	0	24	33	50	59	54	55	37	37	0	0	0	0	0	0
NS06-06	UNNAMED	0	0	0	0	0	5	5	19	29	45	54	54	55	37	32	0	0	0	0	0	0
NS07-05	UNNAMED	0	0	0	0	0	5	5	19	19	41	54	50	46	37	23	0	0	0	0	0	0
NS07-06	UNNAMED	0	0	0	0	0	0	0	29	38	32	54	41	37	23	14	0	0	0	0	0	0
NS08-05	UNNAMED	0	0	0	0	0	0	0	29	38	27	54	36	37	18	9	0	0	0	0	0	0
73 Degrees North Latitude																						
NS05-07	BARROW CANYON	0	0	0	0	0	0	0	19	67	63	77	59	78	60	37	0	0	0	0	0	0
NS05-08	CANADA BASIN WEST	0	0	0	0	0	0	0	14	57	63	72	54	74	37	37	0	0	0	0	0	0
NS06-07	CANADA BASIN	0	0	0	0	0	10	10	38	57	72	72	63	64	37	37	0	0	0	0	0	0
NS06-08	UNNAMED	0	0	0	0	10	20	19	29	57	72	63	63	60	37	37	0	0	0	0	0	0
NS07-07	BEAUFORT TERRACE	0	0	0	0	10	20	19	19	48	50	36	54	46	37	32	0	0	0	0	0	0
NS07-08	UNNAMED	0	0	0	0	0	5	5	10	52	50	54	54	51	28	14	0	0	0	0	0	0
NS08-07	UNNAMED	0	0	0	0	0	0	0	0	38	36	54	36	37	37	18	0	0	0	0	0	0
72 Degrees North Latitude																						
NR05-01	DEASE INLET	0	0	0	0	0	0	14	38	90	86	81	81	92	83	64	4	0	0	0	0	0
NR05-02	HARRISON BAY NORTH	0	0	0	0	0	0	5	38	71	81	86	86	92	69	55	4	0	0	0	0	0
NR06-01	BEECHEY POINT NORTH	5	5	0	0	5	5	10	52	71	81	90	90	83	74	46	8	0	0	0	0	0
NR06-02	FLAXMAN ISLAND N.	10	10	0	0	15	20	29	57	76	72	81	81	64	55	23	16	0	0	0	0	0
NR07-01	UNNAMED	10	5	10	10	20	20	38	48	71	68	68	63	64	46	18	4	0	0	0	0	0
NR07-02	UNNAMED	0	10	15	15	15	15	14	14	67	54	63	63	69	37	23	0	0	0	0	0	0
71 Degrees North Latitude																						
NR05-03	TESHEKPUK	0	0	0	0	0	0	19	57	76	90	90	90	55	37	18	0	0	0	0	0	0
NR05-04	HARRISON BAY	0	0	0	0	0	0	19	57	76	90	81	81	92	64	46	0	0	0	0	0	0
NR06-03	BEECHEY POINT	5	0	0	5	10	0	19	52	76	81	86	81	74	55	46	12	0	0	0	0	0
NR06-04	FLAXMAN ISLAND	15	10	0	25	10	5	19	52	76	86	90	90	87	78	69	12	0	0	0	0	0
NR07-03	BARTER ISLAND	10	25	0	15	20	20	62	71	81	90	86	86	78	87	69	16	0	0	0	0	0
NR07-04	MACKENZIE CANYON N.	0	20	20	29	29	29	57	76	86	90	72	72	74	83	55	16	0	0	0	0	0
70 Degrees North Latitude																						
NR07-05	DEMARCATION POINT	0	0	0	20	39	39	76	76	95	90	90	90	55	55	37	0	0	0	0	0	0
NR07-06	MACKENZIE CANYON	40	40	20	39	98	78	76	95	95	90	90	90	92	92	55	16	0	0	0	0	0

7.4.4 Scenario 6.4 Results

Scenario 6.4 represents SCCE deployment during the period of June through December in the Beaufort Sea with the capability of operating in sea ice conditions. These operations are assumed to be supported by four Polar class ice management vessels. Safe deployment of SCCE for this equipment spread can be conducted in 0 to 7 tenths ice concentration.

Table 7-15 shows the percent probability of safe deployment for scenario 6.4 with varying seasonal sea ice coverage in the Beaufort Sea planning area for the years 2012 to 2016.

The results show that safe SCCE deployment ice conditions (75 percent or greater probability) are suitable for approximately 90 days from early August through October in the historically active exploration area between 70 and 71 degrees north latitude. Between 71 and 72 degrees north latitude, the deployment window decreases by about 10 days on the front and back ends of the season. Above the 73rd parallel, the probability for safe SCCE deployment decreases significantly with no OPDs experiencing any periods with greater than 75 percent deployment probability.

Table 7-15. Scenario 6.4: Percent probability of safe SCCE deployment with sea ice operating capability in the Beaufort Sea, 2012 to 2016.

OPD	OPD Name	June			July			Aug			September			October			November			December		
		1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
NS05-03	UNNAMED	0	0	0	0	0	0	0	0	24	36	42	42	56	33	33	0	0	0	0	0	0
NS05-04	UNNAMED	0	0	0	0	0	0	0	0	29	41	45	54	55	48	33	0	0	0	0	0	0
NS06-03	UNNAMED	0	0	0	0	0	0	0	10	38	45	54	54	55	38	29	0	0	0	0	0	0
74Degrees North Latitude																						
NS05-05	UNNAMED	0	0	0	0	0	0	15	15	43	42	64	64	71	42	37	15	0	0	0	0	0
NS05-06	UNNAMED	0	0	0	0	0	0	5	10	38	71	54	73	69	37	37	10	0	0	0	0	0
NS06-05	UNNAMED	0	0	0	0	0	0	0	34	33	65	64	69	55	37	37	0	0	0	0	0	0
NS06-06	UNNAMED	0	0	0	0	10	10	10	24	29	65	59	54	55	37	37	0	0	0	0	0	0
NS07-05	UNNAMED	0	0	0	0	10	5	5	19	24	46	54	55	56	37	33	0	0	0	0	0	0
NS07-06	UNNAMED	0	0	0	0	0	0	0	34	38	37	54	51	47	38	24	0	0	0	0	0	0
NS08-05	UNNAMED	0	0	0	0	0	0	0	29	38	37	54	46	37	28	9	0	0	0	0	0	0
73 Degrees North Latitude																						
NS05-07	BARROW CANYON	0	0	15	0	0	20	20	49	82	73	87	74	83	85	47	15	5	0	0	0	0
NS05-08	CANADA BASIN WEST	0	0	0	0	0	20	25	44	67	73	72	54	79	67	37	0	0	0	0	0	0
NS06-07	CANADA BASIN	0	5	15	0	5	15	25	38	57	87	82	83	69	57	37	0	0	0	0	0	0
NS06-08	UNNAMED	0	5	15	0	10	20	19	29	62	87	68	68	75	47	37	5	0	0	0	0	0
NS07-07	BEAUFORT TERRACE	0	5	5	5	10	20	29	29	48	70	51	64	51	42	37	5	0	0	0	0	0
NS07-08	UNNAMED	0	0	5	5	0	5	5	20	52	55	59	59	56	28	24	0	0	0	0	0	0
NS08-07	UNNAMED	0	0	0	0	0	0	0	20	38	36	54	36	37	37	18	0	0	0	0	0	0
72 Degrees North Latitude																						
NR05-01	DEASE INLET	0	0	0	10	35	40	49	73	95	91	81	81	92	93	94	34	35	0	0	0	0
NR05-02	HARRISON BAY NORTH	0	5	0	5	30	45	55	58	86	91	86	86	87	94	75	24	5	0	0	0	0
NR06-01	BEECHEY POINT NORTH	15	15	15	0	30	40	45	72	76	91	90	90	93	94	71	38	0	0	0	0	0
NR06-02	FLAXMAN ISLAND N.	20	15	20	10	30	40	49	77	76	87	86	86	84	85	73	26	0	0	0	0	0
NR07-01	UNNAMED	15	15	30	25	30	35	53	73	71	88	83	78	74	76	68	9	0	0	0	0	0
NR07-02	UNNAMED	0	15	15	20	30	25	24	34	72	69	63	68	74	72	53	0	0	0	0	0	0
71 Degrees North Latitude																						
NR05-03	TESHEKPUK	0	0	0	0	80	60	99	97	96	90	90	90	95	77	78	20	20	0	0	0	0
NR05-04	HARRISON BAY	0	0	0	20	80	60	89	97	96	90	91	91	92	94	86	20	10	0	0	0	0
NR06-03	BEECHEY POINT	5	5	5	15	65	60	84	82	96	91	91	91	94	95	81	17	0	10	0	0	0
NR06-04	FLAXMAN ISLAND	15	20	25	35	60	75	84	82	96	91	90	90	92	93	94	37	0	15	0	0	0
NR07-03	BARTER ISLAND	20	40	50	50	60	90	67	86	91	90	91	91	93	92	94	26	10	5	0	0	0
NR07-04	MACKENZIE CANYON N.	0	40	50	59	49	79	67	76	86	90	92	92	94	93	95	16	10	0	0	0	0
70 Degrees North Latitude																						
NR07-05	DEMARCATION POINT	60	40	80	80	99	99	96	96	95	90	90	90	95	95	97	60	20	20	0	0	0
NR07-06	MACKENZIE CANYON	60	80	80	99	98	98	96	95	95	90	90	90	92	92	75	36	20	20	0	0	0

7.5 Task 7 Results: When, and for what duration, metocean conditions over the past 5-years, would have supported safe deployment of a relief well alone in response to a loss-of-well situation in Arctic conditions

7.5.1 Scenario 7.1 Results

Scenario 7.1 represents the situation where a relief well is deployed in the Chukchi Sea in open water conditions which typically occur from late July through October in the historical Chukchi Sea operating area (Colbert, Karo, Posey and Hanna Shoal OPDs). These operations would be supported by two Polar class ice management vessels. Safe deployment of a relief well for this equipment spread can be conducted only in open water with a 30-mile radius buffer to floating sea ice. These restrictive ice conditions are necessary to allow sufficient time to secure well operations and move off location during an ice event.

Table 7-16 shows the percent probability of safe deployment for scenario 7.1 in varying seasonal sea ice coverage in the Chukchi Sea planning area over the period of June through December for the years 2012 to 2016.

The results in table 7-16 show that there is a 90 percent or greater probability that relief well operations can be safely deployed for periods of 80 to 110 days for the majority of the OPDs below the 71st parallel in the southern portion of the planning area. Between 71 and 72 degrees north, this period decreases to about 40 to 70 days, or less. Above 72 degrees, no OPDs have a 90 percent or greater probability for more than 10 consecutive days. Reducing the probability threshold to 75 percent, adds between 10 and 20 days duration to the aforementioned time periods.

Table 7-16. Scenario 7.1: Percent probability of safe open water relief well deployment in the Chukchi Sea, 2012-2016.

OPD #	OPD Name	June			July			Aug			September			October			November			December		
		1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
NS02-04	UNNAMED	0	0	0	0	0	0	0	0	0	29	48	48	77	38	19	0	0	0	0	0	0
NS03-03	UNNAMED	0	0	0	0	0	0	0	0	5	29	48	48	72	19	19	0	0	0	0	0	0
NS03-04	UNNAMED	0	0	0	0	0	0	0	0	30	29	43	43	62	19	5	0	0	0	0	0	0
NS04-03	UNNAMED	0	0	0	0	0	0	0	0	25	24	62	52	48	24	19	0	0	0	0	0	0
NS04-04	UNNAMED	0	0	0	0	0	0	0	0	20	19	57	33	38	19	10	0	0	0	0	0	0
74 Degrees Latitude North																						
NS02-06	UNNAMED	0	0	0	0	0	0	0	10	10	29	67	86	67	48	10	0	0	0	0	0	0
NS03-05	UNNAMED	0	0	0	0	0	0	0	5	20	29	62	81	77	58	14	0	0	0	0	0	0
NS03-06	UNNAMED	0	0	0	0	0	0	0	0	30	67	57	71	91	67	29	0	0	0	0	0	0
NS04-05	UNNAMED	0	0	0	0	0	0	0	0	59	57	81	62	96	48	38	0	0	0	0	0	0
NS04-06	UNNAMED	0	0	0	0	0	0	0	0	40	29	76	57	43	38	38	0	0	0	0	0	0
73 Degrees Latitude North																						
NS02-08	UNNAMED	0	0	0	0	0	20	20	30	50	57	57	86	86	77	67	34	0	8	4	4	4
NS03-07	UNNAMED	0	0	0	0	0	15	20	20	45	43	67	86	96	86	58	25	13	8	2	4	0
NS03-08	UNNAMED	0	0	0	0	0	5	15	15	30	48	62	81	96	86	62	0	4	0	0	0	0
NS04-07	UNNAMED	0	0	0	0	0	0	10	10	25	71	71	76	82	86	58	4	0	0	0	0	0
NS04-08	UNNAMED	0	0	0	0	0	0	0	10	89	76	90	76	96	67	43	0	0	0	0	0	0
72 Degrees Latitude North																						
NR02-02	TISON	0	0	0	0	20	30	59	59	89	95	95	95	96	96	96	59	34	50	8	4	8
NR03-01	KARO	0	0	0	5	25	20	50	69	74	76	90	95	96	96	96	54	34	25	4	0	0
NR03-02	POSEY	0	0	0	10	5	5	30	20	45	43	67	95	96	96	96	34	13	0	0	0	0
NR04-01	HANNA SHOAL	0	0	0	0	0	5	15	25	40	76	67	86	96	96	82	13	0	0	0	0	0
NR04-02	BARROW	0	0	0	5	5	5	20	45	84	86	86	90	96	91	67	0	0	0	0	0	0
71 Degrees Latitude North																						
NR02-04	STUDDS	0	0	0	0	40	40	79	99	99	95	95	95	96	96	96	84	59	50	4	0	0
NR03-03	COLBERT	5	10	15	15	54	74	94	99	99	95	95	95	96	96	96	67	50	42	4	0	0
NR-03-04	SOLIVIK ISLAND	0	5	30	25	50	79	89	99	89	95	90	95	96	96	91	59	29	17	2	0	0
NR04-03	WAINWRIGHT	0	0	20	26	40	33	66	66	92	82	89	95	96	90	64	22	11	6	0	0	0
NR04-04	MEADE RIVER	0	0	0	20	20	40	59	79	99	95	95	95	96	96	77	0	0	0	0	0	0
70 Degrees Latitude North																						
NR02-06	CHUKCHI SEA	0	10	50	50	79	79	89	99	99	95	95	95	96	96	96	84	67	50	12	0	0
NR-03-05	POINT LAY WEST	0	15	40	59	99	94	99	99	99	95	95	95	96	96	96	75	46	25	2	0	0
NR-03-06	POINT LAY	30	15	40	50	99	99	99	99	99	95	90	90	91	72	43	17	8	0	0	0	0
69 Degrees Latitude North																						
NR02-08	POINT HOPE WEST	0	40	69	69	99	99	99	99	99	95	95	95	96	96	96	84	59	34	16	0	0
NR03-07	POINT HOPE	0	30	54	64	94	99	99	99	99	95	95	95	96	96	96	54	34	17	0	0	0
NR03-08	DELONG MOUNTAINS	40	20	20	40	79	99	99	99	99	95	95	95	96	96	58	0	0	0	0	0	0

7.5.2 Scenario 7.2 Results

For scenario 7.2, the potential for a relief well in the Chukchi Sea with sea ice operating capability is presented. This scenario assumes an ice class MODU supported by a minimum of four Polar class ice management vessels. The ice class MODU is assumed to be able to operate in 0 to 8 tenths ice concentration.

Table 7-17 shows the percent probabilities for shoulder season relief well deployment with an ice class MODU in the Chukchi Sea for the period of 2012 to 2016.

The results in table 7-17 show that below 72 degrees latitude, most of the OPDs have periods of 90 percent or greater deployment probability ranging from 70 to 160 days. The Karo, Posey, and Hanna Shoal OPDs are an exception and have more limited periods of acceptable ice conditions for this scenario. Above the 72nd and 73rd parallels, operating windows decrease to a maximum duration of 30 to 40 days with greater than 90 percent probability of deployment for selected OPDs and no continuous operating windows beyond 10 days above the 74th parallel. Reducing the probability threshold to 75 percent, generally adds 10 to 30 days to the aforementioned time periods.

Table 7-17. Scenario 7.2: Percent probability of safe relief well deployment with sea ice operating capability in the Chukchi Sea, 2012-2016.

OPD #	OPD Name	June			July			Aug			September			October			November			December		
		1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
NS02-04	UNNAMED	0	0	0	0	0	10	20	40	20	39	68	58	97	78	39	0	0	0	0	0	0
NS03-03	UNNAMED	0	0	0	0	0	10	20	20	40	39	58	58	92	74	39	0	0	0	0	0	0
NS03-04	UNNAMED	0	0	0	0	0	10	10	5	45	49	53	58	77	44	35	0	0	0	0	0	0
NS04-03	UNNAMED	0	0	0	0	0	0	30	15	45	34	67	57	93	44	39	0	0	0	0	0	0
NS04-04	UNNAMED	0	0	0	0	20	10	20	10	50	44	62	43	73	39	40	5	0	0	0	0	0
74 Degrees North Latitude																						
NS02-06	UNNAMED	0	0	10	10	10	20	20	20	50	49	77	96	87	88	40	10	0	0	0	0	0
NS03-05	UNNAMED	0	0	0	5	0	20	35	40	45	54	67	86	87	88	54	5	0	0	0	0	0
NS03-06	UNNAMED	0	0	0	0	0	5	25	40	55	67	57	76	91	97	54	0	0	0	0	0	0
NS04-05	UNNAMED	0	0	0	0	5	20	30	40	74	67	91	72	96	83	38	20	0	0	0	0	0
NS04-06	UNNAMED	0	0	5	0	0	30	40	35	75	54	91	72	88	48	38	15	0	0	0	0	0
73 Degrees North Latitude																						
NS02-08	UNNAMED	0	0	0	20	20	40	80	80	70	67	77	96	86	97	77	64	60	38	6	6	16
NS03-07	UNNAMED	0	0	0	20	40	40	60	70	75	78	72	96	96	96	93	50	48	28	8	11	15
NS03-08	UNNAMED	0	0	0	20	40	30	50	45	65	83	62	86	96	96	87	25	19	15	0	5	0
NS04-07	UNNAMED	0	0	0	5	10	5	50	60	70	81	71	86	82	86	78	24	0	10	0	0	0
NS04-08	UNNAMED	0	0	0	15	10	10	30	55	89	76	95	76	96	97	53	25	10	0	0	0	0
72 Degrees North Latitude																						
NR02-02	TISON	0	0	0	20	80	80	89	89	99	95	95	95	96	96	96	79	74	50	11	16	11
NR03-01	KARO	0	10	20	40	75	85	85	89	89	96	90	95	96	96	96	80	64	45	16	20	20
NR03-02	POSEY	0	0	15	20	40	80	80	85	90	83	67	95	96	96	96	44	43	35	5	5	0
NR04-01	HANNA SHOAL	5	5	0	20	30	65	75	80	95	96	72	91	96	96	97	43	20	0	0	0	0
NR04-02	BARROW	25	10	10	25	45	65	65	85	99	96	91	90	96	96	92	45	25	10	0	0	0
71 Degrees North Latitude																						
NR02-04	STUDDS	20	0	30	30	80	70	79	99	99	95	95	95	96	96	96	84	69	50	36	20	20
NR03-03	COLBERT	40	40	60	70	84	99	99	99	99	95	95	95	96	96	96	82	70	52	36	20	15
NR-03-04	SOLIVIK ISLAND	40	50	55	60	85	99	99	99	94	95	90	95	96	96	96	79	54	47	33	0	0
NR04-03	WAINWRIGHT	40	53	53	46	86	93	93	99	99	96	89	95	96	96	97	96	45	19	13	0	0
NR04-04	MEADE RIVER	80	40	60	40	100	80	99	99	99	95	95	95	96	96	97	80	40	20	0	0	0
70 Degrees North Latitude																						
NR02-06	CHUKCHI SEA	20	40	90	90	89	89	99	99	99	95	95	95	96	96	96	84	77	70	47	20	20
NR-03-05	POINT LAY WEST	55	70	95	94	99	99	99	99	99	95	95	95	96	96	96	86	81	55	38	5	0
NR-03-06	POINT LAY	65	75	95	95	99	99	99	99	99	95	95	95	96	97	93	62	48	5	5	0	0
69 Degrees North Latitude																						
NR02-08	POINT HOPE WEST	70	100	99	99	99	99	99	99	99	95	95	95	96	96	96	84	89	74	42	20	0
NR03-07	POINT HOPE	90	95	99	99	94	99	99	99	99	95	95	95	96	96	96	90	89	47	35	10	0
NR03-08	DELONG MOUNTAINS	60	80	100	100	79	99	99	99	99	95	95	95	96	96	78	60	20	0	20	20	0

7.5.3 Scenario 7.3 Results

Scenario 7.3 represents the situation where a relief well is deployed in the Beaufort Sea during open water conditions which typically occur from mid- to late-August through October in the historical Beaufort Sea operating area. These operations would be supported by two Polar class ice management vessels. Safe deployment of a relief well for this equipment spread can be conducted only in open water with a 30-mile radius buffer to floating sea ice. These restrictive ice conditions are necessary to allow sufficient time to secure the well operations and move off location during an ice event.

Table 7-18 shows the percent probability of safe deployment for scenario 7.3 in varying seasonal sea ice coverage in the Beaufort Sea planning area over the period of June through December for the years 2012 to 2016.

The results in table 7-18 show that there is a 75 percent or greater probability that relief well operations can be safely deployed for periods of 30 to 60 days for the majority of the OPDs below the 71st parallel in the southern portion of the planning area. Between 71 and 72 degrees north, the period for greater than 75 percent safe deployment decreases to zero to 60 days. Above the 72nd parallel, no OPDs have a 75 percent or greater probability for more than 10 consecutive days.

Table 7-18. Scenario 7.3: Percent probability of safe open water relief well deployment in the Beaufort Sea, 2012-2016.

OPD	OPD Name	June			July			Aug			September			October			November			December		
		1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
NS05-03	UNNAMED	0	0	0	0	0	0	0	0	19	37	33	33	41	23	23	0	0	0	0	0	0
NS05-04	UNNAMED	0	0	0	0	0	0	0	0	19	37	47	56	55	28	18	0	0	0	0	0	0
NS06-03	UNNAMED	0	0	0	0	0	0	0	5	34	47	56	56	55	23	14	0	0	0	0	0	0
74Degrees North Latitude																						
NS05-05	UNNAMED	0	0	0	0	0	0	0	0	34	33	56	56	46	37	37	0	0	0	0	0	0
NS05-06	UNNAMED	0	0	0	0	0	0	0	0	39	42	56	65	64	37	37	0	0	0	0	0	0
NS06-05	UNNAMED	0	0	0	0	0	0	0	24	34	51	60	56	55	37	37	0	0	0	0	0	0
NS06-06	UNNAMED	0	0	0	0	0	5	5	19	29	47	56	56	55	37	32	0	0	0	0	0	0
NS07-05	UNNAMED	0	0	0	0	0	5	5	19	19	42	56	51	46	37	23	0	0	0	0	0	0
NS07-06	UNNAMED	0	0	0	0	0	0	0	29	39	33	56	42	37	23	14	0	0	0	0	0	0
NS08-05	UNNAMED	0	0	0	0	0	0	0	29	39	28	56	37	37	18	9	0	0	0	0	0	0
73 Degrees North Latitude																						
NS05-07	BARROW CANYON	0	0	0	0	0	0	0	19	68	65	79	60	78	60	37	0	0	0	0	0	0
NS05-08	CANADA BASIN WEST	0	0	0	0	0	0	0	15	58	65	74	56	74	37	37	0	0	0	0	0	0
NS06-07	CANADA BASIN	0	0	0	0	0	10	10	39	58	74	74	65	64	37	37	0	0	0	0	0	0
NS06-08	UNNAMED	0	0	0	0	10	20	19	29	58	74	65	65	60	37	37	0	0	0	0	0	0
NS07-07	BEAUFORT TERRACE	0	0	0	0	10	20	19	19	49	51	37	56	46	37	32	0	0	0	0	0	0
NS07-08	UNNAMED	0	0	0	0	0	5	5	10	53	51	56	56	51	28	14	0	0	0	0	0	0
NS08-07	UNNAMED	0	0	0	0	0	0	0	0	39	37	56	37	37	37	18	0	0	0	0	0	0
72 Degrees North Latitude																						
NR05-01	DEASE INLET	0	0	0	0	0	0	15	39	92	88	84	84	92	83	64	4	0	0	0	0	0
NR05-02	HARRISON BAY NORTH	0	0	0	0	0	0	5	39	73	84	88	88	92	69	55	4	0	0	0	0	0
NR06-01	BEECHEY POINT NORTH	5	5	0	0	5	5	10	53	73	84	93	93	83	74	46	8	0	0	0	0	0
NR06-02	FLAXMAN ISLAND N.	10	10	0	0	15	20	29	58	78	74	84	84	64	55	23	16	0	0	0	0	0
NR07-01	UNNAMED	10	5	10	10	20	20	39	49	73	70	70	65	64	46	18	4	0	0	0	0	0
NR07-02	UNNAMED	0	10	15	15	15	15	15	15	68	56	65	65	69	37	23	0	0	0	0	0	0
71 Degrees North Latitude																						
NR05-03	TESHEKPUK	0	0	0	0	0	0	19	58	78	93	93	93	55	37	18	0	0	0	0	0	0
NR05-04	HARRISON BAY	0	0	0	0	0	0	19	58	78	93	84	84	92	64	46	0	0	0	0	0	0
NR06-03	BEECHEY POINT	5	0	0	5	10	0	19	53	78	84	88	84	74	55	46	12	0	0	0	0	0
NR06-04	FLAXMAN ISLAND	15	10	0	25	10	5	19	53	78	88	93	93	87	78	69	12	0	0	0	0	0
NR07-03	BARTER ISLAND	10	25	0	15	20	20	63	73	82	93	88	88	78	87	69	16	0	0	0	0	0
NR07-04	MACKENZIE CANYON N.	0	20	20	29	29	29	58	78	87	93	74	74	74	83	55	16	0	0	0	0	0
70 Degrees North Latitude																						
NR07-05	DEMARCATION POINT	0	0	0	20	39	39	78	78	97	93	93	93	55	55	37	0	0	0	0	0	0
NR07-06	MACKENZIE CANYON	40	40	20	39	98	78	78	97	97	93	93	93	92	92	55	16	0	0	0	0	0

7.5.4 Scenario 7.4 Results

Scenario 7.4 covers the safe deployment of a relief well in the Beaufort Sea with the capability of operating in sea ice conditions. These operations are assumed to be supported by four Polar class ice management vessels and can be conducted in 0 to 8 tenths ice concentration.

Table 7-19 shows the percent probability of safe deployment for scenario 7.4 with varying seasonal sea ice coverage in the Beaufort Sea planning area for the years 2012 to 2016.

The results in table 7-19 show that safe relief well deployment ice conditions are suitable (90 percent or greater probability) in scenario 7.4 for approximately 70 days from mid-August through October in the Beaufort Sea planning area below 71 degrees north latitude. Between 71 and 72 degrees north, the window of greater than 90% probability range decreases to 20 to 50 days in selected OPDs. Moving northward, the percent probabilities decrease further and above the 72nd parallel, no OPDs experience any 10 day periods with greater than 90 percent safe deployment probability. Reducing the probability threshold to 75 percent expands the aforementioned time periods by approximately 10 to 30 days below the 72nd parallel.

Table 7-19. Scenario 7.4: Percent probability of safe relief well deployment with sea ice operating capability in the Beaufort Sea, 2012-2016.

OPD	OPD Name	June			July			Aug			September			October			November			December		
		1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
NS05-03	UNNAMED	0	0	0	0	0	0	0	0	29	37	43	43	56	33	33	0	0	0	0	0	0
NS05-04	UNNAMED	0	0	0	0	0	0	0	0	29	42	47	56	55	48	33	0	0	0	0	0	0
NS06-03	UNNAMED	0	0	0	0	5	0	5	10	39	47	56	56	55	38	29	0	0	0	0	0	0
74 Degrees North Latitude																						
NS05-05	UNNAMED	0	0	0	0	0	0	15	15	44	43	66	66	71	47	37	15	0	0	0	0	0
NS05-06	UNNAMED	0	0	0	0	0	5	10	10	39	72	56	75	74	37	37	20	0	0	0	0	0
NS06-05	UNNAMED	0	0	0	5	0	0	5	34	34	66	65	71	55	37	37	0	0	0	0	0	0
NS06-06	UNNAMED	0	0	5	0	15	20	10	24	34	67	61	56	55	37	37	0	0	0	0	0	0
NS07-05	UNNAMED	0	0	0	5	10	5	5	19	24	47	56	56	56	37	33	0	0	0	0	0	0
NS07-06	UNNAMED	0	0	0	0	0	0	0	34	39	38	56	52	47	38	24	0	0	0	0	0	0
NS08-05	UNNAMED	0	0	0	0	0	0	0	29	39	38	56	47	37	28	9	0	0	0	0	0	0
73 Degrees North Latitude																						
NS05-07	BARROW CANYON	0	0	15	0	0	30	30	49	83	75	89	75	83	85	52	15	5	0	0	0	0
NS05-08	CANADA BASIN WEST	0	5	0	0	0	30	25	45	68	75	74	56	84	72	37	5	0	0	0	0	0
NS06-07	CANADA BASIN	0	5	15	0	5	15	25	39	58	89	84	85	74	67	42	0	0	0	0	0	0
NS06-08	UNNAMED	0	10	15	0	20	25	32	34	63	89	70	70	75	52	37	5	0	0	0	0	0
NS07-07	BEAUFORT TERRACE	0	5	10	10	10	20	34	29	49	71	52	66	51	42	37	5	0	0	0	0	0
NS07-08	UNNAMED	0	0	5	5	0	5	10	20	53	56	61	61	56	53	54	0	0	0	0	0	0
NS08-07	UNNAMED	0	0	20	20	0	0	0	20	39	37	56	37	37	37	18	0	0	0	0	0	0
72 Degrees North Latitude																						
NR05-01	DEASE INLET	0	0	0	15	40	40	50	74	97	93	84	84	92	93	94	39	40	0	0	0	0
NR05-02	HARRISON BAY NORTH	0	5	0	5	30	50	55	59	88	94	88	88	87	94	75	34	15	10	0	0	0
NR06-01	BEECHEY POINT NORTH	15	15	15	5	30	65	50	73	78	94	93	93	93	94	71	38	0	10	0	0	0
NR06-02	FLAXMAN ISLAND N.	20	15	20	15	35	45	54	78	78	89	89	89	84	85	73	26	0	0	0	0	0
NR07-01	UNNAMED	15	20	35	30	30	40	54	79	73	90	85	80	79	81	73	14	0	0	0	0	0
NR07-02	UNNAMED	0	15	15	20	30	25	30	35	73	71	65	70	79	77	53	0	0	0	0	0	0
71 Degrees North Latitude																						
NR05-03	TESHEKPUK	0	0	20	40	100	60	99	98	98	93	93	93	95	97	78	60	80	80	80	60	60
NR05-04	HARRISON BAY	0	0	0	20	80	60	89	98	98	93	94	94	92	94	96	20	20	10	10	20	30
NR06-03	BEECHEY POINT	5	5	5	20	70	65	84	83	98	94	93	94	94	95	91	32	5	20	0	0	0
NR06-04	FLAXMAN ISLAND	15	20	25	35	65	80	84	83	98	93	93	93	92	93	94	37	0	20	0	0	0
NR07-03	BARTER ISLAND	20	40	50	50	70	90	68	88	92	93	93	93	93	92	94	31	10	10	0	0	0
NR07-04	MACKENZIE CANYON N.	0	50	50	59	59	79	68	78	87	93	94	94	94	93	95	16	10	0	0	0	0
70 Degrees North Latitude																						
NR07-05	DEMARCATION POINT	60	60	80	80	99	99	98	98	97	93	93	93	95	95	97	60	20	20	0	0	0
NR07-06	MACKENZIE CANYON	60	80	80	99	98	98	98	97	97	93	93	93	92	92	75	36	20	20	0	0	0

7.6 Task 8 Results: When, and for what duration, metocean conditions over the past 5-years, would have supported safe deployment of either SCCE or a relief well alone in response to a loss-of-well situation in Arctic conditions

7.6.1 Scenario 8.1 Results

Scenario 8.1 covers the situation where operational conditions support safe deployment of both a relief well and SCCE in open water in the Chukchi Sea. For this scenario, SCCE has lower sea state criteria limits for deployment with a significant wave height tolerance of 6.6 feet (2 meters) versus 9.8 feet (3 meters) for relief well deployment (see table 7-10 above). Thus, SCCE deployment carries the limiting criterion for this scenario and the results for this scenario are the same as for scenario 6.1 above. Table 7-20 below presents the results for this scenario.

Table 7-20. Scenario 8.1: Percent probability of safe deployment of both SCCE and a relief well in open water in the Chukchi Sea, 2012-2016.

OPD #	OPD Name	June			July			Aug			September			October			November			December		
		1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
NS02-04	UNNAMED	0	0	0	0	0	0	0	0	0	23	39	39	70	35	17	0	0	0	0	0	0
NS03-03	UNNAMED	0	0	0	0	0	0	0	0	4	23	39	39	65	17	17	0	0	0	0	0	0
NS03-04	UNNAMED	0	0	0	0	0	0	0	0	26	23	35	35	57	17	4	0	0	0	0	0	0
NS04-03	UNNAMED	0	0	0	0	0	0	0	0	22	19	50	42	44	22	17	0	0	0	0	0	0
NS04-04	UNNAMED	0	0	0	0	0	0	0	0	17	15	46	27	35	17	9	0	0	0	0	0	0
74 Degrees North Latitude																						
NS02-06	UNNAMED	0	0	0	0	0	0	0	9	9	23	54	69	61	44	9	0	0	0	0	0	0
NS03-05	UNNAMED	0	0	0	0	0	0	0	4	17	23	50	65	70	52	13	0	0	0	0	0	0
NS03-06	UNNAMED	0	0	0	0	0	0	0	0	26	54	46	58	83	61	26	0	0	0	0	0	0
NS04-05	UNNAMED	0	0	0	0	0	0	0	0	52	46	65	50	87	44	35	0	0	0	0	0	0
NS04-06	UNNAMED	0	0	0	0	0	0	0	0	35	23	62	46	39	35	35	0	0	0	0	0	0
73 Degrees North Latitude																						
NS02-08	UNNAMED	0	0	0	0	0	20	17	26	44	46	46	69	78	70	61	34	0	8	6	6	6
NS03-07	UNNAMED	0	0	0	0	0	15	17	17	39	35	54	69	87	78	52	25	13	8	3	6	0
NS03-08	UNNAMED	0	0	0	0	0	5	13	13	26	39	50	65	87	78	57	0	4	0	0	0	0
NS04-07	UNNAMED	0	0	0	0	0	0	9	9	22	58	58	62	74	78	52	4	0	0	0	0	0
NS04-08	UNNAMED	0	0	0	0	0	0	0	9	78	62	73	62	87	61	39	0	0	0	0	0	0
72 Degrees North Latitude																						
NR02-02	TISON	0	0	0	0	20	30	52	52	78	77	77	77	87	87	87	59	34	50	11	6	11
NR03-01	KARO	0	0	0	5	25	20	44	61	65	62	73	77	87	87	87	55	34	25	6	0	0
NR03-02	POSEY	0	0	0	10	5	5	26	17	39	35	54	77	87	87	87	34	13	0	0	0	0
NR04-01	HANNA SHOAL	0	0	0	0	0	5	13	22	35	62	54	69	87	87	74	13	0	0	0	0	0
NR04-02	BARROW	0	0	0	5	5	5	17	39	74	69	69	73	87	83	61	0	0	0	0	0	0
71 Degrees North Latitude																						
NR02-04	STUDDS	0	0	0	0	40	40	70	87	87	77	77	77	87	87	87	84	59	50	6	0	0
NR03-03	COLBERT	5	10	15	15	54	74	83	87	87	77	77	77	87	87	87	67	50	42	6	0	0
NR-03-04	SOLIVIK ISLAND	0	5	30	25	50	79	78	87	78	77	73	77	87	87	83	59	29	17	3	0	0
NR04-03	WAINWRIGHT	0	0	20	26	40	33	58	58	81	67	72	77	87	81	58	22	11	6	0	0	0
NR04-04	MEADE RIVER	0	0	0	20	20	40	52	70	87	77	77	77	87	87	70	0	0	0	0	0	0
70 Degrees North Latitude																						
NR02-06	CHUKCHI SEA	0	10	50	50	79	79	78	87	87	77	77	77	87	87	87	84	67	50	17	0	0
NR-03-05	POINT LAY WEST	0	15	40	59	99	94	87	87	87	77	77	77	87	87	87	76	46	25	3	0	0
NR-03-06	POINT LAY	30	15	40	50	99	99	87	87	87	77	73	73	83	65	39	17	8	0	0	0	0
69 Degrees North Latitude																						
NR02-08	POINT HOPE WEST	0	40	69	69	99	99	87	87	87	77	77	77	87	87	87	84	59	34	22	0	0
NR03-07	POINT HOPE	0	30	54	64	94	99	87	87	87	77	77	77	87	87	87	55	34	17	0	0	0
NR03-08	DELONG MOUNTAINS	40	20	20	40	79	99	87	87	87	77	77	77	87	87	52	0	0	0	0	0	0

7.6.2 Scenario 8.2 Results

Scenario 8.2 represents the situation where both a relief well and SCCE can be safely deployed with sea ice operating capability in the Chukchi Sea. A minimum of four Polar class ice management vessels are assumed for this scenario where SCCE can be deployed in 0 to 7 tenths ice coverage while relief well drilling with an ice class drilling vessel can continue up to 8 tenths ice coverage. Thus, 0 to 7 tenths ice coverage is the limiting criterion for this scenario and the results for this scenario are the same as for scenario 6.2 above. SCCE also has lower sea state deployment criteria than relief well drilling. Table 7-21 presents the results for this scenario.

Table 7-21. Scenario 8.2: Percent probability of safe deployment of both SCCE and a relief well with sea ice operating capability in the Chukchi Sea, 2012-2016.

OPD #	OPD Name	June			July			Aug			September			October			November			December		
		1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
NS02-04	UNNAMED	0	0	0	0	0	10	20	30	20	33	59	49	90	75	37	0	0	0	0	0	0
NS03-03	UNNAMED	0	0	0	0	0	5	5	10	19	33	49	49	85	72	37	0	0	0	0	0	0
NS03-04	UNNAMED	0	0	0	0	0	0	10	5	41	43	45	45	72	37	24	0	0	0	0	0	0
NS04-03	UNNAMED	0	0	0	0	0	0	30	15	37	29	55	47	84	42	37	0	0	0	0	0	0
NS04-04	UNNAMED	0	0	0	0	10	0	15	10	42	35	51	32	60	27	29	0	0	0	0	0	0
74 Degrees North Latitude																						
NS02-06	UNNAMED	0	0	0	0	0	20	10	9	39	43	54	69	81	84	39	10	0	0	0	0	0
NS03-05	UNNAMED	0	0	0	0	0	10	15	29	37	48	55	70	80	82	43	5	0	0	0	0	0
NS03-06	UNNAMED	0	0	0	0	0	0	15	40	51	54	46	63	83	91	51	0	0	0	0	0	0
NS04-05	UNNAMED	0	0	0	0	0	0	15	30	67	56	75	60	87	69	35	0	0	0	0	0	0
NS04-06	UNNAMED	0	0	0	0	0	10	20	35	60	48	72	56	84	45	35	0	0	0	0	0	0
73 Degrees North Latitude																						
NS02-08	UNNAMED	0	0	0	20	20	30	57	76	54	56	56	69	78	90	71	44	50	38	6	6	16
NS03-07	UNNAMED	0	0	0	20	25	30	32	47	59	70	59	79	87	88	77	35	43	23	8	11	10
NS03-08	UNNAMED	0	0	0	20	35	20	23	28	56	74	50	70	87	88	82	25	19	15	0	5	0
NS04-07	UNNAMED	0	0	0	5	0	5	44	59	67	68	58	72	74	78	67	19	0	5	0	0	0
NS04-08	UNNAMED	0	0	0	5	0	0	30	54	78	62	78	62	87	91	49	15	10	0	0	0	0
72 Degrees North Latitude																						
NR02-02	TISON	0	0	0	20	70	70	82	82	88	77	77	77	87	87	87	79	74	50	11	16	11
NR03-01	KARO	0	5	15	35	65	80	79	81	80	82	73	77	87	87	87	75	54	45	16	20	20
NR03-02	POSEY	0	0	15	20	25	70	71	77	84	75	54	77	87	87	87	44	38	25	5	0	0
NR04-01	HANNA SHOAL	5	5	0	15	10	45	73	72	90	82	59	74	87	87	89	33	10	0	0	0	0
NR04-02	BARROW	20	5	5	15	45	45	52	79	89	79	74	73	87	88	86	30	20	10	0	0	0
71 Degrees North Latitude																						
NR02-04	STUDDS	0	0	30	20	80	60	70	87	87	77	77	77	87	87	87	84	69	50	26	20	20
NR03-03	COLBERT	30	35	40	65	84	99	88	87	87	77	77	77	87	87	87	82	70	52	26	20	10
NR-03-04	SOLIVIK ISLAND	30	50	50	55	75	99	88	87	83	77	73	77	87	87	88	79	49	37	23	0	0
NR04-03	WAINWRIGHT	40	53	53	46	80	93	85	91	88	80	72	77	87	88	91	89	38	19	13	0	0
NR04-04	MEADE RIVER	80	40	20	20	100	80	92	90	87	77	77	77	87	87	90	80	40	20	0	0	0
70 Degrees North Latitude																						
NR02-06	CHUKCHI SEA	10	30	80	90	89	89	88	87	87	77	77	77	87	87	87	84	67	70	37	20	20
NR-03-05	POINT LAY WEST	50	65	90	94	99	99	87	87	87	77	77	77	87	87	87	86	76	50	33	0	0
NR-03-06	POINT LAY	65	75	90	90	99	99	87	87	87	77	78	78	88	90	89	62	38	5	0	0	0
69 Degrees North Latitude																						
NR02-08	POINT HOPE WEST	70	100	99	99	99	99	87	87	87	77	77	77	87	87	87	84	69	74	42	0	0
NR03-07	POINT HOPE	75	85	99	99	94	99	87	87	87	77	77	77	87	87	87	90	79	42	20	5	0
NR03-08	DELONG MOUNTAINS	60	80	100	100	79	99	87	87	87	77	77	77	87	87	72	20	20	0	20	0	0

7.6.3 Scenario 8.3 Results

Scenario 8.3 covers the situation where operational conditions support safe deployment of both a relief well and SCCE in open water in the Beaufort Sea. For this scenario, SCCE has lower sea state criteria limits for deployment with significant wave height tolerance of 6.6 feet (2 meters) versus 9.8 feet (3 meters) for relief well deployment (see table 7-11 above). Thus, SCCE deployment carries the limiting criteria for this scenario and the results for this scenario are the same as for scenario 6.3 above. Table 7-22 below presents the results for this scenario.

Table 7-22. Scenario 8.3: Percent probability of safe deployment of both SCCE and a relief well in open water in the Beaufort Sea, 2012-2016.

OPD	OPD Name	June			July			Aug			September			October			November			December		
		1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
NS05-03	UNNAMED	0	0	0	0	0	0	0	0	19	36	32	32	41	23	23	0	0	0	0	0	0
NS05-04	UNNAMED	0	0	0	0	0	0	0	0	19	36	45	54	55	28	18	0	0	0	0	0	0
NS06-03	UNNAMED	0	0	0	0	0	0	0	5	33	45	54	54	55	23	14	0	0	0	0	0	0
74Degrees North Latitude																						
NS05-05	UNNAMED	0	0	0	0	0	0	0	0	33	32	54	54	46	37	37	0	0	0	0	0	0
NS05-06	UNNAMED	0	0	0	0	0	0	0	0	38	41	54	63	64	37	37	0	0	0	0	0	0
NS06-05	UNNAMED	0	0	0	0	0	0	0	24	33	50	59	54	55	37	37	0	0	0	0	0	0
NS06-06	UNNAMED	0	0	0	0	0	5	5	19	29	45	54	54	55	37	32	0	0	0	0	0	0
NS07-05	UNNAMED	0	0	0	0	0	5	5	19	19	41	54	50	46	37	23	0	0	0	0	0	0
NS07-06	UNNAMED	0	0	0	0	0	0	0	29	38	32	54	41	37	23	14	0	0	0	0	0	0
NS08-05	UNNAMED	0	0	0	0	0	0	0	29	38	27	54	36	37	18	9	0	0	0	0	0	0
73 Degrees North Latitude																						
NS05-07	BARROW CANYON	0	0	0	0	0	0	0	19	67	63	77	59	78	60	37	0	0	0	0	0	0
NS05-08	CANADA BASIN WEST	0	0	0	0	0	0	0	14	57	63	72	54	74	37	37	0	0	0	0	0	0
NS06-07	CANADA BASIN	0	0	0	0	0	10	10	38	57	72	72	63	64	37	37	0	0	0	0	0	0
NS06-08	UNNAMED	0	0	0	0	10	20	19	29	57	72	63	63	60	37	37	0	0	0	0	0	0
NS07-07	BEAUFORT TERRACE	0	0	0	0	10	20	19	19	48	50	36	54	46	37	32	0	0	0	0	0	0
NS07-08	UNNAMED	0	0	0	0	0	5	5	10	52	50	54	54	51	28	14	0	0	0	0	0	0
NS08-07	UNNAMED	0	0	0	0	0	0	0	0	38	36	54	36	37	37	18	0	0	0	0	0	0
72 Degrees North Latitude																						
NR05-01	DEASE INLET	0	0	0	0	0	0	14	38	90	86	81	81	92	83	64	4	0	0	0	0	0
NR05-02	HARRISON BAY NORTH	0	0	0	0	0	0	5	38	71	81	86	86	92	69	55	4	0	0	0	0	0
NR06-01	BEECHEY POINT NORTH	5	5	0	0	5	5	10	52	71	81	90	90	83	74	46	8	0	0	0	0	0
NR06-02	FLAXMAN ISLAND N.	10	10	0	0	15	20	29	57	76	72	81	81	64	55	23	16	0	0	0	0	0
NR07-01	UNNAMED	10	5	10	10	20	20	38	48	71	68	68	63	64	46	18	4	0	0	0	0	0
NR07-02	UNNAMED	0	10	15	15	15	15	14	14	67	54	63	63	69	37	23	0	0	0	0	0	0
71 Degrees North Latitude																						
NR05-03	TESHEKPUK	0	0	0	0	0	0	19	57	76	90	90	90	55	37	18	0	0	0	0	0	0
NR05-04	HARRISON BAY	0	0	0	0	0	0	19	57	76	90	81	81	92	64	46	0	0	0	0	0	0
NR06-03	BEECHEY POINT	5	0	0	5	10	0	19	52	76	81	86	81	74	55	46	12	0	0	0	0	0
NR06-04	FLAXMAN ISLAND	15	10	0	25	10	5	19	52	76	86	90	90	87	78	69	12	0	0	0	0	0
NR07-03	BARTER ISLAND	10	25	0	15	20	20	62	71	81	90	86	86	78	87	69	16	0	0	0	0	0
NR07-04	MACKENZIE CANYON N.	0	20	20	29	29	29	57	76	86	90	72	72	74	83	55	16	0	0	0	0	0
70 Degrees North Latitude																						
NR07-05	DEMARCATION POINT	0	0	0	20	39	39	76	76	95	90	90	90	55	55	37	0	0	0	0	0	0
NR07-06	MACKENZIE CANYON	40	40	20	39	98	78	76	95	95	90	90	90	92	92	55	16	0	0	0	0	0

7.6.4 Scenario 8.4 Results

Scenario 8.4 covers the situation where both a relief well and SCCE can be safely deployed in the Beaufort Sea with sea ice operating capability. A minimum of four Polar class ice management vessels are assumed for this scenario where SCCE can be deployed in 0 to 7 tenths ice coverage while relief well drilling with an ice class drilling vessel can continue up to 8 tenths ice coverage. The relief well also has higher sea state tolerance during deployment (see table 7-11 above). Thus, 0 to 7 tenths ice concentration and 6.6 foot (2 meters) significant wave height limits for SCCE deployment are the limiting criteria for this scenario and the results for this scenario are the same as for 6.4 above. Table 7-23 presents the results for this scenario below.

Table 7-23. Scenario 8.4: Percent probability of safe deployment of both SCCE and a relief well with sea ice operating capability in the Beaufort Sea, 2012-2016.

OPD	OPD Name	June			July			Aug			September			October			November			December		
		1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
NS05-03	UNNAMED	0	0	0	0	0	0	0	0	24	36	42	42	56	33	33	0	0	0	0	0	0
NS05-04	UNNAMED	0	0	0	0	0	0	0	0	29	41	45	54	55	48	33	0	0	0	0	0	0
NS06-03	UNNAMED	0	0	0	0	0	0	0	10	38	45	54	54	55	38	29	0	0	0	0	0	0
74Degrees North Latitude																						
NS05-05	UNNAMED	0	0	0	0	0	0	15	15	43	42	64	64	71	42	37	15	0	0	0	0	0
NS05-06	UNNAMED	0	0	0	0	0	0	5	10	38	71	54	73	69	37	37	10	0	0	0	0	0
NS06-05	UNNAMED	0	0	0	0	0	0	0	34	33	65	64	69	55	37	37	0	0	0	0	0	0
NS06-06	UNNAMED	0	0	0	0	10	10	10	24	29	65	59	54	55	37	37	0	0	0	0	0	0
NS07-05	UNNAMED	0	0	0	0	10	5	5	19	24	46	54	55	56	37	33	0	0	0	0	0	0
NS07-06	UNNAMED	0	0	0	0	0	0	0	34	38	37	54	51	47	38	24	0	0	0	0	0	0
NS08-05	UNNAMED	0	0	0	0	0	0	0	29	38	37	54	46	37	28	9	0	0	0	0	0	0
73 Degrees North Latitude																						
NS05-07	BARROW CANYON	0	0	15	0	0	20	20	49	82	73	87	74	83	85	47	15	5	0	0	0	0
NS05-08	CANADA BASIN WEST	0	0	0	0	0	20	25	44	67	73	72	54	79	67	37	0	0	0	0	0	0
NS06-07	CANADA BASIN	0	5	15	0	5	15	25	38	57	87	82	83	69	57	37	0	0	0	0	0	0
NS06-08	UNNAMED	0	5	15	0	10	20	19	29	62	87	68	68	75	47	37	5	0	0	0	0	0
NS07-07	BEAUFORT TERRACE	0	5	5	5	10	20	29	29	48	70	51	64	51	42	37	5	0	0	0	0	0
NS07-08	UNNAMED	0	0	5	5	0	5	5	20	52	55	59	59	56	28	24	0	0	0	0	0	0
NS08-07	UNNAMED	0	0	0	0	0	0	0	20	38	36	54	36	37	37	18	0	0	0	0	0	0
72 Degrees North Latitude																						
NR05-01	DEASE INLET	0	0	0	10	35	40	49	73	95	91	81	81	92	93	94	34	35	0	0	0	0
NR05-02	HARRISON BAY NORTH	0	5	0	5	30	45	55	58	86	91	86	86	87	94	75	24	5	0	0	0	0
NR06-01	BEECHEY POINT NORTH	15	15	15	0	30	40	45	72	76	91	90	90	93	94	71	38	0	0	0	0	0
NR06-02	FLAXMAN ISLAND N.	20	15	20	10	30	40	49	77	76	87	86	86	84	85	73	26	0	0	0	0	0
NR07-01	UNNAMED	15	15	30	25	30	35	53	73	71	88	83	78	74	76	68	9	0	0	0	0	0
NR07-02	UNNAMED	0	15	15	20	30	25	24	34	72	69	63	68	74	72	53	0	0	0	0	0	0
71 Degrees North Latitude																						
NR05-03	TESHEKPUK	0	0	0	0	80	60	99	97	96	90	90	90	95	77	78	20	20	0	0	0	0
NR05-04	HARRISON BAY	0	0	0	20	80	60	89	97	96	90	91	91	92	94	86	20	10	0	0	0	0
NR06-03	BEECHEY POINT	5	5	5	15	65	60	84	82	96	91	91	91	94	95	81	17	0	10	0	0	0
NR06-04	FLAXMAN ISLAND	15	20	25	35	60	75	84	82	96	91	90	90	92	93	94	37	0	15	0	0	0
NR07-03	BARTER ISLAND	20	40	50	50	60	90	67	86	91	90	91	91	93	92	94	26	10	5	0	0	0
NR07-04	MACKENZIE CANYON N.	0	40	50	59	49	79	67	76	86	90	92	92	94	93	95	16	10	0	0	0	0
70 Degrees North Latitude																						
NR07-05	DEMARCATION POINT	60	40	80	80	99	99	96	96	95	90	90	90	95	95	97	60	20	20	0	0	0
NR07-06	MACKENZIE CANYON	60	80	80	99	98	98	96	95	95	90	90	90	92	92	75	36	20	20	0	0	0

7.7 Task 9 Results: When, and for what duration, metocean conditions over the past 5-years, would have supported safe deployment of neither SCCE nor a relief well alone in response to a loss-of-well situation in Arctic conditions

7.7.1 Scenario 9.1 Results

Scenario 9.1 covers the potential for when neither SCCE nor a relief well can be deployed in the Chukchi Sea during the open water season typically from late-July or early-August to early October, depending on the location. This scenario assumes that two Polar class ice management vessels are in attendance and that both the relief well and SCCE operations require open water with a 30 nautical mile radius no ice-buffer zone. Since the relief well operation has a higher probability of deployment due to higher criterion limits including 9.8 foot (3 meter) significant wave height versus 6.6 feet (2 meters) for SCCE deployment, the 9.8 foot (3 meter) significant wave height is the limiting criterion for this scenario above which neither technology can be deployed. The results for scenario 9.1 are presented below in table 7-24.

The results in table 7-24 show extended durations of very low (10 percent or less) probability where neither SCCE nor a relief well can be deployed. These durations range from 30 to 110 days below the 71st parallel. Above the 71st parallel, the percent probability that neither technology can be deployed increases with increasing ice coverage to the north to the point where above the 74th parallel, the percent probability that neither technology can be deployed is 100 percent from June to mid-August and November through December.

Table 7-24. Scenario 9.1: Percent probability of neither safe SCCE nor relief well deployment in open water in the Chukchi Sea, 2012-2016.

OPD #	OPD Name	June			July			Aug			September			October			November			December		
		1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
NS02-04	UNNAMED	100	100	100	100	100	100	100	100	100	72	53	53	23	62	81	100	100	100	100	100	100
NS03-03	UNNAMED	100	100	100	100	100	100	100	100	95	72	53	53	28	81	81	100	100	100	100	100	100
NS03-04	UNNAMED	100	100	100	100	100	100	100	100	70	72	57	57	38	81	95	100	100	100	100	100	100
NS04-03	UNNAMED	100	100	100	100	100	100	100	100	75	76	38	48	52	76	81	100	100	100	100	100	100
NS04-04	UNNAMED	100	100	100	100	100	100	100	100	80	81	43	67	62	81	90	100	100	100	100	100	100
74 Degrees Latitude North																						
NS02-06	UNNAMED	100	100	100	100	100	100	100	90	90	72	34	15	33	52	90	100	100	100	100	100	100
NS03-05	UNNAMED	100	100	100	100	100	100	100	95	80	72	38	19	23	42	86	100	100	100	100	100	100
NS03-06	UNNAMED	100	100	100	100	100	100	100	100	70	34	43	29	9	33	71	100	100	100	100	100	100
NS04-05	UNNAMED	100	100	100	100	100	100	100	100	41	43	19	38	4	52	62	100	100	100	100	100	100
NS04-06	UNNAMED	100	100	100	100	100	100	100	100	60	72	24	43	57	62	62	100	100	100	100	100	100
73 Degrees Latitude North																						
NS02-08	UNNAMED	100	100	100	100	100	80	80	70	51	43	43	15	14	23	33	66	100	92	96	96	96
NS03-07	UNNAMED	100	100	100	100	100	85	80	80	55	57	34	15	4	14	42	75	87	92	98	96	100
NS03-08	UNNAMED	100	100	100	100	100	95	85	85	70	53	38	19	4	14	38	100	96	100	100	100	100
NS04-07	UNNAMED	100	100	100	100	100	100	90	90	75	29	29	24	18	14	42	96	100	100	100	100	100
NS04-08	UNNAMED	100	100	100	100	100	100	100	90	11	24	10	24	4	33	57	100	100	100	100	100	100
72 Degrees Latitude North																						
NR02-02	TISON	100	100	100	100	80	70	41	41	11	5	5	5	4	4	4	41	66	50	92	96	92
NR03-01	KARO	100	100	100	95	75	80	51	31	26	24	10	5	4	4	4	46	66	75	96	100	100
NR03-02	POSEY	100	100	100	90	95	95	70	80	55	57	34	5	4	4	4	66	87	100	100	100	100
NR04-01	HANNA SHOAL	100	100	100	100	100	95	85	75	60	24	34	15	4	4	18	87	100	100	100	100	100
NR04-02	BARROW	100	100	100	95	95	95	80	55	16	15	15	10	4	9	33	100	100	100	100	100	100
71 Degrees Latitude North																						
NR02-04	STUDDS	100	100	100	100	60	60	21	1	1	5	5	5	4	4	4	16	41	50	96	100	100
NR03-03	COLBERT	95	90	85	85	46	26	6	1	1	5	5	5	4	4	4	33	50	58	96	100	100
NR-03-04	SOLIVIK ISLAND	100	95	70	75	51	21	11	1	11	5	10	5	4	4	9	41	71	83	98	100	100
NR04-03	WAINWRIGHT	100	100	80	74	60	67	34	34	8	18	11	5	4	10	36	78	89	94	100	100	100
NR04-04	MEADE RIVER	100	100	100	80	80	60	41	21	1	5	5	5	4	4	23	100	100	100	100	100	100
70 Degrees Latitude North																						
NR02-06	CHUKCHI SEA	100	90	51	51	21	21	11	1	1	5	5	5	4	4	4	16	33	50	88	100	100
NR-03-05	POINT LAY WEST	100	85	60	41	1	6	1	1	1	5	5	5	4	4	4	25	54	75	98	100	100
NR-03-06	POINT LAY	70	85	60	51	1	1	1	1	1	5	10	10	9	28	57	83	92	100	100	100	100
69 Degrees Latitude North																						
NR02-08	POINT HOPE WEST	100	60	31	31	1	1	1	1	1	5	5	5	4	4	4	16	41	66	84	100	100
NR03-07	POINT HOPE	100	70	46	36	6	1	1	1	1	5	5	5	4	4	4	46	66	83	100	100	100
NR03-08	DELONG MOUNTAINS	60	80	80	60	21	1	1	1	1	5	5	5	4	4	42	100	100	100	100	100	100

7.7.2 Scenario 9.2 Results

Scenario 9.2 represents the situation where neither SCCE nor a relief well can be deployed with sea ice operating capability in the Chukchi Sea. This scenario assumes that a minimum of four Polar class ice management vessels are available to support operations. SCCE for this scenario can be deployed in 0 to 7 tenths ice coverage and relief well drilling operations can be conducted in 0 to 8 tenths ice coverage. SCCE is also limited to 6.6 foot (2 meter) significant wave height criteria versus the 9.8 foot (3 meter) significant wave height deployment limit for the relief well rig. Thus, ice conditions greater than 8 tenths concentration and the 9.8 foot (3 meter) significant wave height are the limiting criteria for this scenario, above which neither technology can be deployed. The results for scenario 9.2 are presented below in table 7-25.

The results in table 7-25 show extended durations of very low (10 percent or less) probability that neither SCCE nor a relief well can be deployed. These durations range from 80 to 170 days below the 71st parallel. Above the 71st parallel, the percent probability that neither technology can be deployed increases with increasing ice coverage to the north to the point where above the 74th parallel, the percent probability that neither technology can be deployed is 100 percent for any time periods from June to mid-July and November through December.

Table 7-25. Scenario 9.2: Percent probability of safe deployment of neither SCCE nor a relief well with sea ice operating capability in the Chukchi Sea, 2012-2016.

OPD #	OPD Name	June			July			Aug			September			October			November			December		
		1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
NS02-04	UNNAMED	100	100	100	100	100	90	80	60	80	62	33	43	3	22	61	100	100	100	100	100	100
NS03-03	UNNAMED	100	100	100	100	100	90	80	80	60	62	43	43	8	26	61	100	100	100	100	100	100
NS03-04	UNNAMED	100	100	100	100	100	90	90	95	55	52	47	42	23	56	65	100	100	100	100	100	100
NS04-03	UNNAMED	100	100	100	100	100	100	70	85	55	66	33	43	7	56	61	100	100	100	100	100	100
NS04-04	UNNAMED	100	100	100	100	80	90	80	90	50	56	38	57	27	61	60	95	100	100	100	100	100
74 Degrees North Latitude																						
NS02-06	UNNAMED	100	100	90	90	90	80	80	80	50	52	24	5	13	12	60	90	100	100	100	100	100
NS03-05	UNNAMED	100	100	100	95	100	80	65	60	55	47	33	14	13	12	46	95	100	100	100	100	100
NS03-06	UNNAMED	100	100	100	100	100	95	75	60	45	34	43	24	9	3	46	100	100	100	100	100	100
NS04-05	UNNAMED	100	100	100	100	95	80	70	60	26	33	9	28	4	17	62	80	100	100	100	100	100
NS04-06	UNNAMED	100	100	95	100	100	70	60	65	25	47	9	28	12	52	62	85	100	100	100	100	100
73 Degrees North Latitude																						
NS02-08	UNNAMED	100	100	100	80	80	60	20	20	31	33	23	5	14	3	23	36	40	62	95	95	85
NS03-07	UNNAMED	100	100	100	80	60	60	40	30	25	22	29	5	4	4	7	50	52	72	92	90	85
NS03-08	UNNAMED	100	100	100	80	60	70	50	55	35	18	38	14	4	4	13	75	81	85	100	95	100
NS04-07	UNNAMED	100	100	100	95	90	95	50	40	30	19	29	14	18	14	22	76	100	90	100	100	100
NS04-08	UNNAMED	100	100	100	85	90	90	70	45	11	24	5	24	4	3	47	75	90	100	100	100	100
72 Degrees North Latitude																						
NR02-02	TISON	100	100	100	80	20	20	11	11	1	5	5	5	4	4	4	21	26	50	89	85	89
NR03-01	KARO	100	90	80	60	25	15	16	11	11	4	10	5	4	4	4	20	36	55	85	80	80
NR03-02	POSEY	100	100	85	80	60	20	20	15	10	17	34	5	4	4	4	56	57	65	95	95	100
NR04-01	HANNA SHOAL	95	95	100	80	70	35	25	20	5	4	29	10	4	4	3	57	80	100	100	100	100
NR04-02	BARROW	75	90	90	75	55	35	35	15	1	5	10	10	4	4	8	55	75	90	100	100	100
71 Degrees North Latitude																						
NR02-04	STUDDS	80	100	70	70	20	30	21	1	1	5	5	5	4	4	4	16	31	50	65	80	80
NR03-03	COLBERT	60	60	40	30	16	1	1	1	1	5	5	5	4	4	4	18	30	48	65	80	85
NR-03-04	SOLIVIK ISLAND	60	50	45	40	16	1	1	1	6	5	10	5	4	4	4	21	46	53	67	100	100
NR04-03	WAINWRIGHT	60	47	47	54	14	7	7	1	1	4	11	5	4	4	3	4	55	81	87	100	100
NR04-04	MEADE RIVER	20	60	40	60	0	20	1	1	1	5	5	5	4	4	3	20	60	80	100	100	100
70 Degrees North Latitude																						
NR02-06	CHUKCHI SEA	80	60	11	11	11	11	1	1	1	5	5	5	4	4	4	16	23	30	54	80	80
NR-03-05	POINT LAY WEST	45	30	5	6	1	1	1	1	1	5	5	5	4	4	4	14	19	45	62	95	100
NR-03-06	POINT LAY	35	25	5	6	1	1	1	1	1	5	5	5	4	3	7	38	52	95	95	100	100
69 Degrees North Latitude																						
NR02-08	POINT HOPE WEST	30	0	1	1	1	1	1	1	1	5	5	5	4	4	4	16	11	26	58	80	100
NR03-07	POINT HOPE	10	5	1	1	6	1	1	1	1	5	5	5	4	4	4	10	11	53	65	90	100
NR03-08	DELONG MOUNTAINS	40	20	0	0	21	1	1	1	1	5	5	5	4	4	22	40	80	100	80	80	100

7.7.3 Scenario 9.3 Results

Scenario 9.3 covers the potential for when neither SCCE nor a relief well can be deployed in the Beaufort Sea during the open water season typically from mid to late-August to early October in the historically active exploration area. This scenario assumes that two Polar class ice management vessels are in attendance and that both the relief well and SCCE operations require open water with a 30 nautical mile radius no ice-buffer zone. Since the relief well operation has a higher probability of deployment due to higher criteria limits including 9.8 foot (3 meter) significant wave height versus 6.6 feet (2 meters) for SCCE deployment, the 9.8 foot (3 meter) significant wave height is the limiting criterion for this scenario above which neither technology can be deployed. The results for scenario 9.3 are presented below in table 7-26.

The results in table 7-26 show limited durations of low (20 percent or less) probability where neither SCCE nor a relief well can be deployed. These durations range from 20 to 70 days below the 71st parallel. Above the 71st parallel, the percent probability that neither technology can be deployed increases with increasing ice coverage to the north with no probability of less than 20 percent above the 72nd parallel.

Table 7-26. Scenario 9.3: Percent probability of neither safe relief well nor SCCE deployment in open water in the Beaufort Sea, 2012-2016.

OPD	OPD Name	June			July			Aug			September			October			November			December		
		1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
NS05-03	UNNAMED	100	100	100	100	100	100	100	100	81	63	67	67	59	77	77	100	100	100	100	100	100
NS05-04	UNNAMED	100	100	100	100	100	100	100	100	81	63	54	44	45	72	82	100	100	100	100	100	100
NS06-03	UNNAMED	100	100	100	100	100	100	100	95	66	54	44	44	45	77	86	100	100	100	100	100	100
74Degrees North Latitude																						
NS05-05	UNNAMED	100	100	100	100	100	100	100	100	66	67	44	44	54	63	63	100	100	100	100	100	100
NS05-06	UNNAMED	100	100	100	100	100	100	100	100	61	58	44	35	36	63	63	100	100	100	100	100	100
NS06-05	UNNAMED	100	100	100	100	100	100	100	76	66	49	40	44	45	63	63	100	100	100	100	100	100
NS06-06	UNNAMED	100	100	100	100	100	95	95	81	71	54	44	44	45	63	68	100	100	100	100	100	100
NS07-05	UNNAMED	100	100	100	100	100	95	95	81	81	58	44	49	54	63	77	100	100	100	100	100	100
NS07-06	UNNAMED	100	100	100	100	100	100	100	71	61	67	44	58	63	77	86	100	100	100	100	100	100
NS08-05	UNNAMED	100	100	100	100	100	100	100	71	61	72	44	63	63	82	91	100	100	100	100	100	100
73 Degrees North Latitude																						
NS05-07	BARROW CANYON	100	100	100	100	100	100	100	81	32	35	21	40	22	40	63	100	100	100	100	100	100
NS05-08	CANADA BASIN WEST	100	100	100	100	100	100	100	85	42	35	26	44	26	63	63	100	100	100	100	100	100
NS06-07	CANADA BASIN	100	100	100	100	100	90	90	61	42	26	26	35	36	63	63	100	100	100	100	100	100
NS06-08	UNNAMED	100	100	100	100	90	80	81	71	42	26	35	35	40	63	63	100	100	100	100	100	100
NS07-07	BEAUFORT TERRACE	100	100	100	100	90	80	81	81	52	49	63	44	54	63	68	100	100	100	100	100	100
NS07-08	UNNAMED	100	100	100	100	100	95	95	90	47	49	44	44	49	72	86	100	100	100	100	100	100
NS08-07	UNNAMED	100	100	100	100	100	100	100	100	61	63	44	63	63	63	82	100	100	100	100	100	100
72 Degrees North Latitude																						
NR05-01	DEASE INLET	100	100	100	100	100	100	85	61	8	12	16	16	8	17	36	96	100	100	100	100	100
NR05-02	HARRISON BAY NORTH	100	100	100	100	100	100	95	61	27	16	12	12	8	31	45	96	100	100	100	100	100
NR06-01	BEECHEY POINT NORTH	95	95	100	100	95	95	90	47	27	16	7	7	17	26	54	92	100	100	100	100	100
NR06-02	FLAXMAN ISLAND N.	90	90	100	100	85	80	71	42	22	26	16	16	36	45	77	84	100	100	100	100	100
NR07-01	UNNAMED	90	95	90	90	80	80	61	52	27	30	30	35	36	54	82	96	100	100	100	100	100
NR07-02	UNNAMED	100	90	85	85	85	85	85	85	32	44	35	35	31	63	77	100	100	100	100	100	100
71 Degrees North Latitude																						
NR05-03	TESHEKPUK	100	100	100	100	100	100	81	42	22	7	7	7	45	63	82	100	100	100	100	100	100
NR05-04	HARRISON BAY	100	100	100	100	100	100	81	42	22	7	16	16	8	36	54	100	100	100	100	100	100
NR06-03	BEECHEY POINT	95	100	100	95	90	100	81	47	22	16	12	16	26	45	54	88	100	100	100	100	100
NR06-04	FLAXMAN ISLAND	85	90	100	76	90	95	81	47	22	12	7	7	13	22	31	88	100	100	100	100	100
NR07-03	BARTER ISLAND	90	75	100	85	80	80	37	27	18	7	12	12	22	13	31	84	100	100	100	100	100
NR07-04	MACKENZIE CANYON N.	100	80	80	71	71	71	42	22	13	7	26	26	26	17	45	84	100	100	100	100	100
70 Degrees North Latitude																						
NR07-05	DEMARCATION POINT	100	100	100	80	61	61	22	22	3	7	7	7	45	45	63	100	100	100	100	100	100
NR07-06	MACKENZIE CANYON	60	60	80	61	2	22	22	3	3	7	7	7	8	8	45	84	100	100	100	100	100

7.7.4 Scenario 9.4 Results

Scenario 9.4 covers the possibility where neither SCCE nor a relief well can be deployed in the Beaufort Sea with sea ice operating capability. This scenario assumes that a minimum of four Polar class ice management vessels are available to support operations. SCCE for this scenario can be deployed in 0 to 7 tenths ice coverage and relief well drilling operations can be conducted in 0 to 8 tenths ice coverage. Thus, ice conditions greater than 8 tenths coverage is the limiting criterion for this scenario where neither technology can be deployed. Relief well drilling also has higher deployment criteria for sea state conditions. The results for scenario 9.4 are presented below in table 7-27.

The results in table 7-27 show extended durations of very low (10 percent or less) probability that neither SCCE nor a relief well can be deployed. These durations range from 60 to 110 days below the 71st parallel. Above the 71st parallel, the probability that neither technology can be deployed increases modestly during the primary operating season and continues to increase as ice coverage to the north increases to the point where above the 73rd parallel, nearly all percent probabilities are 40 percent or greater that neither SCCE or a relief well can be safely deployed for any time periods during the period of September and October.

Table 7-27. Scenario 9.4: Percent probability of safe deployment of neither SCCE nor a relief well with sea ice operating capability in the Beaufort Sea, 2012-2016.

OPD	OPD Name	June			July			Aug			September			October			November			December		
		1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
NS05-03	UNNAMED	100	100	100	100	100	100	100	100	71	63	57	57	44	67	67	100	100	100	100	100	100
NS05-04	UNNAMED	100	100	100	100	100	100	100	100	71	58	54	44	45	52	67	100	100	100	100	100	100
NS06-03	UNNAMED	100	100	100	100	95	100	95	90	61	54	44	44	45	62	71	100	100	100	100	100	100
74 Degrees North Latitude																						
NS05-05	UNNAMED	100	100	100	100	100	100	85	85	56	57	34	34	29	53	63	85	100	100	100	100	100
NS05-06	UNNAMED	100	100	100	100	100	95	90	90	61	28	44	25	26	63	63	80	100	100	100	100	100
NS06-05	UNNAMED	100	100	100	95	100	100	95	66	66	34	35	29	45	63	63	100	100	100	100	100	100
NS06-06	UNNAMED	100	100	95	100	85	80	90	76	66	34	39	44	45	63	63	100	100	100	100	100	100
NS07-05	UNNAMED	100	100	100	95	90	95	95	81	76	53	44	44	44	63	67	100	100	100	100	100	100
NS07-06	UNNAMED	100	100	100	100	100	100	100	66	61	62	44	48	53	62	76	100	100	100	100	100	100
NS08-05	UNNAMED	100	100	100	100	100	100	100	71	61	62	44	53	63	72	91	100	100	100	100	100	100
73 Degrees North Latitude																						
NS05-07	BARROW CANYON	100	100	85	100	100	70	70	51	17	25	11	25	17	15	48	85	95	100	100	100	100
NS05-08	CANADA BASIN WEST	100	95	100	100	100	70	75	55	32	25	26	44	16	28	63	95	100	100	100	100	100
NS06-07	CANADA BASIN	100	95	85	100	95	85	75	61	42	11	16	15	26	33	58	100	100	100	100	100	100
NS06-08	UNNAMED	100	90	85	100	80	75	68	66	37	11	30	30	25	48	63	95	100	100	100	100	100
NS07-07	BEAUFORT TERRACE	100	95	90	90	90	80	66	71	52	29	48	34	49	58	63	95	100	100	100	100	100
NS07-08	UNNAMED	100	100	95	95	100	95	90	80	47	44	39	39	44	47	46	100	100	100	100	100	100
NS08-07	UNNAMED	100	100	80	80	100	100	100	80	61	63	44	63	63	63	82	100	100	100	100	100	100
72 Degrees North Latitude																						
NR05-01	DEASE INLET	100	100	100	85	60	60	50	26	3	7	16	16	8	7	6	61	60	100	100	100	100
NR05-02	HARRISON BAY NORTH	100	95	100	95	70	50	45	41	12	6	12	12	13	6	25	66	85	90	100	100	100
NR06-01	BEECHEY POINT NORTH	85	85	85	95	70	35	50	27	22	6	7	7	7	6	29	62	100	90	100	100	100
NR06-02	FLAXMAN ISLAND N.	80	85	80	85	65	55	46	22	22	11	11	11	16	15	27	74	100	100	100	100	100
NR07-01	UNNAMED	85	80	65	70	70	60	46	22	27	10	15	20	21	19	27	86	100	100	100	100	100
NR07-02	UNNAMED	100	85	85	80	70	75	70	65	27	29	35	30	21	23	47	100	100	100	100	100	100
71 Degrees North Latitude																						
NR05-03	TESHEKPUK	100	100	80	60	0	40	1	2	2	7	7	7	5	3	22	40	20	20	20	40	40
NR05-04	HARRISON BAY	100	100	100	80	20	40	11	2	2	7	6	6	8	6	4	80	80	90	90	80	70
NR06-03	BEECHEY POINT	95	95	95	80	30	35	16	17	2	6	7	6	6	5	9	68	95	80	100	100	100
NR06-04	FLAXMAN ISLAND	85	80	75	66	35	20	16	17	2	7	7	7	8	7	6	63	100	80	100	100	100
NR07-03	BARTER ISLAND	80	60	50	50	30	10	32	12	8	7	7	7	7	8	6	69	90	90	100	100	100
NR07-04	MACKENZIE CANYON N.	100	50	50	41	41	21	32	22	13	7	6	6	6	7	5	84	90	100	100	100	100
70 Degrees North Latitude																						
NR07-05	DEMARCATION POINT	40	40	20	20	1	1	2	2	3	7	7	7	5	5	3	40	80	80	100	100	100
NR07-06	MACKENZIE CANYON	40	20	20	1	2	2	2	3	3	7	7	7	8	8	25	64	80	80	100	100	100

7.8 Task 10 Results: When, and for what duration, metocean conditions over the past 5-years, would have supported safe deployment of one method of response to a loss-of-well situation in Arctic conditions, but would have precluded the other method.

7.8.1 Scenario 10.1 Results

Scenario 10.1 represents the scenario where a relief well would be deployable in open water but not SCCE in the Chukchi Sea planning area. This scenario assumes that two Polar class ice management vessels are available to support operations and both SCCE and the relief well require open water with a 30 nautical mile radius no-ice buffer zone. The results for scenario 10.1 are presented below in table 7-28.

The results in table 7-28 show that a relief well has a higher probability of deployment during the open water operation season in the Chukchi Sea. The relief well deployment criteria are higher than those for SCCE and therefore, the relief well has a higher deployment probability. The probabilities shown in table 7-28 indicate that the relief well has approximately 10 to 20 percent higher probability for deployment during the August to October open water period. Table 7-28 also shows that September has the lowest probabilities for open water SCCE deployment due to the higher wave heights that occur during this month.

Table 7-28. Scenario 10.1: Percent probability that safe deployment of a relief well is possible but not SCCE in open water in the Chukchi Sea, 2012-2016.

OPD #	OPD Name	June			July			Aug			September			October			November			December		
		1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
NS02-04	UNNAMED	0	0	0	0	0	0	0	0	0	5	9	9	7	4	2	0	0	0	0	0	0
NS03-03	UNNAMED	0	0	0	0	0	0	0	0	1	5	9	9	7	2	2	0	0	0	0	0	0
NS03-04	UNNAMED	0	0	0	0	0	0	0	0	4	5	8	8	6	2	0	0	0	0	0	0	0
NS04-03	UNNAMED	0	0	0	0	0	0	0	0	3	5	12	10	5	2	2	0	0	0	0	0	0
NS04-04	UNNAMED	0	0	0	0	0	0	0	0	2	4	11	6	4	2	1	0	0	0	0	0	0
74 Degrees Latitude North																						
NS02-06	UNNAMED	0	0	0	0	0	0	0	1	1	5	13	16	6	5	1	0	0	0	0	0	0
NS03-05	UNNAMED	0	0	0	0	0	0	0	1	2	5	12	15	7	5	1	0	0	0	0	0	0
NS03-06	UNNAMED	0	0	0	0	0	0	0	0	4	13	11	14	9	6	3	0	0	0	0	0	0
NS04-05	UNNAMED	0	0	0	0	0	0	0	0	7	11	15	12	9	5	4	0	0	0	0	0	0
NS04-06	UNNAMED	0	0	0	0	0	0	0	0	5	5	14	11	4	4	4	0	0	0	0	0	0
73 Degrees Latitude North																						
NS02-08	UNNAMED	0	0	0	0	0	0	2	4	6	11	11	16	8	7	6	0	0	0	0	0	0
NS03-07	UNNAMED	0	0	0	0	0	0	2	2	5	8	13	16	9	8	5	0	0	0	0	0	0
NS03-08	UNNAMED	0	0	0	0	0	0	2	2	4	9	12	15	9	8	6	0	0	0	0	0	0
NS04-07	UNNAMED	0	0	0	0	0	0	1	1	3	14	14	14	8	8	5	0	0	0	0	0	0
NS04-08	UNNAMED	0	0	0	0	0	0	0	1	11	14	17	14	9	6	4	0	0	0	0	0	0
72 Degrees Latitude North																						
NR02-02	TISON	0	0	0	0	0	0	7	7	11	18	18	18	9	9	9	0	0	0	0	0	0
NR03-01	KARO	0	0	0	0	0	0	6	8	9	14	17	18	9	9	9	0	0	0	0	0	0
NR03-02	POSEY	0	0	0	0	0	0	4	2	5	8	13	18	9	9	9	0	0	0	0	0	0
NR04-01	HANNA SHOAL	0	0	0	0	0	0	2	3	5	14	13	16	9	9	8	0	0	0	0	0	0
NR04-02	BARROW	0	0	0	0	0	0	2	5	10	16	16	17	9	9	6	0	0	0	0	0	0
71 Degrees Latitude North																						
NR02-04	STUDDS	0	0	0	0	0	0	10	12	12	18	18	18	9	9	9	0	0	0	0	0	0
NR03-03	COLBERT	0	0	0	0	0	0	11	12	12	18	18	18	9	9	9	0	0	0	0	0	0
NR-03-04	SOLIVIK ISLAND	0	0	0	0	0	0	11	12	11	18	17	18	9	9	9	0	0	0	0	0	0
NR04-03	WAINWRIGHT	0	0	0	0	0	0	8	8	11	16	17	18	9	8	6	0	0	0	0	0	0
NR04-04	MEADE RIVER	0	0	0	0	0	0	7	10	12	18	18	18	9	9	7	0	0	0	0	0	0
70 Degrees Latitude North																						
NR02-06	CHUKCHI SEA	0	0	0	0	0	0	11	12	12	18	18	18	9	9	9	0	0	0	0	0	0
NR-03-05	POINT LAY WEST	0	0	0	0	0	0	12	12	12	18	18	18	9	9	9	0	0	0	0	0	0
NR-03-06	POINT LAY	0	0	0	0	0	0	12	12	12	18	17	17	9	7	4	0	0	0	0	0	0
69 Degrees Latitude North																						
NR02-08	POINT HOPE WEST	0	0	0	0	0	0	12	12	12	18	18	18	9	9	9	0	0	0	0	0	0
NR03-07	POINT HOPE	0	0	0	0	0	0	12	12	12	18	18	18	9	9	9	0	0	0	0	0	0
NR03-08	DELONG MOUNTAINS	0	0	0	0	0	0	12	12	12	18	18	18	9	9	5	0	0	0	0	0	0

7.8.2 Scenario 10.2 Results

Scenario 10.2 covers the situation where a relief well or SCCE would be deployable in the Chukchi Sea planning area with sea ice operating capability. Again, as with other scenarios above, the relief well scenario has higher critical deployment criteria tolerance for wave height and sea ice concentration versus SCCE deployment. This scenario also assumes that four Polar class ice management vessels are available to support operations. The results for scenario 10.2 are presented below in table 7-29.

The results in table 7-29 show that the relief well has a 5 to 20 percent greater deployment probability over much of the June through December timeframe. The data also show that during the open water season SCCE deployment probability is reduced due to the higher wave heights that are typically encountered in August and September; these wave heights have a greater impact to SCCE deployment than to relief well deployment. Higher probabilities for relief well deployment are also evident during the sea ice season and the result of slightly higher sea ice concentration criteria for relief well deployment than for SCCE deployment.

Table 7-29. Scenario 10.2: Percent probability that safe deployment of a relief well is possible but not SCCE with sea ice operating capability in the Chukchi Sea, 2012-2016.

OPD #	OPD Name	June			July			Aug			September			October			November			December		
		1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
NS02-04	UNNAMED	0	0	0	0	0	0	0	10	0	5	9	9	7	4	2	0	0	0	0	0	0
NS03-03	UNNAMED	0	0	0	0	0	5	15	10	21	5	9	9	7	2	2	0	0	0	0	0	0
NS03-04	UNNAMED	0	0	0	0	0	10	0	0	4	5	8	13	6	7	10	0	0	0	0	0	0
NS04-03	UNNAMED	0	0	0	0	0	0	0	0	8	5	12	10	10	2	2	0	0	0	0	0	0
NS04-04	UNNAMED	0	0	0	0	10	10	5	0	7	9	11	11	14	12	11	5	0	0	0	0	0
74 Degrees North Latitude																						
NS02-06	UNNAMED	0	0	10	10	10	0	10	11	11	5	23	26	6	5	1	0	0	0	0	0	0
NS03-05	UNNAMED	0	0	0	5	0	10	20	11	7	5	12	15	7	5	11	0	0	0	0	0	0
NS03-06	UNNAMED	0	0	0	0	0	5	10	0	4	13	11	14	9	6	3	0	0	0	0	0	0
NS04-05	UNNAMED	0	0	0	0	5	20	15	10	7	11	15	12	9	15	4	20	0	0	0	0	0
NS04-06	UNNAMED	0	0	5	0	0	20	20	0	15	5	19	16	4	4	4	15	0	0	0	0	0
73 Degrees North Latitude																						
NS02-08	UNNAMED	0	0	0	0	0	10	22	4	16	11	21	26	8	7	6	20	10	0	0	0	0
NS03-07	UNNAMED	0	0	0	0	15	10	27	22	15	8	13	16	9	8	15	15	5	5	0	0	5
NS03-08	UNNAMED	0	0	0	0	5	10	27	17	9	9	12	15	9	8	6	0	0	0	0	0	0
NS04-07	UNNAMED	0	0	0	0	10	0	6	1	3	14	14	14	8	8	10	5	0	5	0	0	0
NS04-08	UNNAMED	0	0	0	10	10	10	0	1	11	14	17	14	9	6	4	10	0	0	0	0	0
72 Degrees North Latitude																						
NR02-02	TISON	0	0	0	0	10	10	7	7	11	18	18	18	9	9	9	0	0	0	0	0	0
NR03-01	KARO	0	5	5	5	10	5	6	8	9	14	17	18	9	9	9	5	10	0	0	0	0
NR03-02	POSEY	0	0	0	0	15	10	9	7	5	8	13	18	9	9	9	0	5	10	0	5	0
NR04-01	HANNA SHOAL	0	0	0	5	20	20	2	8	5	14	13	16	9	9	8	10	10	0	0	0	0
NR04-02	BARROW	5	5	5	10	0	20	12	5	10	16	16	17	9	9	6	15	5	0	0	0	0
71 Degrees North Latitude																						
NR02-04	STUDDS	20	0	0	10	0	10	10	12	12	18	18	18	9	9	9	0	0	0	10	0	0
NR03-03	COLBERT	10	5	20	5	0	0	11	12	12	18	18	18	9	9	9	0	0	0	10	0	5
NR-03-04	SOLIVIK ISLAND	10	0	5	5	10	0	11	12	11	18	17	18	9	9	9	0	5	10	10	0	0
NR04-03	WAINWRIGHT	0	0	0	0	7	0	8	8	11	16	17	18	9	8	6	7	7	0	0	0	0
NR04-04	MEADE RIVER	0	0	40	20	0	0	7	10	12	18	18	18	9	9	7	0	0	0	0	0	0
70 Degrees North Latitude																						
NR02-06	CHUKCHI SEA	10	10	10	0	0	0	11	12	12	18	18	18	9	9	9	0	10	0	10	0	0
NR-03-05	POINT LAY WEST	5	5	5	0	0	0	12	12	12	18	18	18	9	9	9	0	5	5	5	5	0
NR-03-06	POINT LAY	0	0	5	5	0	0	12	12	12	18	17	17	9	7	4	0	10	0	5	0	0
69 Degrees North Latitude																						
NR02-08	POINT HOPE WEST	0	0	0	0	0	0	12	12	12	18	18	18	9	9	9	0	20	0	0	20	0
NR03-07	POINT HOPE	15	10	0	0	0	0	12	12	12	18	18	18	9	9	9	0	10	5	15	5	0
NR03-08	DELONG MOUNTAINS	0	0	0	0	0	0	12	12	12	18	18	18	9	9	5	40	0	0	0	20	0

7.8.3 Scenario 10.3 Results

Scenario 10.3 represents the scenario where a relief well would be deployable in open water but not SCCE in the Beaufort Sea planning area. This scenario assumes that two Polar class ice management vessels are available to support operations and both SCCE and the relief well require open water with a 30 nautical mile radius no-ice buffer zone. The results for scenario 10.3 are presented below in table 7-30.

The results in table 7-30 show that in the Beaufort Sea planning area, the probability for open water relief well deployment is only slightly higher than for SCCE deployment. This is due to lower wave heights in the Beaufort Sea that increase the deployment probability for SCCE but do not result in a corresponding increase of probability for relief well deployment due to the higher wave height criteria limit for relief well deployment. The data also reflect that September is the month with the highest wave heights where SCCE deployment has less tolerance for high waves than relief well operations although the differences are very slight in this scenario.

Table 7-30. Scenario 10.3: Percent probability that safe deployment of a relief well is possible but not SCCE in open water in the Beaufort Sea, 2012-2016.

OPD	OPD Name	June			July			Aug			September			October			November			December		
		1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
NS05-03	UNNAMED	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0
NS05-04	UNNAMED	0	0	0	0	0	0	0	0	0	1	2	2	0	0	0	0	0	0	0	0	0
NS06-03	UNNAMED	0	0	0	0	0	0	0	0	1	2	2	2	0	0	0	0	0	0	0	0	0
74Degrees North Latitude																						
NS05-05	UNNAMED	0	0	0	0	0	0	0	0	1	1	2	2	0	0	0	0	0	0	0	0	0
NS05-06	UNNAMED	0	0	0	0	0	0	0	0	1	1	2	2	0	0	0	0	0	0	0	0	0
NS06-05	UNNAMED	0	0	0	0	0	0	0	1	1	2	2	2	0	0	0	0	0	0	0	0	0
NS06-06	UNNAMED	0	0	0	0	0	0	0	0	1	2	2	2	0	0	0	0	0	0	0	0	0
NS07-05	UNNAMED	0	0	0	0	0	0	0	0	0	1	2	2	0	0	0	0	0	0	0	0	0
NS07-06	UNNAMED	0	0	0	0	0	0	0	1	1	1	2	1	0	0	0	0	0	0	0	0	0
NS08-05	UNNAMED	0	0	0	0	0	0	0	1	1	1	2	1	0	0	0	0	0	0	0	0	0
73 Degrees North Latitude																						
NS05-07	BARROW CANYON	0	0	0	0	0	0	0	0	1	2	3	2	0	0	0	0	0	0	0	0	0
NS05-08	CANADA BASIN WEST	0	0	0	0	0	0	0	0	1	2	2	2	0	0	0	0	0	0	0	0	0
NS06-07	CANADA BASIN	0	0	0	0	0	0	0	1	1	2	2	2	0	0	0	0	0	0	0	0	0
NS06-08	UNNAMED	0	0	0	0	0	0	0	1	1	2	2	2	0	0	0	0	0	0	0	0	0
NS07-07	BEAUFORT TERRACE	0	0	0	0	0	0	0	0	1	2	1	2	0	0	0	0	0	0	0	0	0
NS07-08	UNNAMED	0	0	0	0	0	0	0	0	1	2	2	2	0	0	0	0	0	0	0	0	0
NS08-07	UNNAMED	0	0	0	0	0	0	0	0	1	1	2	1	0	0	0	0	0	0	0	0	0
72 Degrees North Latitude																						
NR05-01	DEASE INLET	0	0	0	0	0	0	0	1	2	3	3	3	0	0	0	0	0	0	0	0	0
NR05-02	HARRISON BAY NORTH	0	0	0	0	0	0	0	1	2	3	3	3	0	0	0	0	0	0	0	0	0
NR06-01	BEECHEY POINT NORTH	0	0	0	0	0	0	0	1	2	3	3	3	0	0	0	0	0	0	0	0	0
NR06-02	FLAXMAN ISLAND N.	0	0	0	0	0	0	1	1	2	2	3	3	0	0	0	0	0	0	0	0	0
NR07-01	UNNAMED	0	0	0	0	0	0	1	1	2	2	2	2	0	0	0	0	0	0	0	0	0
NR07-02	UNNAMED	0	0	0	0	0	0	0	0	1	2	2	2	0	0	0	0	0	0	0	0	0
71 Degrees North Latitude																						
NR05-03	TESHEKPUK	0	0	0	0	0	0	0	1	2	3	3	3	0	0	0	0	0	0	0	0	0
NR05-04	HARRISON BAY	0	0	0	0	0	0	0	1	2	3	3	3	0	0	0	0	0	0	0	0	0
NR06-03	BEECHEY POINT	0	0	0	0	0	0	0	1	2	3	3	3	0	0	0	0	0	0	0	0	0
NR06-04	FLAXMAN ISLAND	0	0	0	0	0	0	0	1	2	3	3	3	0	0	0	0	0	0	0	0	0
NR07-03	BARTER ISLAND	0	0	0	0	0	0	1	2	2	3	3	3	0	0	0	0	0	0	0	0	0
NR07-04	MACKENZIE CANYON N.	0	0	0	0	0	0	1	2	2	3	2	2	0	0	0	0	0	0	0	0	0
70 Degrees North Latitude																						
NR07-05	DEMARCATION POINT	0	0	0	0	0	0	2	2	2	3	3	3	0	0	0	0	0	0	0	0	0
NR07-06	MACKENZIE CANYON	0	0	0	0	0	0	2	2	2	3	3	3	0	0	0	0	0	0	0	0	0

7.8.4 Scenario 10.4 Results

Scenario 10.4, similar to 10.2 above, represents the situation in the Beaufort Sea planning area where a relief well could be deployable while SCCE would be unavailable due to the slightly lower ice conditions required for safe deployment. In this case, SCCE would be deployable in 0 to 7 tenths ice coverage conditions while a relief well with an ice class drilling vessel could operate in 0 to 8 tenths coverage. This scenario also assumes that four Polar class ice management vessels are available to support operations. The results for scenario 10.4 are presented below in table 7-31.

The results in table 7-31 show the differences in probability between relief well drilling and SCCE deployment during the sea ice season before and after the open water season. These probability differences are the result of the relief well sea ice deployment capability in 0 to 8 tenths ice concentration versus 0 to 7 tenths for SCCE deployment. Relief well drilling also has higher deployment criteria for sea state conditions. Similar to scenario 10.3 above, during the open water season in August and September, the probabilities for deployment of SCCE and a relief well are nearly the same with the relief well having a 1 to 3 percent higher deployment probability than for SCCE deployment.

Table 7-31. Scenario 10.4: Percent probability that safe deployment of a relief well is possible but not SCCE with sea ice operating capability in the Beaufort Sea, 2012-2016.

OPD	OPD Name	June			July			Aug			September			October			November			December		
		1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
NS05-03	UNNAMED	0	0	0	0	0	0	0	0	5	1	1	1	0	0	0	0	0	0	0	0	0
NS05-04	UNNAMED	0	0	0	0	0	0	0	0	0	1	2	2	0	0	0	0	0	0	0	0	0
NS06-03	UNNAMED	0	0	0	0	5	0	5	0	1	2	2	2	0	0	0	0	0	0	0	0	0
74 Degrees North Latitude																						
NS05-05	UNNAMED	0	0	0	0	0	0	0	0	1	1	2	2	0	5	0	0	0	0	0	0	0
NS05-06	UNNAMED	0	0	0	0	0	5	5	0	1	1	2	2	5	0	0	10	0	0	0	0	0
NS06-05	UNNAMED	0	0	0	5	0	0	5	1	1	2	2	2	0	0	0	0	0	0	0	0	0
NS06-06	UNNAMED	0	0	5	0	5	10	0	0	6	2	2	2	0	0	0	0	0	0	0	0	0
NS07-05	UNNAMED	0	0	0	5	0	0	0	0	0	1	2	2	0	0	0	0	0	0	0	0	0
NS07-06	UNNAMED	0	0	0	0	0	0	0	1	1	1	2	1	0	0	0	0	0	0	0	0	0
NS08-05	UNNAMED	0	0	0	0	0	0	0	1	1	1	2	1	0	0	0	0	0	0	0	0	0
73 Degrees North Latitude																						
NS05-07	BARROW CANYON	0	0	0	0	0	10	10	0	1	2	3	2	0	0	5	0	0	0	0	0	0
NS05-08	CANADA BASIN WEST	0	5	0	0	0	10	0	0	1	2	2	2	5	5	0	5	0	0	0	0	0
NS06-07	CANADA BASIN	0	0	0	0	0	0	0	1	1	2	2	2	5	10	5	0	0	0	0	0	0
NS06-08	UNNAMED	0	5	0	0	10	5	13	6	1	2	2	2	0	5	0	0	0	0	0	0	0
NS07-07	BEAUFORT TERRACE	0	0	5	5	0	0	5	0	1	2	1	2	0	0	0	0	0	0	0	0	0
NS07-08	UNNAMED	0	0	0	0	0	0	5	0	1	2	2	2	0	25	30	0	0	0	0	0	0
NS08-07	UNNAMED	0	0	20	20	0	0	0	0	1	1	2	1	0	0	0	0	0	0	0	0	0
72 Degrees North Latitude																						
NR05-01	DEASE INLET	0	0	0	5	5	0	0	1	2	3	3	3	0	0	0	5	5	0	0	0	0
NR05-02	HARRISON BAY NORTH	0	0	0	0	0	5	0	1	2	3	3	3	0	0	0	10	10	10	0	0	0
NR06-01	BEECHEY POINT NORTH	0	0	0	5	0	25	5	1	2	3	3	3	0	0	0	0	0	10	0	0	0
NR06-02	FLAXMAN ISLAND N.	0	0	0	5	5	5	6	1	2	2	3	3	0	0	0	0	0	0	0	0	0
NR07-01	UNNAMED	0	5	5	5	0	5	1	6	2	2	2	2	5	5	5	5	0	0	0	0	0
NR07-02	UNNAMED	0	0	0	0	0	0	5	0	1	2	2	2	5	5	0	0	0	0	0	0	0
71 Degrees North Latitude																						
NR05-03	TESHEKPUK	0	0	20	40	20	0	0	1	2	3	3	3	0	20	0	40	60	80	80	60	60
NR05-04	HARRISON BAY	0	0	0	0	0	0	0	1	2	3	3	3	0	0	10	0	10	10	10	20	30
NR06-03	BEECHEY POINT	0	0	0	5	5	5	0	1	2	3	3	3	0	0	10	15	5	10	0	0	0
NR06-04	FLAXMAN ISLAND	0	0	0	0	5	5	0	1	2	3	3	3	0	0	0	0	0	5	0	0	0
NR07-03	BARTER ISLAND	0	0	0	0	10	0	1	2	2	3	3	3	0	0	0	5	0	5	0	0	0
NR07-04	MACKENZIE CANYON N.	0	10	0	0	10	0	1	2	2	3	2	2	0	0	0	0	0	0	0	0	0
70 Degrees North Latitude																						
NR07-05	DEMARCATION POINT	0	20	0	0	0	0	2	2	2	3	3	3	0	0	0	0	0	0	0	0	0
NR07-06	MACKENZIE CANYON	0	0	0	0	0	0	2	2	2	3	3	3	0	0	0	0	0	0	0	0	0

7.9 Post Deployment Operating Limits for SCCE and Relief Well Drilling

Once the critical deployment operations have been completed, open water SCCE and relief well drilling operations will be able to continue with a higher tolerance for elevated winds and sea states. For SCCE equipment that may be involved in an ongoing cap and flow or containment dome operation and for a relief well drilling rig, it is reasonable for the fleet to operate above the 99th percentile or higher conditions for the critical deployment sea state and wind speed criteria. Seasonal open water 99th percentile values for the Beaufort and Chukchi Sea are presented in table 7-32.

Table 7-32. Seasonal 99th percentile values for critical open water metocean criteria.

Deployment Criteria	Chukchi Sea (99th Pecentile)	Beaufort Sea (99th Percentile)
Significant wave height	11.8 feet (3.6 m)	8.9 feet (2.7 m)
Wave period	10.5 s	9.5 s
Wind Speed	30 knots (15.5 meters/s)	40 knots (20.6 meters/s)

It should be noted that 99th percentile winds for a sustained period of time will likely drive significant wave heights well above the values listed in table 7-32. For the relief well drilling rig, the values in table 7-32 are within the normal operating limits of the existing fleet of semisubmersible or jackup MODUs. SCCE operations, being fit for purpose, can be planned to accommodate the anticipated 99th percentile or higher conditions at a given location.

7.10 Bathymetry

Unlike ice concentration and other metocean conditions which are affected by season and location, bathymetry limitations are solely dependent on location. Results were therefore presented in the form of maps of each planning area that depict the location of key isobaths, representing the operating depth ranges for specific types of deployment vessels or equipment to operate.

7.10.1 Chukchi Sea Planning Area Bathymetry

Figure 7-1 shows the bathymetry of the Chukchi Sea planning area. Selected isobaths have been presented to graphically depict the operating limitations presented by the bathymetry of the Chukchi Sea. The water depth ranges for these limitations and the resultant effects on relief well and SCCE deployment are summarized in table 7-33.

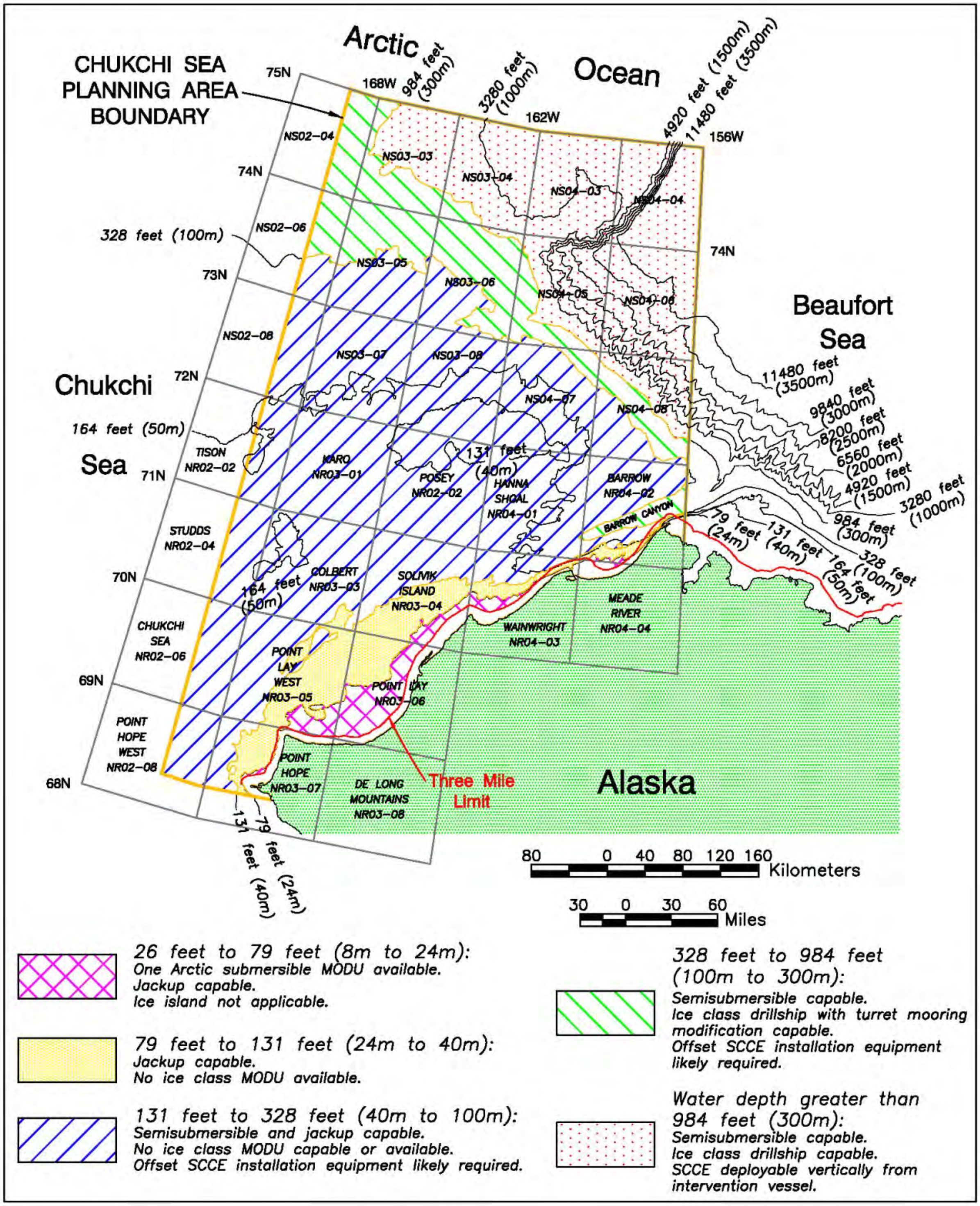


Figure 7-1. Chukchi Sea planning area bathymetry and operating limitations.

Table 7-33. Chukchi Sea planning area bathymetry limitations for relief well and SCCE deployment.

Water Depth	Map Guide	Relief well rig available for deployment	SCCE Deployment Limitations
26 to 79 feet (8 to 24 m)	▩	SDC Arctic submersible MODU	SCCE not directly deployable
79 to 131 feet (24 to 40 m)	🟨	Jackup MODU	SCCE not directly deployable
131 to 328 feet (40 to 100 m)	▨	Jackup MODU	SCCE requires offset installation equipment if well is accessible
		Semisubmersible or jackup MODU	SCCE requires offset installation equipment if well is accessible
328 to 984 feet (100 to 300 m)	▧	Semisubmersible MODU Ice-class drillship with turret mooring system modification	SCCE likely requires offset installation equipment
>984 feet (>300 m)	░	Semisubmersible MODU Ice-class drillship with DP and possibly turret mooring system modification	SCCE directly deployable from above well

7.10.2 Beaufort Sea Planning Area Bathymetry

Figure 7-2 shows the bathymetry of the Beaufort Sea planning area. Selected isobaths have been presented to graphically depict the operating limitations related to the bathymetry of the Beaufort Sea. The water depth ranges for these limitations and the resultant effects on relief well and SCCE deployment are summarized in table 7-34.

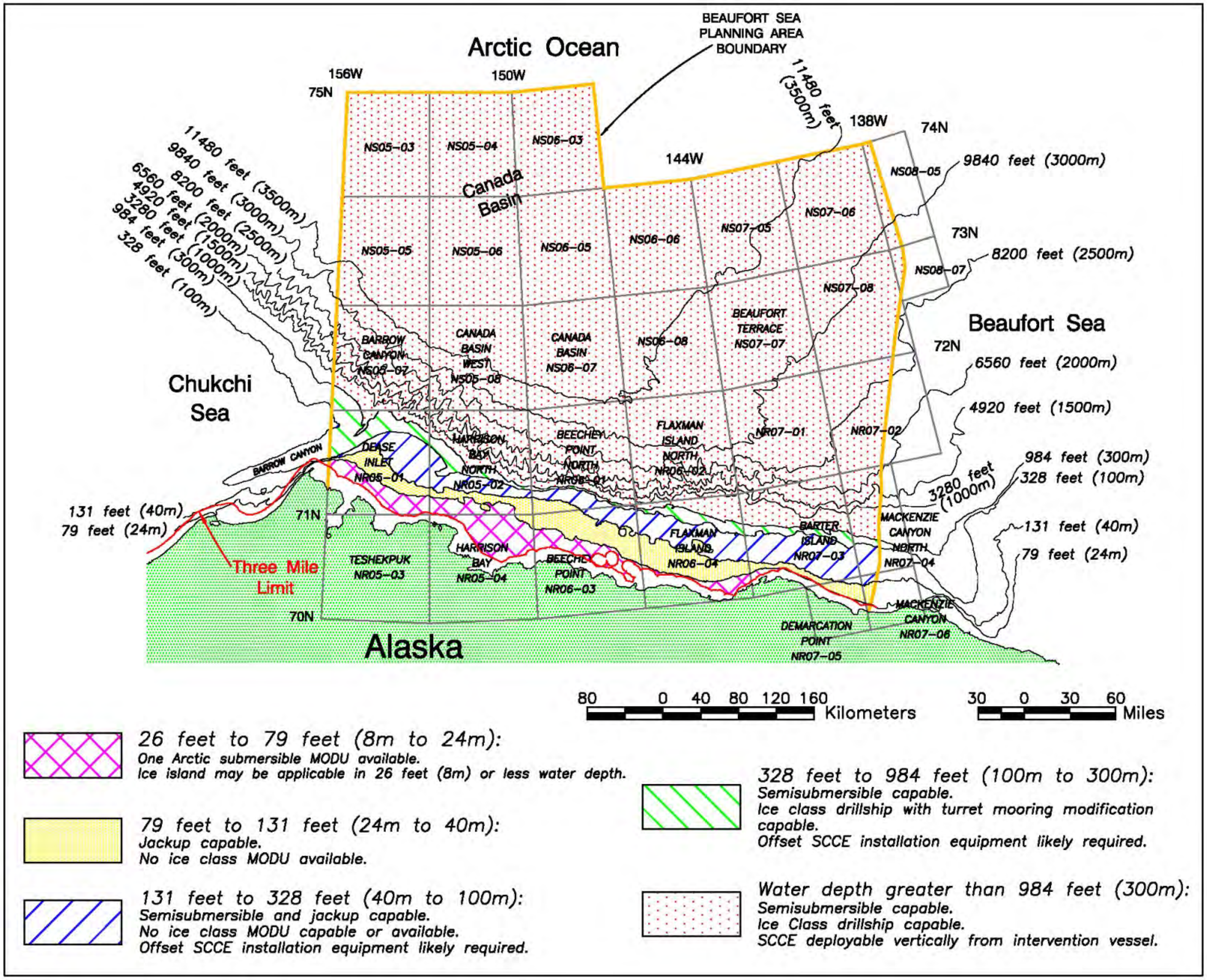


Figure 7-2. Beaufort Sea planning area bathymetry and operating limitations.

Table 7-34. Beaufort Sea planning area bathymetry limitations for relief well and SCCE deployment.

Water Depth	Map Guide	Relief well rig type available for deployment	SCCE Deployment Limitations
< 26 feet (<8 m)		Ice island with land rig	SCCE not directly deployable
26 to 79 feet (8 to 24 m)	▩	SDC Arctic submersible MODU	SCCE not directly deployable
79 to 131 feet (24 to 40 m)	🟨	Jackup MODU	SCCE not directly deployable
131 to 328 feet (40 to 100 m)	▨	Jackup MODU	SCCE requires offset installation equipment if well is accessible
		Semisubmersible or jackup MODU	SCCE requires offset installation equipment if well is accessible
328 to 984 feet (100 to 300 m)	▧	Semisubmersible MODU Ice-class drillship with turret mooring system modification	SCCE likely requires offset installation equipment
>984 feet (>300 m)	░	Semisubmersible MODU Ice-class drillship with DP and possibly turret mooring system modification	SCCE directly deployable from above well

8.0 Summary and Conclusions

The results described in this Report led the team to make the following conclusions regarding safe deployment of SCCE and relief wells in the Chukchi Sea and Beaufort Sea planning areas:

Operating Seasons

The available open water operating season in the Chukchi Sea planning area ranges from approximately 60 to 90 days in the historically active exploration area of the Chukchi Sea planning area. In the Beaufort Sea planning area, the available open water operating season is limited to approximately 50 to 60 days across the historically active exploration area of the Beaufort Sea planning area. Sea ice capability can extend the above operating seasons from 30 to 60 days depending upon the operating location within the planning areas.

Bathymetry Conditions

Bathymetric conditions can limit safe deployment of SCCE equipment and relief well operations due to vessel restrictions and the potential for gas boil hazards at the sea surface. The existing available ice class Arctic floating drilling fleet is very limited and does not have the capability to operate in water depths shallower than 984 feet (300 meters) unless outfitted with a turret mooring modification that could reduce the minimum operating water depth to approximately 328 feet (100 meters). Deployment of SCCE is likely to be impaired in water depths below 984 feet (300 meters), which are potentially subject to a gas boil at the surface from a subsea blowing well. This situation will likely require offset installation equipment in water depths shallower than 984 feet (300 meters). Modeling analysis of the blowout plume in the water column may provide a better estimate of the maximum depth that would be necessary for offset installation equipment in the Chukchi Sea and Beaufort Sea planning areas.

Metocean Conditions

Air temperature is a limiting factor for open water SCCE and relief well operations when it falls below -4 F (-20 C), ice conditions generally limit deployment operations before the onset of critically low temperatures. Air temperature is a limiting factor for ice class vessels when it falls below -22F (-30 C). There is a low probability (12-14 percent) of this occurring across the Chukchi and Beaufort Sea planning areas in October and November, it reaches is highest probability in the eastern Beaufort Sea planning area in early to mid-December.

Moderate to near gale strength wind speeds of or more than 30 knots create unsafe deployment conditions for SCCE equipment and relief well drilling rigs; winds above 30 knots occur about 4 percent of the time on average throughout the Chukchi Sea and Beaufort Sea planning areas. Winds are typically highest at Point Hope in the southern Chukchi Sea compared to all other coastal stations.

Wave height is a limitation for deployment of SCCE equipment at heights of 6.6 feet (2 meters); a situation that could prohibit SCCE deployment for up to 23 percent of the time during September when wave heights are at their highest in the Chukchi Sea. However, relief well deployment operations have greater tolerance for high sea states and can be safely conducted with wave heights up to 9.8 feet (3 meters); as a result, relief well deployment would only be limited by wave height for 5 percent of the time during September in the Chukchi Sea. For the Beaufort Sea, wave heights are lower than in the Chukchi Sea and the corresponding reduction in efficiency would be approximately 10 percent and 2 percent for SCCE and relief well deployment in September, respectively. Wave height is damped by the presence of sea ice and therefore wave height is not a significant concern during sea ice operations.

Wave periods of less than 10 seconds are unlikely to affect the safe deployment of SCCE or relief well drilling operations. Wave periods of greater than 10 seconds could theoretically be a limiting factor for SCCE deployment and relief well drilling; however, wave height in the Chukchi Sea and Beaufort Sea also increases with increasing wave period and wave height becomes a limiting factor before the wave period reaches or exceeds the 10 second criterion.

When considering all Metocean Efficiency Reduction Factors (MERFs), SCCE deployment and relief well drilling operations share similar types of determining factors; wind speed is the primary limiting factor in June and July, wave height is the primary limiting factor in August through October, and air temperature is the limiting factor in November and December. However, the percent probability that these factors will affect the two different technologies does differ. The greatest difference being that SCCE deployment is likely to be more limited than relief well deployment from August through October; the probability of wave height and/or wind speed limiting safe deployment for SCCE in the Beaufort Sea during this time period is 1 to 3 percent greater than for relief well deployment; in the Chukchi Sea, the probability for wave height limiting SCCE deployment is 9 to 18 percent higher than for relief well operations.

For operations in sea ice conditions, SCCE deployment can occur in 0 to 7 tenths ice coverage; relief well deployment has slightly higher sea ice concentration limits and can be safely conducted in up to 8 tenths ice concentration.

When comparing SCCE deployment versus relief well deployment, the two technologies do not demonstrate many significant differences in safe deployment requirements; however, SCCE deployment has a slightly lower tolerance for ice coverage and a lower tolerance for significant wave height; these differences do result in some advantage to the safe deployment of relief wells over SCCE equipment.

SCCE Deployment versus Relief Well Scenario Comparison in the Chukchi Sea in Open Water

In the Chukchi Sea planning area, during the open water season, SCCE equipment can safely be deployed 75 percent of the time from July 15 through October (approximately 105 days) throughout the southern extent of the planning area, further north above the 71st parallel this operating window decreases to late September through October (approximately 40 days), further north above the 72nd parallel the percent probability for safe deployment continues to decrease rapidly.

For these same areas during the open water season, relief well drilling can safely be conducted in the southern area with greater percent probability (90 percent probability) for slightly longer time periods (approximately 80 to 110 days early in the season, decreasing to an additional 40 to 70 days above the 71st parallel later in the season. Similar to SCCE deployment, percent probability for relief well drilling reduces rapidly as you approach the 72nd parallel.

SCCE Deployment Versus Relief Well Scenario Comparison in the Chukchi Sea in Sea Ice Conditions

During sea ice conditions, Chukchi Sea SCCE deployment can safely occur for up to 6 months (approximately 180 days) in the Southwest area, but further north above the 71st and 72nd parallels deployment is limited to August through October.

Relief well drilling can be safely conducted in sea ice conditions in the Chukchi Sea with 90 percent probability for 70 to 160 days below the 72nd parallel, decreasing to 30 to 40 days above the 72nd parallel.

In general, relief well deployment can be conducted with greater percent probability than SCCE deployment, but it is difficult to make a comparative statement about the time periods due to differences in percent probability and delineation of southern and northern study areas.

SCCE Deployment Versus Relief Well Scenario Comparison in the Beaufort Sea in Open Water

In the Beaufort Sea planning area, during the open water season, SCCE can safely be deployed with 75 percent probability or greater from late August through mid-October (approximately 50 to 60 days) in the southern area; moving north above the 72nd parallel this generally decreases rapidly with the exception of the far western portion of the Beaufort Sea in the Dease Inlet OPD which remains similar to the probability exhibited in the southern area.

For these same areas, relief well operations can safely be deployed during open water conditions with 75 percent or greater probability for 30 to 60 days in the southern area, this decreases to 0 to 60 days between the 71st and 72nd parallels and 0 days above the 73rd parallel.

In general, SCCE and relief well deployment share the same percent probability and similar time periods for deployment during open water in the Beaufort Sea.

SCCE Deployment versus Relief Well Scenario Comparison in the Beaufort Sea in Sea Ice Conditions

During sea ice conditions, Beaufort Sea SCCE deployment can safely occur with a 75 percent probability from early August through October (approximately 90 days) between the 70th and 71st parallels; this decreases to 80 days between the 71st and 72nd parallels and drops off to no time periods above the 73rd parallel.

Relief well deployment for these same areas can safely be conducted with a 90 percent or greater probability for 70 days from mid-August through October south of the 71st parallel; this decreases to 20 to 50 days between the 71st and 72nd parallels, and no days above the 72nd parallel.

In general, relief well deployment operations can be conducted with greater percent probability than SCCE deployment in the Beaufort Sea planning area in sea ice conditions.

SCCE Deployment Options

SCCE deployment equipment varies and has different requirements and benefits, some notable equipment characteristics are listed as follows:

- SCCE, including offset installation equipment for SCCE deployment in shallow waters, will need to be fit for purpose due to the bathymetry limitations and logistical requirements of the Chukchi Sea and Beaufort Sea planning areas where rapid deployment of response equipment from worldwide staging areas such as the Gulf of Mexico or Europe is unlikely.
- Subsea Isolation Devices (SIDs) are a practical means of mitigating a substantial portion of the risk associated with loss of well control within a very short timeframe. As a preinstalled form of SCCE, SIDs can be deployed under most sea states and weather conditions throughout the year.
- Prestaging of SCCE, including offset installation equipment, in wet storage on the seafloor will likely reduce response time and reduce deployment downtime due to sea state conditions.
- Late season SCCE deployment in sea ice conditions is a viable option if open water relief well drilling operations are not able to be completed before the open water season ends.

APPENDIX A

Vessels and Technology for Offshore Operations in the Chukchi Sea and Beaufort Sea Planning Areas

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Vessels and Technology for Offshore Operations in the Chukchi Sea and Beaufort Sea Planning Areas

1.0 Drilling Vessels

1.1 Currently Available Ice Class Drilling Vessels

Three ice-class floating drilling vessels exist today; these vessels include the Stena IceMAX, Noble Bully I and Bully II. All of these are deep-water drillships with minimum operating depths on the order of 1,000 feet (≈300 meters). The IceMAX also has a conceptual design for a turret-mooring modification that could reduce operating water depth to approximately 100 meters (Efraimsson). General specifications for these vessels are listed below:

1.1.1 Stena IceMax

Rig Type/Design:	Polar class – dynamically positioned, harsh environment DP3 drillship
Construction Shipyard:	SHI (Samsung Heavy Industries)
Year Entered Service:	April 2012
Significant Upgrades:	N/A
Classification:	DNV: +1A1 Ship-Shaped Drilling Unit (N) BIS BWM(T) Crane DRILL (N) DYNPOS (AUTRO) EO F(A,M) HELDKIS PC(4) winterized (Cold, -20 C, -30C)
Flag:	United Kingdom (UK)
Length:	228 meters (748 feet)
Width:	42 meters (138 feet)
Molded Depth:	19 meters (62 feet)
Draft:	12 meters (39 feet) operating 8.5 meters (28 feet) transit
Accommodations:	180 (220 with modifications) personnel
Variable Deck (Operating):	17,500 metric tons @ 12 meters
Transit Speed:	up to 12 knots
Minimum Water Depth:	984 feet (300 meters), 328 feet (100 meters) with turret mooring modification
Maximum Water Depth:	3,000 meters designed/2,285 meters outfitted/ additional riser available 10,000 meters designed/7,500 outfitted/ additional riser available
Maximum Drilling Depth:	10,700 meters/35,104 feet – with offset setback stand building capability
Helideck:	rated for EH-101 and S-92, equipped with trace heating

Figure 1-1. Stena IceMAX drillship (Stena Drilling, 2018).

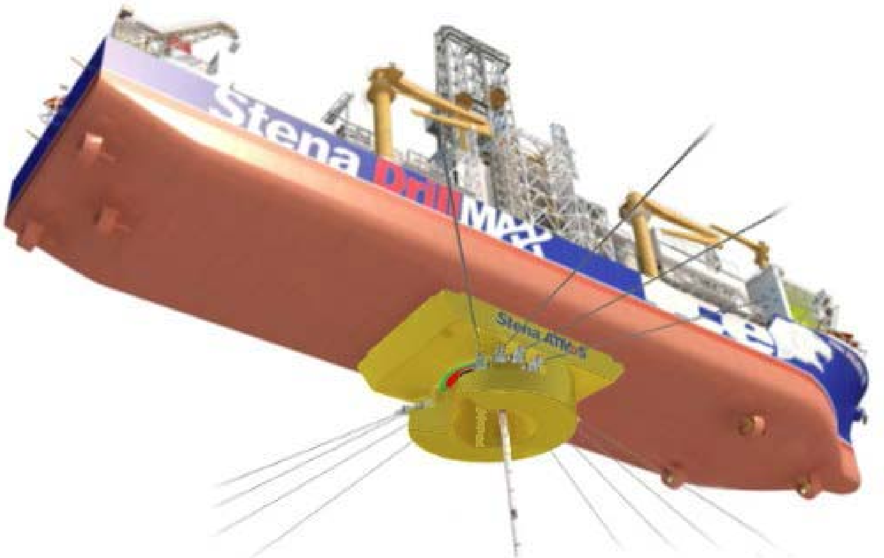


Figure 1-2. Stena Drilling's turret-mooring modification design for the Stena IceMAX (Stena, 2018).

1.1.2 Noble Bully I and Bully II

The Noble Bully I and its sister ship, the Bully, II are nearly identical in their general arrangements with the exception that the Bully II is capable of working in 10,000 feet (3,050 meters) water depth while the Bully I is limited to 8,200 feet (2,500 meters). It should be noted that the ice classification for the Bully vessels is below that of the IceMAX above and would have lower operating limits in sea ice than the IceMAX. General information on the Bully I vessel is provided below.

Rig Type:	Drillship
Rig Design:	Gusto MSC Design - PRD12,000
Builder:	Shanghai Shipbuilding Co. Ltd.; Keppel
Year Built/Upgraded:	2011
Classification:	DNV +1A1, ICE-05, Ship Shaped Drilling Unit, DYNPOS-AUTR, BIS
Flag:	Liberia
MODU Code:	1989 (Cons. 2001 Ed.)
Minimum Water Depth:	300 meters (984 feet)
Maximum Water Depth:	2500 meters (8,200 feet)
Drilling Depth:	12,192 meters (40,000 feet)
Variable Deck Load:	27,117 kips
Hook Load:	2,000 kips on main hoist; 1,000 kips on auxiliary hoist
Setback Capacity:	2,100 kips
Quarters Capacity:	168 personnel
Draft (Operating/Transit):	10 meters (33 feet / 33 feet)
Moonpool:	19.5 x 12.5 meters (64 feet x 41 feet)
Depth:	15 meters (49 feet)
Length:	187.5 meters (615 feet)
Breadth:	39 meters (128 feet)

Figure 1-3. Noble Bully I (Noble, 2018).

1.2 Developing Concepts for Ice-Class Drilling Vessels

Several companies have developed new ice-class drilling-vessel designs including Aker, GustoMSC, Huisman, and others. These conceptual designs and their general characteristics are presented below:

1.2.1 Huisman's Arctic S Semisubmersible Design

Huisman's Arctic S semisubmersible design is shown below. It is capable of operating as a floating drilling vessel in water depths between 50 meters (164 feet) and 1,500 meters (1,640 feet) and can also be set on the seafloor as a submersible vessel in shallow-water depths from 12 to 30.5 meters. These operating depths are subject to change as the vessel design is refined.

Minimum Water Depth(floating):	50 meters (164 feet)
Minimum Water Depth (on seafloor):	12 meters (39 feet)
Maximum Water Depth (Open Water):	1,500 meters (4,920 feet)
Maximum Water Depth (Ice-laden Water):	500 meters (1,640 feet)
Maximum Water Depth (Sitting on the Seabed):	30.5 meters (100 feet)
Maximum Drilling Depth from the Water Line:	12,190 meters (40,000 feet)

Classification:	ABS:AA1column-stabilized drilling unit A AAMS AACCU CDS HELIDK CRC Ice class PC 4

Figure 1-4. Huisman Arctic S drilling vessel concept design (Huisman, 2018).

1.2.2 Aker Solution's Turret-Moored Drillship

Aker Solutions has designed a turret-moored drillship that has the turret located near the bow of the vessel for optimal heading and station keeping in sea ice conditions. When operating in ice-free waters globally, the turret can be disconnected and the drillship can operate using DP positioning only. General information on Aker's ice-class drillship design is presented below.

Rig Type/Design:	Polar class – dynamically positioned, harsh environment DP3 drillship
Classification:	DNV: +1A1, Drill (N), PC(5), winterized (Cold, -40C)
Length:	232 meters (762 feet)
Width:	42 meters (138 feet)
Accommodations:	160 personnel
Mooring:	12 point turret system
Minimum Water Depth:	Not available
Maximum Water Depth:	Not available

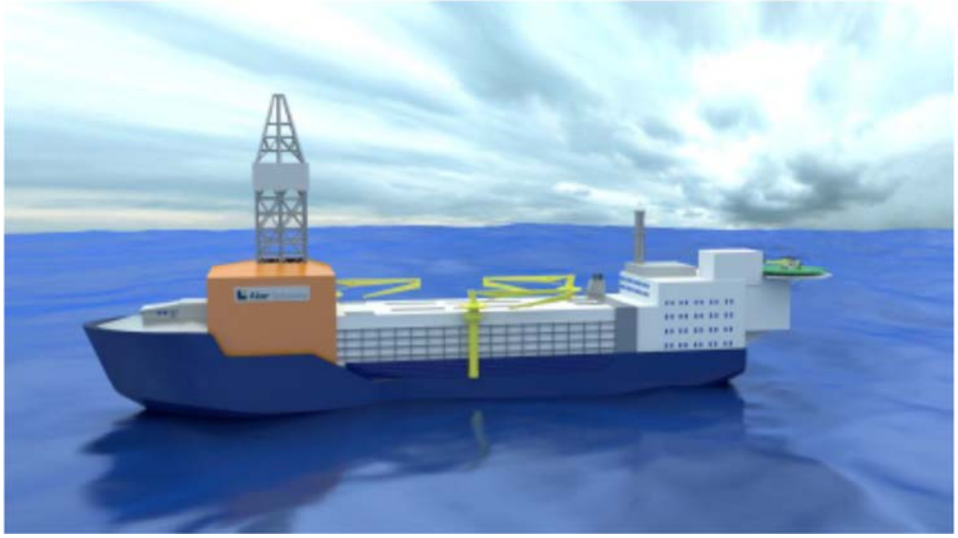


Figure 1-5. Aker Solutions turret-moored Arctic drillship design (Hanus/Aker, 2018).

1.2.3 GustoMSC's Turret-Moored Arctic Drillship

GustoMSC's design for a turret-moored Arctic drillship is the NanuQ 5000 TM shown below.

Length:	238 meters (781 feet)
Breadth:	40.0 meters (131 feet)
Depth at Centerline:	21.6 meters (71 feet)
Drill floor Height (Above Keel Level):	46.8 meters (154 feet)
Displacement:	110,000 tons
Ice Class:	Polar class 2
Mooring system**:**	Internal turret with 16-point mooring system
DP System:	DP2
Drilling Depth:	35,000 feet MD from RKB
Minimum Water Depth:	25 meters (82 feet)
Maximum Water Depth:	3,500 meters (11,480 feet)

Figure 1-6. GustoMSC NanuQ 5000 TM Arctic-drillship design concept (GustoMSC, 2018).

1.3 Historical Arctic Drilling Vessels

Arctic drilling vessels that have been utilized in the Chukchi Sea and Beaufort Sea planning areas include the former fleets of Canadian drilling companies including Canadian Marine Drilling Ltd. (CANMAR), Beaudril Ltd., and the former U. S. drilling contractor Global Marine Drilling Company (GMDC). These vessels included submersibles, a semisubmersible and several drillships. General information on these vessels is presented below.

1.3.1 Submersible Drilling Vessels

1.3.1.1 Steel Drilling Caisson (SDC)

The SDC has been used to drill five exploration wells in the Alaska Beaufort Sea and additional wells in the Canadian Beaufort Sea. Most recently, in 2006, the SDC was used to drill the Paktoa well in the Canadian Beaufort Sea. The SDC is the only remaining submersible that is available for service in shallow Alaska Arctic waters. It consists of a converted very large crude carrier (VLCC) that sits on top of a steel mat that was added to the vessel in 1986. The SDC's main dimensions are as follows:

Length on Main Deck Including Helideck:	218 meters (715 feet)
Main Deck Width:	53 meters (174 feet)
SDC Height to Main Deck:	26 meters (85 feet)
MAT Length:	168 meters (551 feet)
MAT Width:	110 meters (361 feet)
MAT Height Including Skirts and Foam:	16 meters (52.5 feet)
Height to Main Deck, Excluding 2-meter Skirts:	40/42 meters Bow (131/137 feet)
Range of Water Depths:	8 to 24 meters (26 to 79 feet)

Figure 1-7. SDC submersible Arctic drilling unit (SolstenXP, 2018).

1.3.1.2 Molikpaq

The Molikpaq is a submersible mobile Arctic caisson that was operated by Beaudril Ltd. for four winter seasons in the Canadian Beaufort Sea. The vessel consisted of a steel annulus core that was filled with hydraulically dredged sand to provide additional ice-force resistance. It was capable of operating in water depths from 9 to 21 meters and deeper depths if positioned on a dredged sand berm (32 meters was the deepest water it operated in). The Molikpaq was first used in 1984; in 1997, it was towed to Russia to be repurposed as a development structure for the Piltun Astoskhskoye field offshore of Sakhalin Island.

Figure 1-8. Molikpaq mobile Arctic drilling caisson (Timco and Frederking, 2018).

1.3.1.3 Concrete Island Drilling System (CIDS)

The CIDS (also known as the Glomar Beaufort Sea I) was built in 1983 by GMDC and drilled four exploration wells in the Alaska Beaufort Sea between 1984 and 1997. The unit consisted of a steel mud base with a concrete honeycomb brick midsection. The topsides were two heavy-duty deck barges that sat parallel to each other on top of the concrete brick. In 2001, the CIDS was towed to Sav Gavin, Russia and then Korea to be retrofitted as a drilling and production platform (Orlan) for ExxonMobil's Chayvo field offshore of Sakhalin Island. General information on the CIDS is as follows:

Main Deck:	88 meters (290.5 feet) long 84 meters (274 feet) breadth
Mud Base:	95 meters (312.5 feet) by 90 meters
(295 feet)Main Deck to Baseline:	29 meters (95 feet)
Operating Water Depth:	11 to 18 meters (35 to 60 feet)
Towing Speed:	4 knots with two 22,000 hp tugs
Design Temperature:	- 60 degrees F
Structural Design Ice Load:	460,000 lbs per diagonal foot Brick diagonal breadth is 85 meters (278 feet)
Ice Contact Pressure:	900 psi over a 1.5 X 1.5 meters area (5 X 5 foot area)

Maximum Wave Height at 55-Foot Draft:	5.3 meters (17.7 foot) Hs and 10 meter (33 foot) max

Figure 1-9. CIDS mobile Arctic drilling caisson (SolstenXP, 2018).

1.3.2 Arctic Barge Drilling Vessel

1.3.2.1 Kulluk

Built in 1983, the Arctic drilling barge Kulluk was operated by Beaudril Ltd. followed by CANMAR who acquired the vessel in 1993. It was capable of working in the Beaufort Sea in 10 tenths ice coverage as documented by sea ice observers and the international standard for reporting ice coverage in an ice regime. The vessel was conical in shape and had a 12-point mooring system. It was capable of operating in water depths as shallow as 20 meters as well as up to a maximum operating depth of 180 meters. The Kulluk drilled five wells in the Beaufort Sea planning area between 1988 and 1993. In 2005, it was sold to Shell for their Beaufort Sea campaign and ultimately scrapped after becoming damaged in a grounding incident in 2012.

Type:	Semisubmersible mobile offshore drilling unit
Tonnage:	27,968 gross tons
Displacement:	17,500 tons (lightship)

	28,000 tons (full)[5]
Diameter:	81 meters (266 feet) (main deck)
Draft:	8 meters (26 feet) (lightship) 10–12.5 meters (33–41 feet) (operating)
Depth:	18.5 meters (61 feet)
Ice Class:	Arctic class 4
Installed Power:	Four diesel engines
Propulsion:	None
Accommodation:	108 personnel
Status: `	Decommissioned and scrapped in 2014

Figure 1-10. Kulluk semisubmersible Arctic-drilling vessel (Connelly, 2018).

1.3.3 Ice Class Drillships

CANMAR built four Arctic-class drillships, the Explorer, Explorer II, Explorer III and Explorer IV. The Explorer III was a pelican-class drillship that was converted for Arctic deployment by ice strengthening the hull and winterizing the vessel. The others were built by converting existing commercial vessels to drillships with ice strengthened hulls and anchor-mooring systems. The Explorer IV was the most advanced of the vessels with subsea fairleads for the anchor-mooring lines; these provided better stationkeeping ability when operating in icy conditions. All Explorer vessels had 8-point anchor-mooring systems. The Explorer III drilled five wells in the Chukchi Sea planning area and the Explorer II drilled three wells in the Beaufort Sea planning area.

All of these vessels have been scrapped and are no longer available with the exception of the Explorer III which is now the Jasper Explorer. In 2006 and 2009, the Explorer III underwent major upgrades and is now a DP vessel (without the 8 point mooring system) for use in water depths up to 5,000 feet. As a result of the upgrades, the Jasper Explorer is no longer an ice-class vessel and is not suitable for use in the Chukchi Sea or Beaufort Sea. General characteristics for these vessels are presented below.

1.3.3.1 CANMAR Explorer I

Length, Overall:	114.90 meters (377 feet)
Beam, Main Deck:	30.48 meters (100 feet)
Height to Main Deck:	8.71 meters (29 feet)
Draft (Maximum):	6.8 meters (22 feet)
Displacement (Maximum):	13,137 tonnes (12,931 tons)
Displacement (Lightship):	7,434 tonnes (7,317 tons)
Variable Load:	5,704 tonnes (5,614 tons)
Water Depth Drilling Capacity:	30 – 183 meters (100-600 feet)
Helideck Capacity:	Sikorsky S-61 or similar, plus refueling system
Accommodations:	106 personnel, recreation area, and a 4-bed hospital
Ice Reinforcement:	Hull reinforced to ABS classification 1A Super Ice Class 1AA corresponding to Type A (hull) under Canadian regulations
Status:	Decommissioned and scrapped

Figure 1-11. CANMAR Explorer drillship (Connelly, 2018).

1.3.3.2 CANMAR Explorer II

Length, Overall:	114.90 meters (377 feet)
Beam, Main Deck:	30.48 meters (100 feet)
Height to Main Deck:	8.71 meters (28 feet)
Draft (Maximum):	6.8 meters (22 feet)
Displacement (Maximum):	13,137 tonnes (12,931 tons)
Displacement (Lightship):	7,434 tonnes (7,317 tons)
Variable Load:	5,704 tonnes (5,614 tons)
Water Depth Drilling Capacity:	30 – 183 meters (100-600 feet)
Helideck Capacity:	Sikorsky S-61 or similar, plus refueling system
Accommodations:	106 personnel, recreation area, and a 4-bed hospital
Ice Reinforcement:	Hull reinforced to ABS classification 1A Super Ice Class 1AA corresponding to Type A (hull) under Canadian regulations.
Status:	Decommissioned and scrapped

Figure 1-12. CANMAR Explorer II drillship (Yergins, 2018).

1.3.3.3 CANMAR Explorer III

Length, Overall	: 149.25 meters (490 feet)
Beam, Main Deck:	23.79 meters (78 feet)
Height to Main Deck:	12.50 meters (41 feet)
Draft (Maximum):	7.50 meters (25 feet)
Displacement (Maximum):	16,519 tonnes (16,260 tons)
Displacement (Lightship):	9,229 tonnes (9,152 tons)
Variable Load:	7,220 tonnes (7,106 tons)
Water Depth Drilling Capacity:	30 – 305 meters (100-1,000 feet)
Helideck Capacity:	Sikorsky S-61 or similar, plus refueling system
Accommodations:	103 personnel, recreation area, and a 4-bed hospital
Ice Reinforcement:	Hull reinforced to DNV 1A1* Ice A*specification. Propulsion equipment meets DNV 1A1 Ice B specification. Hull corresponds to Type C of Canadian regulations.
Status:	Upgraded with DP 2 system in 2009, equipped to work in 1,525 meters (5,000 feet), no longer ice class

Figure 1-13. CANMAR Explorer III drillship (Yergins, 2018).

1.3.3.4 CANMAR Explorer IV

Length, Overall:	115.62 meters (379 feet)
Beam, Main Deck:	25.00 meters (83 feet)
Height to Main Deck:	8.71 meters (29 feet)
Draft (Maximum):	6.40 meters (21 feet)
Displacement (Maximum):	12,105 tonnes (11,910 tons)
Displacement (Lightship):	6,760 tonnes (6,652 tons)
Variable Load:	5,345 tonnes (5,258 tons)
Water Depth Drilling Capacity:	30 – 183 meters (100-600 feet)
Helideck Capacity:	Sikorsky S-61 or similar, plus refueling system
Accommodations:	106 personnel, recreation area, conference room and a 3-bed hospital
Ice Reinforcement:	Hull reinforced to Lloyd's Ice Class 1A.Super specifications corresponding to Type a (Hull) under Canadian regulations.
Status:	Decommissioned and scrapped

Figure 1-14. CANMAR Explorer IV drillship (Yergins, 2018).

1.3.3.5 Noble Discoverer

The Noble Discoverer was the last remaining turret-moored drillship on the worldwide market when Shell retained it for their Chukchi Sea and Beaufort Sea drilling campaign from 2012 to 2015. The vessel was modified with sponsons added to the hull prior to working in Alaska to provide ice resistance capability for escorted transit in ice conditions. After the completion of Shell's operations in the Chukchi Sea in 2015, the vessel was decommissioned and scrapped.

Type – Design:	Drillship – Sonat Offshore Drilling Discoverer Class
Shape:	Monohull with sponsons added for ice-resistance
Shipbuilder:	Namura Zonshno Shipyard, Japan hull number 355
Year of Hull Construction:	1965
Year of Conversion:	1976
Date of Last Dry-Docking:	2010
Length:	156.7 meters (514 feet)
Length Between Perpendiculars (LBP):	148.2 meters (486 feet)
Width:	26 meters (85 feet)
Height (Maximum Above Keel):	83.7 meters (274 feet)
Height of Derrick Above Rig Floor:	53.3 meters (175 feet)

Figure 1-15. Noble Discoverer drillship (Noble,2018).

2.0 Support Vessels

Offshore operations in the Chukchi Sea and Beaufort Sea planning areas may require a variety of ice-class support vessels for ice management, anchor-handling tug and supply (AHTS), material supply, fuel supply, spill response and other functions. Examples of currently available and historic support vessels are presented below.

2.1 Currently Available Support Vessels

2.1.1 Ice Management and AHTS

Ice Management/AHTS vessels are critical for supporting any drilling operation in Arctic waters to provide anchor handling, ice management, well intervention such as source containment control equipment (SCCE) deployment, and general supply support. A selected listing of the currently available vessels capable of these multi-tasking support operations are provided below in table 2-1. It should be noted that three Norwegian ice management vessels, the Tor Viking II, Vidar Viking and Balder Viking have recently (2018) been sold to the Canadian Coast Guard and are no longer available to support Arctic offshore operations in the Alaska OCS. Additional vessels are available from Russian operators but are typically not contracted for Chukchi Sea and Beaufort Sea applications due to the advanced age of most of the Russian fleet, although a number of newly built ice-class AHTS vessels have recently entered the Russian market.

Table 2-1. Selected ice-class AHTS vessels.

Vessel:	Fennica	Nordica	Polaris	Otso	Aiviq	Everest
						
Project Duties	Ice Management, AHTS	Ice Management, AHTS	Ice Management, Emergency Towing, Spill Response	Ice Management, Emergency Towing	Ice Management, AHTS, Spill Reponse	Well Intervention, Ice Mannagement, ROV & Diving
Mob / Demob / Port	From/To Helsinki Finland	From/To Helsinki Finland	From/To Helsinki Finland	From/To Helsinki Finland	From/To Gulf of Mexico	From/To Singapore or Worldwide
Vessel General Description						
Year Built	1993	1994	2016	1986 (Upgraded 2015)	2012	2017
Lengh Over All	381 feet (116 meters)	381 feet (116 meters)	361 feet (110 meters)	325 feet (99 meters)	361 feet (110 meters)	465 feet (142 meters)
Horse Power	29,000 HP	29,000 HP	29,000 HP	29,000 HP	21,760 HP	33,800 HP
Propulsion	2 x Aquamaster	2 x Aquamaster	3 x ABB Azipods	2 x Variable pitch propeller, 2 ea Rudders with 30 deg offset	Variable Pitch / Twin Screw	2 x Azimuth
Thrusters	Three x 1,100 kW	Three x 1,100 kW	See above	1 x ABB Bow Thruster 1,720 kW	3 x Bow (one being a fold down azimuthing type) and 1 x Stern thruster	2 x Fwd tunnel 2,700 kW, 1 x tunnel 600 kW, 1 x retractable azimuth 3,000 kW
Ice Class	DNV Polar 10	DNV Polar 10	LR PC 4	DNV 1A Super	ABS A3	BV Ice Class IA Super
Ice Class Common	PC 3	PC 3	PC 4	PC 4	PC 4	PC 4
Bollard Pull	232 ton	230 ton	214 ton	160 ton	200 ton	120 ton
Flag State	Finnish	Finnish	Finnish	Finnish	USA	Bahamas
Classification	DNV	DNV	DNV	DNV	ABS	BV
Helideck	Approved for Super Puma	Approved for Super Puma	Winch only	Weight limit 2.9 ton	Sikorsky S92	Sikorski S92A & 61N
Accommodation	Total 77 personnel, 21 crew	Total 77 personnel, 21 crew	Total 80 personnel, 16 crew	Total 35 personnel, 21 crew	Total 92 personnel, 28 crew	Total 140 personnel, 24 crew
DP	Yes	Yes	Yes	No	Yes	Yes
Cranes	30 ton, 5 ton	160 ton AHC, 5 ton	2 each < 30 ton	No	15 ton, 2 each 5 ton	250 ton AHC, 50 ton AHC
Moonpool	No	No	No	No	No	Main 7.2m x 7.2m, Dive 4m x 4m, ROV 5.6m x 4m

2.1.2 Ice-Class Fuel Tankers

Ice-class fuel tankers are available on the worldwide market from Canadian, European and Russian contractors. Routine fuel deliveries in the Arctic summer months and on an emergency basis are often made with ice-class tankers. Extended offshore operations in the Chukchi Sea or Beaufort Sea planning areas could use similar equipment to provide fuel for continuous operations into the fall and early winter sea-ice season. Examples of this fleet are presented below.

2.1.2.1 Stena Polaris

Summer Deadweight:	64,917 metric tons
Total Cubic Capacity:	67,315 meters^3
Year Built:	2010
Gross Tonnage:	36,168.00 tons
Ice Class Level:	ICE-1A
Length Overall:	183 meters (600 feet)
Extreme Breadth:	40 meters (131 feet)
Trading:	Worldwide
Flag:	Bermuda

Figure 2-1. Stena Polaris ice class fuel tanker (Stena, 2018).

2.1.2.2 Mia Desgagnes

Gross Tonnage: 12,061 tons
Net Tonnage: 4,332 tons
LOA: 135.00 meters (444 feet)
Breadth: 23.50 meters (77 feet)
Depth: 11.30 meters (37 feet)
Total Capacity: 17,505 meters^3
Deadweight: 14,986 metric tons at a draft of 7.9 meters
Builder: Besiktas Gemi Insa Shipyard, Turkey, 2017
Port of Registry: Quebec
Flag: Canada
Type: IMO 2 Chemical Product Carrier
Class: Bureau Veritas I Hull, Unrestricted Navigation, Polar Class 7

Figure 2-2. Ice class product tanker Mia Desgagnes (Group Desgagnes, 2018).

2.1.3 Ice Class Spill-Response Vessels

Oil-spill-response vessel (OSRV) is a broad category of vessels that can support response efforts in a spill scenario. In general, purpose built ice-class OSRVs with oil-recovery and storage capability are of limited availability but can be contracted with adequate lead time. Example of ice-class OSRV’s are presented below.

2.1.3.1 OSRV Nanuq

The Nanuq was constructed by Edison Chouest in 2007 specifically for OSRV service in the Chukchi Sea and Beaufort Sea. At the time of construction it was considered the most advanced OSRV in service.

Length:	91.9 meters (301 feet)
Width:	18.3 meters (60 feet)
Draft:	5.8 meters (19 feet)
Class:	Arctic A-1
Accommodations:	41
Maximum Speed:	16 knots (30 kilometers/hour.)
Available Fuel Storage:	7,692 bbl (1,223 meters^3)
Available Liquid Storage:	12,245 bbl (1,947 meters^3)

Figure 2-3. Nanuq OSRV (Edison Chouest, 2018).

2.1.3.2 OSRV Louhi

The OSRV Louhi was constructed in 2011 to serve as a pollution-control vessel in the Baltic Region. It is owned by the Finnish Environmental Institute and operated by the Finnish Navy. Thus, it may not be available for commercial use in the Chukchi Sea or Beaufort Sea but it is a good example of a modern ice-class OSRV. The Louhi general characteristics are as follows:

Vessel Type:	Oil spill response vessel
Displacement:	2,200 tons (lightship) 3,450 tons (max)
Length:	71.4 meters (234.3 feet)
Beam:	14.5 meters (47.6 feet)
Height:	24.0 meters (78.7 feet)
Draft:	5.0 meters (16.4 feet)
Ice Class:	1A Super
Installed Power:	4 × Wärtsilä 9L20 (4 × 1,800 kW)
Propulsion:	Diesel-electric Two Rolls-Royce azimuth thrusters (2 × 2,700 kW) Bow thruster (500 kW)
Speed:	15 knots (28 km/hour; 17 miles/hour) in open water
Range:	11,000 km (6,000 nautical miles)
Endurance:	20 days
Available Liquid Storage:	1,200 meters^3 (7,548 bbl) for recovered oil 200 meters^3 (1,258 bbl) for chemicals
Crew:	10–15; accommodation for 40 personnel

Figure 2-4. Finnish OSRV Louhi (Finnish Environment Institute, 2018).

2.2 Historical Arctic Support Vessels

A specific fleet of offshore support vessels was built by both CANMAR and Beaudril to support operations in the Canadian and U.S. Beaufort Sea and the Chukchi Sea. These vessels included AHTS vessels, ice management vessels, supply ships and other general support vessels. While advanced for their time, very few of these vessels are still operating today. General information on the CANMAR and Beaudril fleets is presented below.

2.2.1 Kalvik/Terry Fox AHTS Vessels

The Kalvik and Terry Fox were sister ships that provided ice-class AHTS service for Beaudril. The vessels were built in 1983 and both remain in service. The Kalvik is now operated as the Vladimir Ignatyuk in Russia and the Terry Fox is operated by the Canadian Coast guard.

Vessel Type:	Icebreaker/AHTS
Tonnage:	4,233 gross tons 1,955 net tons
Displacement:	7,100 long tons (7,200 tons) (full load)
Length:	88 meters (289 feet)
Beam:	17.9 meters (59 feet)
Draught:	8.3 meters (27 feet)
Ice Class:	Arctic Class 4
Installed Power:	4 × Stork-Werkspoor 8TM410 17,300 kW (23,200 hp) (combined)
Propulsion:	Two shafts, controllable pitch propellers
Speed:	16 knots (30 kilometers/hour; 18 mph)
Range:	1,920 nm (3,560 kilometers; 2,210 miles) at 15 knots (28 kilometers/hour; 17 miles/hour)
Endurance:	58 days
Crew Complement:	24 personnel
Status:	Operating in Russia as the Vladimir Ignatyuk

Figure 2-5. AHTS Kalvik (now Vladimir Ignatyuk) (Wikipedia, 2018).

2.2.2 Miscaroo/Ikaluk AHTS Vessels

The Miscaroo and Ikaluk were also sister ships built by Beaudril. They were launched in 1983 and were eventually sold into the Russian market in 1998. Both vessels have been retired and scrapped.

Vessel Type:	Icebreaker, AHTS
Tonnage:	3,227 gross tons 968 net tons [5] 1,200 DWT (design draught)
Displacement:	5,050 tons
Length:	78.85 meters (259 feet)
Beam:	17.22 meters (56 feet)
Draught:	7.5 meters (25 feet) (design)
Depth:	9.7 meters (32 feet)
Ice Class:	CASPPR Arctic Class 4
Installed Power:	4 × Wärtsilä Vasa 8R32 (4 × 3,725 hp)
Propulsion:	Two shafts; controllable pitch propellers
Speed:	15.5 knots (28.7 kilometers/hour; 17.8 miles/hour) (4 engines) 12.5 knots (23.2 kilometers/hour; 14.4 miles/hour) (2 engines) 3–4 knots (5.6–7.4 kilometers/hour; 3.5–4.6 miles/hour) in 1.2 meters (4 feet) ice
Crew:	22 personnel
Status:	Decommissioned and scrapped in 2017

Figure 2-6. Miscaroo AHTS vessel (Connelly, 2018).

2.2.3 Kigoriak AHTS Vessel

The Kigoriak was built in 1979 by CANMAR and remains in service today. In 2003 it was sold into the Russian market.

Length Overall:	90.70 meters (297.57 feet)
Length Waterline	84.86 meters (278.41 feet)
Breadth Molded	17.25 meters (56.59 feet)
Depth Main Deck	10.00 meters (32.80 feet)
Design Draft	8.50 meters (27.88 feet)
Propulsion Power	12800 kW (16800 hp)
Speed (Service)	16.5 knots
Speed (Ice)	3.0 knots (in 1 meter 1st year ice)
Classification	Lloyd's 100A1 Arctic Class-3 Icebreaker
Status:	In service in Russia

Figure 2-7. Kigoriak AHTS vessel (Vard Marine, 2018).

2.2.4 Robert LeMeur AHTS Vessel

The Robert LeMeur was another of the versatile AHTS vessels in the CANMAR fleet. The vessel was launched in 1982 and sold into the Chinese market in 1997. It was scrapped in 2016. Its general characteristics are as follows:

Vessel Type:	Icebreaker, AHTS
Tonnage:	3,285 gross tons
	1,502 net tons
	2,458 DWT
Displacement:	5,853 tons
Length:	82.8 meters (272 feet)
Beam:	19 meters (62 feet) (reamers)
	18 meters (59 feet) (hull)
Draught:	5.5 meters (18 feet)
Depth:	7.5 meters (25 feet)
Ice Class:	CASPPR Arctic Class 3
Installed Power:	2 × MaK 12M453AK (2 × 4,800 hp)
Propulsion:	Two shafts; controllable pitch propellers
Speed:	13.5 knots (25.0 kilometers/hour; 15.5 miles/hour)
Crew:	14 personnel
Status:	Decommissioned and scrapped in 2016

Figure 2-8. Robert LeMeur AHTS vessel (Yergins, 2018).

3.0 SCCE Technology

3.1 Existing SCCE Technology

SCCE technology for the offshore industry has rapidly developed since the Macondo incident in 2010. In order to develop the technology quickly and to share costs across many potential users of the technology, offshore operators have formed consortiums to share the cost of maintaining ready-available technology that will only be used on a very infrequent basis. These technologies include capping stacks, containment domes (also referred to as a top hat), cap-and-flow systems, SIDs and an offset-installation system. A summary of the well-control consortiums and their SCCE resources is listed below in table 3-1.

Table 3-1. Entities providing SCCE resources.

Entity	Structure	SCCE Equipment	Support Area
Shell	Operator	Capping stacks	Global for Shell, Arctic
BP	Operator	Capping stacks	Global for BP
Oil Spill Response Ltd. (OSRL)	Consortium, over 40 members	Capping stacks, Cap-and-flow system, Offset-installation system for shallow water	Global
Marine Well Containment Company (MWCC)	Consortium, 10 members	Capping stacks, Cap-and-flow systems, containment dome	US Gulf of Mexico
Helix Well Containment Group (HWCG)	Consortium, 16 members	Capping stacks, Cap-and-flow system, containment dome	US Gulf of Mexico
Oil Spill Prevention and Response Group (OSPRAG)	Consortium	Capping stack	United Kingdom
Wild Well Control	Well services company	WellContained system, Capping stacks	Global
Halliburton/Boots and Coots	Well services company	RapidCap capping stack	Global

It is important to note that the majority of the organizations listed above are focused on active offshore markets such as the North Sea, Gulf of Mexico, West Africa and other current offshore operating theaters. The equipment they maintain is generally designed for deep-water and high-temperature applications with very little consideration for Arctic applications. Only Shell has designed and maintained a capping stack for Arctic waters; this capping stack has considerations for low-temperature operating conditions and is capable of deploying the unit onto a subsea BOP in a mudline cellar that is often used to protect the wellhead in shallow Arctic waters from ice scour or other ice intrusion at the mudline. Furthermore, in the shallow waters of the Chukchi Sea and Beaufort Sea, it is likely necessary to use an offset-installation system for SCCE deployment; OSRL built, tested and maintains the only such system in existence today that can deploy a capping stack on a well.

Examples and more detailed information on each type of currently-available SCCE technology are provided in the sections below.

3.1.1 Capping Stack

Manufacturers including Trendsetter Engineering, Cameron, Aker Solutions, Wild Well Control and Worldwide Oilfield Machine have manufactured capping stacks for use by the industry. Figure 3-1 shows the subsea-capping-stack arrangement that Shell developed with Trendsetter Engineering for Arctic application.

Figure 3-1. Capping stack for Arctic application (Trendsetter, 2018).

3.1.2 Containment Dome

A containment dome suitable for use in Arctic waters was developed by Superior Energy Services for Shell’s use in the Chukchi Sea and Beaufort Sea. The unit had a built in offset installation system with cable winches mounted to the dome structure that would be connected to anchors on the seafloor surrounding the well. The dome was tested in Bellingham, Washington and certified by the USCG and American Bureau of Shipping. The unit was never deployed and is available for use in Arctic waters in conjunction with the Arctic Challenger discussed above. Figure 3-2 shows the containment dome being loaded aboard the Arctic Challenger processing vessel.

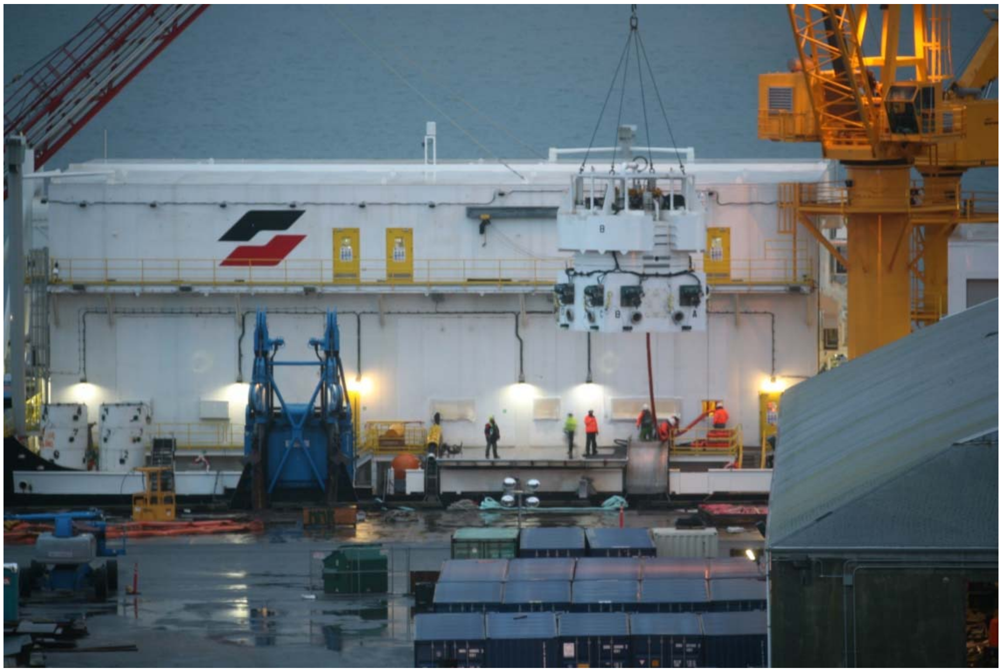


Figure 3-2. Containment dome being loaded aboard the Arctic Challenger (Wikimedia, 2012).

Several of the consortium SCCE providers listed above also maintain containment dome systems as a potential first containment response if a capping stack cannot be immediately deployed due to the circumstances surrounding the wellhead on the seafloor. Since containment domes are non-sealing and rely on gravity flow of the oil and gas upwards to the processing vessel at the surface, it is likely that they will only contain or recover a portion of the ongoing flow of oil at the wellhead. Figure 3-3 shows a currently available containment dome manufactured by Trendsetter Engineering. Of note is the reduced size of the current containment dome technology versus the original designs manufactured for the Macondo incident and Shell’s Arctic application.

Figure 3-3. Containment dome (top hat) example (Trendsetter, 2018).

3.1.3 Cap and Flow Systems

Cap-and-flow systems have also been developed for wells that may not be able to be shut in due to the risk of well-casing failure and a resulting breach of oil and gas to the seafloor surface. Cap-and-flow systems collect oil at the well through a subsea-containment assembly (usually a capping stack designed to be able to flow oil and gas) and flow it to vessels at the surface where the oil can be processed and handled.

3.1.3.1 Arctic Challenger Oil and Gas Processing Barge

Shell outfitted the Arctic Challenger barge to be able to process oil recovered during a potential cap and flow situation for its Chukchi Sea drilling programs in 2015. The system was set up to receive oil and gas from either a capping stack or containment dome and burn off the produced oil and gas. The Arctic Challenger was certified by the US Coast Guard and the American Bureau of Shipping (ABS). General specifications for the vessel are provided below. Figure 3-4 shows the Arctic Challenger outfitted for oil and gas processing.

Hull Constructed:	1976 classed with Ice Strengthening
Class:	A1 Floating Offshore Installation (FOI).
Dimensions:	96 meters x 32 meters (316.5'x105.75') with approximately 3 meters (10 feet) main deck freeboard
Mooring System:	Eight point catenary spread mooring system with sheaves submerged below ice and ACE winches on deck
Cranes:	Sparrows EC1000 (160,600 73 tonne capacity) Sparrows EC65 (10 tonne capacity)
Accommodations:	72 personnel, medical clinic, galley, offices, laundry, lounge
ROV:	SMD Quantum work class ROV system
Containment Dome:	Containment Capacity: 25,000 bpd of light crude oil
Subsea pumps:	2x Bornemann SOGS6
High-Pressure Choke Manifold:	Designed for 10,000psi capability
Processing Module:	3 phase process module designed to separate water from gas and oil with glycol process heaters and chemical injection system
Flare Boom:	Flaring Capacity: 25,000 bpd of light crude oil

Figure 3-4. Arctic Challenger oil and gas processing barge (Wikimedia, 2018).

The Arctic Challenger and associated oil and gas processing equipment has been sold to a surplus equipment company and is for sale at this time. The vessel has been renamed the Poseidon by its new owner and is available for use in the Arctic.

3.1.3.2 Consortium Cap and Flow Systems

Cap-and-flow systems offered by the consortiums listed above in table 3-1, all utilize capping stack technology for their cap and flow systems. Consortium cap and flow providers have designated minimum water depth ranges for their equipment generally from 500 to 1,000 feet (≈150 to ≈300 meters). These minimum operating water depth limitations may be due in part for the potential need for offset installation equipment below 1,000 feet (≈300 meters) which has only been developed by OSRL and is housed in Italy (see section 3.1.4 below). With operating water depths in the Chukchi and Beaufort seas much shallower than this range, it is important to note that a cap and flow system for the Alaska Arctic OCS will need to be fit for purpose to accommodate the shallow water, cold temperatures and the difficult logistical requirements for the area that prevent the rapid deployment of a consortium's equipment that is staged and maintained near the work area such as in the Gulf of Mexico. An example of Marine Well Containment Company's (MWCC's) cap and flow system for Gulf of Mexico application is shown in Figure 3-5.

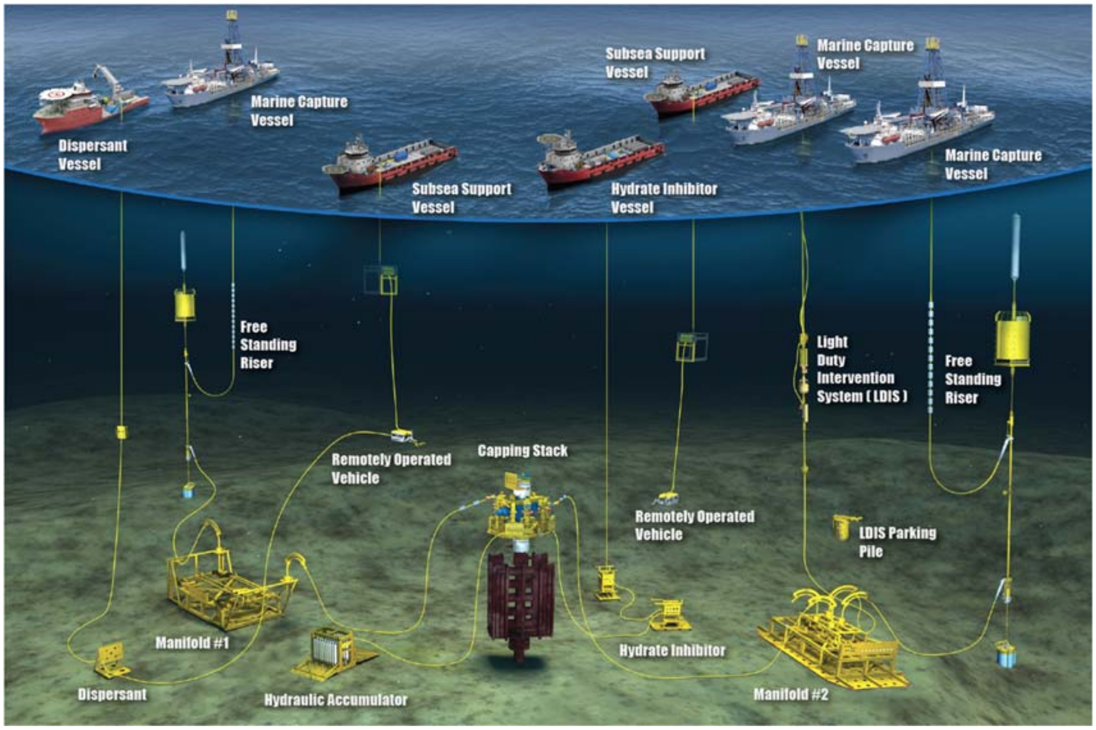


Figure 3-5. MWCC's cap-and-flow system for the Gulf of Mexico (MWCC, 2018).

Several of the consortium SCCE providers listed above also maintain containment dome systems as a potential first containment response if a capping stack cannot be immediately deployed due to the circumstances surrounding the wellhead on the seafloor. Since containment domes are non-sealing and rely on gravity flow of the oil and gas upwards to the processing vessel at the surface, it is likely that they will only contain or recover a portion of the ongoing flow of oil at the wellhead. A currently available containment dome manufactured by Trendsetter Engineering is shown above in Figure 3-3. Of note is the reduced size of the current containment dome technology versus the original designs manufactured for the Macondo incident and Shell's Arctic application.

3.1.4 Offset-Installation Equipment

Offset-installation equipment has been developed to allow installation of a capping stack or cap-and-flow system in shallow water where direct overhead access to the well is not possible due to a gas boil at the surface. OSRL has developed and field tested an offset-installation system for use in shallow waters with a minimum operating depth of 148 feet (45 meters) based on discussions with OSRL technical staff. In the Arctic, with the use of a recessed seafloor cellar, this depth may be reduced to approximately 131 feet (40 meters) and possibly even shallower depths with design modifications (OSRL, 2018). OSRL's offset-installation system is shown in Figure 3-6. A video animation of the system can be viewed on OSRL's website at https://www.oilspillresponse.com/services/subsea-well-intervention-services/offset-installation/.

Figure 3-6. OSRL offset SCCE installation system (OSRL, 2018).

OSRL has constructed one offset-installation system and has no plans to construct additional systems at this time; they are capable of deploying the existing package worldwide by air transport. The OSRL offset-installation system design may also require modifications for use in sea-ice conditions. Potential system design modifications to accommodate shallow water operations, sea ice and other limiting factors could be made through the engineering and design of a fit for purpose system for the Alaska Arctic OCS. The ability to work below the sea ice with ROV's and the OSRL type equipment handling capability could be a valuable tool for capping stack installation in sea ice laden waters.

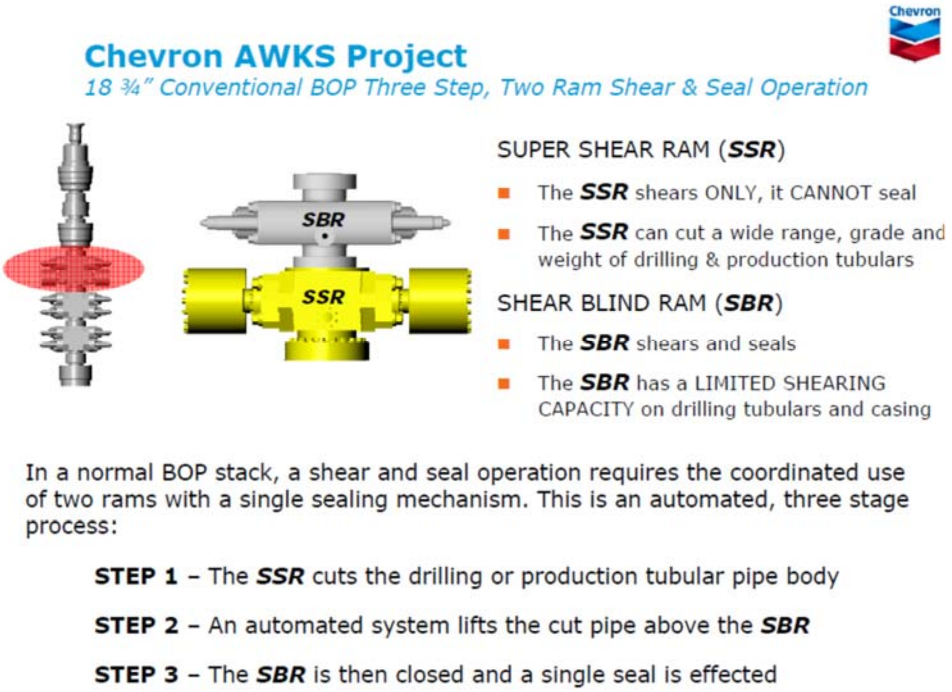
The offshore-design firm Royal IHC has designed a similar offset-installation system but has not built or tested their design as of this time.

3.1.5 Subsea Intervention Devices

A Subsea Intervention Device (SID), also known as a pre-installed capping device (PCD) is a device that is installed on the wellhead near the seafloor early on in the drilling process. The SID is designed to immediately seal the well and can be remotely activated in the event that well control is lost.

Devon, in conjunction with Cameron/Schlumberger, designed a promising SID which included a supershear and seal system referred to as the Advanced Well Kill System (AWKS); this system was installed and field-tested on the SDC vessel for the Paktoa well in the Canadian Beaufort Sea at the conclusion of its 2005/2006 drilling program. They proposed that the National Energy Board of Canada consider the use of AWKS as an alternative technology to the Canadian same-season relief-well requirement. However, research and development delays prevented the system from being completed in time to both meet the approval process timelines and meet shipping deadlines required for timely implementation of the unit at site (it needed to be onsite prior to the minimum construction schedule required for building an ice island to support a relief-well event).

Chevron has since taken over ownership of the AWKS from Devon and has continued the research and development process. Figure 3-7 shows the AWKS system as presented by Chevron and the advantages of the AWKS. It has the capability to shear any drill pipe or casing inside the AWKS and then extract it before sealing the well with a standard BOP blind ram. This capability prevents the potential problem where drill-string components or well casing could be stuck in the BOP stack preventing the sealing of the well.



Chevron AWKS Project

18 ¾" Conventional BOP Three Step, Two Ram Shear & Seal Operation

SUPER SHEAR RAM (***SSR***)

- The ***SSR*** shears ONLY, it CANNOT seal
- The ***SSR*** can cut a wide range, grade and weight of drilling & production tubulars

SHEAR BLIND RAM (***SBR***)

- The ***SBR*** shears and seals
- The ***SBR*** has a LIMITED SHEARING CAPACITY on drilling tubulars and casing

In a normal BOP stack, a shear and seal operation requires the coordinated use of two rams with a single sealing mechanism. This is an automated, three stage process:

STEP 1 – The ***SSR*** cuts the drilling or production tubular pipe body

STEP 2 – An automated system lifts the cut pipe above the ***SBR***

STEP 3 – The ***SBR*** is then closed and a single seal is effected

Figure 3-7. The Advanced Well Kill System (AWKS) (Chevron, 2009).

In addition, Trendsetter Engineering has also developed separate SID technology known as a mudline closure device (MCD) which is designed to shear off drillpipe and seal the well similarly to the AKWS system.

Examples of SID use include ExxonMobil and Rosneft who have employed SIDs in the Kara Sea in the Russian Arctic (ExxonMobil, 2014). ConocoPhillips also proposed to use an SID in conjunction with a jackup drilling vessel for their planned 2014 Devil's Paw well in the Chukchi Sea; however, they cancelled the project during the permitting phase. Figure 3-8 shows the concept of a jackup with a SID installed near the seafloor (Faust, 2012).

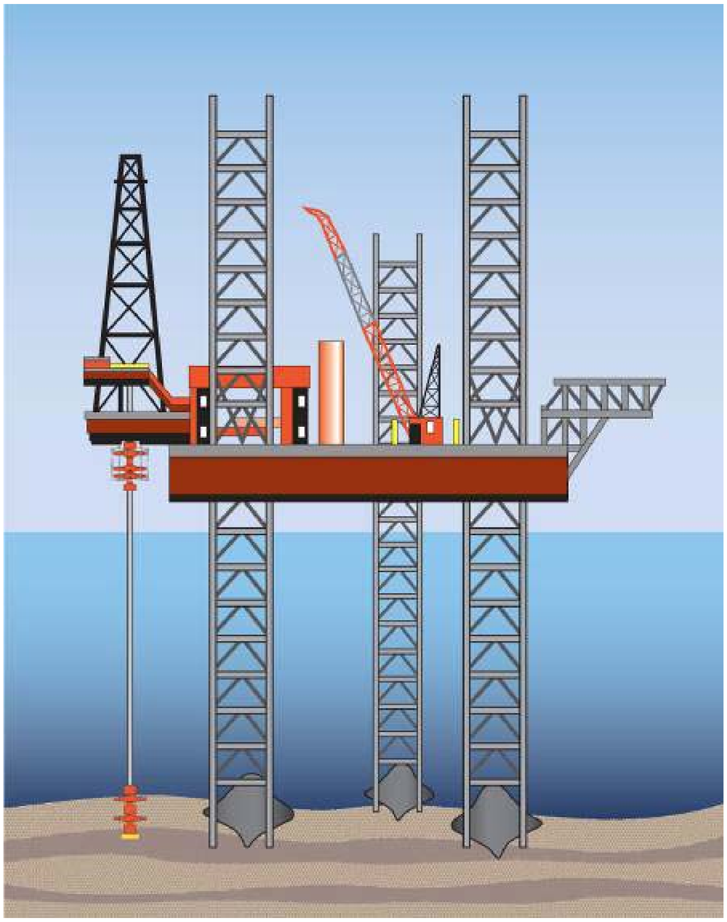


Figure 3-8. Jackup drilling vessel with SID installed near the seafloor (Faust, 2012).

3.2 Potential Future Technology for Arctic SCCE and Relief Well Applications

Developing technologies that may enhance Arctic operations include new ice-class drilling vessel concepts and subsea applications for well intervention and SCCE deployment.

3.2.1 Ice-Class Drilling Vessels

Several new concepts for ice class drilling vessels have been identified above in section 1.2. These concept vessels, if built, could enhance relief well capability in the Chukchi Sea and Beaufort Sea planning areas by providing a broader range of accessible water depths for drilling including shallow water applications that are currently inaccessible with the available ice-class drilling fleet. In addition, these vessels would be outfitted with state of the art drilling and stationkeeping systems that could expedite relief well drilling and SCCE deployment.

3.2.2 Submarine Deployment System

ThyssenKrupp Marine Systems and Statoil have developed a concept for a submarine with a winch system and cargo hold that can be used for maintenance and emergency response activities. Conceivably, it could deploy SCCE on a blowing well when sea-ice or gas-boil conditions may preclude deployment from the surface. Figures 3-9 and 3-10 show the submarine concept in more detail. The initial design characteristics of the vessel are as follows:

Length:	99.7 meters (327 feet)
Breadth:	10 meters (33 feet)
Height:	9.5 meters (31 feet)
Draft (Surfaced):	7.7 meters (25 feet)
Service Speed (Surfaced):	approximately 10.5 knots
Service Speed (Submerged):	approximately 6.5 knots
Displacement:	approximately 3500 tons
Nominal Diving Depth:	150 meters (492 feet)
Working Depth:	1,500 meters (4,921)
Oil Response Capability:	2,800 meters^3
Payload:	289 tons
DP System:	8 thrusters
Classification Society:	DNV-GL
Crew:	19 personnel

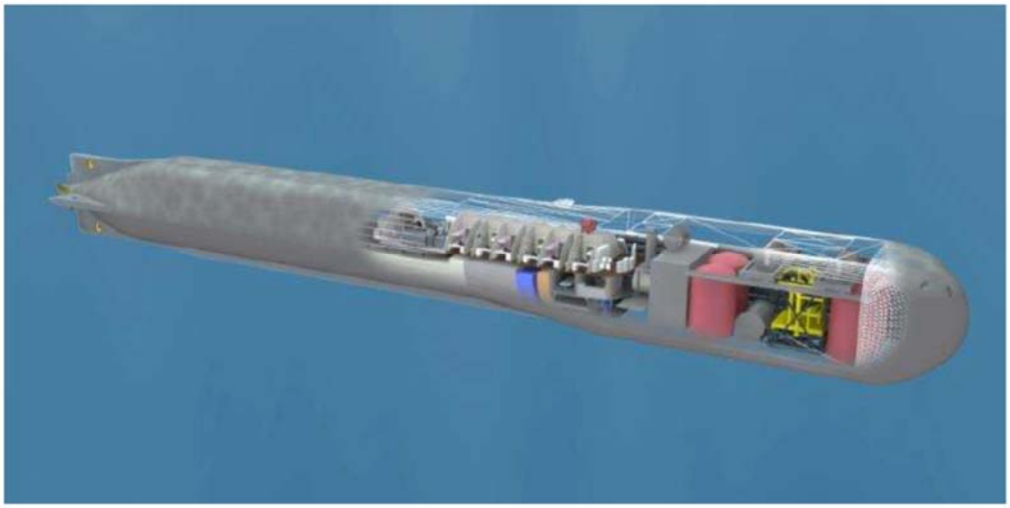


Figure 3-9. Submarine concept for well intervention operations (Brandt and Fruhling, 2015).

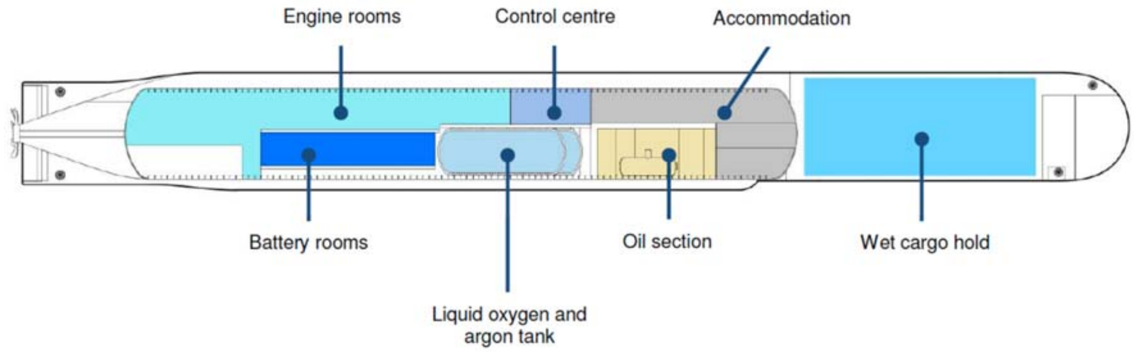


Figure 3-10. Well intervention submarine internal layout (Brandt and Fruhling, 2015).

APPENDIX B

Sea Ice Analysis Data Outputs for Official Protraction Diagram Quadrants

2012-2016

Chukchi Sea and Beaufort Sea Planning Areas

Description of Appendix B Data

Appendix B herein, is supplemental data to the US Bureau of Safety and Environmental Enforcement (BSEE) Suitability of Source Control and Containment Equipment (SCCE) versus Same Season Relief Well in the Alaska Arctic OCS Region Report. This appendix presents the sea ice data collected for the periods of June through December from 2012 to 2016 over the Chukchi Sea and Beaufort Sea planning areas. The sea ice data has been utilized in the deployment analysis for multiple operating scenarios in the aforementioned Report.

The scope of work for the Report included tasks 6 through 10 which required a five year historical analysis of metocean conditions that would impact the deployment of SCCE or a relief well. Please refer to sections 6.3 and 6.4 of the subject Report for a complete description of the scope of work tasks. For the deployment analysis (section 6.0 of the report), four base operating scenarios were developed for task 6 and four more for task 7. These base operating scenarios are 6.1, 6.2, 7.1, and 7.2 in the Chukchi Sea planning area and scenarios 6.3, 6.4, 7.3, 7.4 in Beaufort Sea planning area. Scenarios 6.1, 6.3, 7.1 and 7.3 are open water scenarios while the remaining scenarios (6.2, 6.4, 7.2 and 7.4) have sea ice operating capability. In addition to the base operating scenarios, 12 additional scenarios (8.1 to 8.4, 9.1 to 9.4 and 10.1 to 10.4) have been created to address tasks 8, 9 and 10 of the Report scope of work (see section 6.3.3 of the Report for a detailed description of the scenarios associated with tasks 8, 9 and 10). Each of the scenarios in this group require comparison of the base operating scenarios described above. Because they are comparisons of the base operating scenarios, there is no need to present sea ice data for the 12 additional scenarios under tasks 8, 9 and 10.

The sea ice data was obtained from the US National Ice Center (US NIC) for the area in each Official Protraction Diagram (OPD) in the Chukchi Sea and Beaufort Sea planning areas. These OPDs were further subdivided into four quadrants to provide higher resolution of the sea ice data in the event evaluation of a specific location was desired within an OPD. The quadrants presented in appendix B below are 0.5-degree latitude by 1.5-degrees longitude cells that measure approximately 30 nautical miles by 30 nautical miles. These cells are equal to ¼ (or one quadrant) of a full-sized OPD that measures approximately 1-degree latitude by 3-degrees longitude or approximately 60 nautical miles by 60 nautical miles.

The sea ice concentration in the quadrants is presented as the percent probability for a given sea ice criteria limit. For example, the number 50 in a quadrant represents a 50 percent probability for the specified sea ice condition to occur such as open water or 0 to 7 tenths ice concentration. Sea ice concentrations are measured as tenths of coverage where 0 tenths is open water and 7 tenths is 70% coverage or concentration.

The sea ice data is presented in 10-day periods that fit into a month creating three each 10-day periods within each month: days 1 - 10, 11 - 20, 21 - 30 (31) from June through December for the period from 2012 to 2016. This results in 21 each 10 day periods presented for each base operating scenario. Thus, each base operating scenario has 21 pages of sea ice data with each page covering a 10 or 11 day period.

The data presented below can be utilized in conjunction with the deployment analyses in sections 6 and 7 of the Report to confirm the five year historical sea ice conditions at a given quadrant location during the months of June through December.

Scenario 6.1:

Safe Open Water SCCE Deployment in the Chukchi Sea.

Sea ice data for the probability of open water, within a 30 nautical mile ice free radius, for the period from June through December, 2012 to 2016, in the Chukchi Sea.

0 UNNAMED NS02-04 0	0 0 UNNAMED NS03-03 0 0	0 0 UNNAMED NS03-04 0 0	0 0 UNNAMED NS04-03 0 0	0 0 UNNAMED NS04-04 0 0
0 UNNAMED NS02-06 0	0 0 UNNAMED NS03-05 0 0	0 0 UNNAMED NS03-06 0 0	0 0 UNNAMED NS04-05 0 0	0 0 UNNAMED NS04-06 0 0
0 UNNAMED NS02-08 0	0 0 UNNAMED NS03-07 0 0	0 0 UNNAMED NS03-038 0 0	0 0 UNNAMED NS04-07 0 0	0 0 UNNAMED NS04-08 0 0
0 TISON NR02-02 0	0 0 KARO NR03-01 0 0	0 0 POSEY NR03-02 0 0	0 0 HANNA SHOAL NR04-01 0 0	0 0 BARROW NR04-02 0 0
0 STUDDS NR02-04 0	0 0 COLBERT NR03-03 0 20	0 0 SOLIVIK ISLAND NR03-04 0 0	0 0 WAINWRIGHT NR04-03 0	MEADE RIVER 0 NR04-04
0 CHUKCHI SEA NR02-06 0	0 0 POINT LAY WEST NR03-05 0 0	40 20 POINT LAY NR03-06 20 40		
0 PT. HOPE W. NR02-08 0	0 0 POINT HOPE NR03-07 0 0	DE LONG MTS. 40 NR03-08		

2012 to 2016

1-Jun 10-Jun

Sea Ice 6.1.1 Scenario 6.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

0 UNNAMED NS02-04 0	0 0 UNNAMED NS03-03 0 0	0 0 UNNAMED NS03-04 0 0	0 0 UNNAMED NS04-03 0 0	0 0 UNNAMED NS04-04 0 0
0 UNNAMED NS02-06 0	0 0 UNNAMED NS03-05 0 0	0 0 UNNAMED NS03-06 0 0	0 0 UNNAMED NS04-05 0 0	0 0 UNNAMED NS04-06 0 0
0 UNNAMED NS02-08 0	0 0 UNNAMED NS03-07 0 0	0 0 UNNAMED NS03-038 0 0	0 0 UNNAMED NS04-07 0 0	0 0 UNNAMED NS04-08 0 0
0 TISON NR02-02 0	0 0 KARO NR03-01 0 0	0 0 POSEY NR03-02 0 0	0 0 HANNA SHOAL NR04-01 0 0	0 0 BARROW NR04-02 0 0
0 STUDDS NR02-04 0	0 20 COLBERT NR03-03 0 20	0 0 SOLIVIK ISLAND NR03-04 20 0	0 0 WAINWRIGHT NR04-03 0	MEADE RIVER 0 NR04-04
0 CHUKCHI SEA NR02-06 20	0 20 POINT LAY WEST NR03-05 20 20	20 20 POINT LAY NR03-06 0 20		
40 PT. HOPE W. NR02-08 40	20 20 POINT HOPE NR03-07 40 40	DE LONG MTS. 20 NR03-08		

2012 to 2016

11-Jun 20-Jun

Sea Ice 6.1.2 Scenario 6.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
0	0	0	0	0	0	0	0	0
0	0	20	20	20	20	0	MEADE RIVER	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		0	
NR02-04	NR03-03		NR03-04		NR04-03		NR04-04	
0	20	20	20	60	40			
20	40	20	40	40				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
80	60	40	40	40				
60	40	20	DE LONG MTS.					
PT. HOPE W.	POINT HOPE		20					
NR02-08	NR03-07		NR03-08					
80	80	80						

2012 to 2016

21-Jun 30-Jun

Sea Ice 6.1.3 Scenario 6.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-04 0	NS03-03 0	0	NS03-04 0	0	NS04-03 0	0	NS04-04 0	0
0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-06 0	NS03-05 0	0	NS03-06 0	0	NS04-05 0	0	NS04-06 0	0
0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-08 0	NS03-07 0	0	NS03-038 0	0	NS04-07 0	0	NS04-08 0	0
0 TISON	0 KARO	0	0 POSEY	0	0 HANNA SHOAL	0	0 BARROW	0
NR02-02 0	NR03-01 0	20	NR03-02 20	20	NR04-01 0	0	NR04-02 0	20
0 STUDDS	20 COLBERT	20	20 SOLIVIK ISLAND	20	20 WAINWRIGHT	20	MEADE RIVER 20 NR04-04	
NR02-04 0	NR03-03 0	20	NR03-04 20	40	NR04-03 40			
20 CHUKCHI SEA	80 POINT LAY WEST	40	40 POINT LAY	60				
NR02-06 80	NR03-05 80	40	NR03-06 40	60				
60 PT. HOPE W.	60 POINT HOPE	40	DE LONG MTS. 40 NR03-08					
NR02-08 80	NR03-07 80	80						

2012 to 2016

1-Jul 10-Jul

Sea Ice 6.1.4 Scenario 6.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
0	0	0	0	0	0	0	0	0
20	20	20	0	0	0	0	0	0
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
20	40	20	20	0	0	0	20	0
40	60	20	20	20	0	40	MEADE RIVER	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		20	
NR02-04	NR03-03		NR03-04		NR04-03		NR04-04	
40	80	60	80	80	80			
60	100	100	100	100				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	100	100				
100	100	80	DE LONG MTS.					
PT. HOPE W.	POINT HOPE		80					
NR02-08	NR03-07		NR03-08					
100	100	100						

2012 to 2016

11-Jul 20-Jul

Sea Ice 6.1.5 Scenario 6.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
0	0	0	0	0	0	0	0	0
20	20	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
20	20	20	20	0	0	0	0	0
20	20	0	0	0	0	0	0	0
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
40	40	20	20	0	0	20	20	0
40	60	80	60	60	0	20	40	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		MEADE RIVER	
NR02-04	NR03-03		NR03-04		NR04-03		NR04-04	
40	60	100	100	100	80			
60	80	100	100	100				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	100	100				
100	100	100	100					
PT. HOPE W.	POINT HOPE		DE LONG MTS.					
NR02-08	NR03-07		NR03-08					
100	100	100						

2012 to 2016

21-Jul 31-Jul

Sea Ice 6.1.6 Scenario 6.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-04 0	NS03-03 0	0	NS03-04 0	0	NS04-03 0	0	NS04-04 0	0
0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-06 0	NS03-05 0	0	NS03-06 0	0	NS04-05 0	0	NS04-06 0	0
20 UNNAMED	20 UNNAMED	20	20 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-08 20	NS03-07 20	20	NS03-038 20	20	NS04-07 20	20	NS04-08 0	0
40 TISON	40 KARO	40	40 POSEY	20	0 HANNA SHOAL	20	0 BARROW	0
NR02-02 80	NR03-01 60	60	NR03-02 40	20	NR04-01 20	20	NR04-02 40	40
80 STUDDS	100 COLBERT	100	80 SOLIVIK ISLAND	80	60 WAINWRIGHT	40	MEADE RIVER 60 NR04-04	
NR02-04 80	NR03-03 80	100	NR03-04 100	100	NR04-03 100			
80 CHUKCHI SEA	100 POINT LAY WEST	100	100 POINT LAY	100				
NR02-06 100	NR03-05 100	100	NR03-06 100	100				
100 PT. HOPE W.	100 POINT HOPE	100	DE LONG MTS. 100 NR03-08					
NR02-08 100	NR03-07 100	100						

2012 to 2016

1-Aug 10-Aug

Sea Ice 6.1.7 Scenario 6.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
20	20	0	0	0	0	0	0	0
20	20	20	20	0	0	0	0	20
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
40	20	20	20	20	20	20	0	20
40	40	40	20	20	20	20	0	40
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
80	100	100	20	20	20	40	80	60
100	100	100	100	100	60	40	80	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		MEADE RIVER	
NR02-04	NR03-03		NR03-04		NR04-03		NR04-04	
100	100	100	100	100	100			
100	100	100	100	100				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	100	100				
100	100	100	100					
PT. HOPE W.	POINT HOPE		DE LONG MTS.					
NR02-08	NR03-07		NR03-08					
100	100	100						

2012 to 2016

11-Aug 20-Aug

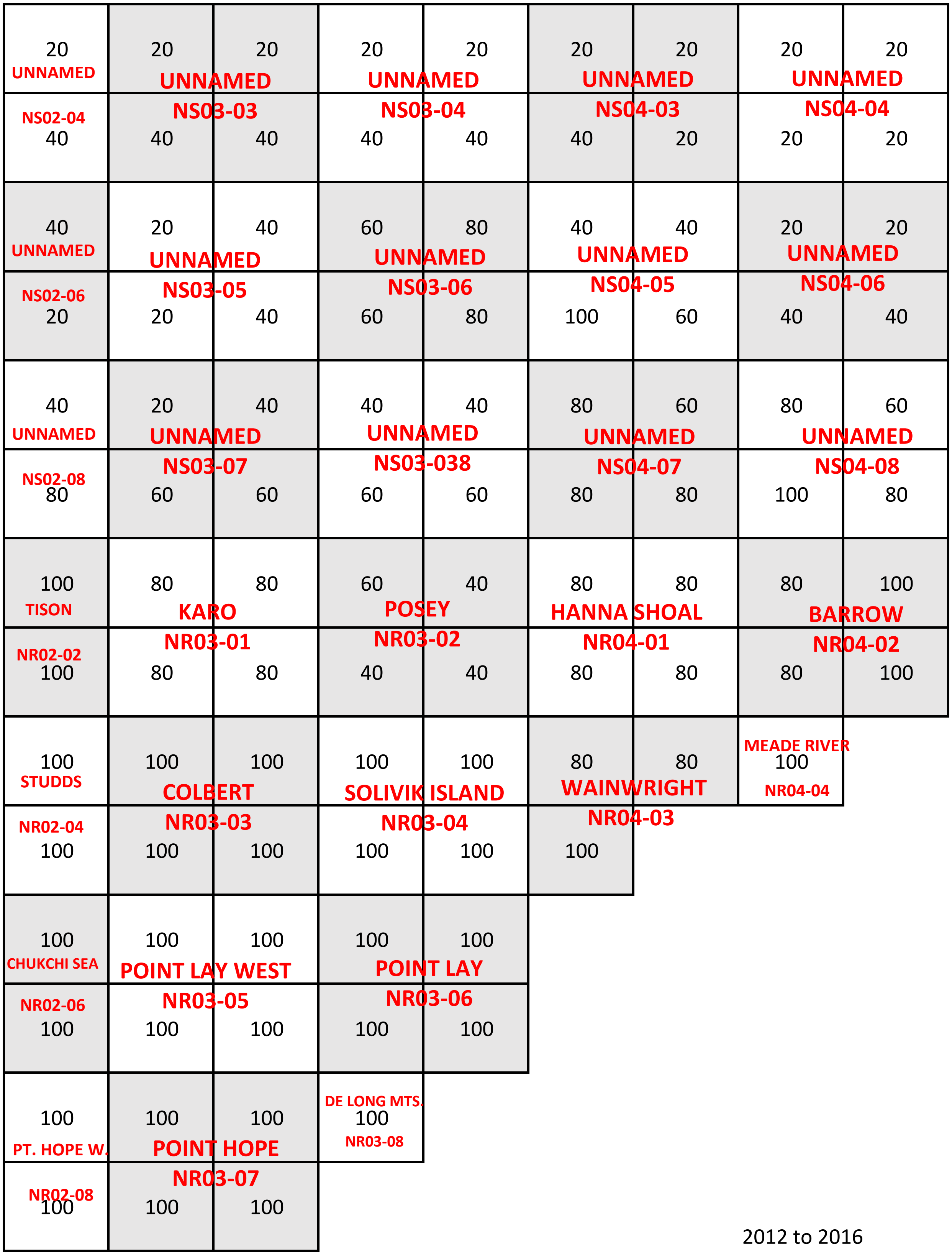
Sea Ice 6.1.8 Scenario 6.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

0	0	0	40	20	20	20	20	20
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
0	0	20	20	40	40	20	20	20
0	20	20	20	60	40	40	20	20
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
20	20	20	20	20	100	60	80	40
40	40	20	20	20	20	40	100	80
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
60	60	60	60	20	20	20	80	100
80	80	60	40	40	20	40	60	100
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
100	80	80	60	40	60	40	80	100
100	100	100	80	80	80	100	MEADE RIVER 100 NR04-04	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT			
NR02-04	NR03-03		NR03-04		NR04-03			
100	100	100	100	100	100			
100	100	100	100	100				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	100	100				
100	100	100	DE LONG MTS. 100 NR03-08					
PT. HOPE W.	POINT HOPE							
NR02-08	NR03-07							
100	100	100						

2012 to 2016

21-Aug 31-Aug

Sea Ice 6.1.9 Scenario 6.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.



20	20	20	20	20	20	20	20	20
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
40	40	40	40	40	40	20	20	20
40	20	40	60	80	40	40	20	20
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
20	20	40	60	80	100	60	40	40
40	20	40	40	40	80	60	80	60
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
80	60	60	60	60	80	80	100	80
100	80	80	60	40	80	80	80	100
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
100	80	80	40	40	80	80	80	100
100	100	100	100	100	80	80	MEADE RIVER 100 NR04-04	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT			
NR02-04	NR03-03		NR03-04		NR04-03			
100	100	100	100	100	100			
100	100	100	100	100				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	100	100				
100	100	100	DE LONG MTS. 100 NR03-08					
PT. HOPE W.	POINT HOPE							
NR02-08	NR03-07							
100	100	100						

2012 to 2016

1-Sep 10-Sep

Sea Ice 6.1.10 Scenario 6.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

40	40	40	40	60	60	60	60	40
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
60	60	60	40	40	60	80	80	60
80	60	60	60	60	80	80	80	80
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
60	60	80	60	60	80	100	80	80
40	40	60	60	60	80	100	100	100
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
80	100	80	80	60	60	60	80	100
100	100	80	80	60	60	60	80	100
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
100	100	100	80	60	80	80	80	100
100	100	100	100	80	80	100	MEADE RIVER 100 NR04-04	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT			
NR02-04	NR03-03		NR03-04		NR04-03			
100	100	100	100	100	100			
100	100	100	100	80				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	100	100				
100	100	100	DE LONG MTS. 100 NR03-08					
PT. HOPE W.	POINT HOPE							
NR02-08	NR03-07							
100	100	100						

2012 to 2016

11-Sep 20-Sep

Sea Ice 6.1.11 Scenario 6.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

40	40	40	40	60	60	40	40	20
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
60	60	60	40	40	60	60	40	40
100	80	80	80	60	60	60	60	60
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
80	80	100	80	80	60	80	60	60
80	80	80	80	80	80	80	80	80
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
100	100	100	100	80	80	80	80	80
100	100	100	100	100	80	80	80	100
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
100	100	100	100	100	100	100	100	100
100	100	100	100	100	100	100	MEADE RIVER 100	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		NR04-04	
NR02-04	NR03-03		NR03-04		NR04-03			
100	100	100	100	100	100			
100	100	100	100	80				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	100	100				
100	100	100	DE LONG MTS. 100					
PT. HOPE W.	POINT HOPE		NR03-08					
NR02-08	NR03-07							
100	100	100						

2012 to 2016

21-Sep 30-Sep

Sea Ice 6.1.12 Scenario 6.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

80	60	80	80	40	40	40	40	40
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
80	80	80	80	60	60	60	40	40
80	80	100	100	100	100	100	40	40
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
60	60	80	100	80	100	100	60	40
80	100	100	100	100	80	100	100	100
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
100	100	100	100	100	80	80	100	100
100	100	100	100	100	100	100	100	100
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
100	100	100	100	100	100	100	100	100
							MEADE RIVER	
100	100	100	100	100	100	100	100	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		NR04-04	
NR02-04	NR03-03		NR03-04		NR04-03			
100	100	100	100	100	100			
			DE LONG MTS.					
100	100	100	100	80				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	100	100				
100	100	100	100					
PT. HOPE W.	POINT HOPE		NR03-08					
NR02-08	NR03-07							
100	100	100						

2012 to 2016

1-Oct 10-Oct

Sea Ice 6.1.13 Scenario 6.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

40 UNNAMED	20 UNNAMED	20	20 UNNAMED	20	20 UNNAMED	20	20 UNNAMED	20
NS02-04 40	NS03-03 20	20	NS03-04 20	20	NS04-03 40	20	NS04-04 20	20
40 UNNAMED	40 UNNAMED	60	60 UNNAMED	40	40 UNNAMED	40	40 UNNAMED	40
NS02-06 60	NS03-05 60	80	NS03-06 80	100	NS04-05 60	60	NS04-06 40	40
60 UNNAMED	80 UNNAMED	80	80 UNNAMED	80	80 UNNAMED	80	60 UNNAMED	40
NS02-08 100	NS03-07 100	100	NS03-038 100	100	NS04-07 100	100	NS04-08 100	80
100 TISON	100 KARO	100	100 POSEY	100	100 HANNA SHOAL	100	100 BARROW	100
NR02-02 100	NR03-01 100	100	NR03-02 100	100	NR04-01 100	100	NR04-02 100	80
100 STUDDS	100 COLBERT	100	100 SOLIVIK ISLAND	100	100 WAINWRIGHT	80	MEADE RIVER 100 NR04-04	
NR02-04 100	NR03-03 100	100	NR03-04 100	100	NR04-03 100			
100 CHUKCHI SEA	100 POINT LAY WEST	100	100 POINT LAY	20				
NR02-06 100	NR03-05 100	100	NR03-06 100	80				
100 PT. HOPE W.	100 POINT HOPE	100	DE LONG MTS. 100 NR03-08					
NR02-08 100	NR03-07 100	100						

2012 to 2016

11-Oct 20-Oct

Sea Ice 6.1.14 Scenario 6.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

20	20	20	0	0	20	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
20	20	20	0	20	40	20	20	20
20	40	20	40	40	40	40	40	40
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
0	0	0	0	40	40	40	40	40
40	40	20	40	40	40	40	40	40
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
100	80	100	100	80	80	80	60	40
100	100	100	100	100	100	80	80	60
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
100	100	100	100	100	80	80	80	60
100	100	100	100	100	100	20	MEADE RIVER 80 NR04-04	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT			
NR02-04	NR03-03		NR03-04		NR04-03			
100	100	100	100	80	80			
100	100	100	100	0				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	40	40				
100	100	100	DE LONG MTS. 60 NR03-08					
PT. HOPE W.	POINT HOPE							
NR02-08	NR03-07							
100	100	100						

2012 to 2016

21-Oct 31-Oct

Sea Ice 6.1.15 Scenario 6.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

0	0	0	0	0	0	0	0	0
UNNAMED NS02-04	UNNAMED NS03-03		UNNAMED NS03-04		UNNAMED NS04-03		UNNAMED NS04-04	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED NS02-06	UNNAMED NS03-05		UNNAMED NS03-06		UNNAMED NS04-05		UNNAMED NS04-06	
0	0	0	0	0	0	0	0	0
20	20	20	0	0	0	0	0	0
UNNAMED NS02-08	UNNAMED NS03-07		UNNAMED NS03-038		UNNAMED NS04-07		UNNAMED NS04-08	
60	40	40	0	0	20	0	0	0
60	60	60	40	40	20	0	0	0
TISON NR02-02	KARO NR03-01		POSEY NR03-02		HANNA SHOAL NR04-01		BARROW NR04-02	
80	80	60	40	40	20	20	0	0
100	80	60	80	60	40	0	MEADE RIVER 0 NR04-04	
STUDDS NR02-04	COLBERT NR03-03		SOLIVIK ISLAND NR03-04		WAINWRIGHT NR04-03			
100	100	80	80	60	40			
100	100	100	80	0				
CHUKCHI SEA NR02-06	POINT LAY WEST NR03-05		POINT LAY NR03-06					
100	100	60	0	0				
100	80	20	DE LONG MTS. 0 NR03-08					
PT. HOPE W. NR02-08	POINT HOPE NR03-07							
100	80	80						

2012 to 2016

1-Nov 10-Nov

Sea Ice 6.1.16 Scenario 6.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
0	40	20	20	0	0	0	0	0
40	40	40	20	0	0	0	0	0
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
40	40	40	40	0	0	0	0	0
60	60	60	40	40	40	0	MEADE RIVER 0	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		NR04-04	
NR02-04	NR03-03		NR03-04		NR04-03			
80	80	40	40	20	0			
80	80	60	40	0				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
80	40	40	0	0				
80	40	20	DE LONG MTS. 0					
PT. HOPE W.	POINT HOPE		NR03-08					
NR02-08	NR03-07							
60	40	60						

2012 to 2016

11-Nov 20-Nov

Sea Ice 6.1.17 Scenario 6.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-04 0	NS03-03 0	0	NS03-04 0	0	NS04-03 0	0	NS04-04 0	0
0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-06 0	NS03-05 0	0	NS03-06 0	0	NS04-05 0	0	NS04-06 0	0
0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-08 20	NS03-07 20	20	NS03-038 0	0	NS04-07 0	0	NS04-08 0	0
60 TISON	20 KARO	20	0 POSEY	0	0 HANNA SHOAL	0	0 BARROW	0
NR02-02 60	NR03-01 60	20	NR03-02 0	0	NR04-01 0	0	NR04-02 0	0
60 STUDDS	60 COLBERT	40	40 SOLIVIK ISLAND	20	0 WAINWRIGHT	0	MEADE RIVER 0 NR04-04	
NR02-04 60	NR03-03 60	40	NR03-04 20	0	NR04-03 20			
60 CHUKCHI SEA	60 POINT LAY WEST	20	0 POINT LAY	0				
NR02-06 60	NR03-05 40	0	NR03-06 0	0				
40 PT. HOPE W.	0 POINT HOPE	0	DE LONG MTS. 0 NR03-08					
NR02-08 40	NR03-07 40	40						

2012 to 2016

21-Nov 30-Nov

Sea Ice 6.1.18 Scenario 6.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

UNNAMED	NS02-04	0		0	
UNNAMED	NS03-03	0	0	0	0
UNNAMED	NS03-04	0	0	0	0
UNNAMED	NS04-03	0	0	0	0
UNNAMED	NS04-04	0	0	0	0
UNNAMED	NS02-06	0		0	
UNNAMED	NS03-05	0	0	0	0
UNNAMED	NS03-06	0	0	0	0
UNNAMED	NS04-05	0	0	0	0
UNNAMED	NS04-06	0	0	0	0
UNNAMED	NS02-08	0		20	
UNNAMED	NS03-07	0	0	20	0
UNNAMED	NS03-038	0	0	0	0
UNNAMED	NS04-07	0	0	0	0
UNNAMED	NS04-08	0	0	0	0
TISON	NR02-02	20		20	
KARO	NR03-01	20	0	20	0
POSEY	NR03-02	0	0	0	0
HANNA SHOAL	NR04-01	0	0	0	0
BARROW	NR04-02	0	0	0	0
STUDDS	NR02-04	20		0	
COLBERT	NR03-03	20	20	0	0
SOLIVIK ISLAND	NR03-04	20	0	0	0
WAINWRIGHT	NR04-03	0	0	0	
MEADE RIVER	NR04-04	0			
CHUKCHI SEA	NR02-06	20		40	
POINT LAY WEST	NR03-05	20	0	0	0
POINT LAY	NR03-06	0	0	0	0
PT. HOPE W.	NR02-08	40		40	
POINT HOPE	NR03-07	0	0	0	0
DE LONG MTS.	NR03-08	0			

2012 to 2016

1-Dec 10-Dec

Sea Ice 6.1.19 Scenario 6.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

0 UNNAMED NS02-04 0	0 0 UNNAMED NS03-03 0 0	0 0 UNNAMED NS03-04 0 0	0 0 UNNAMED NS04-03 0 0	0 0 UNNAMED NS04-04 0 0
0 UNNAMED NS02-06 0	0 0 UNNAMED NS03-05 0 0	0 0 UNNAMED NS03-06 0 0	0 0 UNNAMED NS04-05 0 0	0 0 UNNAMED NS04-06 0 0
0 UNNAMED NS02-08 20	0 0 UNNAMED NS03-07 20 20	0 0 UNNAMED NS03-038 0 0	0 0 UNNAMED NS04-07 0 0	0 0 UNNAMED NS04-08 0 0
20 TISON NR02-02 0	0 0 KARO NR03-01 0 0	0 0 POSEY NR03-02 0 0	0 0 HANNA SHOAL NR04-01 0 0	0 0 BARROW NR04-02 0 0
0 STUDDS NR02-04 0	0 0 COLBERT NR03-03 0 0	0 0 SOLIVIK ISLAND NR03-04 0 0	0 0 WAINWRIGHT NR04-03 0	MEADE RIVER 0 NR04-04
0 CHUKCHI SEA NR02-06 0	0 0 POINT LAY WEST NR03-05 0 0	0 0 POINT LAY NR03-06 0 0		
0 PT. HOPE W. NR02-08 0	0 0 POINT HOPE NR03-07 0 0	DE LONG MTS. 0 NR03-08		

2012 to 2016

11-Dec 20-Dec

Sea Ice 6.1.20 Scenario 6.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

0	0	0	0	0	0	0	0	0
UNNAMED NS02-04	UNNAMED NS03-03		UNNAMED NS03-04		UNNAMED NS04-03		UNNAMED NS04-04	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED NS02-06	UNNAMED NS03-05		UNNAMED NS03-06		UNNAMED NS04-05		UNNAMED NS04-06	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED NS02-08	UNNAMED NS03-07		UNNAMED NS03-038		UNNAMED NS04-07		UNNAMED NS04-08	
20	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0
TISON NR02-02	KARO NR03-01		POSEY NR03-02		HANNA SHOAL NR04-01		BARROW NR04-02	
20	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	
STUDDS NR02-04	COLBERT NR03-03		SOLIVIK ISLAND NR03-04		WAINWRIGHT NR04-03		MEADE RIVER NR04-04	
0	0	0	0	0	0			
0	0	0	0	0				
CHUKCHI SEA NR02-06	POINT LAY WEST NR03-05		POINT LAY NR03-06					
0	0	0	0	0				
0	0	0	0					
PT. HOPE W. NR02-08	POINT HOPE NR03-07		DE LONG MTS. NR03-08					
0	0	0						

2012 to 2016

21-Dec 31-Dec

Sea Ice 6.1.21 Scenario 6.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

Scenario 6.2:
Safe SCCE Deployment with Sea Ice Operating Capability in the Chukchi Sea.

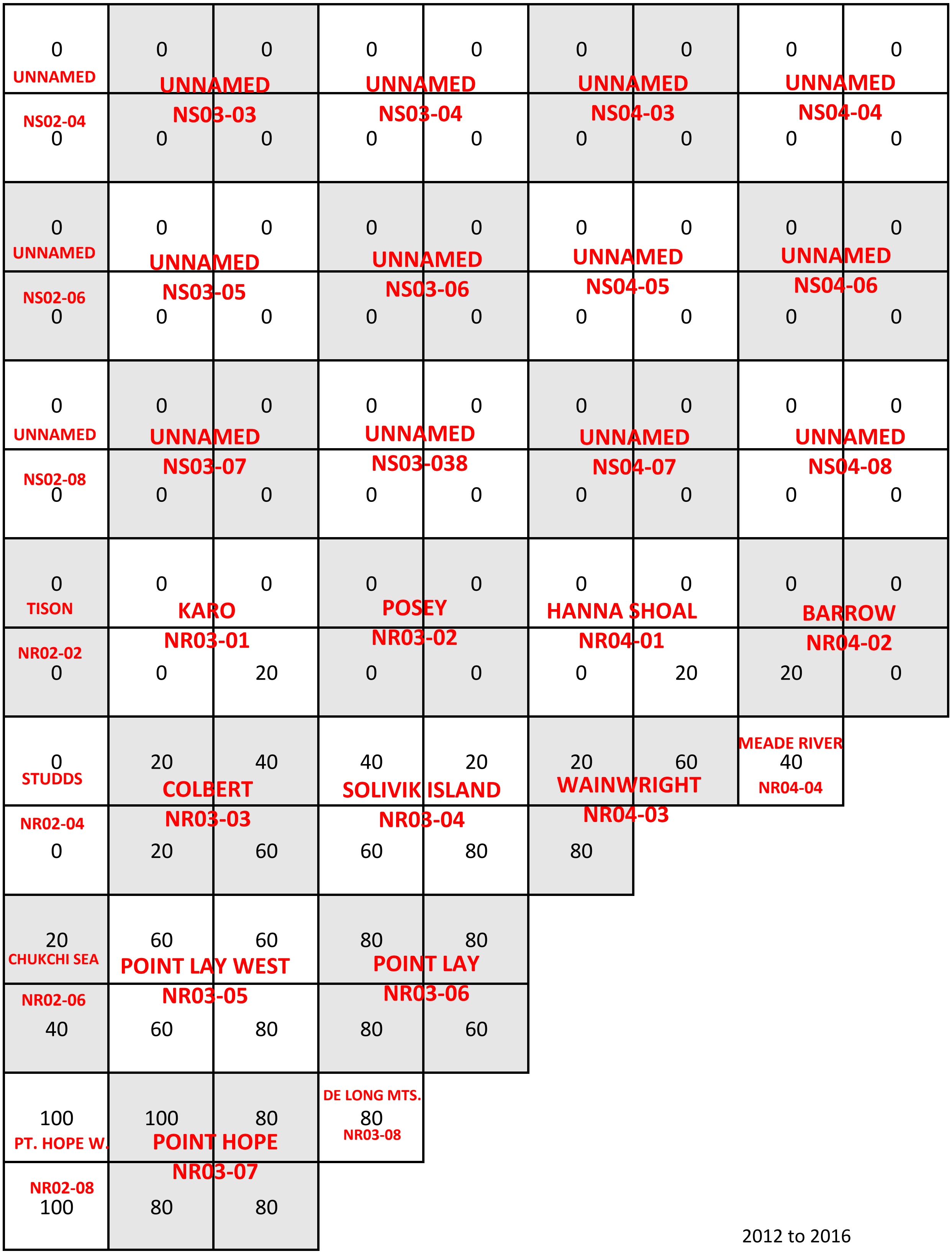
Sea ice data for the probability of sea ice concentration from 0 to 7 tenths, for the period from June through December, 2012 to 2016, in the Chukchi Sea.

0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-04 0	NS03-03 0	0	NS03-04 0	0	NS04-03 0	0	NS04-04 0	0
0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-06 0	NS03-05 0	0	NS03-06 0	0	NS04-05 0	0	NS04-06 0	0
0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-08 0	NS03-07 0	0	NS03-038 0	0	NS04-07 0	0	NS04-08 0	0
0 TISON	0 KARO	0	0 POSEY	0	0 HANNA SHOAL	0	0 BARROW	0
NR02-02 0	NR03-01 0	0	NR03-02 0	0	NR04-01 0	20	NR04-02 40	40
0 STUDDS	20 COLBERT	20	20 SOLIVIK ISLAND	0	0 WAINWRIGHT	40	MEADE RIVER 80 NR04-04	
NR02-04 0	NR03-03 40	40	NR03-04 40	60	NR04-03 80			
0 CHUKCHI SEA	20 POINT LAY WEST	60	80 POINT LAY	60				
NR02-06 20	NR03-05 40	80	NR03-06 80	40				
60 PT. HOPE W.	80 POINT HOPE	40	DE LONG MTS. 60 NR03-08					
NR02-08 80	NR03-07 100	80						

2012 to 2016

1-Jun 10-Jun

Sea Ice 6.2.1 Scenario 6.2: Percent probability of sea ice concentration from 0 to 7 tenths, Chukchi Sea.



UNNAMED	NS02-04	0		0	
UNNAMED	NS03-03	0	0	0	0
UNNAMED	NS03-04	0	0	0	0
UNNAMED	NS04-03	0	0	0	0
UNNAMED	NS04-04	0	0	0	0
UNNAMED	NS02-06	0		0	
UNNAMED	NS03-05	0	0	0	0
UNNAMED	NS03-06	0	0	0	0
UNNAMED	NS04-05	0	0	0	0
UNNAMED	NS04-06	0	0	0	0
UNNAMED	NS02-08	0		0	
UNNAMED	NS03-07	0	0	0	0
UNNAMED	NS03-038	0	0	0	0
UNNAMED	NS04-07	0	0	0	0
UNNAMED	NS04-08	0	0	0	0
TISON	NR02-02	0		0	
KARO	NR03-01	0	0	0	20
POSEY	NR03-02	0	0	0	0
HANNA SHOAL	NR04-01	0	0	0	20
BARROW	NR04-02	0	0	20	0
STUDDS	NR02-04	0		0	
COLBERT	NR03-03	20	40	20	60
SOLIVIK ISLAND	NR03-04	40	20	60	80
WAINWRIGHT	NR04-03	20	60	80	
MEADE RIVER	NR04-04	40			
CHUKCHI SEA	NR02-06	20		40	
POINT LAY WEST	NR03-05	60	60	60	80
POINT LAY	NR03-06	80	80	80	60
PT. HOPE W.	NR02-08	100		100	
POINT HOPE	NR03-07	100	80	80	80
DE LONG MTS.	NR03-08	80			

2012 to 2016

11-Jun 20-Jun

Sea Ice 6.2.2 Scenario 6.2: Percent probability of sea ice concentration from 0 to 7 tenths, Chukchi Sea.

0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-04 0	NS03-03 0	0	NS03-04 0	0	NS04-03 0	0	NS04-04 0	0
0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-06 0	NS03-05 0	0	NS03-06 0	0	NS04-05 0	0	NS04-06 0	0
0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-08 0	NS03-07 0	0	NS03-038 0	0	NS04-07 0	0	NS04-08 0	0
0 TISON	0 KARO	20	20 POSEY	0	0 HANNA SHOAL	0	0 BARROW	0
NR02-02 0	NR03-01 20	20	NR03-02 20	20	NR04-01 0	0	NR04-02 0	20
20 STUDDS	20 COLBERT	40	20 SOLIVIK ISLAND	20	20 WAINWRIGHT	40	MEADE RIVER 20 NR04-04	
NR02-04 40	NR03-03 60	40	NR03-04 80	80	NR04-03 100			
60 CHUKCHI SEA	60 POINT LAY WEST	100	60 POINT LAY	100				
NR02-06 100	NR03-05 100	100	NR03-06 100	100				
100 PT. HOPE W.	100 POINT HOPE	100	DE LONG MTS. 100 NR03-08					
NR02-08 100	NR03-07 100	100						

2012 to 2016

21-Jun 30-Jun

Sea Ice 6.2.3 Scenario 6.2: Percent probability of sea ice concentration from 0 to 7 tenths, Chukchi Sea.

0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-04 0	NS03-03 0	0	NS03-04 0	0	NS04-03 0	0	NS04-04 0	0
0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-06 0	NS03-05 0	0	NS03-06 0	0	NS04-05 0	0	NS04-06 0	0
20 UNNAMED	20 UNNAMED	20	20 UNNAMED	20	0 UNNAMED	0	0 UNNAMED	0
NS02-08 20	NS03-07 20	20	NS03-038 20	20	NS04-07 20	0	NS04-08 0	20
20 TISON	40 KARO	40	20 POSEY	20	20 HANNA SHOAL	0	0 BARROW	20
NR02-02 20	NR03-01 40	20	NR03-02 20	20	NR04-01 20	20	NR04-02 20	20
20 STUDDS	40 COLBERT	60	40 SOLIVIK ISLAND	20	20 WAINWRIGHT	20	MEADE RIVER 20 NR04-04	
NR02-04 20	NR03-03 80	80	NR03-04 80	80	NR04-03 100			
80 CHUKCHI SEA	80 POINT LAY WEST	100	60 POINT LAY	100				
NR02-06 100	NR03-05 100	100	NR03-06 100	100				
100 PT. HOPE W.	100 POINT HOPE	100	DE LONG MTS. 100 NR03-08					
NR02-08 100	NR03-07 100	100						

2012 to 2016

1-Jul 10-Jul

Sea Ice 6.2.4 Scenario 6.2: Percent probability of sea ice concentration from 0 to 7 tenths, Chukchi Sea.

0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	20
NS02-04 0	NS03-03 0	0	NS03-04 0	0	NS04-03 0	0	NS04-04 20	0
0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-06 0	NS03-05 0	0	NS03-06 0	0	NS04-05 0	0	NS04-06 0	0
20 UNNAMED	20 UNNAMED	20	20 UNNAMED	20	0 UNNAMED	0	0 UNNAMED	0
NS02-08 20	NS03-07 20	40	NS03-038 60	40	NS04-07 0	0	NS04-08 0	0
60 TISON	80 KARO	40	40 POSEY	20	0 HANNA SHOAL	0	20 BARROW	40
NR02-02 80	NR03-01 80	60	NR03-02 20	20	NR04-01 20	20	NR04-02 40	80
80 STUDDS	80 COLBERT	80	60 SOLIVIK ISLAND	40	40 WAINWRIGHT	100	MEADE RIVER 100 NR04-04	
NR02-04 80	NR03-03 80	100	NR03-04 100	100	NR04-03 100			
80 CHUKCHI SEA	100 POINT LAY WEST	100	100 POINT LAY	100				
NR02-06 100	NR03-05 100	100	NR03-06 100	100				
100 PT. HOPE W.	100 POINT HOPE	80	DE LONG MTS. 80 NR03-08					
NR02-08 100	NR03-07 100	100						

2012 to 2016

11-Jul 20-Jul

Sea Ice 6.2.5 Scenario 6.2: Percent probability of sea ice concentration from 0 to 7 tenths, Chukchi Sea.

0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
20	20	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
20	40	0	0	0	0	0	20	20
40	40	40	20	20	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
20	20	20	20	20	20	0	0	0
60	60	80	80	60	60	20	40	40
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
80	80	100	80	60	60	40	40	60
60	100	100	100	100	100	80	MEADE RIVER 80 NR04-04	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT			
NR02-04	NR03-03		NR03-04		NR04-03			
60	100	100	100	100	100			
80	100	100	100	100				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	100	100				
100	100	100	DE LONG MTS. 100 NR03-08					
PT. HOPE W.	POINT HOPE							
NR02-08	NR03-07							
100	100	100						

2012 to 2016

21-Jul 31-Jul

Sea Ice 6.2.6 Scenario 6.2: Percent probability of sea ice concentration from 0 to 7 tenths, Chukchi Sea.

20 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	20 UNNAMED	40	0 UNNAMED	0
NS02-04 20	NS03-03 20	0	NS03-04 20	20	NS04-03 20	40	NS04-04 40	20
0 UNNAMED	20 UNNAMED	20	20 UNNAMED	20	0 UNNAMED	20	20 UNNAMED	20
NS02-06 20	NS03-05 20	0	NS03-06 20	0	NS04-05 20	20	NS04-06 20	20
60 UNNAMED	20 UNNAMED	20	20 UNNAMED	20	40 UNNAMED	40	20 UNNAMED	20
NS02-08 60	NS03-07 60	40	NS03-038 40	20	NS04-07 60	40	NS04-08 40	40
80 TISON	80 KARO	80	80 POSEY	60	80 HANNA SHOAL	60	40 BARROW	60
NR02-02 100	NR03-01 80	100	NR03-02 80	80	NR04-01 80	80	NR04-02 60	60
80 STUDDS	100 COLBERT	100	100 SOLIVIK ISLAND	100	100 WAINWRIGHT	80	MEADE RIVER 100 NR04-04	
NR02-04 80	NR03-03 100	100	NR03-04 100	100	NR04-03 100			
100 CHUKCHI SEA	100 POINT LAY WEST	100	100 POINT LAY	100				
NR02-06 100	NR03-05 100	100	NR03-06 100	100				
100 PT. HOPE W.	100 POINT HOPE	100	DE LONG MTS. 100 NR03-08					
NR02-08 100	NR03-07 100	100						

2012 to 2016

1-Aug 10-Aug

Sea Ice 6.2.7 Scenario 6.2: Percent probability of sea ice concentration from 0 to 7 tenths, Chukchi Sea.

20	20	0	0	0	0	20	0	0
UNNAMED NS02-04	UNNAMED NS03-03		UNNAMED NS03-04		UNNAMED NS04-03		UNNAMED NS04-04	
40	20	0	0	20	20	20	20	20
0	20	40	40	20	20	20	20	40
UNNAMED NS02-06	UNNAMED NS03-05		UNNAMED NS03-06		UNNAMED NS04-05		UNNAMED NS04-06	
20	20	40	60	40	40	40	40	40
80	40	20	20	20	60	60	40	40
UNNAMED NS02-08	UNNAMED NS03-07		UNNAMED NS03-038		UNNAMED NS04-07		UNNAMED NS04-08	
80	80	60	40	40	60	60	80	60
80	80	80	80	40	60	80	80	80
TISON NR02-02	KARO NR03-01		POSEY NR03-02		HANNA SHOAL NR04-01		BARROW NR04-02	
100	100	100	100	100	80	80	80	100
100	100	100	100	100	100	100	MEADE RIVER 100 NR04-04	
STUDDS NR02-04	COLBERT NR03-03		SOLIVIK ISLAND NR03-04		WAINWRIGHT NR04-03			
100	100	100	100	100	100			
100	100	100	100	100				
CHUKCHI SEA NR02-06	POINT LAY WEST NR03-05		POINT LAY NR03-06					
100	100	100	100	100				
100	100	100	DE LONG MTS. 100 NR03-08					
PT. HOPE W. NR02-08	POINT HOPE NR03-07							
100	100	100						

2012 to 2016

11-Aug 20-Aug

Sea Ice 6.2.8 Scenario 6.2: Percent probability of sea ice concentration from 0 to 7 tenths, Chukchi Sea.

20	20	20	40	40	40	20	40	40
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
20	20	20	40	60	60	40	60	40
40	40	60	40	80	60	60	60	60
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
40	40	20	40	60	100	80	80	60
40	40	40	60	40	60	100	100	80
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
80	80	100	60	80	40	80	80	100
100	100	100	100	60	100	80	100	100
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
100	80	80	100	100	100	100	100	100
100	100	100	80	100	100	100	MEADE RIVER 100	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		NR04-04	
NR02-04	NR03-03		NR03-04		NR04-03			
100	100	100	100	100	100			
100	100	100	100	100				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	100	100				
100	100	100	DE LONG MTS. 100 NR03-08					
PT. HOPE W.	POINT HOPE							
NR02-08	NR03-07							
100	100	100						

2012 to 2016

21-Aug 31-Aug

Sea Ice 6.2.9 Scenario 6.2: Percent probability of sea ice concentration from 0 to 7 tenths, Chukchi Sea.

40 UNNAMED	40 UNNAMED	40	40 UNNAMED	40	20 UNNAMED	20	40 UNNAMED	40
NS02-04 40	NS03-03 40	40	NS03-04 60	60	NS04-03 60	40	NS04-04 40	40
40 UNNAMED	60 UNNAMED	40	60 UNNAMED	80	60 UNNAMED	60	60 UNNAMED	40
NS02-06 60	NS03-05 60	60	NS03-06 60	80	NS04-05 100	60	NS04-06 60	60
40 UNNAMED	40 UNNAMED	80	80 UNNAMED	60	80 UNNAMED	60	80 UNNAMED	60
NS02-08 100	NS03-07 100	100	NS03-038 100	100	NS04-07 100	100	NS04-08 100	80
100 TISON	100 KARO	100	100 POSEY	80	100 HANNA SHOAL	100	100 BARROW	100
NR02-02 100	NR03-01 100	100	NR03-02 80	80	NR04-01 100	100	NR04-02 100	100
100 STUDDS	100 COLBERT	100	100 SOLIVIK ISLAND	100	100 WAINWRIGHT	100	MEADE RIVER 100 NR04-04	
NR02-04 100	NR03-03 100	100	NR03-04 100	100	NR04-03 100			
100 CHUKCHI SEA	100 POINT LAY WEST	100	100 POINT LAY	100				
NR02-06 100	NR03-05 100	100	NR03-06 100	100				
100 PT. HOPE W.	100 POINT HOPE	100	DE LONG MTS. 100 NR03-08					
NR02-08 100	NR03-07 100	100						

2012 to 2016

1-Sep 10-Sep

Sea Ice 6.2.10 Scenario 6.2: Percent probability of sea ice concentration from 0 to 7 tenths, Chukchi Sea.

80	60	60	40	60	60	60	60	40
UNNAMED NS02-04	UNNAMED NS03-03		UNNAMED NS03-04		UNNAMED NS04-03		UNNAMED NS04-04	
60	60	60	60	60	80	80	80	80
80	60	80	60	60	100	100	80	80
UNNAMED NS02-06	UNNAMED NS03-05		UNNAMED NS03-06		UNNAMED NS04-05		UNNAMED NS04-06	
60	60	80	60	60	80	100	100	100
40	40	60	60	60	80	100	100	100
UNNAMED NS02-08	UNNAMED NS03-07		UNNAMED NS03-038		UNNAMED NS04-07		UNNAMED NS04-08	
100	100	100	80	60	60	60	100	100
100	100	80	80	60	80	60	100	100
TISON NR02-02	KARO NR03-01		POSEY NR03-02		HANNA SHOAL NR04-01		BARROW NR04-02	
100	100	100	80	60	80	80	80	100
100	100	100	100	80	80	100	100	
STUDDS NR02-04	COLBERT NR03-03		SOLIVIK ISLAND NR03-04		WAINWRIGHT NR04-03		MEADE RIVER NR04-04	
100	100	100	100	100	100			
100	100	100	100	100				
CHUKCHI SEA NR02-06	POINT LAY WEST NR03-05		POINT LAY NR03-06					
100	100	100	100	100				
100	100	100	100					
PT. HOPE W. NR02-08	POINT HOPE NR03-07		DE LONG MTS. NR03-08					
100	100	100						

2012 to 2016

11-Sep 20-Sep

Sea Ice 6.2.11 Scenario 6.2: Percent probability of sea ice concentration from 0 to 7 tenths, Chukchi Sea.

60	60	60	40	60	60	40	40	40
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
60	60	60	60	60	80	60	40	40
100	80	80	80	60	80	80	60	60
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
80	100	100	80	100	60	80	80	80
80	100	100	100	80	100	80	80	80
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
100	100	100	100	80	80	100	80	80
100	100	100	100	100	80	100	80	100
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
100	100	100	100	100	100	100	100	100
100	100	100	100	100	100	100	MEADE RIVER 100	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		NR04-04	
NR02-04	NR03-03		NR03-04		NR04-03			
100	100	100	100	100	100			
100	100	100	100	100				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	100	100				
100	100	100	DE LONG MTS. 100					
PT. HOPE W.	POINT HOPE		NR03-08					
NR02-08	NR03-07							
100	100	100						

2012 to 2016

21-Sep 30-Sep

Sea Ice 6.2.12 Scenario 6.2: Percent probability of sea ice concentration from 0 to 7 tenths, Chukchi Sea.

100 UNNAMED NS02-04 100	100 100 UNNAMED NS03-03 100 80	80 80 UNNAMED NS03-04 80 80	80 80 UNNAMED NS04-03 100 100	40 80 UNNAMED NS04-04 100 40
100 UNNAMED NS02-06 80	100 100 UNNAMED NS03-05 80 80	100 100 UNNAMED NS03-06 100 80	100 100 UNNAMED NS04-05 100 100	100 100 UNNAMED NS04-06 80 80
80 UNNAMED NS02-08 100	100 100 UNNAMED NS03-07 100 100	100 100 UNNAMED NS03-038 100 100	80 100 UNNAMED NS04-07 80 80	100 100 UNNAMED NS04-08 100 100
100 TISON NR02-02 100	100 100 KARO NR03-01 100 100	100 100 POSEY NR03-02 100 100	100 100 HANNA SHOAL NR04-01 100 100	100 100 BARROW NR04-02 100 100
100 STUDDS NR02-04 100	100 100 COLBERT NR03-03 100 100	100 100 SOLIVIK ISLAND NR03-04 100 100	100 100 WAINWRIGHT NR04-03 100	MEADE RIVER 100 NR04-04
100 CHUKCHI SEA NR02-06 100	100 100 POINT LAY WEST NR03-05 100 100	100 100 POINT LAY NR03-06 100 100		
100 PT. HOPE W. NR02-08 100	100 100 POINT HOPE NR03-07 100 100	DE LONG MTS. 100 NR03-08		

2012 to 2016

1-Oct 10-Oct

Sea Ice 6.2.13 Scenario 6.2: Percent probability of sea ice concentration from 0 to 7 tenths, Chukchi Sea.

80	80	60	20	20	40	60	20	20
UNNAMED NS02-04	UNNAMED NS03-03		UNNAMED NS03-04		UNNAMED NS04-03		UNNAMED NS04-04	
80	80	80	80	40	40	40	40	40
80	80	80	100	100	60	60	40	40
UNNAMED NS02-06	UNNAMED NS03-05		UNNAMED NS03-06		UNNAMED NS04-05		UNNAMED NS04-06	
100	100	100	100	100	100	80	80	40
100	100	100	100	100	80	80	100	100
UNNAMED NS02-08	UNNAMED NS03-07		UNNAMED NS03-038		UNNAMED NS04-07		UNNAMED NS04-08	
100	100	100	100	100	100	100	100	100
100	100	100	100	100	100	100	100	100
TISON NR02-02	KARO NR03-01		POSEY NR03-02		HANNA SHOAL NR04-01		BARROW NR04-02	
100	100	100	100	100	100	100	100	100
100	100	100	100	100	100	100	MEADE RIVER 100 NR04-04	
STUDDS NR02-04	COLBERT NR03-03		SOLIVIK ISLAND NR03-04		WAINWRIGHT NR04-03			
100	100	100	100	100	100			
100	100	100	100	100				
CHUKCHI SEA NR02-06	POINT LAY WEST NR03-05		POINT LAY NR03-06					
100	100	100	100	100				
100	100	100	DE LONG MTS. 100 NR03-08					
PT. HOPE W. NR02-08	POINT HOPE NR03-07							
100	100	100						

2012 to 2016

11-Oct 20-Oct

Sea Ice 6.2.14 Scenario 6.2: Percent probability of sea ice concentration from 0 to 7 tenths, Chukchi Sea.

40	40	40	0	20	40	40	20	20
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
40	40	40	40	40	40	40	40	40
40	40	40	60	40	40	40	40	40
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
40	40	60	60	60	40	40	40	40
60	80	60	80	80	80	60	40	40
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
100	100	100	100	100	80	80	80	60
100	100	100	100	100	100	100	100	80
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
100	100	100	100	100	100	100	100	100
100	100	100	100	100	100	100	MEADE RIVER 100 NR04-04	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT			
NR02-04	NR03-03		NR03-04		NR04-03			
100	100	100	100	100	100			
100	100	100	100	100				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	100	80				
100	100	100	DE LONG MTS. 80 NR03-08					
PT. HOPE W.	POINT HOPE							
NR02-08	NR03-07							
100	100	100						

2012 to 2016

21-Oct 31-Oct

Sea Ice 6.2.15 Scenario 6.2: Percent probability of sea ice concentration from 0 to 7 tenths, Chukchi Sea.

0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
20	20	0	0	0	0	0	0	0
40	40	20	20	0	0	0	20	20
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
60	60	40	40	40	40	40	0	20
80	100	60	40	40	40	20	20	0
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
100	100	80	60	60	60	20	60	40
100	100	80	80	80	100	80	MEADE RIVER	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		80	
NR02-04	NR03-03		NR03-04		NR04-03		NR04-04	
100	100	100	100	100	100			
100	100	100	100	80				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	80	0				
100	100	100	DE LONG MTS.					
PT. HOPE W.	POINT HOPE		20					
NR02-08	NR03-07		NR03-08					
100	100	100						

2012 to 2016

1-Nov 10-Nov

Sea Ice 6.2.16 Scenario 6.2: Percent probability of sea ice concentration from 0 to 7 tenths, Chukchi Sea.

0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
0	0	0	0	0	0	0	0	0
20	40	20	20	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
80	60	60	40	20	0	0	20	20
80	60	40	40	40	0	0	0	20
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
80	80	60	40	40	40	0	20	40
							MEADE RIVER	
80	80	80	60	60	40	40	40	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		NR04-04	
NR02-04	NR03-03		NR03-04		NR04-03			
80	80	80	60	40	40			
80	80	80	60	40				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
80	100	80	40	20				
			DE LONG MTS.					
80	100	60	20					
PT. HOPE W.	POINT HOPE		NR03-08					
NR02-08	NR03-07							
80	80	100						

2012 to 2016

11-Nov 20-Nov

Sea Ice 6.2.17 Scenario 6.2: Percent probability of sea ice concentration from 0 to 7 tenths, Chukchi Sea.

0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
0	0	0	0	0	0	0	0	0
20	20	20	0	20	20	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
60	40	20	20	20	0	0	0	0
60	60	40	20	0	0	0	0	0
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
60	60	40	60	20	0	0	20	20
							MEADE RIVER	
60	60	60	60	40	20	20	20	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		NR04-04	
NR02-04	NR03-03		NR03-04		NR04-03			
60	60	60	40	20	20			
80	60	60	20	0				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
80	60	40	0	0				
			DE LONG MTS.					
80	40	20	0					
PT. HOPE W.	POINT HOPE		NR03-08					
NR02-08	NR03-07							
80	60	60						

2012 to 2016

21-Nov 30-Nov

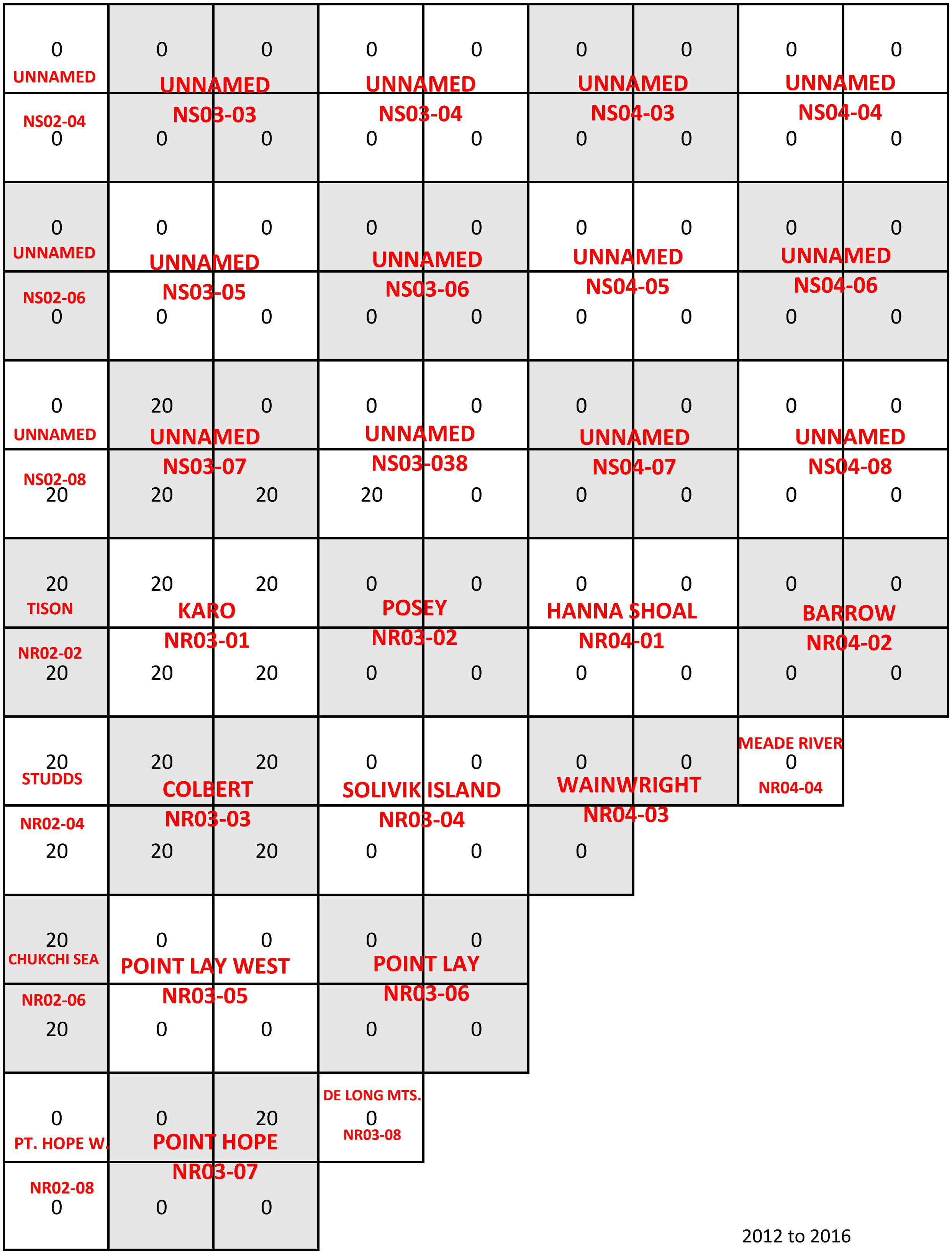
Sea Ice 6.2.18 Scenario 6.2: Percent probability of sea ice concentration from 0 to 7 tenths, Chukchi Sea.

0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-04 0	NS03-03 0	0	NS03-04 0	0	NS04-03 0	0	NS04-04 0	0
0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-06 0	NS03-05 0	0	NS03-06 0	0	NS04-05 0	0	NS04-06 0	0
0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-08 20	NS03-07 20	20	NS03-038 0	0	NS04-07 0	0	NS04-08 0	0
20 TISON	20 KARO	20	0 POSEY	0	0 HANNA SHOAL	0	0 BARROW	0
NR02-02 20	NR03-01 20	20	NR03-02 20	0	NR04-01 0	0	NR04-02 0	0
20 STUDDS	20 COLBERT	20	20 SOLIVIK ISLAND	20	40 WAINWRIGHT	0	MEADE RIVER 0 NR04-04	
NR02-04 40	NR03-03 40	40	NR03-04 40	20	NR04-03 0			
40 CHUKCHI SEA	60 POINT LAY WEST	20	0 POINT LAY	0				
NR02-06 60	NR03-05 60	0	NR03-06 0	0				
60 PT. HOPE W.	20 POINT HOPE	0	DE LONG MTS. 20 NR03-08					
NR02-08 60	NR03-07 40	20						

2012 to 2016

1-Dec 10-Dec

Sea Ice 6.2.19 Scenario 6.2: Percent probability of sea ice concentration from 0 to 7 tenths, Chukchi Sea.



0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
0	0	0	0	0	0	0	0	0
0	20	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
20	20	20	20	0	0	0	0	0
20	20	20	0	0	0	0	0	0
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
20	20	20	0	0	0	0	0	0
20	20	20	0	0	0	0	0	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		MEADE RIVER	
NR02-04	NR03-03		NR03-04		NR04-03		NR04-04	
20	20	20	0	0	0			
20	0	0	0	0				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
20	0	0	0	0				
0	0	20	0					
PT. HOPE W.	POINT HOPE		DE LONG MTS.					
NR02-08	NR03-07		NR03-08					
0	0	0						

2012 to 2016

11-Dec 20-Dec

Sea Ice 6.2.20 Scenario 6.2: Percent probability of sea ice concentration from 0 to 7 tenths, Chukchi Sea.

0	0	0	0	0	0	0	0	0
UNNAMED NS02-04	UNNAMED NS03-03		UNNAMED NS03-04		UNNAMED NS04-03		UNNAMED NS04-04	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED NS02-06	UNNAMED NS03-05		UNNAMED NS03-06		UNNAMED NS04-05		UNNAMED NS04-06	
0	0	0	0	0	0	0	0	0
20	20	0	0	0	0	0	0	0
UNNAMED NS02-08	UNNAMED NS03-07		UNNAMED NS03-038		UNNAMED NS04-07		UNNAMED NS04-08	
20	20	0	0	0	0	0	0	0
20	20	20	0	0	0	0	0	0
TISON NR02-02	KARO NR03-01		POSEY NR03-02		HANNA SHOAL NR04-01		BARROW NR04-02	
20	20	20	0	0	0	0	0	0
20	20	20	0	0	0	0	0	
STUDDS NR02-04	COLBERT NR03-03		SOLIVIK ISLAND NR03-04		WAINWRIGHT NR04-03		MEADE RIVER NR04-04	
20	0	0	0	0	0			
20	0	0	0	0				
CHUKCHI SEA NR02-06	POINT LAY WEST NR03-05		POINT LAY NR03-06					
20	0	0	0	0				
0	0	0	0					
PT. HOPE W. NR02-08	POINT HOPE NR03-07		DE LONG MTS. NR03-08					
0	0	0						

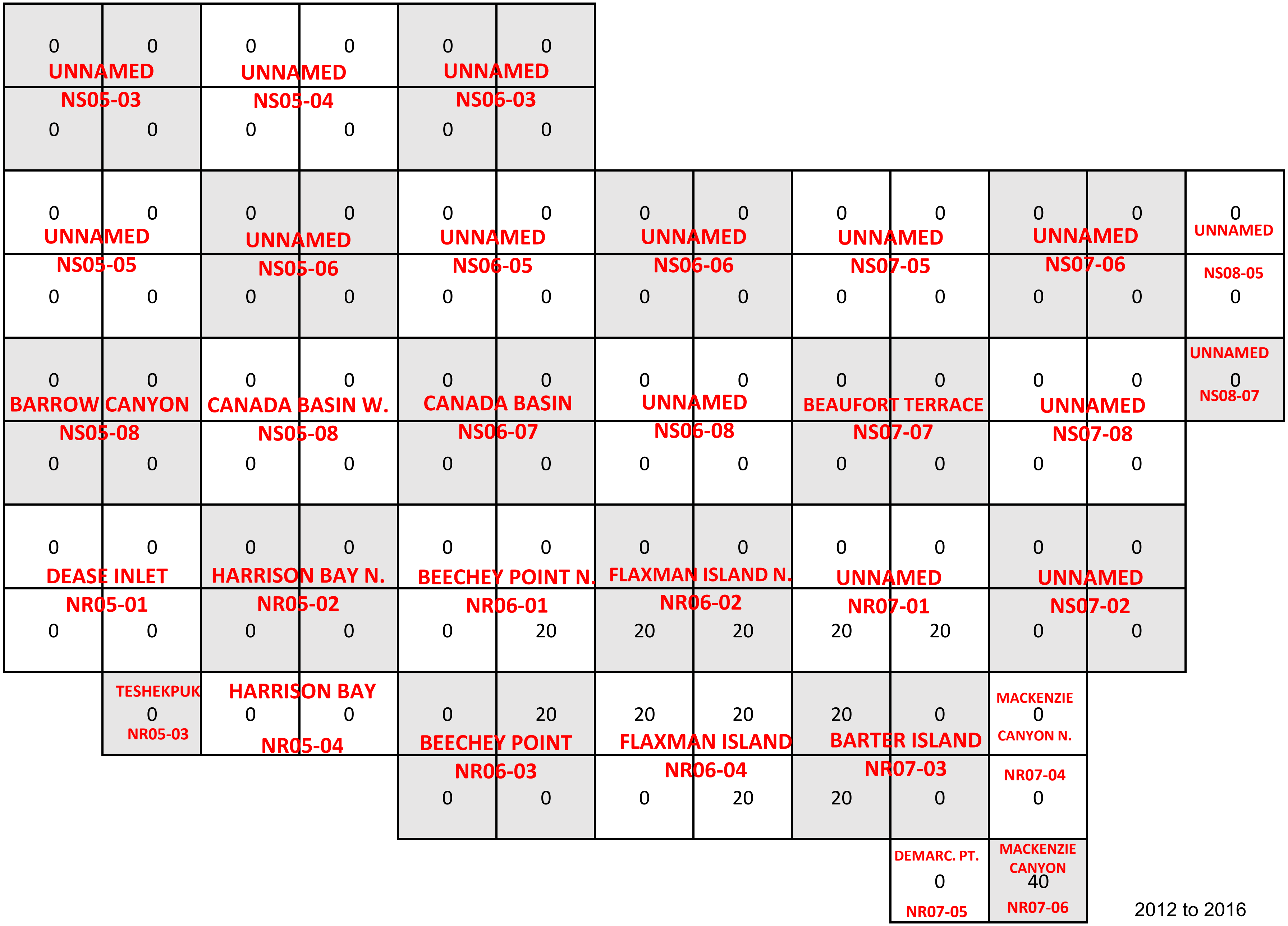
2012 to 2016

21-Dec 31-Dec

Sea Ice 6.2.21 Scenario 6.2: Percent probability of sea ice concentration from 0 to 7 tenths, Chukchi Sea.

Scenario 6.3:
Safe Open Water SCCE Deployment in the Beaufort Sea.

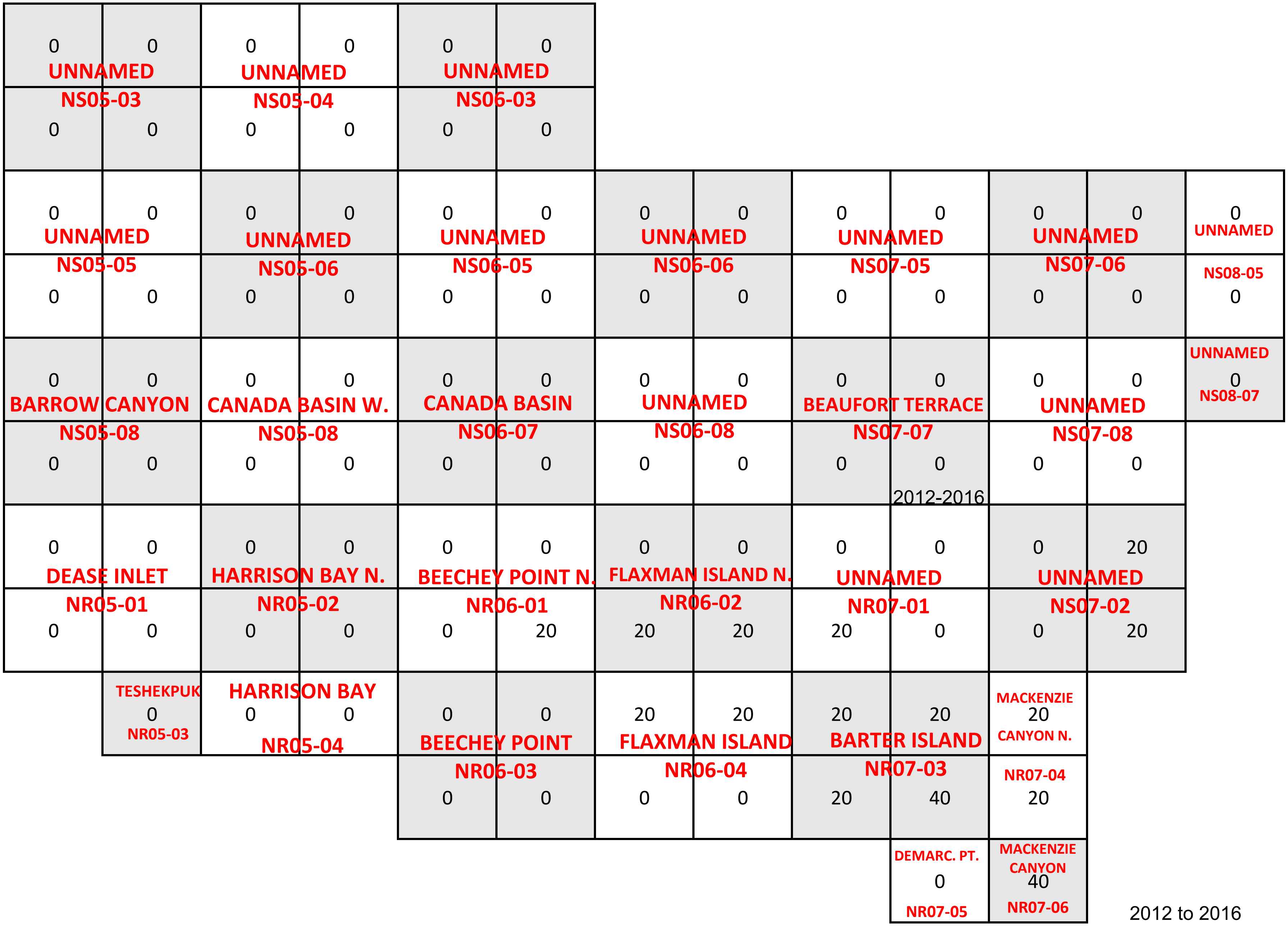
Sea ice data for the probability of open water, within a 30 nautical mile ice free radius, for the period from June through December, 2012 to 2016 in the Beaufort Sea.



2012 to 2016

1-Jun 10-Jun

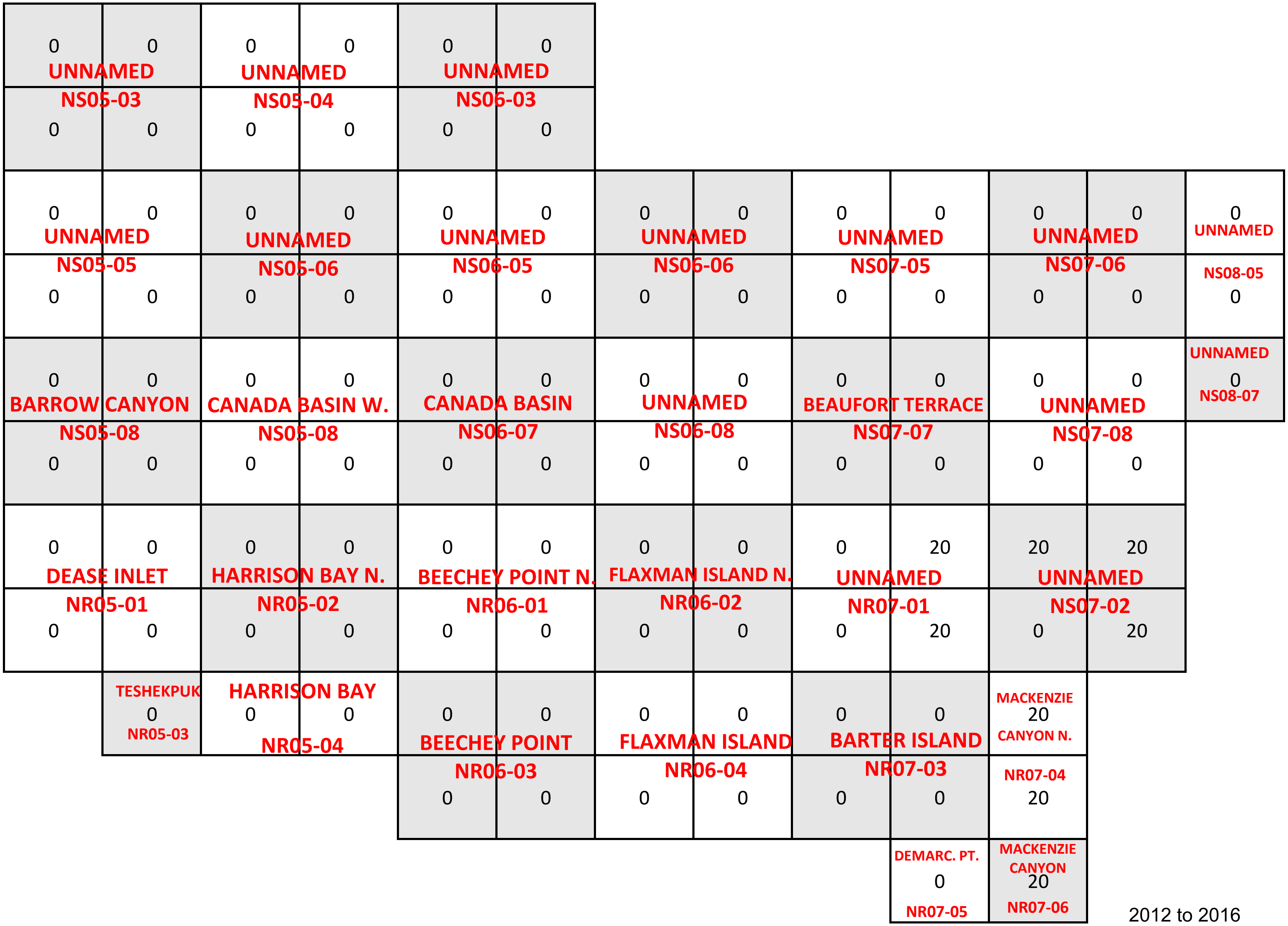
Sea Ice 6.3.1 Scenario 6.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea.



UNNAMED	NS05-03	0	0	0	0
UNNAMED	NS05-04	0	0	0	0
UNNAMED	NS06-03	0	0	0	0
UNNAMED	NS05-05	0	0	0	0
UNNAMED	NS05-06	0	0	0	0
UNNAMED	NS06-05	0	0	0	0
UNNAMED	NS06-06	0	0	0	0
UNNAMED	NS07-05	0	0	0	0
UNNAMED	NS07-06	0	0	0	0
UNNAMED	NS08-05	0		0	
BARROW CANYON	NS05-08	0	0	0	0
CANADA BASIN W.	NS05-08	0	0	0	0
CANADA BASIN	NS06-07	0	0	0	0
UNNAMED	NS06-08	0	0	0	0
BEAUFORT TERRACE	NS07-07	0	0	0	0
UNNAMED	NS07-08	0	0	0	0
UNNAMED	NS08-07	0			
DEASE INLET	NR05-01	0	0	0	0
HARRISON BAY N.	NR05-02	0	0	0	0
BEECHEY POINT N.	NR06-01	0	0	0	20
FLAXMAN ISLAND N.	NR06-02	0	0	20	20
UNNAMED	NR07-01	0	0	20	0
UNNAMED	NS07-02	0	20	0	20
TESHEKPUK	NR05-03		0		
HARRISON BAY	NR05-04	0	0		
BEECHEY POINT	NR06-03	0	0	0	0
FLAXMAN ISLAND	NR06-04	20	20	0	0
BARTER ISLAND	NR07-03	20	20	20	40
MACKENZIE CANYON N.	NR07-04	20		20	
DEMARC. PT.	NR07-05	0			
MACKENZIE CANYON	NR07-06	40			

2012 to 2016

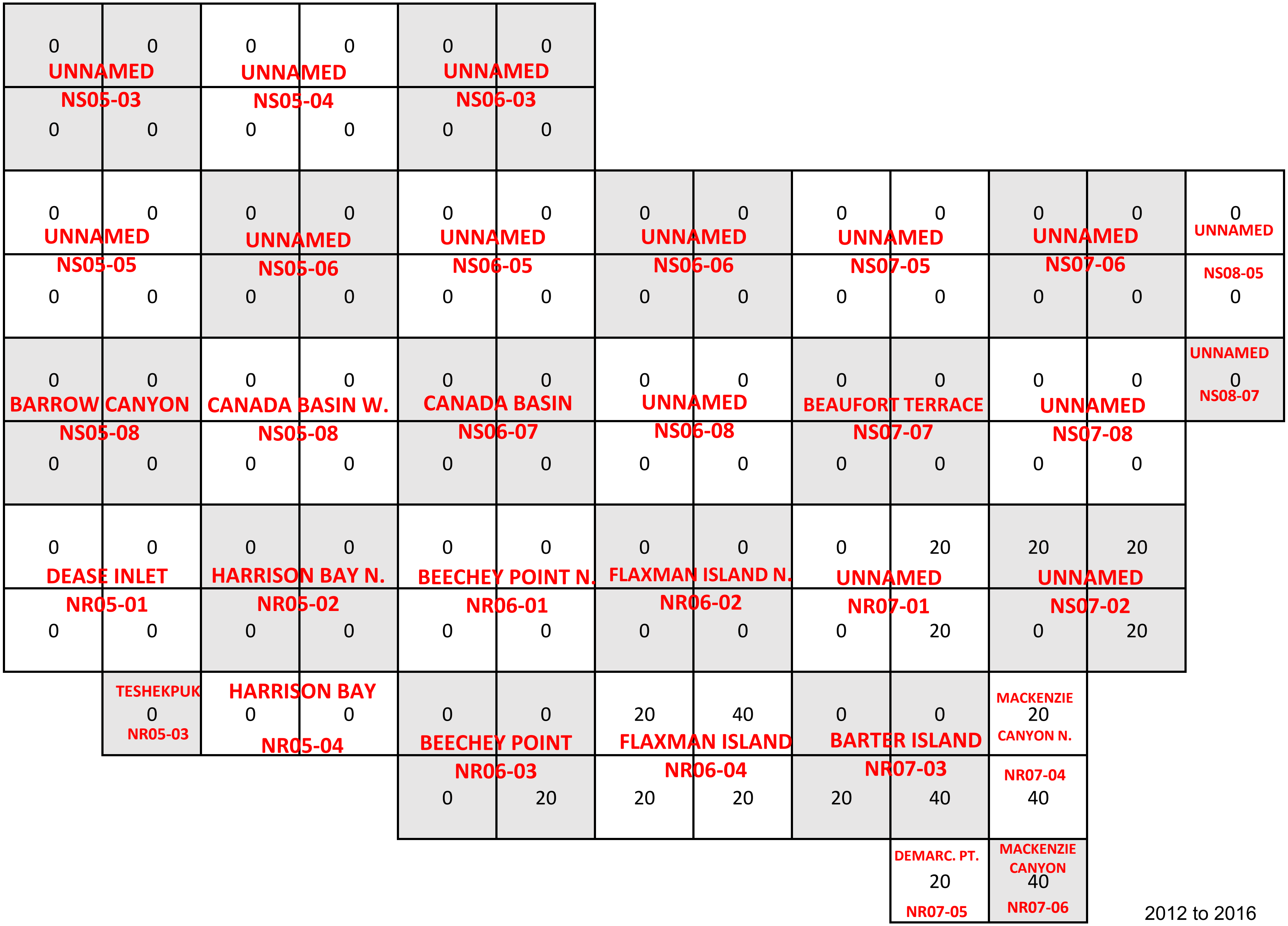
Sea Ice 6.3.2 Scenario 6.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea. 11-Jun 20-Jun



UNNAMED	NS05-03	0	0	0	0
UNNAMED	NS05-04	0	0	0	0
UNNAMED	NS06-03	0	0	0	0
UNNAMED	NS05-05	0	0	0	0
UNNAMED	NS05-06	0	0	0	0
UNNAMED	NS06-05	0	0	0	0
UNNAMED	NS06-06	0	0	0	0
UNNAMED	NS07-05	0	0	0	0
UNNAMED	NS07-06	0	0	0	0
UNNAMED	NS08-05	0		0	
BARROW CANYON	NS05-08	0	0	0	0
CANADA BASIN W.	NS05-08	0	0	0	0
CANADA BASIN	NS06-07	0	0	0	0
UNNAMED	NS06-08	0	0	0	0
BEAUFORT TERRACE	NS07-07	0	0	0	0
UNNAMED	NS07-08	0	0	0	0
UNNAMED	NS08-07	0			
DEASE INLET	NR05-01	0	0	0	0
HARRISON BAY N.	NR05-02	0	0	0	0
BEECHEY POINT N.	NR06-01	0	0	0	0
FLAXMAN ISLAND N.	NR06-02	0	0	0	0
UNNAMED	NR07-01	0	20	0	20
UNNAMED	NS07-02	20	20	0	20
TESHEKPUK	NR05-03		0		
HARRISON BAY	NR05-04	0	0		
BEECHEY POINT	NR06-03	0	0	0	0
FLAXMAN ISLAND	NR06-04	0	0	0	0
BARTER ISLAND	NR07-03	0	0	0	0
MACKENZIE CANYON N.	NR07-04	20		20	
DEMARC. PT.	NR07-05	0			
MACKENZIE CANYON	NR07-06	20			

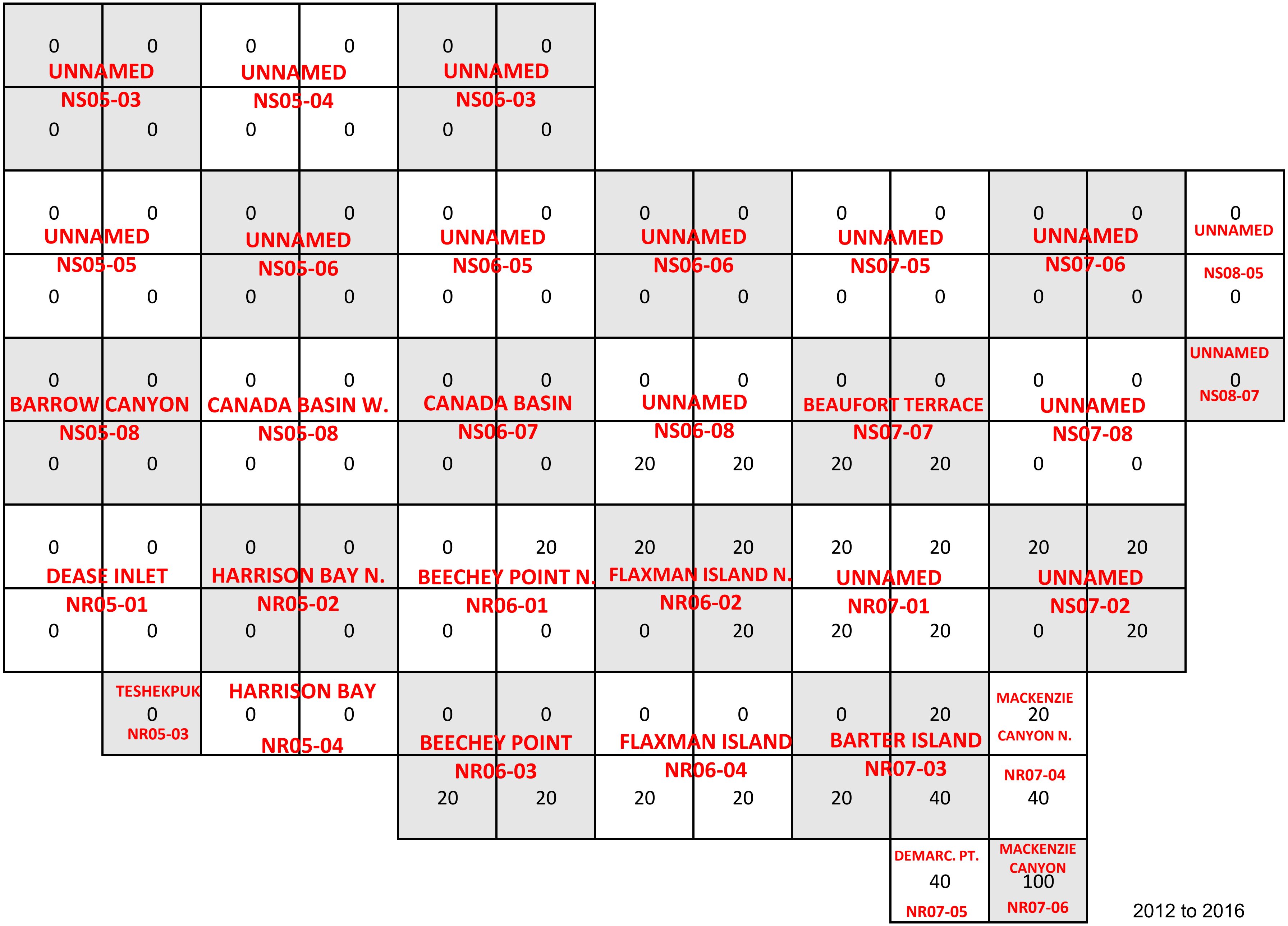
2012 to 2016

Sea Ice 6.3.3 Scenario 6.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea. 21-Jun 30-Jun



2012 to 2016

Sea Ice 6.3.4 Scenario 6.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea. 1-Jul 10-Jul



0 0
UNNAMED
NS05-03
0 0

0 0
UNNAMED
NS05-04
0 0

0 0
UNNAMED
NS06-03
0 0

0 0
UNNAMED
NS05-05
0 0

0 0
UNNAMED
NS05-06
0 0

0 0
UNNAMED
NS06-05
0 0

0 0
UNNAMED
NS06-06
0 0

0 0
UNNAMED
NS07-05
0 0

0 0
UNNAMED
NS07-06
0 0

0
UNNAMED
NS08-05
0

0 0
BARROW CANYON
NS05-08
0 0

0 0
CANADA BASIN W.
NS05-08
0 0

0 0
CANADA BASIN
NS06-07
0 0

0 0
UNNAMED
NS06-08
20 20

0 0
BEAUFORT TERRACE
NS07-07
20 20

0 0
UNNAMED
NS07-08
0 0

UNNAMED
0
NS08-07

0 0
DEASE INLET
NR05-01
0 0

0 0
HARRISON BAY N.
NR05-02
0 0

0 20
BEECHEY POINT N.
NR06-01
0 0

20 20
FLAXMAN ISLAND N.
NR06-02
0 20

20 20
UNNAMED
NR07-01
20 20

20 20
UNNAMED
NS07-02
0 20

TESHEKPUK
0
NR05-03

HARRISON BAY
0 0
NR05-04

0 0
BEECHEY POINT
NR06-03
20 20

0 0
FLAXMAN ISLAND
NR06-04
20 20

0 20
BARTER ISLAND
NR07-03
20 40

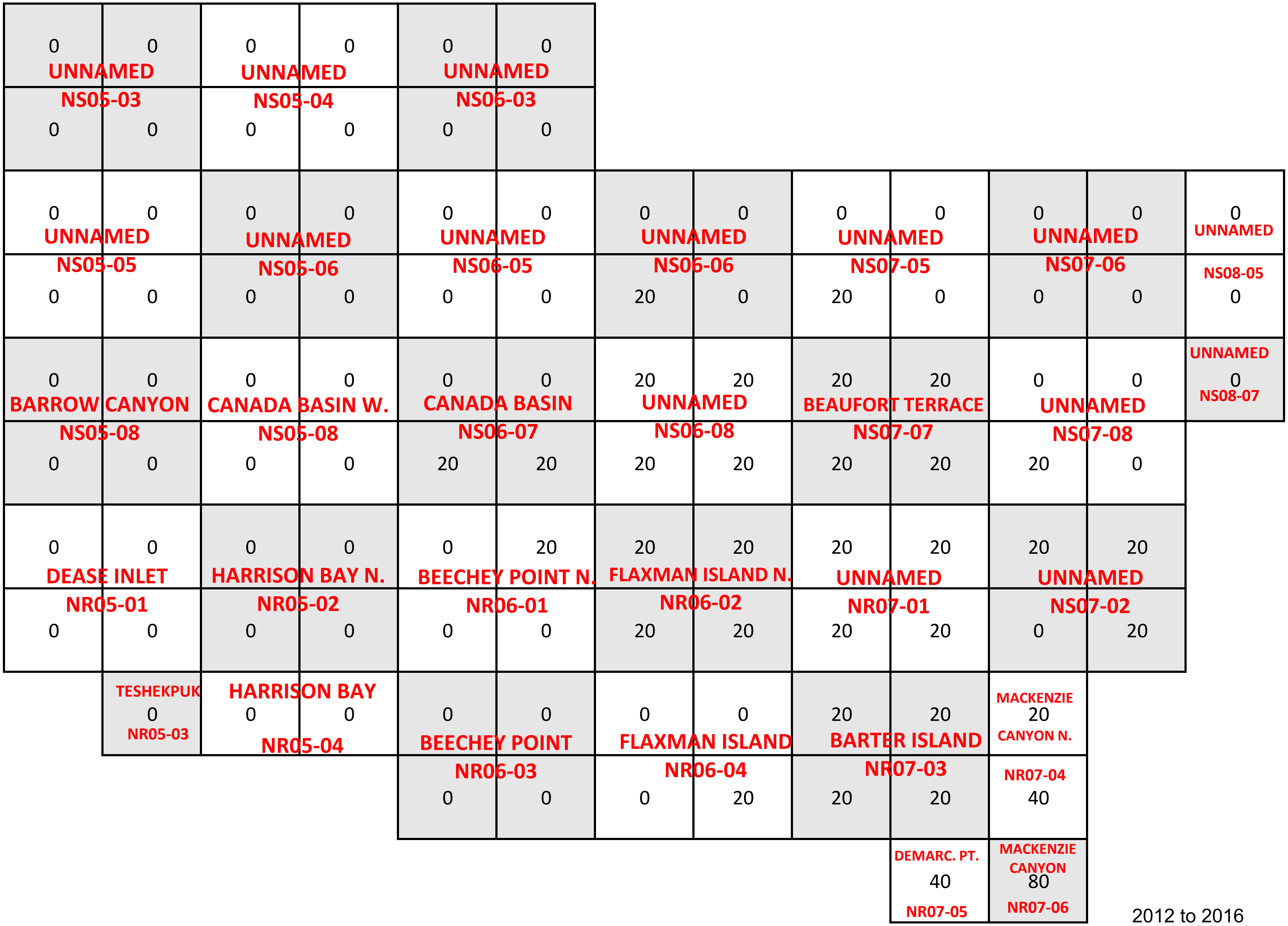
MACKENZIE
20
CANYON N.
NR07-04
40

DEMARC. PT.
40
NR07-05

MACKENZIE
CANYON
100
NR07-06

2012 to 2016

Sea Ice 6.3.5 Scenario 6.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea. 11-Jul 20-Jul



UNNAMED	NS05-03	0	0	0	0
UNNAMED	NS05-04	0	0	0	0
UNNAMED	NS06-03	0	0	0	0
UNNAMED	NS05-05	0	0	0	0
UNNAMED	NS05-06	0	0	0	0
UNNAMED	NS06-05	0	0	0	0
UNNAMED	NS06-06	0	0	20	0
UNNAMED	NS07-05	0	0	20	0
UNNAMED	NS07-06	0	0	0	0
UNNAMED	NS08-05	0		0	
BARROW CANYON	NS05-08	0	0	0	0
CANADA BASIN W.	NS05-08	0	0	0	0
CANADA BASIN	NS06-07	0	0	20	20
UNNAMED	NS06-08	20	20	20	20
BEAUFORT TERRACE	NS07-07	20	20	20	20
UNNAMED	NS07-08	0	0	20	0
UNNAMED	NS08-07	0			
DEASE INLET	NR05-01	0	0	0	0
HARRISON BAY N.	NR05-02	0	0	0	0
BEECHEY POINT N.	NR06-01	0	20	0	0
FLAXMAN ISLAND N.	NR06-02	20	20	20	20
UNNAMED	NR07-01	20	20	20	20
UNNAMED	NS07-02	20	20	0	20
TESHEKPUK	NR05-03	0			
HARRISON BAY	NR05-04	0	0		
BEECHEY POINT	NR06-03	0	0	0	0
FLAXMAN ISLAND	NR06-04	0	0	0	20
BARTER ISLAND	NR07-03	20	20	20	20
MACKENZIE CANYON N.	NR07-04	20		40	
DEMARC. PT.	NR07-05	40			
MACKENZIE CANYON	NR07-06	80			

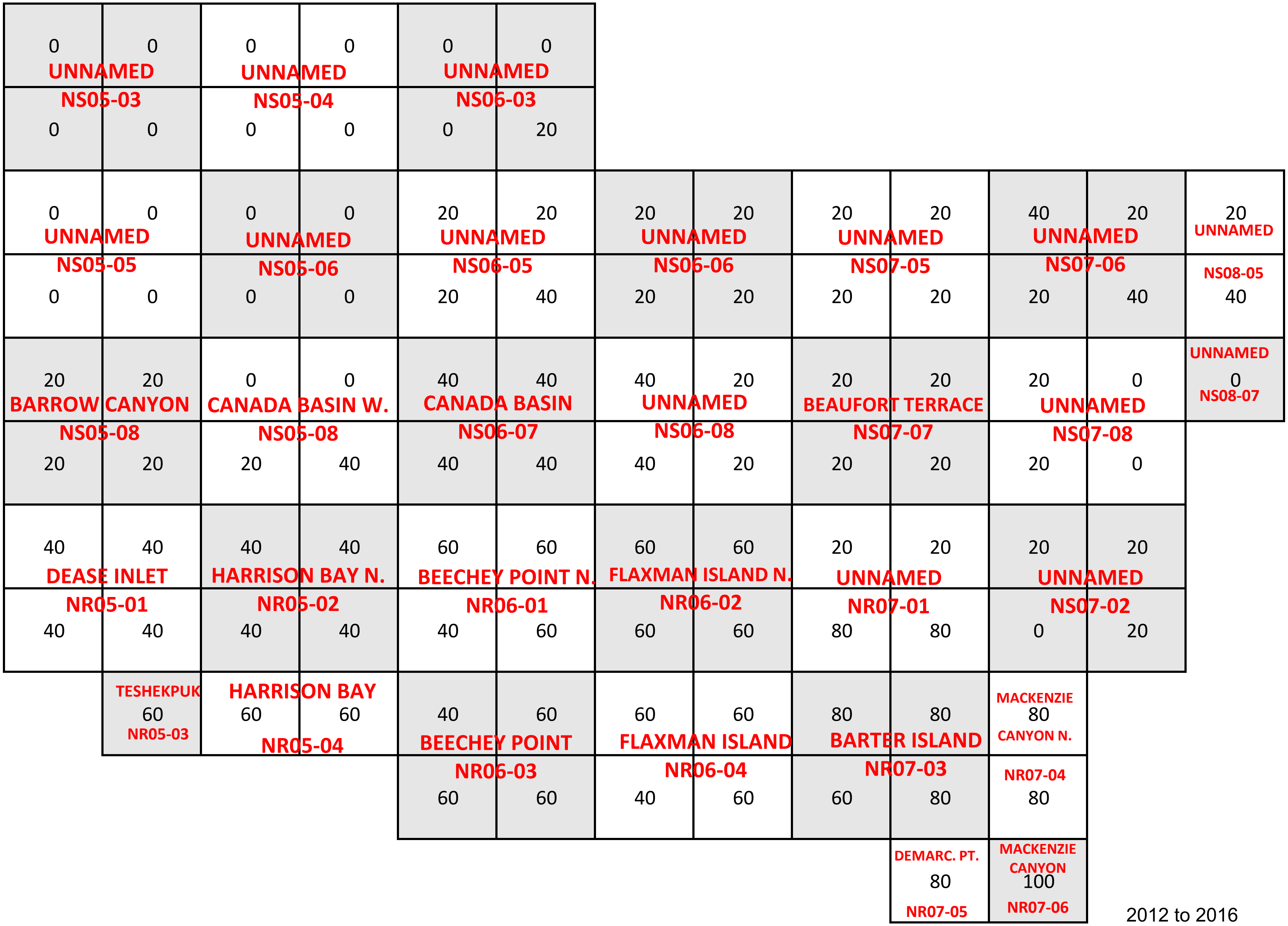
2012 to 2016

Sea Ice 6.3.6 Scenario 6.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea. 21-Jul 31-Jul

0 0 UNNAMED NS05-03 0 0	0 0 UNNAMED NS05-04 0 0	0 0 UNNAMED NS06-03 0 0				
0 0 UNNAMED NS05-05 0 0	0 0 UNNAMED NS05-06 0 0	0 0 UNNAMED NS06-05 0 0	0 0 UNNAMED NS06-06 20 0	0 0 UNNAMED NS07-05 20 0	0 0 UNNAMED NS07-06 0 0	0 UNNAMED NS08-05 0
0 0 BARROW CANYON NS05-08 0 0	0 0 CANADA BASIN W. NS05-08 0 0	0 0 CANADA BASIN NS06-07 20 20	20 20 UNNAMED NS06-08 20 20	20 20 BEAUFORT TERRACE NS07-07 20 20	0 0 UNNAMED NS07-08 20 0	UNNAMED 0 NS08-07
0 20 DEASE INLET NR05-01 20 20	0 0 HARRISON BAY N. NR05-02 20 0	0 20 BEECHEY POINT N. NR06-01 0 20	20 20 FLAXMAN ISLAND N. NR06-02 40 40	20 20 UNNAMED NR07-01 60 60	20 20 UNNAMED NS07-02 0 20	
TESHEKPUK 20 NR05-03	HARRISON BAY 20 20 NR05-04	0 20 BEECHEY POINT NR06-03 40 20	20 20 FLAXMAN ISLAND NR06-04 20 20	60 60 BARTER ISLAND NR07-03 80 60	MACKENZIE 60 CANYON N. NR07-04 60	
				DEMARC. PT. 80 NR07-05	MACKENZIE CANYON 80 NR07-06	

2012 to 2016

Sea Ice 6.3.7 Scenario 6.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea. 1-Aug 10-Aug



UNNAMED	NS05-03	0	0	0	0
UNNAMED	NS05-04	0	0	0	0
UNNAMED	NS06-03	0	0	0	20
UNNAMED	NS05-05	0	0	0	0
UNNAMED	NS05-06	0	0	0	0
UNNAMED	NS06-05	20	20	20	40
UNNAMED	NS06-06	20	20	20	20
UNNAMED	NS07-05	20	20	20	20
UNNAMED	NS07-06	40	20	20	40
UNNAMED	NS08-05	20		40	
BARROW CANYON	NS05-08	20	20	20	20
CANADA BASIN W.	NS05-08	0	0	20	40
CANADA BASIN	NS06-07	40	40	40	40
UNNAMED	NS06-08	40	20	40	20
BEAUFORT TERRACE	NS07-07	20	20	20	20
UNNAMED	NS07-08	20	0	20	0
UNNAMED	NS08-07	0			
DEASE INLET	NR05-01	40	40	40	40
HARRISON BAY N.	NR05-02	40	40	40	40
BEECHEY POINT N.	NR06-01	60	60	40	60
FLAXMAN ISLAND N.	NR06-02	60	60	60	60
UNNAMED	NR07-01	20	20	80	80
UNNAMED	NS07-02	20	20	0	20
TESHEKPUK	NR05-03	60			
HARRISON BAY	NR05-04	60	60		
BEECHEY POINT	NR06-03	40	60	60	60
FLAXMAN ISLAND	NR06-04	60	60	40	60
BARTER ISLAND	NR07-03	80	80	60	80
MACKENZIE CANYON N.	NR07-04	80		80	
DEMARC. PT.	NR07-05			80	
MACKENZIE CANYON	NR07-06			100	

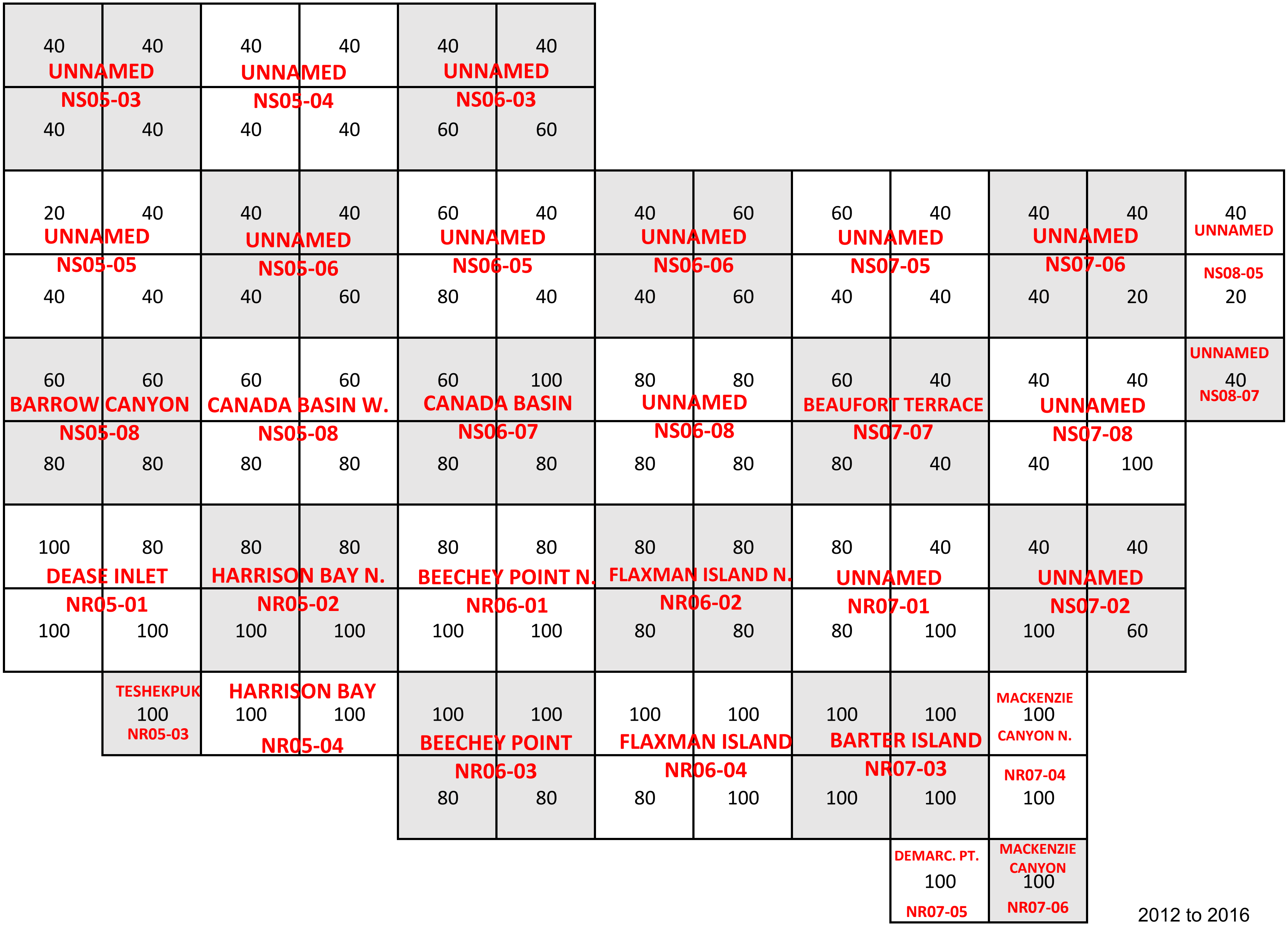
2012 to 2016

Sea Ice 6.3.8 Scenario 6.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea. 11-Aug 20-Aug

20 20 UNNAMED NS05-03 20 20	20 20 UNNAMED NS05-04 20 20	40 40 UNNAMED NS06-03 20 40				
20 40 UNNAMED NS05-05 40 40	40 40 UNNAMED NS05-06 40 40	40 20 UNNAMED NS06-05 40 40	20 20 UNNAMED NS06-06 40 40	20 20 UNNAMED NS07-05 20 20	40 40 UNNAMED NS07-06 40 40	40 UNNAMED NS08-05 40
60 60 BARROW CANYON NS05-08 80 80	60 40 CANADA BASIN W. NS05-08 80 60	60 60 CANADA BASIN NS06-07 60 60	60 40 UNNAMED NS06-08 60 80	40 40 BEAUFORT TERRACE NS07-07 60 60	40 40 UNNAMED NS07-08 40 100	UNNAMED 40 NS08-07
100 100 DEASE INLET NR05-01 100 80	80 60 HARRISON BAY N. NR05-02 80 80	60 80 BEECHEY POINT N. NR06-01 80 80	80 80 FLAXMAN ISLAND N. NR06-02 80 80	80 60 UNNAMED NR07-01 80 80	60 40 UNNAMED NS07-02 100 80	
TESHEKPUK 80 NR05-03	HARRISON BAY 80 80 NR05-04	80 80 BEECHEY POINT NR06-03 80 80	80 80 FLAXMAN ISLAND NR06-04 80 80	80 80 BARTER ISLAND NR07-03 80 100	MACKENZIE 80 CANYON N. NR07-04 100	
				DEMARC. PT. 100 NR07-05	MACKENZIE CANYON 100 NR07-06	

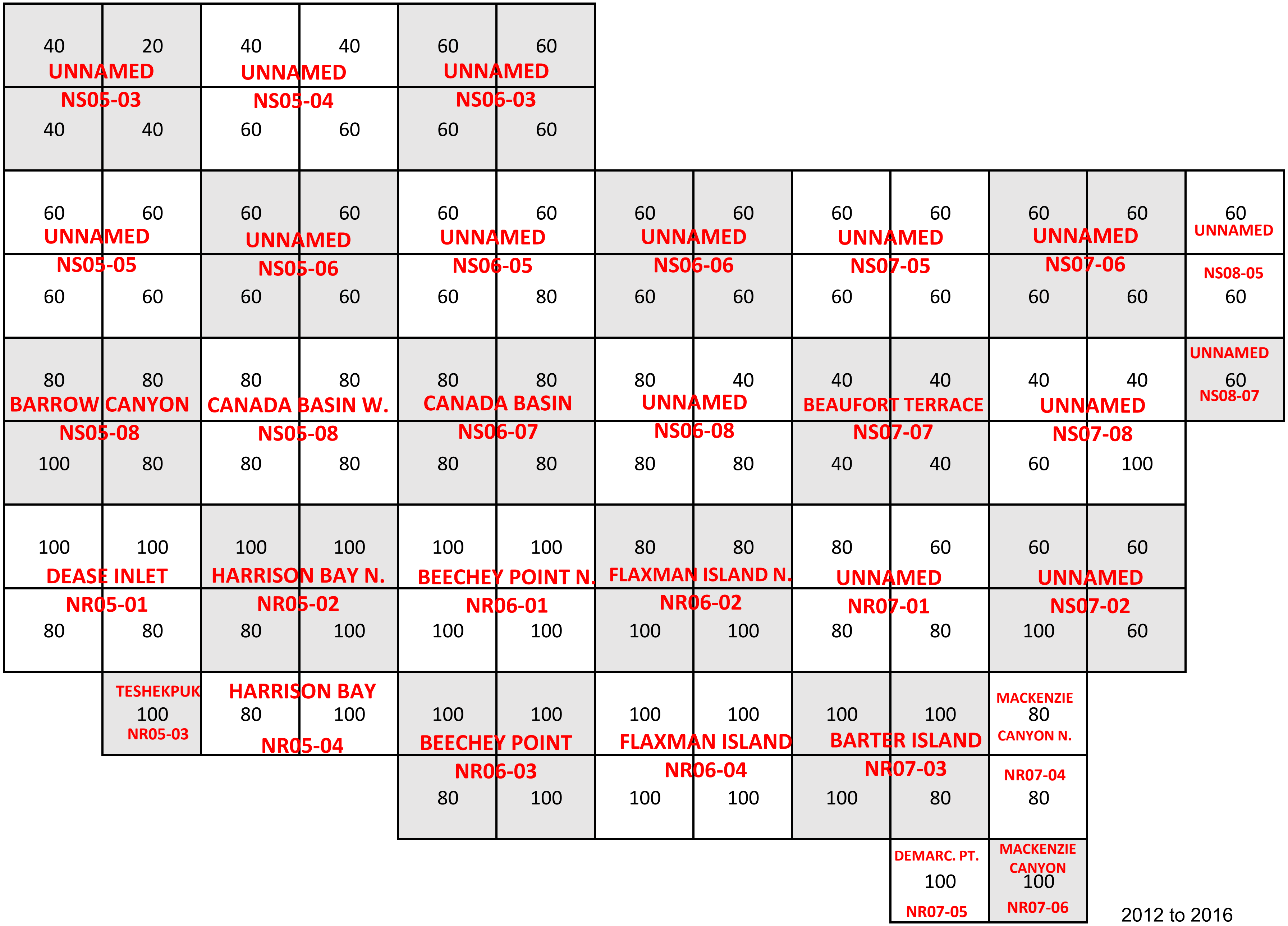
2012 to 2016
21-Aug 31-Aug

Sea Ice 6.3.9 Scenario 6.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea.



2012 to 2016
1-Sep 10-Sep

Sea Ice 6.3.10 Scenario 6.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea.



UNNAMED	NS05-03	40	20	40	40
UNNAMED	NS05-04	40	40	60	60
UNNAMED	NS06-03	60	60	60	60
UNNAMED	NS05-05	60	60	60	60
UNNAMED	NS05-06	60	60	60	60
UNNAMED	NS06-05	60	60	60	80
UNNAMED	NS06-06	60	60	60	60
UNNAMED	NS07-05	60	60	60	60
UNNAMED	NS07-06	60	60	60	60
UNNAMED	NS08-05	60		60	
BARROW CANYON	NS05-08	80	80	100	80
CANADA BASIN W.	NS05-08	80	80	80	80
CANADA BASIN	NS06-07	80	80	80	80
UNNAMED	NS06-08	80	40	80	80
BEAUFORT TERRACE	NS07-07	40	40	40	40
UNNAMED	NS07-08	40	40	60	100
UNNAMED	NS08-07	60			
DEASE INLET	NR05-01	100	100	80	80
HARRISON BAY N.	NR05-02	100	100	80	100
BEECHEY POINT N.	NR06-01	100	100	100	100
FLAXMAN ISLAND N.	NR06-02	80	80	100	100
UNNAMED	NR07-01	80	60	80	80
UNNAMED	NS07-02	60	60	100	60
TESHEKPUK	NR05-03	100			
HARRISON BAY	NR05-04	80	100		
BEECHEY POINT	NR06-03	100	100	80	100
FLAXMAN ISLAND	NR06-04	100	100	100	100
BARTER ISLAND	NR07-03	100	100	100	80
MACKENZIE CANYON N.	NR07-04	80		80	
DEMARC. PT.	NR07-05	100			
MACKENZIE CANYON	NR07-06	100			

2012 to 2016
11-Sep 20-Sep

Sea Ice 6.3.11 Scenario 6.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea.

20	40	60	60	60	60							
UNNAMED		UNNAMED		UNNAMED								
NS05-03		NS05-04		NS06-03								
40	40	60	60	60	60							
60	60	60	60	60	60	60	60	60	40	40	40	40
UNNAMED		UNNAMED		UNNAMED		UNNAMED		UNNAMED		UNNAMED		UNNAMED
NS05-05		NS05-06		NS06-05		NS06-06		NS07-05		NS07-06		NS08-05
60	60	80	80	60	60	60	60	60	60	60	40	40
60	60	60	60	60	80	60	60	60	60	60	40	UNNAMED
BARROW CANYON		CANADA BASIN W.		CANADA BASIN		UNNAMED		BEAUFORT TERRACE		UNNAMED		40
NS05-08		NS05-08		NS06-07		NS06-08		NS07-07		NS07-08		NS08-07
80	60	60	60	60	80	80	80	60	60	40	100	
100	100	100	100	100	100	80	80	80	60	60	40	
DEASE INLET		HARRISON BAY N.		BEECHEY POINT N.		FLAXMAN ISLAND N.		UNNAMED		UNNAMED		
NR05-01		NR05-02		NR06-01		NR06-02		NR07-01		NS07-02		
80	80	80	100	100	100	100	100	80	60	100	80	
	TESHEKPUK	HARRISON BAY								MACKENZIE		
	100	80	100	100	100	100	100	100	100	80		
	NR05-03	NR05-04		BEECHEY POINT		FLAXMAN ISLAND		BARTER ISLAND		CANYON N.		
				NR06-03		NR06-04		NR07-03		NR07-04		
				80	80	100	100	100	80	80		
									DEMARC. PT.	MACKENZIE CANYON		
									100	100		
									NR07-05	NR07-06		

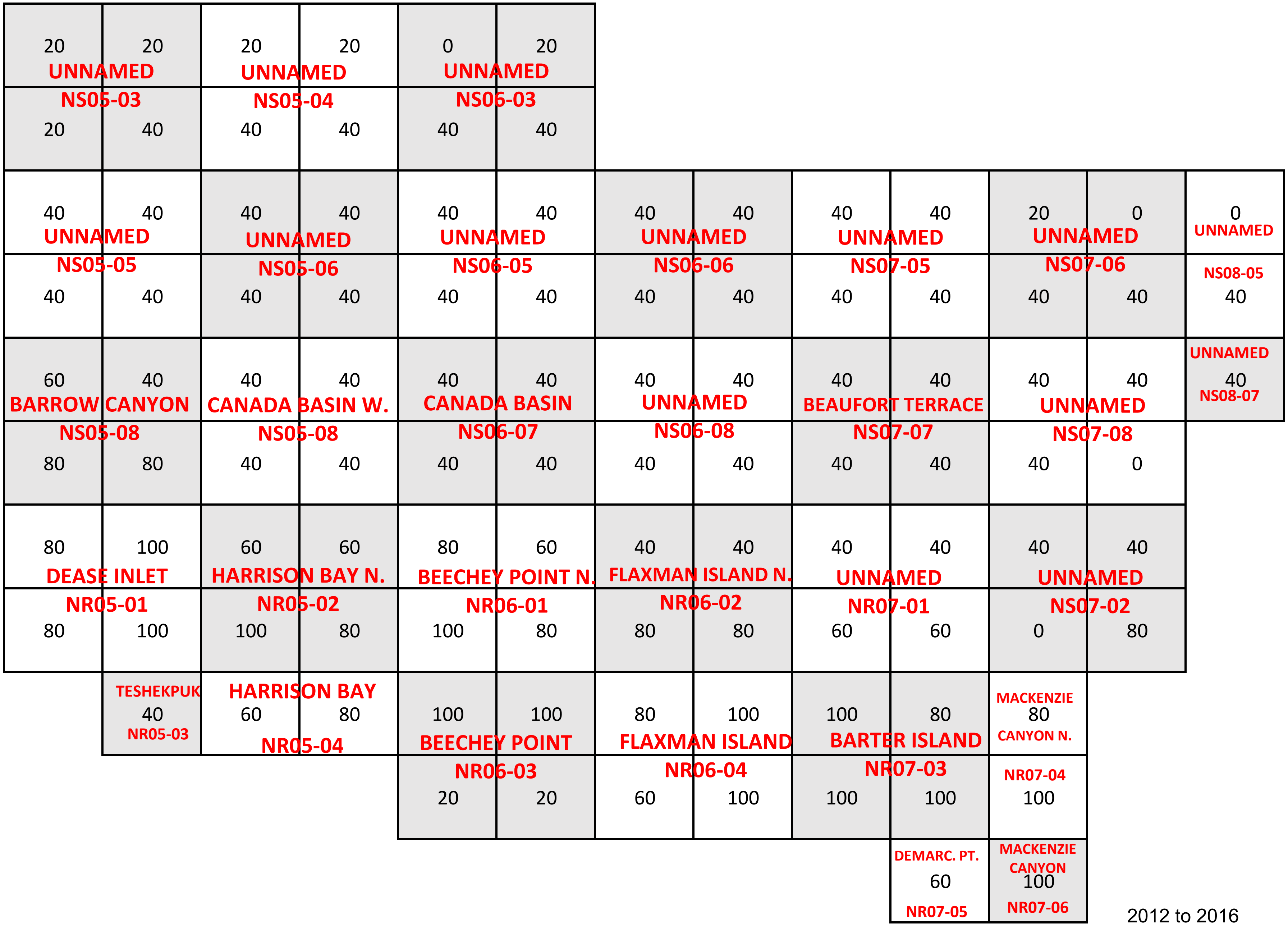
Sea Ice 6.3.12 Scenario 6.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea.

2012 to 2016
21-Sep 30-Sep

40 40 UNNAMED NS05-03 40 60	60 60 UNNAMED NS05-04 60 60	60 60 UNNAMED NS06-03 60 60				
40 40 UNNAMED NS05-05 40 80	60 60 UNNAMED NS05-06 80 80	60 60 UNNAMED NS06-05 60 60	60 60 UNNAMED NS06-06 60 60	60 60 UNNAMED NS07-05 40 40	40 40 UNNAMED NS07-06 40 40	40 UNNAMED NS08-05 40
80 60 BARROW CANYON NS05-08 100 100	80 80 CANADA BASIN W. NS05-08 80 80	60 60 CANADA BASIN NS06-07 80 80	60 60 UNNAMED NS06-08 80 60	40 40 BEAUFORT TERRACE NS07-07 60 60	40 40 UNNAMED NS07-08 40 100	UNNAMED 40 NS08-07
100 100 DEASE INLET NR05-01 100 100	100 100 HARRISON BAY N. NR05-02 100 100	80 80 BEECHEY POINT N. NR06-01 100 100	60 60 FLAXMAN ISLAND N. NR06-02 80 80	60 60 UNNAMED NR07-01 80 80	60 60 UNNAMED NS07-02 100 80	
TESHEKPUK 60 NR05-03	HARRISON BAY 100 100 NR05-04	100 100 BEECHEY POINT NR06-03 60 60	100 80 FLAXMAN ISLAND NR06-04 100 100	80 80 BARTER ISLAND NR07-03 100 80	MACKENZIE 80 CANYON N. NR07-04 80	
				DEMARC. PT. 60 NR07-05	MACKENZIE CANYON 100 NR07-06	

Sea Ice 6.3.13 Scenario 6.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea.

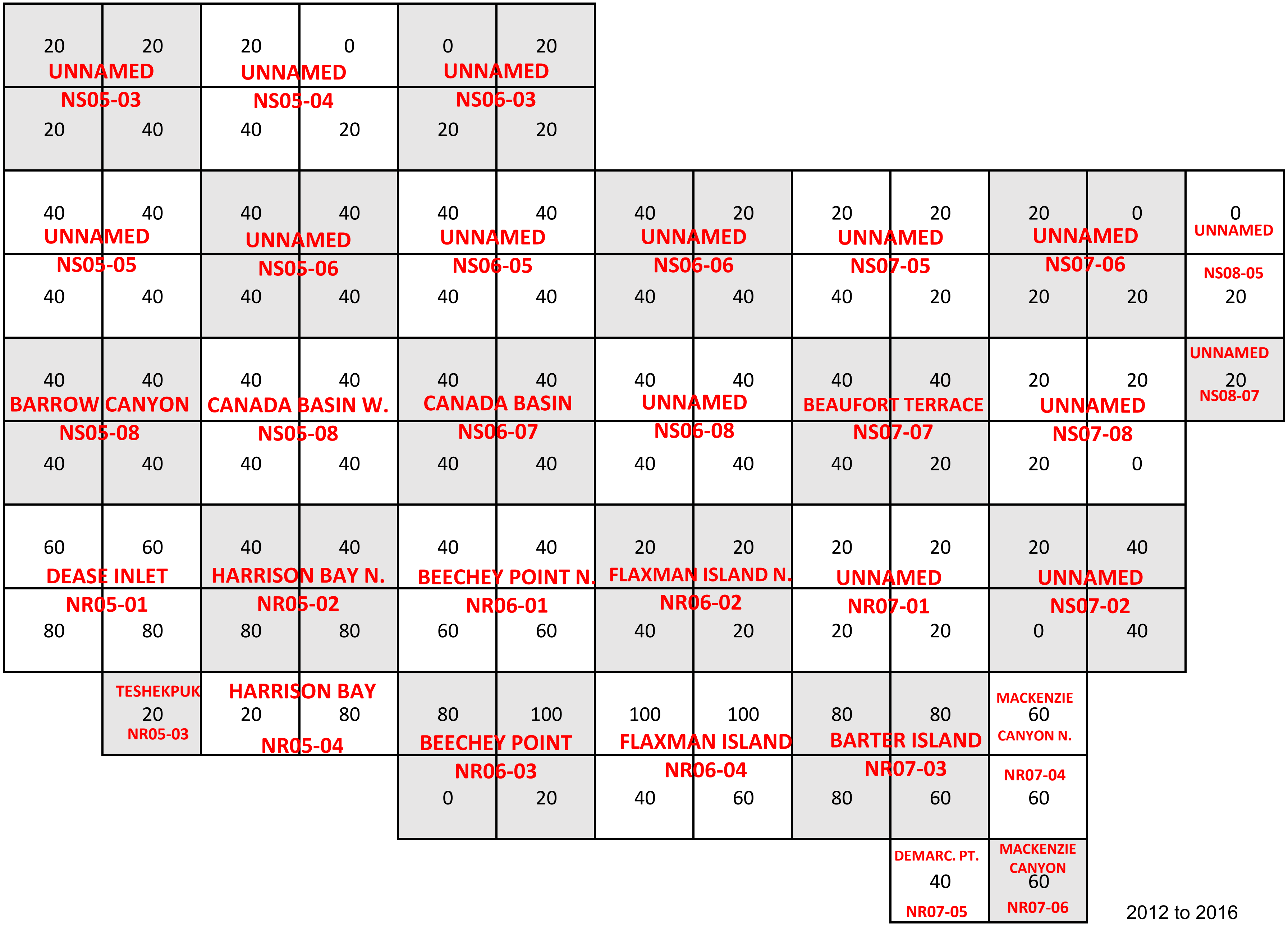
2012 to 2016
1-Oct 10-Oct



UNNAMED	NS05-03	20	20	20	40
UNNAMED	NS05-04	20	20	40	40
UNNAMED	NS06-03	0	20	40	40
UNNAMED	NS05-05	40	40	40	40
UNNAMED	NS05-06	40	40	40	40
UNNAMED	NS06-05	40	40	40	40
UNNAMED	NS06-06	40	40	40	40
UNNAMED	NS07-05	40	40	40	40
UNNAMED	NS07-06	20	0	40	40
UNNAMED	NS08-05	0		40	
BARROW CANYON	NS05-08	60	40	80	80
CANADA BASIN W.	NS05-08	40	40	40	40
CANADA BASIN	NS06-07	40	40	40	40
UNNAMED	NS06-08	40	40	40	40
BEAUFORT TERRACE	NS07-07	40	40	40	40
UNNAMED	NS07-08	40	40	40	0
UNNAMED	NS08-07	40			
DEASE INLET	NR05-01	80	100	80	100
HARRISON BAY N.	NR05-02	60	60	100	80
BEECHEY POINT N.	NR06-01	80	60	100	80
FLAXMAN ISLAND N.	NR06-02	40	40	80	80
UNNAMED	NR07-01	40	40	60	60
UNNAMED	NS07-02	40	40	0	80
TESHEKPUK	NR05-03	40			
HARRISON BAY	NR05-04	60	80		
BEECHEY POINT	NR06-03	100	100	20	20
FLAXMAN ISLAND	NR06-04	80	100	60	100
BARTER ISLAND	NR07-03	100	80	100	100
MACKENZIE CANYON N.	NR07-04	80		100	
DEMARC. PT.	NR07-05	60			
MACKENZIE CANYON	NR07-06	100			

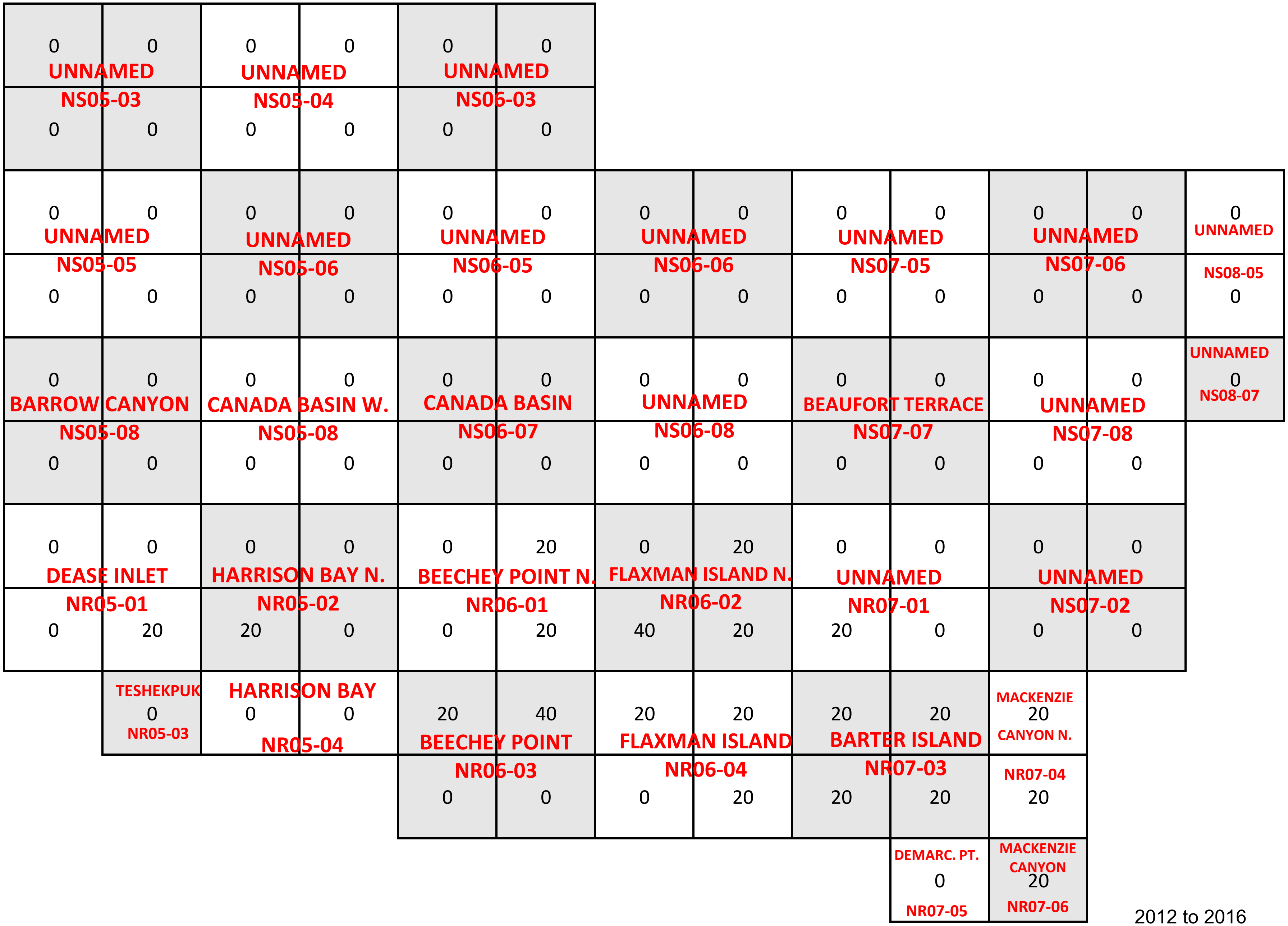
2012 to 2016

Sea Ice 6.3.14 Scenario 6.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea. 11-Oct 20-Oct



2012 to 2016

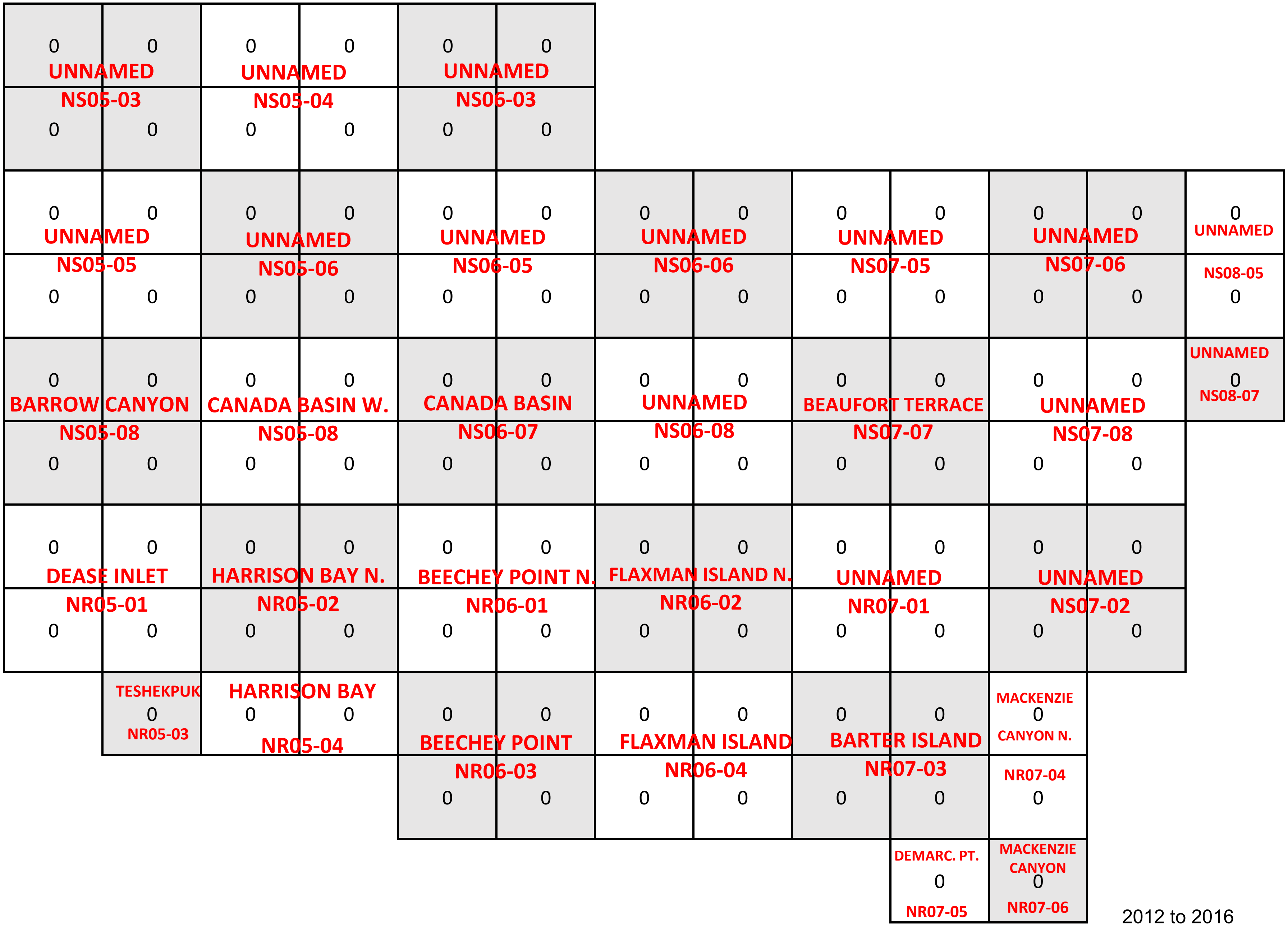
Sea Ice 6.3.15 Scenario 6.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea. 21-Oct 31-Oct



UNNAMED	NS05-03	0	0	0	0
UNNAMED	NS05-04	0	0	0	0
UNNAMED	NS06-03	0	0	0	0
UNNAMED	NS05-05	0	0	0	0
UNNAMED	NS05-06	0	0	0	0
UNNAMED	NS06-05	0	0	0	0
UNNAMED	NS06-06	0	0	0	0
UNNAMED	NS07-05	0	0	0	0
UNNAMED	NS07-06	0	0	0	0
UNNAMED	NS08-05	0		0	
BARROW CANYON	NS05-08	0	0	0	0
CANADA BASIN W.	NS05-08	0	0	0	0
CANADA BASIN	NS06-07	0	0	0	0
UNNAMED	NS06-08	0	0	0	0
BEAUFORT TERRACE	NS07-07	0	0	0	0
UNNAMED	NS07-08	0	0	0	0
UNNAMED	NS08-07	0			
DEASE INLET	NR05-01	0	0	0	20
HARRISON BAY N.	NR05-02	0	0	20	0
BEECHEY POINT N.	NR06-01	0	20	0	20
FLAXMAN ISLAND N.	NR06-02	0	20	40	20
UNNAMED	NR07-01	0	0	20	0
UNNAMED	NS07-02	0	0	0	0
TESHEKPUK	NR05-03	0			
HARRISON BAY	NR05-04	0	0		
BEECHEY POINT	NR06-03	20	40	0	0
FLAXMAN ISLAND	NR06-04	20	20	0	20
BARTER ISLAND	NR07-03	20	20	20	20
MACKENZIE CANYON N.	NR07-04	20		20	
DEMARC. PT.	NR07-05	0			
MACKENZIE CANYON	NR07-06	20			

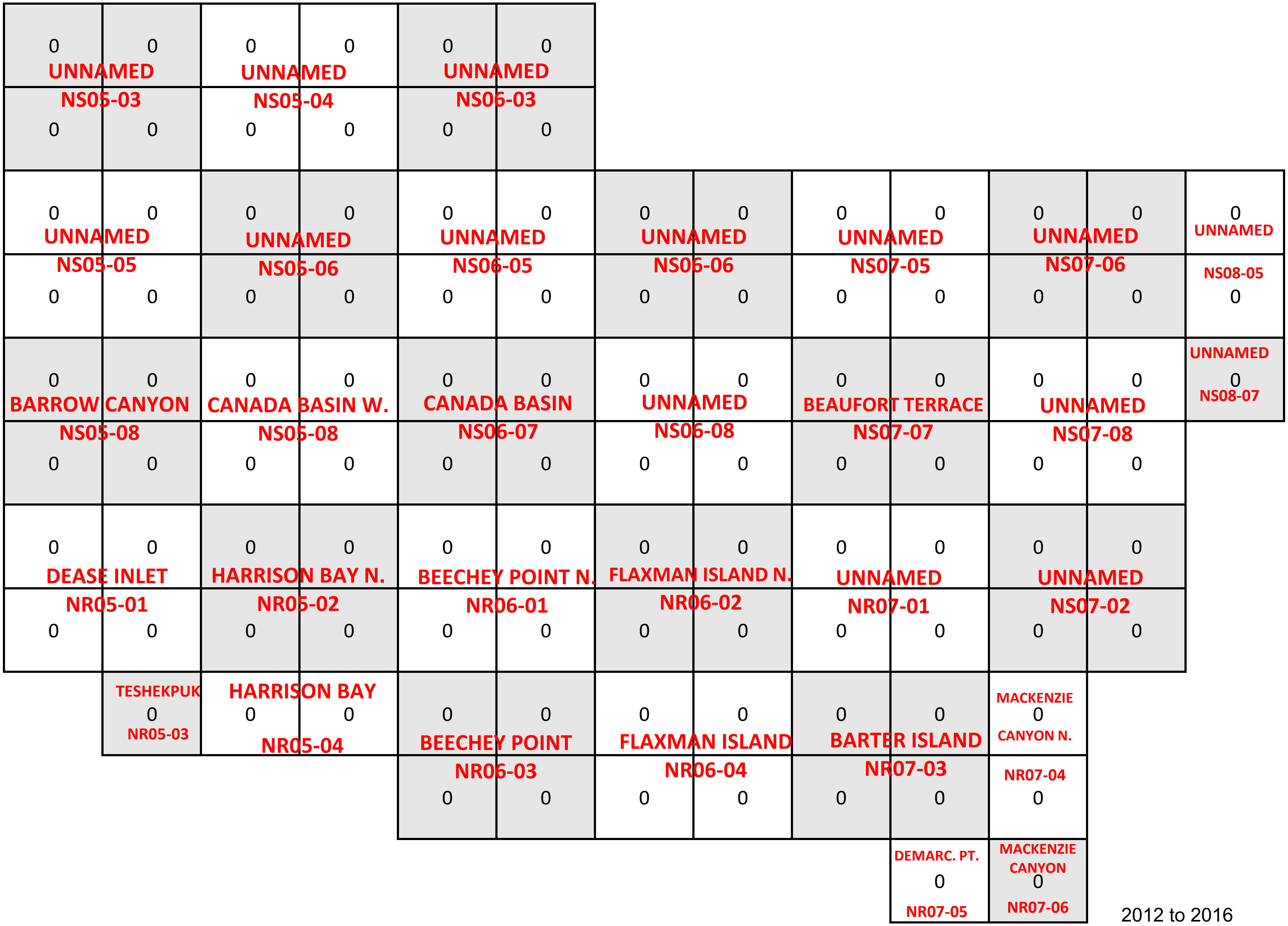
2012 to 2016
1-Nov 10-Nov

Sea Ice 6.3.16 Scenario 6.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea.



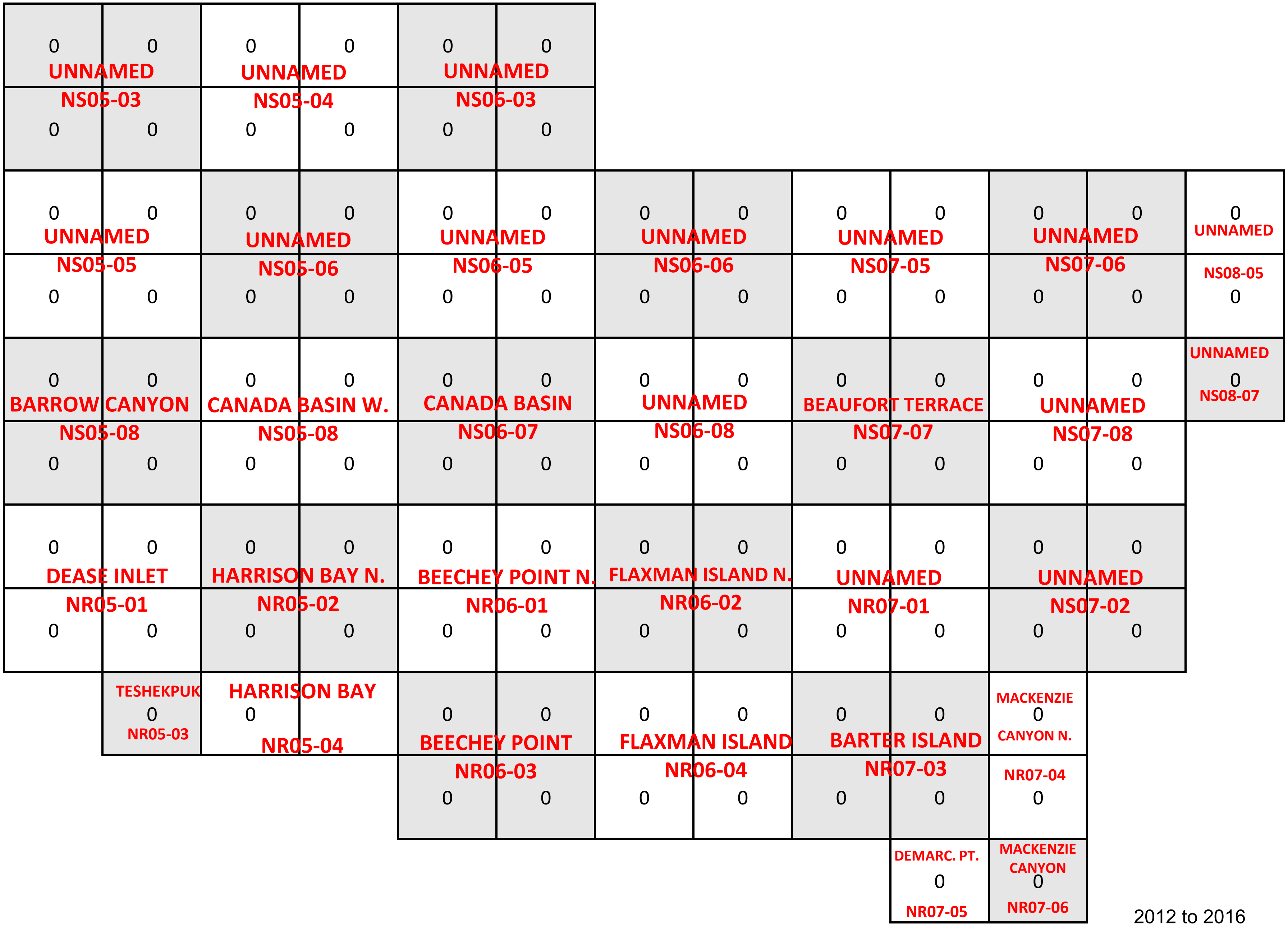
2012 to 2016
11-Nov 20-Nov

Sea Ice 6.3.17 Scenario 6.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea.



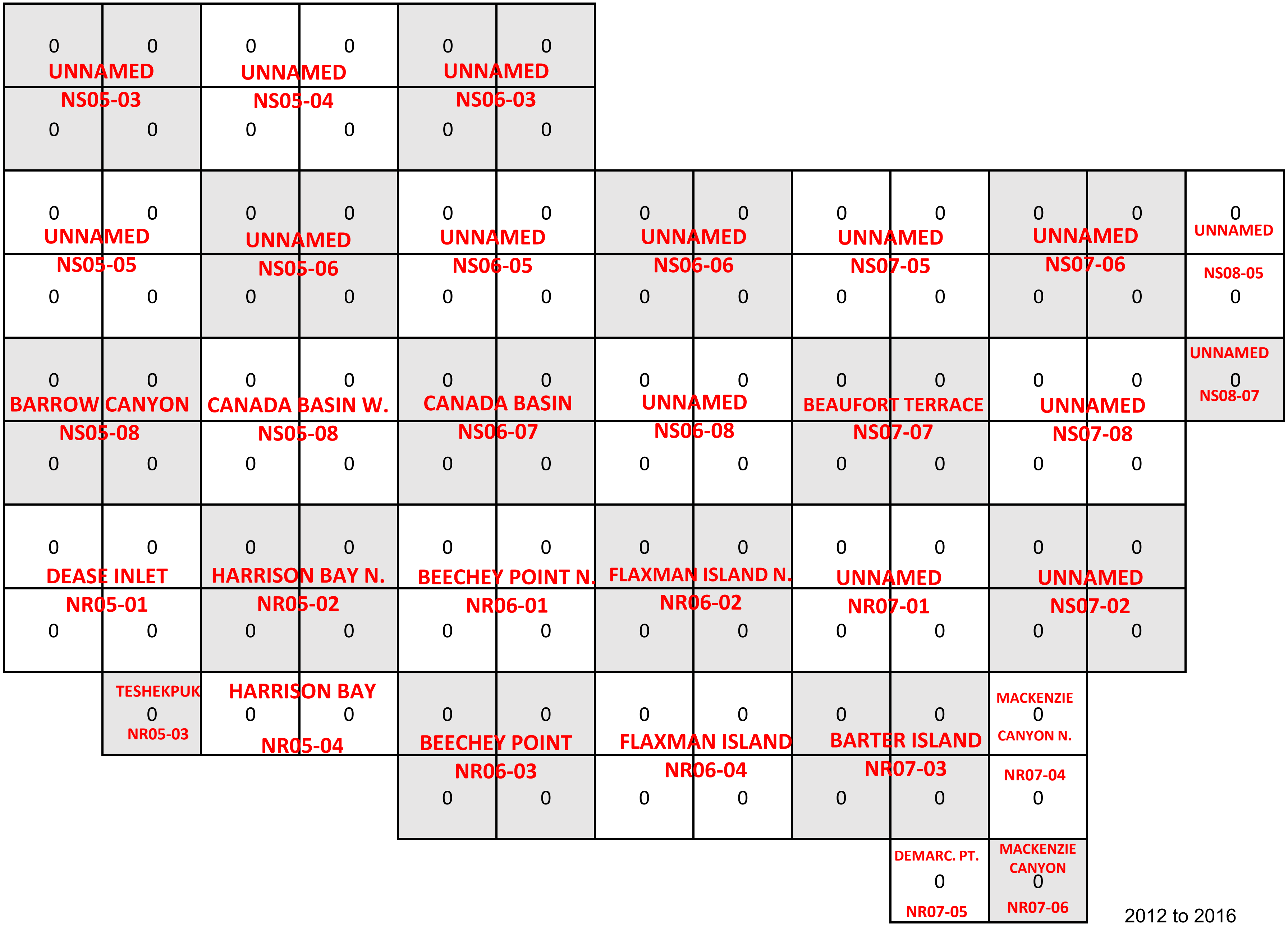
2012 to 2016
21-Nov 30-Nov

Sea Ice 6.3.18 Scenario 6.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea.



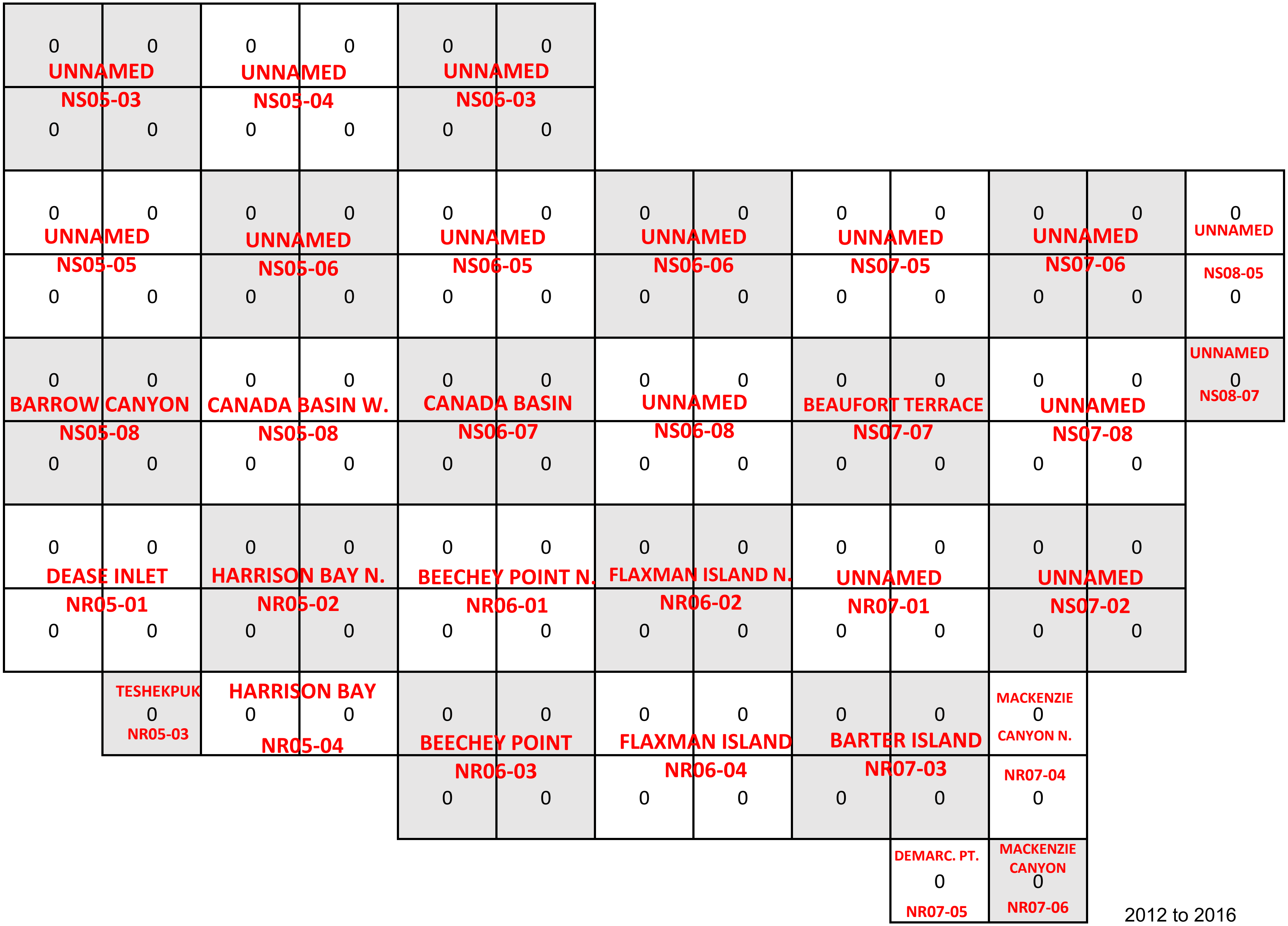
2012 to 2016
1-Dec 10-Dec

Sea Ice 6.3.19 Scenario 6.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea.



2012 to 2016
11-Dec 20-Dec

Sea Ice 6.3.20 Scenario 6.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea.



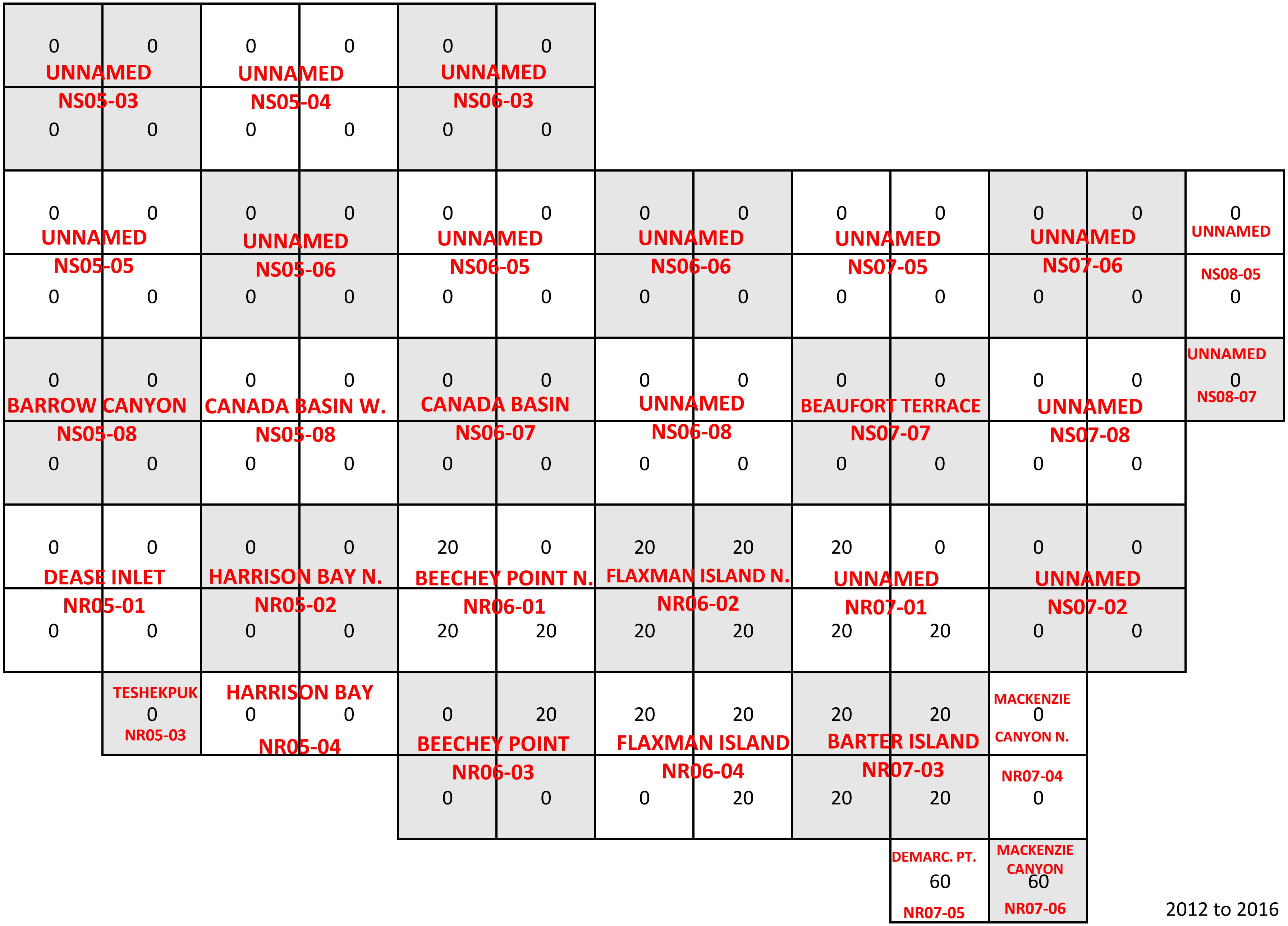
2012 to 2016
21-Dec 31-Dec

Sea Ice 6.3.21 Scenario 6.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea.

Scenario 6.4:

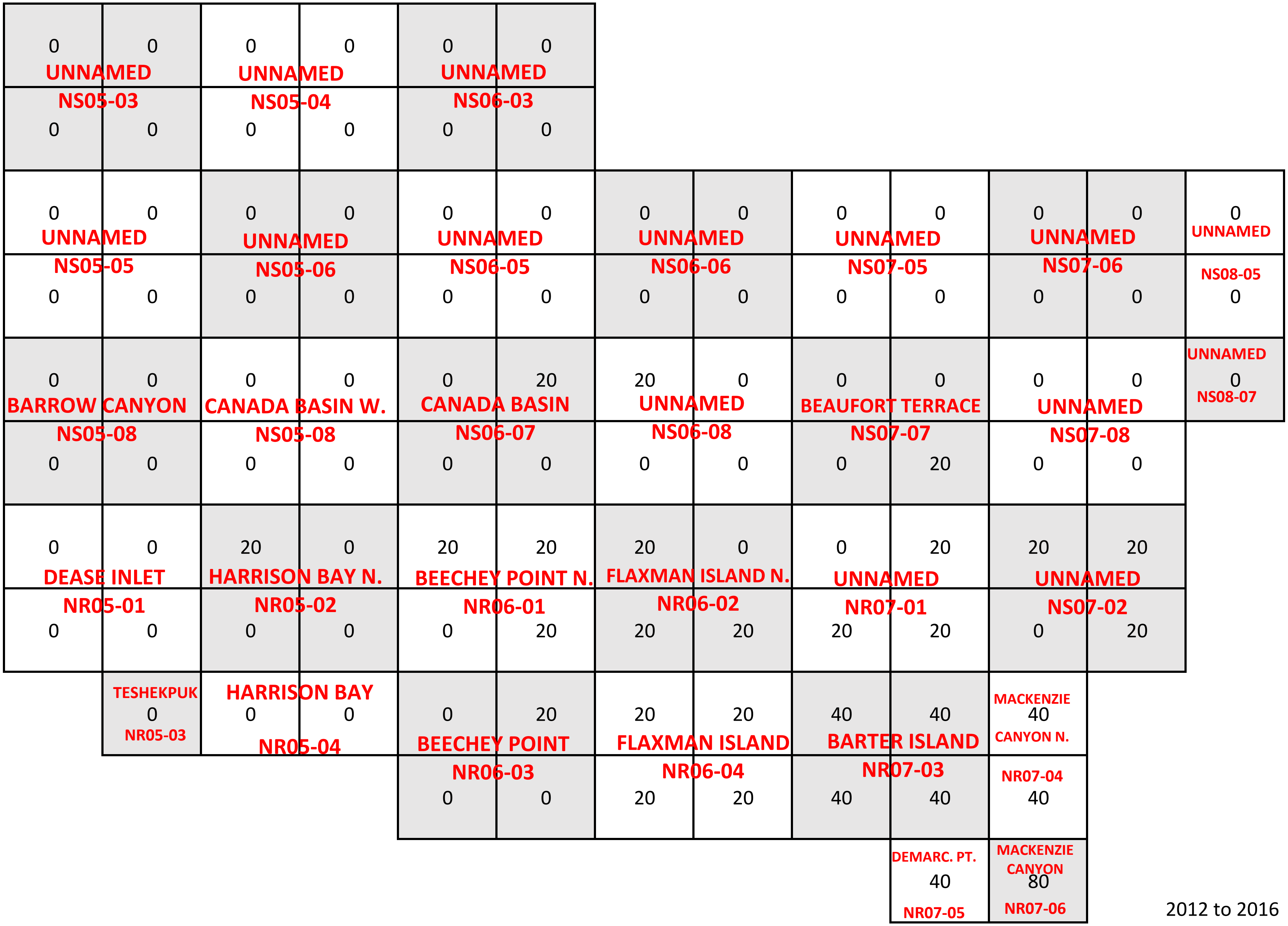
Safe SCCE Deployment with Sea Ice Operating Capability in the Beaufort Sea.

Sea ice data for the probability of sea ice concentration from 0 to 7 tenths, for the period from June through December, 2012 to 2016, in the Beaufort Sea.



2012 to 2016

Sea Ice 6.4.1 Scenario 6.4: Percent probability of sea ice concentration from 0 to 7 tenths, Beaufort Sea. 1-Jun 10-Jun



0 0 UNNAMED NS05-03 0 0	0 0 UNNAMED NS05-04 0 0	0 0 UNNAMED NS06-03 0 0				
0 0 UNNAMED NS05-05 0 0	0 0 UNNAMED NS05-06 0 0	0 0 UNNAMED NS06-05 0 0	0 0 UNNAMED NS06-06 0 0	0 0 UNNAMED NS07-05 0 0	0 0 UNNAMED NS07-06 0 0	0 UNNAMED NS08-05 0
0 0 BARROW CANYON NS05-08 0 0	0 0 CANADA BASIN W. NS05-08 0 0	0 20 CANADA BASIN NS06-07 0 0	20 0 UNNAMED NS06-08 0 0	0 0 BEAUFORT TERRACE NS07-07 0 20	0 0 UNNAMED NS07-08 0 0	UNNAMED 0 NS08-07
0 0 DEASE INLET NR05-01 0 0	20 0 HARRISON BAY N. NR05-02 0 0	20 20 BEECHEY POINT N. NR06-01 0 20	20 0 FLAXMAN ISLAND N. NR06-02 20 20	0 20 UNNAMED NR07-01 20 20	20 20 UNNAMED NS07-02 0 20	
TESHEKPUK 0 NR05-03	HARRISON BAY 0 0 NR05-04	0 20 BEECHEY POINT NR06-03 0 0	20 20 FLAXMAN ISLAND NR06-04 20 20	40 40 BARTER ISLAND NR07-03 40 40	MACKENZIE 40 CANYON N. NR07-04 40	
				DEMARC. PT. 40 NR07-05	MACKENZIE CANYON 80 NR07-06	

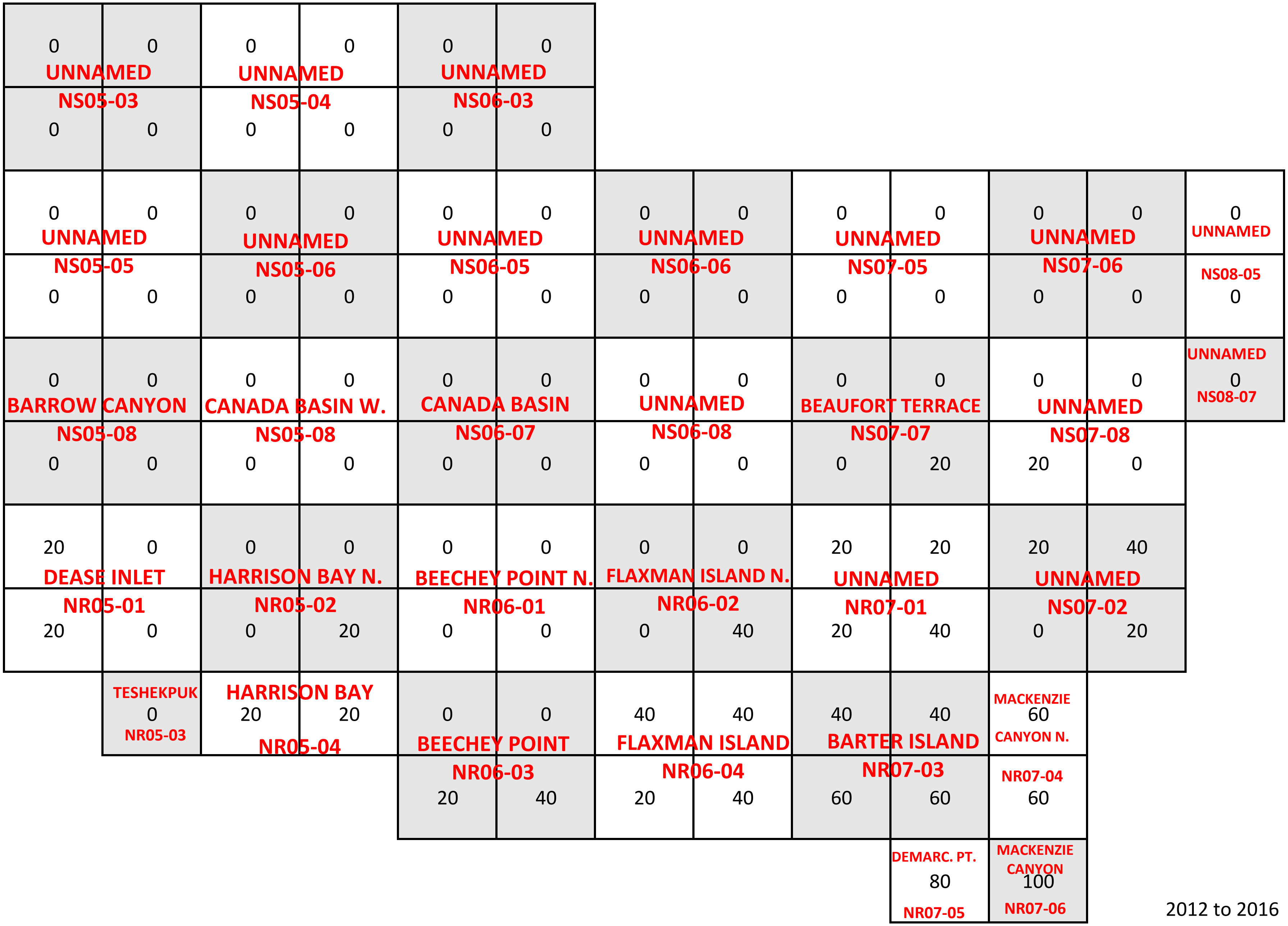
2012 to 2016

Sea Ice 6.4.2 Scenario 6.4: Percent probability of sea ice concentration from 0 to 7 tenths, Beaufort Sea. 11-Jun 20-Jun

0 0 UNNAMED NS05-03 0 0	0 0 UNNAMED NS05-04 0 0	0 0 UNNAMED NS06-03 0 0				
0 0 UNNAMED NS05-05 0 0	0 0 UNNAMED NS05-06 0 0	0 0 UNNAMED NS06-05 0 0	0 0 UNNAMED NS06-06 0 0	0 0 UNNAMED NS07-05 0 0	0 0 UNNAMED NS07-06 0 0	0 UNNAMED NS08-05 0
20 20 BARROW CANYON NS05-08 0 20	0 0 CANADA BASIN W. NS05-08 0 0	20 0 CANADA BASIN NS06-07 20 20	20 0 UNNAMED NS06-08 20 20	0 0 BEAUFORT TERRACE NS07-07 0 20	0 0 UNNAMED NS07-08 20 0	UNNAMED 0 NS08-07
0 0 DEASE INLET NR05-01 0 0	0 0 HARRISON BAY N. NR05-02 0 0	20 20 BEECHEY POINT N. NR06-01 0 20	20 20 FLAXMAN ISLAND N. NR06-02 20 20	40 20 UNNAMED NR07-01 40 20	20 20 UNNAMED NS07-02 0 20	
TESHEKPUK 0 NR05-03	HARRISON BAY 0 0 NR05-04	0 20 BEECHEY POINT NR06-03 0 0	20 20 FLAXMAN ISLAND NR06-04 20 40	40 40 BARTER ISLAND NR07-03 60 60	MACKENZIE 40 CANYON N. NR07-04 60	
				DEMARC. PT. 80 NR07-05	MACKENZIE CANYON 80 NR07-06	

2012 to 2016

Sea Ice 6.4.3 Scenario 6.4: Percent probability of sea ice concentration from 0 to 7 tenths, Beaufort Sea. 21-Jun 30-Jun



0 0
UNNAMED
NS05-03
0 0

0 0
UNNAMED
NS05-04
0 0

0 0
UNNAMED
NS06-03
0 0

0 0
UNNAMED
NS05-05
0 0

0 0
UNNAMED
NS05-06
0 0

0 0
UNNAMED
NS06-05
0 0

0 0
UNNAMED
NS06-06
0 0

0 0
UNNAMED
NS07-05
0 0

0 0
UNNAMED
NS07-06
0 0

0
UNNAMED
NS08-05
0

0 0
BARROW CANYON
NS05-08
0 0

0 0
CANADA BASIN W.
NS05-08
0 0

0 0
CANADA BASIN
NS06-07
0 0

0 0
UNNAMED
NS06-08
0 0

0 0
BEAUFORT TERRACE
NS07-07
0 20

0 0
UNNAMED
NS07-08
20 0

UNNAMED
0
NS08-07

20 0
DEASE INLET
NR05-01
20 0

0 0
HARRISON BAY N.
NR05-02
0 20

0 0
BEECHEY POINT N.
NR06-01
0 0

0 0
FLAXMAN ISLAND N.
NR06-02
0 40

20 20
UNNAMED
NR07-01
20 40

20 40
UNNAMED
NS07-02
0 20

TESHEKPUK
0
NR05-03

HARRISON BAY
20 20
NR05-04

0 0
BEECHEY POINT
NR06-03
20 40

40 40
FLAXMAN ISLAND
NR06-04
20 40

40 40
BARTER ISLAND
NR07-03
60 60

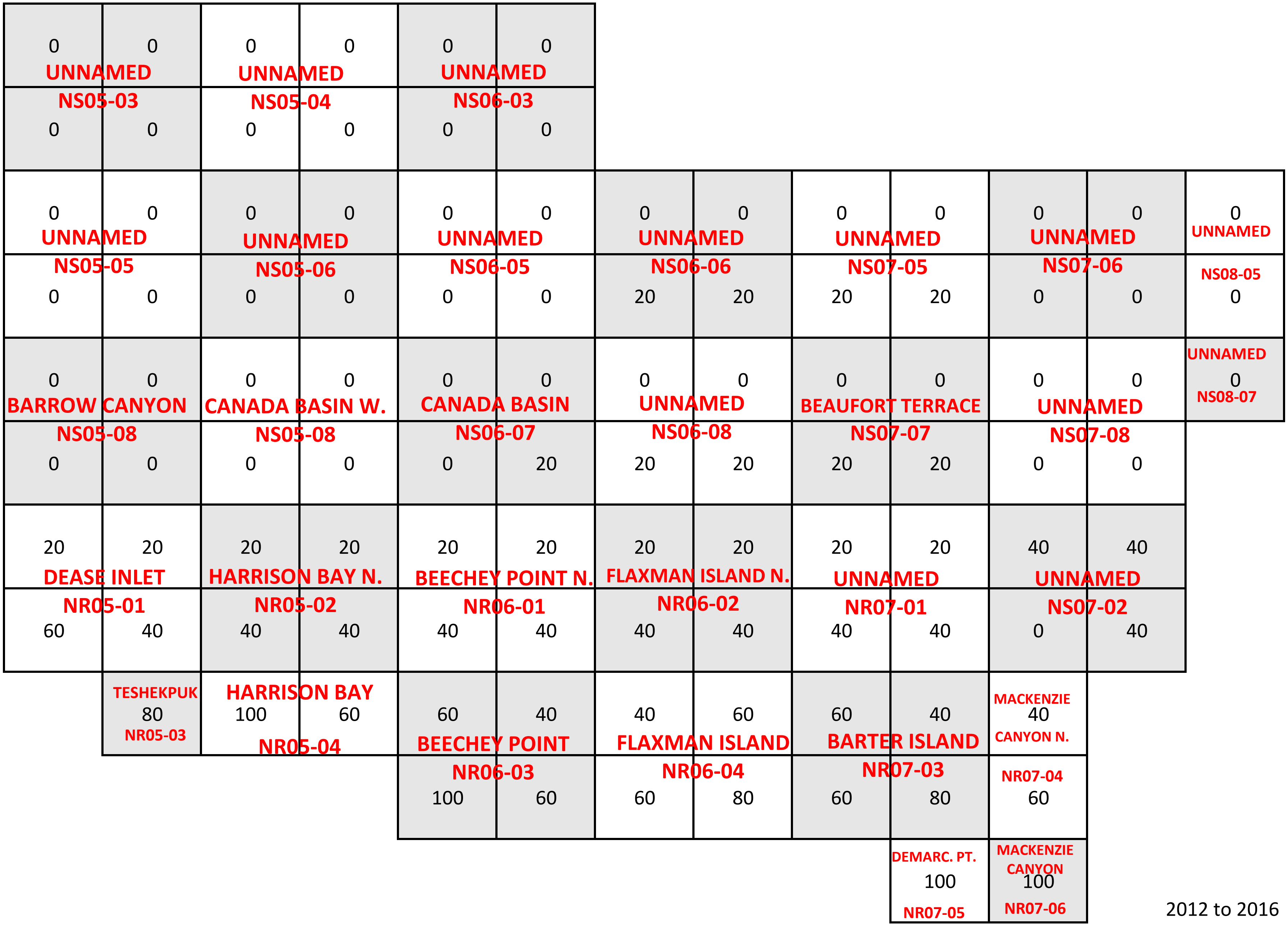
MACKENZIE
60
CANYON N.
NR07-04
60

DEMARC. PT.
80
NR07-05

MACKENZIE
CANYON
100
NR07-06

2012 to 2016

Sea Ice 6.4.4 Scenario 6.4: Percent probability of sea ice concentration from 0 to 7 tenths, Beaufort Sea. 1-Jul 10-Jul



0 0
UNNAMED
NS05-03
0 0

0 0
UNNAMED
NS05-04
0 0

0 0
UNNAMED
NS06-03
0 0

0 0
UNNAMED
NS05-05
0 0

0 0
UNNAMED
NS05-06
0 0

0 0
UNNAMED
NS06-05
0 0

0 0
UNNAMED
NS06-06
20 20

0 0
UNNAMED
NS07-05
20 20

0 0
UNNAMED
NS07-06
0 0

0
UNNAMED
NS08-05
0

0 0
BARROW CANYON
NS05-08
0 0

0 0
CANADA BASIN W.
NS05-08
0 0

0 0
CANADA BASIN
NS06-07
0 20

0 0
UNNAMED
NS06-08
20 20

0 0
BEAUFORT TERRACE
NS07-07
20 20

0 0
UNNAMED
NS07-08
0 0

UNNAMED
0
NS08-07

20 20
DEASE INLET
NR05-01
60 40

20 20
HARRISON BAY N.
NR05-02
40 40

20 20
BEECHEY POINT N.
NR06-01
40 40

20 20
FLAXMAN ISLAND N.
NR06-02
40 40

20 20
UNNAMED
NR07-01
40 40

40 40
UNNAMED
NS07-02
0 40

TESHEKPUK
80
NR05-03

HARRISON BAY
100 60
NR05-04

60 40
BEECHEY POINT
NR06-03
100 60

40 60
FLAXMAN ISLAND
NR06-04
60 80

60 40
BARTER ISLAND
NR07-03
60 80

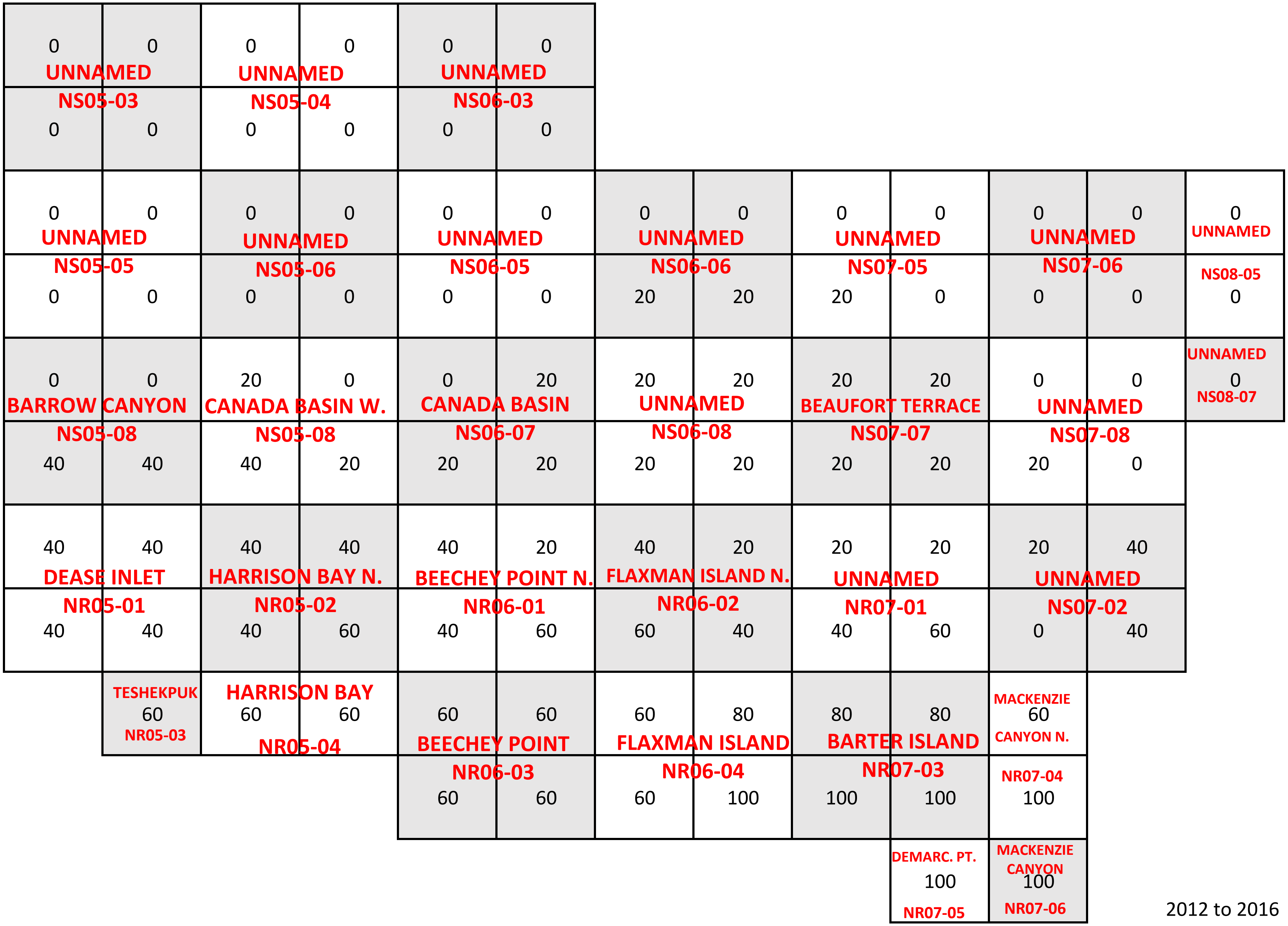
MACKENZIE
40
CANYON N.
NR07-04
60

DEMARC. PT.
100
NR07-05

MACKENZIE
CANYON
100
NR07-06

2012 to 2016

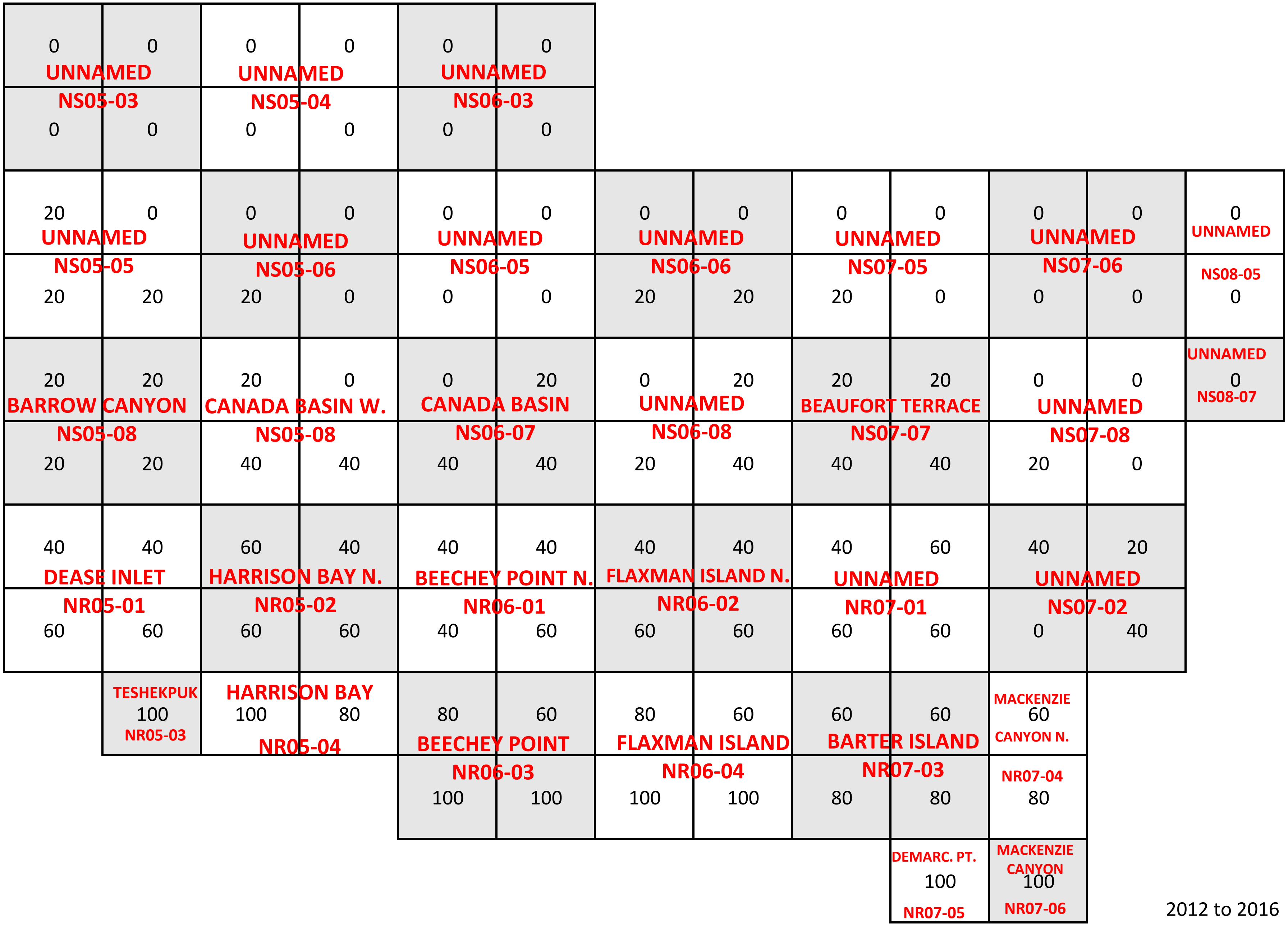
Sea Ice 6.4.5 Scenario 6.4: Percent probability of sea ice concentration from 0 to 7 tenths, Beaufort Sea. 11-Jul 20-Jul



UNNAMED	NS05-03	0	0	0	0
UNNAMED	NS05-04	0	0	0	0
UNNAMED	NS06-03	0	0	0	0
UNNAMED	NS05-05	0	0	0	0
UNNAMED	NS05-06	0	0	0	0
UNNAMED	NS06-05	0	0	0	0
UNNAMED	NS06-06	0	0	20	20
UNNAMED	NS07-05	0	0	20	0
UNNAMED	NS07-06	0	0	0	0
UNNAMED	NS08-05	0		0	
BARROW CANYON	NS05-08	0	0	40	40
CANADA BASIN W.	NS05-08	20	0	40	20
CANADA BASIN	NS06-07	0	20	20	20
UNNAMED	NS06-08	20	20	20	20
BEAUFORT TERRACE	NS07-07	20	20	20	20
UNNAMED	NS07-08	0	0	20	0
UNNAMED	NS08-07	0			
DEASE INLET	NR05-01	40	40	40	40
HARRISON BAY N.	NR05-02	40	40	40	60
BEECHEY POINT N.	NR06-01	40	20	40	60
FLAXMAN ISLAND N.	NR06-02	40	20	60	40
UNNAMED	NR07-01	20	20	40	60
UNNAMED	NS07-02	20	40	0	40
TESHEKPUK	NR05-03	60			
HARRISON BAY	NR05-04	60	60		
BEECHEY POINT	NR06-03	60	60	60	60
FLAXMAN ISLAND	NR06-04	60	80	60	100
BARTER ISLAND	NR07-03	80	80	100	100
MACKENZIE CANYON N.	NR07-04	60		100	
DEMARC. PT.	NR07-05	100			
MACKENZIE CANYON	NR07-06	100			

2012 to 2016

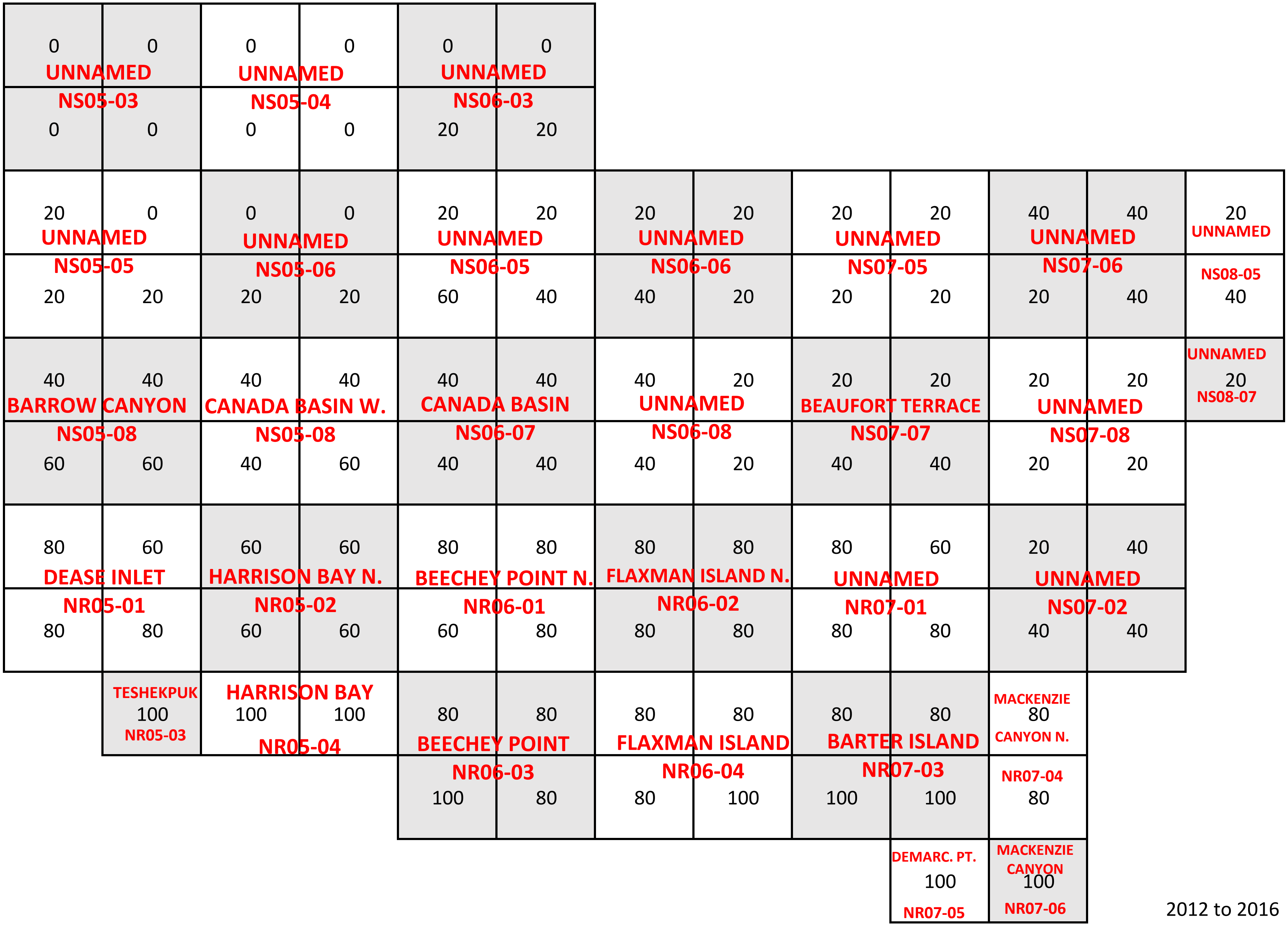
Sea Ice 6.4.6 Scenario 6.4: Percent probability of sea ice concentration from 0 to 7 tenths, Beaufort Sea. 21-Jul 31-Jul



UNNAMED	NS05-03	0	0	0	0
UNNAMED	NS05-04	0	0	0	0
UNNAMED	NS06-03	0	0	0	0
UNNAMED	NS05-05	20	0	20	20
UNNAMED	NS05-06	0	0	20	0
UNNAMED	NS06-05	0	0	0	0
UNNAMED	NS06-06	0	0	20	20
UNNAMED	NS07-05	0	0	20	0
UNNAMED	NS07-06	0	0	0	0
UNNAMED	NS08-05	0		0	
BARROW CANYON	NS05-08	20	20	20	20
CANADA BASIN W.	NS05-08	20	0	40	40
CANADA BASIN	NS06-07	0	20	40	40
UNNAMED	NS06-08	0	20	20	40
BEAUFORT TERRACE	NS07-07	20	20	40	40
UNNAMED	NS07-08	0	0	20	0
UNNAMED	NS08-07	0			
DEASE INLET	NR05-01	40	40	60	60
HARRISON BAY N.	NR05-02	60	40	60	60
BEECHEY POINT N.	NR06-01	40	40	40	60
FLAXMAN ISLAND N.	NR06-02	40	40	60	60
UNNAMED	NR07-01	40	60	60	60
UNNAMED	NS07-02	40	20	0	40
TESHEKPUK	NR05-03	100			
HARRISON BAY	NR05-04	100	80		
BEECHEY POINT	NR06-03	80	60	100	100
FLAXMAN ISLAND	NR06-04	80	60	100	100
BARTER ISLAND	NR07-03	60	60	80	80
MACKENZIE CANYON N.	NR07-04	60		80	
DEMARC. PT.	NR07-05	100			
MACKENZIE CANYON	NR07-06	100			

2012 to 2016

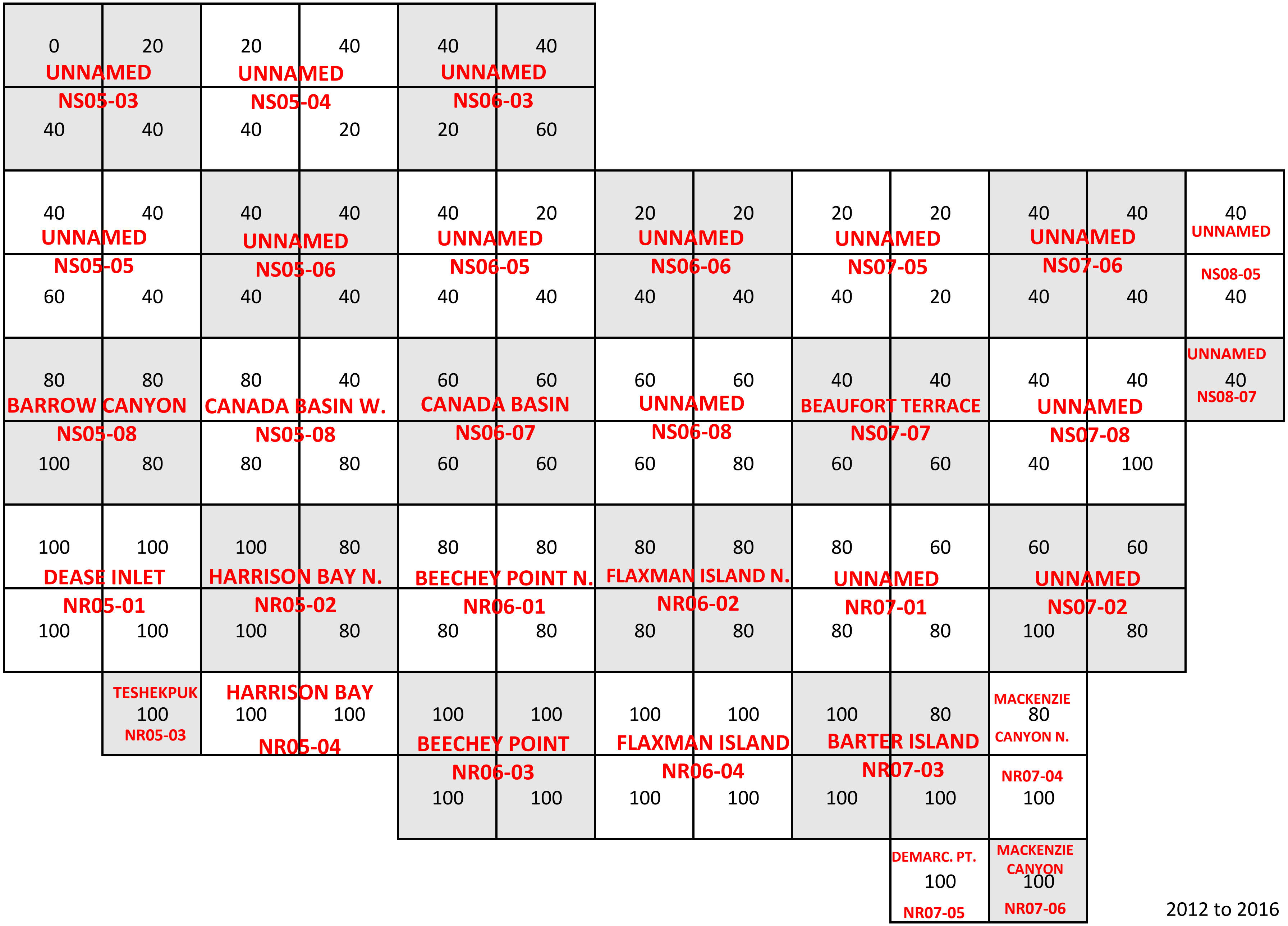
Sea Ice 6.4.7 Scenario 6.4: Percent probability of sea ice concentration from 0 to 7 tenths, Beaufort Sea. 1-Aug 10-Aug



UNNAMED	NS05-03	0	0	0	0
UNNAMED	NS05-04	0	0	0	0
UNNAMED	NS06-03	0	0	20	20
UNNAMED	NS05-05	20	0	20	20
UNNAMED	NS05-06	0	0	20	20
UNNAMED	NS06-05	20	20	60	40
UNNAMED	NS06-06	20	20	40	20
UNNAMED	NS07-05	20	20	20	20
UNNAMED	NS07-06	40	40	20	40
UNNAMED	NS08-05	20		40	
BARROW CANYON	NS05-08	40	40	60	60
CANADA BASIN W.	NS05-08	40	40	40	60
CANADA BASIN	NS06-07	40	40	40	40
UNNAMED	NS06-08	40	20	40	20
BEAUFORT TERRACE	NS07-07	20	20	40	40
UNNAMED	NS07-08	20	20	20	20
UNNAMED	NS08-07	20			
DEASE INLET	NR05-01	80	60	80	80
HARRISON BAY N.	NR05-02	60	60	60	60
BEECHEY POINT N.	NR06-01	80	80	60	80
FLAXMAN ISLAND N.	NR06-02	80	80	80	80
UNNAMED	NR07-01	80	60	80	80
UNNAMED	NS07-02	20	40	40	40
TESHEKPUK	NR05-03	100			
HARRISON BAY	NR05-04	100	100		
BEECHEY POINT	NR06-03	80	80	100	80
FLAXMAN ISLAND	NR06-04	80	80	80	100
BARTER ISLAND	NR07-03	80	80	100	100
MACKENZIE CANYON N.	NR07-04	80		80	
DEMARC. PT.	NR07-05	100			
MACKENZIE CANYON	NR07-06	100			

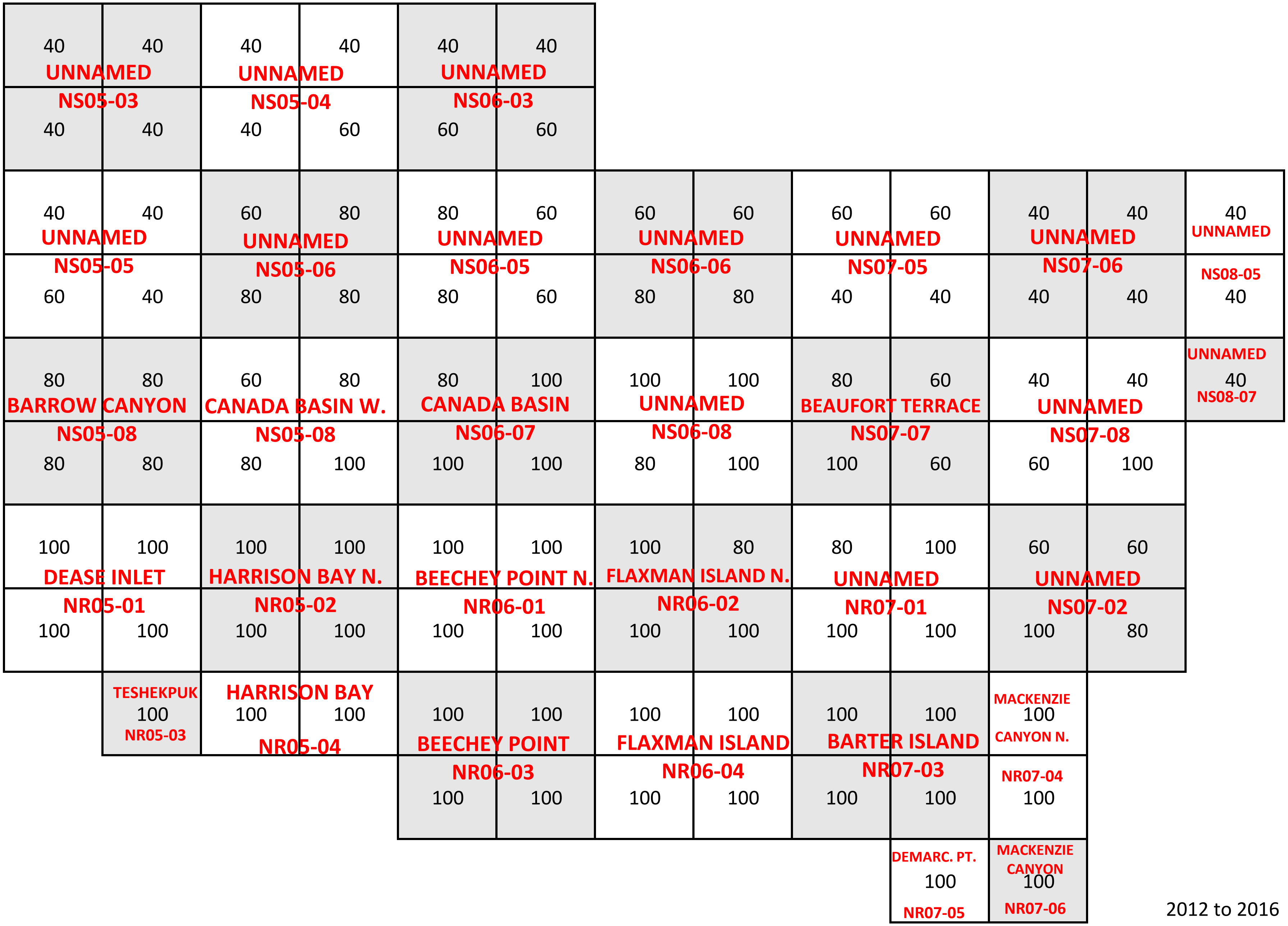
2012 to 2016

Sea Ice 6.4.8 Scenario 6.4: Percent probability of sea ice concentration from 0 to 7 tenths, Beaufort Sea. 11-Aug 20-Aug



2012 to 2016

Sea Ice 6.4.9 Scenario 6.4: Percent probability of sea ice concentration from 0 to 7 tenths, Beaufort Sea. 21-Aug 31-Aug



40 40
UNNAMED
NS05-03
40 40

40 40
UNNAMED
NS05-04
40 60

40 40
UNNAMED
NS06-03
60 60

40 40
UNNAMED
NS05-05
60 40

60 80
UNNAMED
NS05-06
80 80

80 60
UNNAMED
NS06-05
80 60

60 60
UNNAMED
NS06-06
80 80

60 60
UNNAMED
NS07-05
40 40

40 40
UNNAMED
NS07-06
40 40

40
UNNAMED
NS08-05
40

80 80
BARROW CANYON
NS05-08
80 80

60 80
CANADA BASIN W.
NS05-08
80 100

80 100
CANADA BASIN
NS06-07
100 100

100 100
UNNAMED
NS06-08
80 100

80 60
BEAUFORT TERRACE
NS07-07
100 60

40 40
UNNAMED
NS07-08
60 100

UNNAMED
40
NS08-07

100 100
DEASE INLET
NR05-01
100 100

100 100
HARRISON BAY N.
NR05-02
100 100

100 100
BEECHEY POINT N.
NR06-01
100 100

100 80
FLAXMAN ISLAND N.
NR06-02
100 100

80 100
UNNAMED
NR07-01
100 100

60 60
UNNAMED
NS07-02
100 80

TESHEKPUK
100
NR05-03

HARRISON BAY
100 100
NR05-04

100 100
BEECHEY POINT
NR06-03
100 100

100 100
FLAXMAN ISLAND
NR06-04
100 100

100 100
BARTER ISLAND
NR07-03
100 100

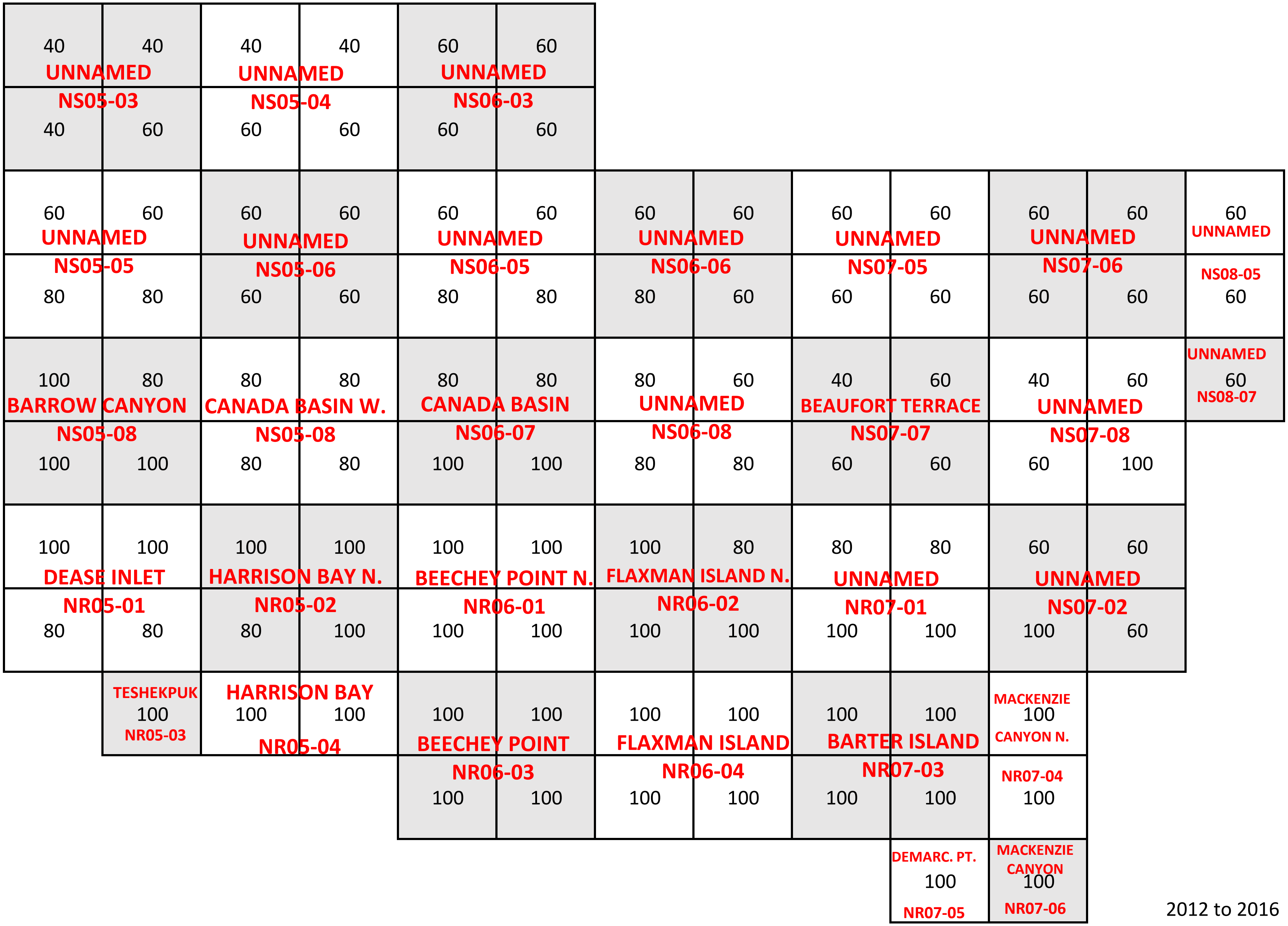
MACKENZIE
100
CANYON N.
NR07-04
100

DEMARC. PT.
100
NR07-05

MACKENZIE
CANYON
100
NR07-06

2012 to 2016

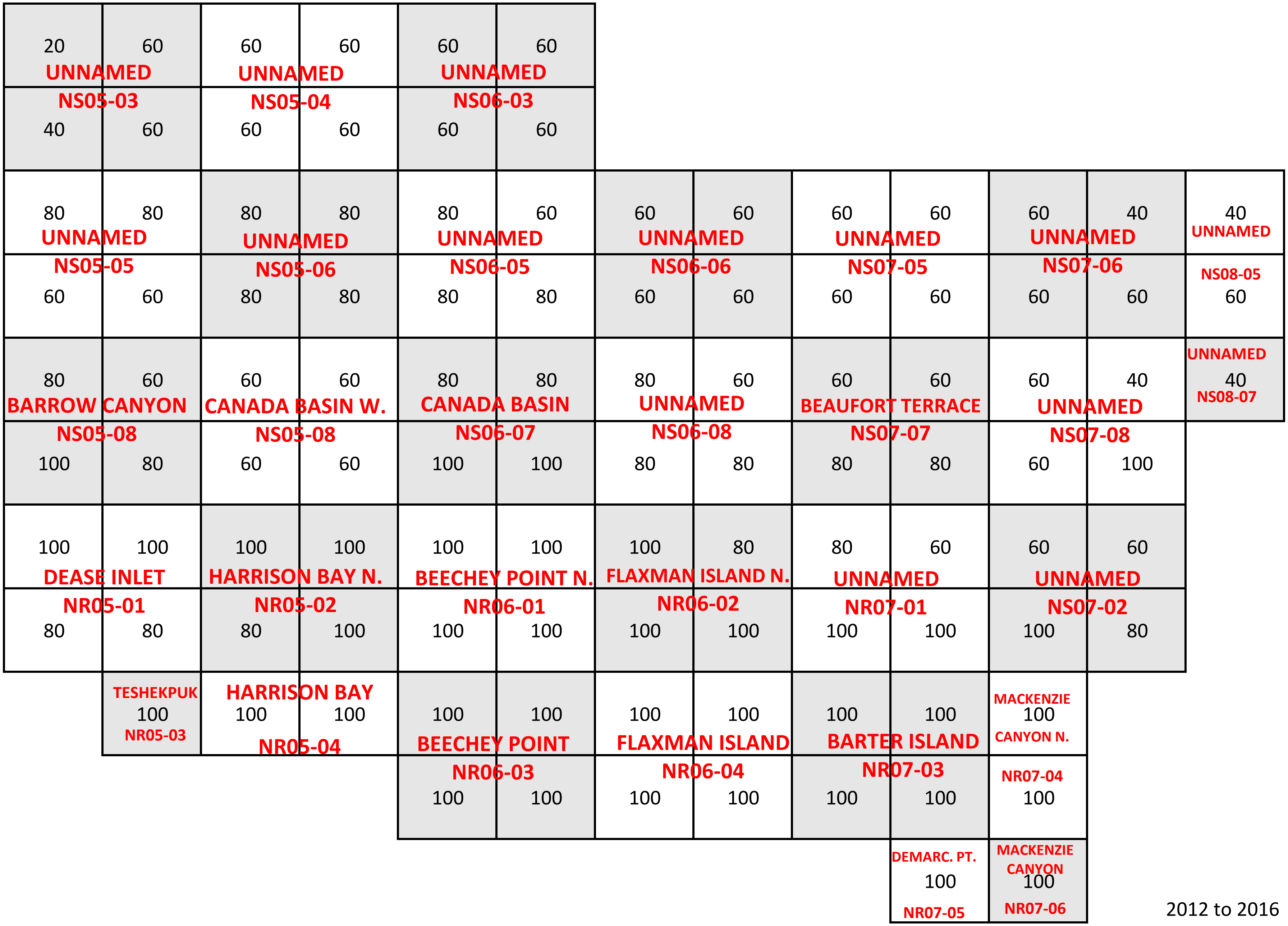
Sea Ice 6.4.10 Scenario 6.4: Percent probability of sea ice concentration from 0 to 7 tenths, Beaufort Sea. 1-Sep 10-Sep



UNNAMED	NS05-03	40	40	40	60
UNNAMED	NS05-04	40	40	60	60
UNNAMED	NS06-03	60	60	60	60
UNNAMED	NS05-05	60	60	80	80
UNNAMED	NS05-06	60	60	60	60
UNNAMED	NS06-05	60	60	80	80
UNNAMED	NS06-06	60	60	80	60
UNNAMED	NS07-05	60	60	60	60
UNNAMED	NS07-06	60	60	60	60
UNNAMED	NS08-05	60		60	
BARROW CANYON	NS05-08	100	80	100	100
CANADA BASIN W.	NS05-08	80	80	80	80
CANADA BASIN	NS06-07	80	80	100	100
UNNAMED	NS06-08	80	60	80	80
BEAUFORT TERRACE	NS07-07	40	60	60	60
UNNAMED	NS07-08	40	60	60	100
UNNAMED	NS08-07	60			
DEASE INLET	NR05-01	100	100	80	80
HARRISON BAY N.	NR05-02	100	100	80	100
BEECHEY POINT N.	NR06-01	100	100	100	100
FLAXMAN ISLAND N.	NR06-02	100	80	100	100
UNNAMED	NR07-01	80	80	100	100
UNNAMED	NS07-02	60	60	100	60
TESHEKPUK	NR05-03	100			
HARRISON BAY	NR05-04	100	100		
BEECHEY POINT	NR06-03	100	100	100	100
FLAXMAN ISLAND	NR06-04	100	100	100	100
BARTER ISLAND	NR07-03	100	100	100	100
MACKENZIE CANYON N.	NR07-04	100		100	
DEMARC. PT.	NR07-05	100			
MACKENZIE CANYON	NR07-06	100			

Sea Ice 6.4.11 Scenario 6.4: Percent probability of sea ice concentration from 0 to 7 tenths, Beaufort Sea.

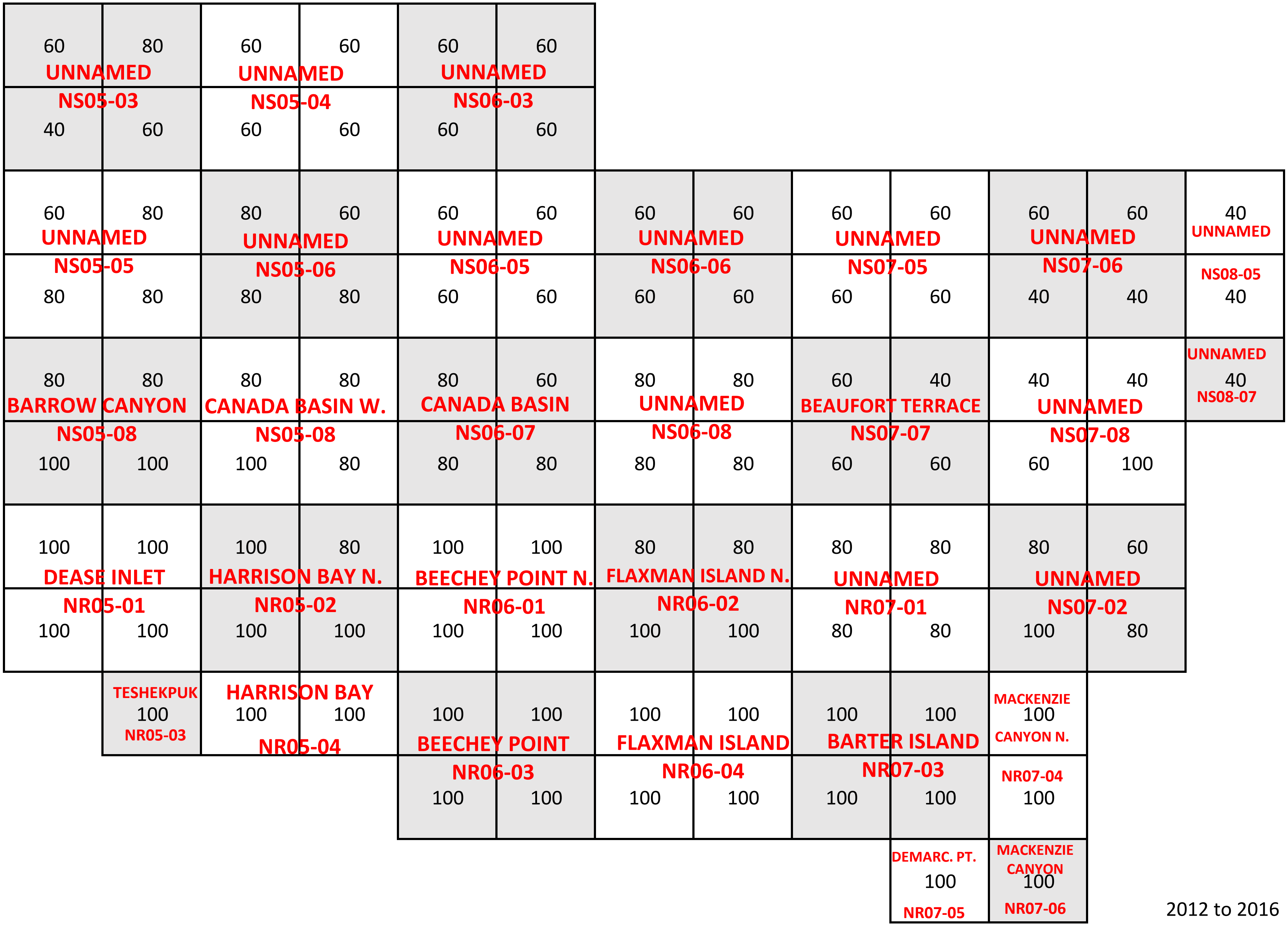
2012 to 2016
11-Sep 20-Sep



20 60 UNNAMED NS05-03 40 60	60 60 UNNAMED NS05-04 60 60	60 60 UNNAMED NS06-03 60 60				
80 80 UNNAMED NS05-05 60 60	80 80 UNNAMED NS05-06 80 80	80 60 UNNAMED NS06-05 80 80	60 60 UNNAMED NS06-06 60 60	60 60 UNNAMED NS07-05 60 60	60 40 UNNAMED NS07-06 60 60	40 UNNAMED NS08-05 60
80 60 BARROW CANYON NS05-08 100 80	60 60 CANADA BASIN W. NS05-08 60 60	80 80 CANADA BASIN NS06-07 100 100	80 60 UNNAMED NS06-08 80 80	60 60 BEAUFORT TERRACE NS07-07 80 80	60 40 UNNAMED NS07-08 60 100	UNNAMED 40 NS08-07
100 100 DEASE INLET NR05-01 80 80	100 100 HARRISON BAY N. NR05-02 80 100	100 100 BEECHEY POINT N. NR06-01 100 100	100 80 FLAXMAN ISLAND N. NR06-02 100 100	80 60 UNNAMED NR07-01 100 100	60 60 UNNAMED NS07-02 100 80	
TESHEKPUK 100 NR05-03	HARRISON BAY 100 100 NR05-04	100 100 BEECHEY POINT NR06-03 100 100	100 100 FLAXMAN ISLAND NR06-04 100 100	100 100 BARTER ISLAND NR07-03 100 100	MACKENZIE 100 CANYON N. NR07-04 100	
				DEMARC. PT. 100 NR07-05	MACKENZIE CANYON 100 NR07-06	

2012 to 2016

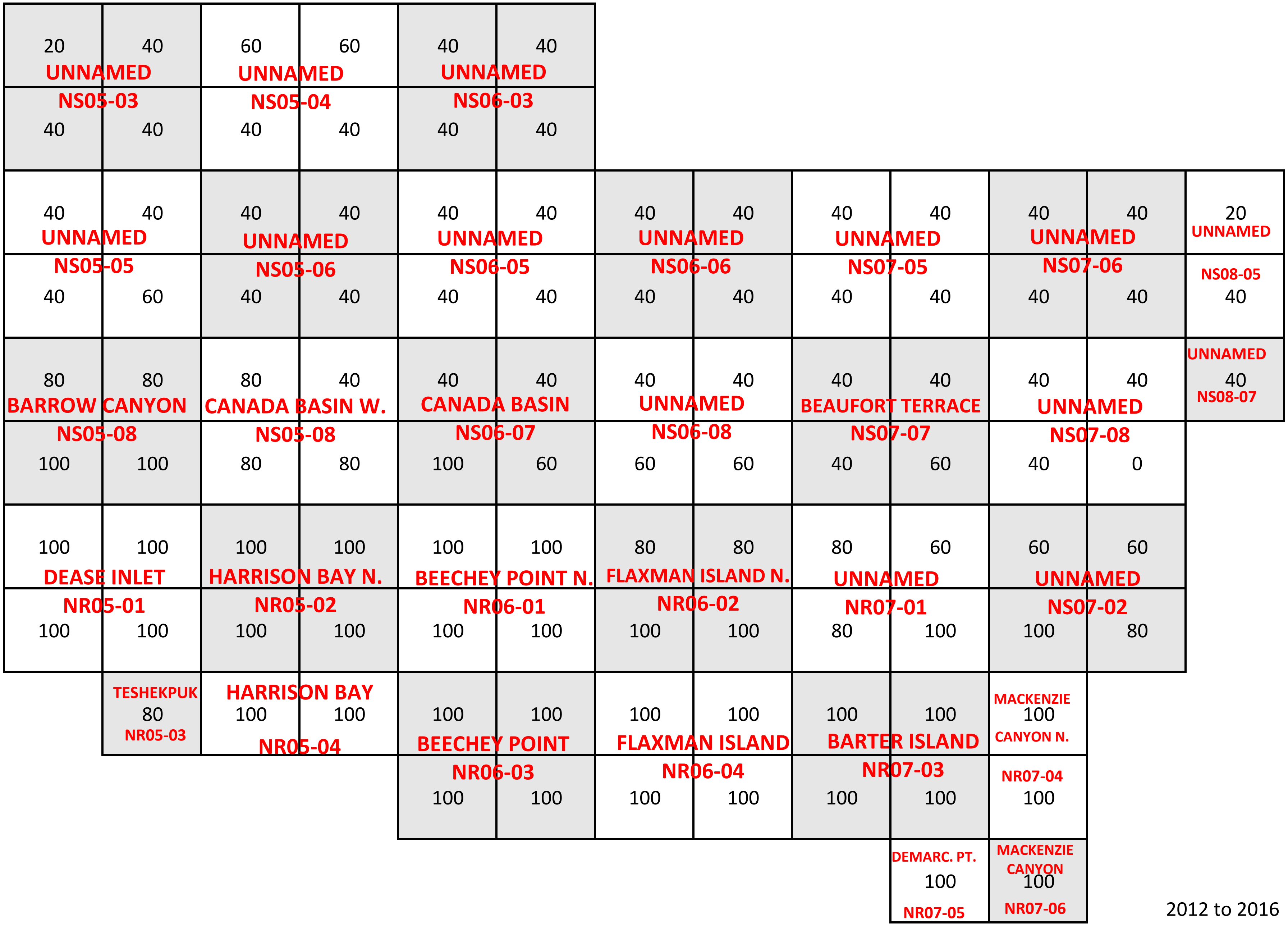
Sea Ice 6.4.12 Scenario 6.4: Percent probability of sea ice concentration from 0 to 7 tenths, Beaufort Sea. 21-Sep 30-Sep



UNNAMED	NS05-03	60	80	40	60
UNNAMED	NS05-04	60	60	60	60
UNNAMED	NS06-03	60	60	60	60
UNNAMED	NS05-05	60	80	80	80
UNNAMED	NS05-06	80	60	80	80
UNNAMED	NS06-05	60	60	60	60
UNNAMED	NS06-06	60	60	60	60
UNNAMED	NS07-05	60	60	60	60
UNNAMED	NS07-06	60	60	40	40
UNNAMED	NS08-05	40		40	
BARROW CANYON	NS05-08	80	80	100	100
CANADA BASIN W.	NS05-08	80	80	100	80
CANADA BASIN	NS06-07	80	60	80	80
UNNAMED	NS06-08	80	80	80	80
BEAUFORT TERRACE	NS07-07	60	40	60	60
UNNAMED	NS07-08	40	40	60	100
UNNAMED	NS08-07	40			
DEASE INLET	NR05-01	100	100	100	100
HARRISON BAY N.	NR05-02	100	80	100	100
BEECHEY POINT N.	NR06-01	100	100	100	100
FLAXMAN ISLAND N.	NR06-02	80	80	100	100
UNNAMED	NR07-01	80	80	80	80
UNNAMED	NS07-02	80	60	100	80
TESHEKPUK	NR05-03	100			
HARRISON BAY	NR05-04	100	100		
BEECHEY POINT	NR06-03	100	100	100	100
FLAXMAN ISLAND	NR06-04	100	100	100	100
BARTER ISLAND	NR07-03	100	100	100	100
MACKENZIE CANYON N.	NR07-04	100		100	
DEMARC. PT.	NR07-05	100			
MACKENZIE CANYON	NR07-06	100			

2012 to 2016

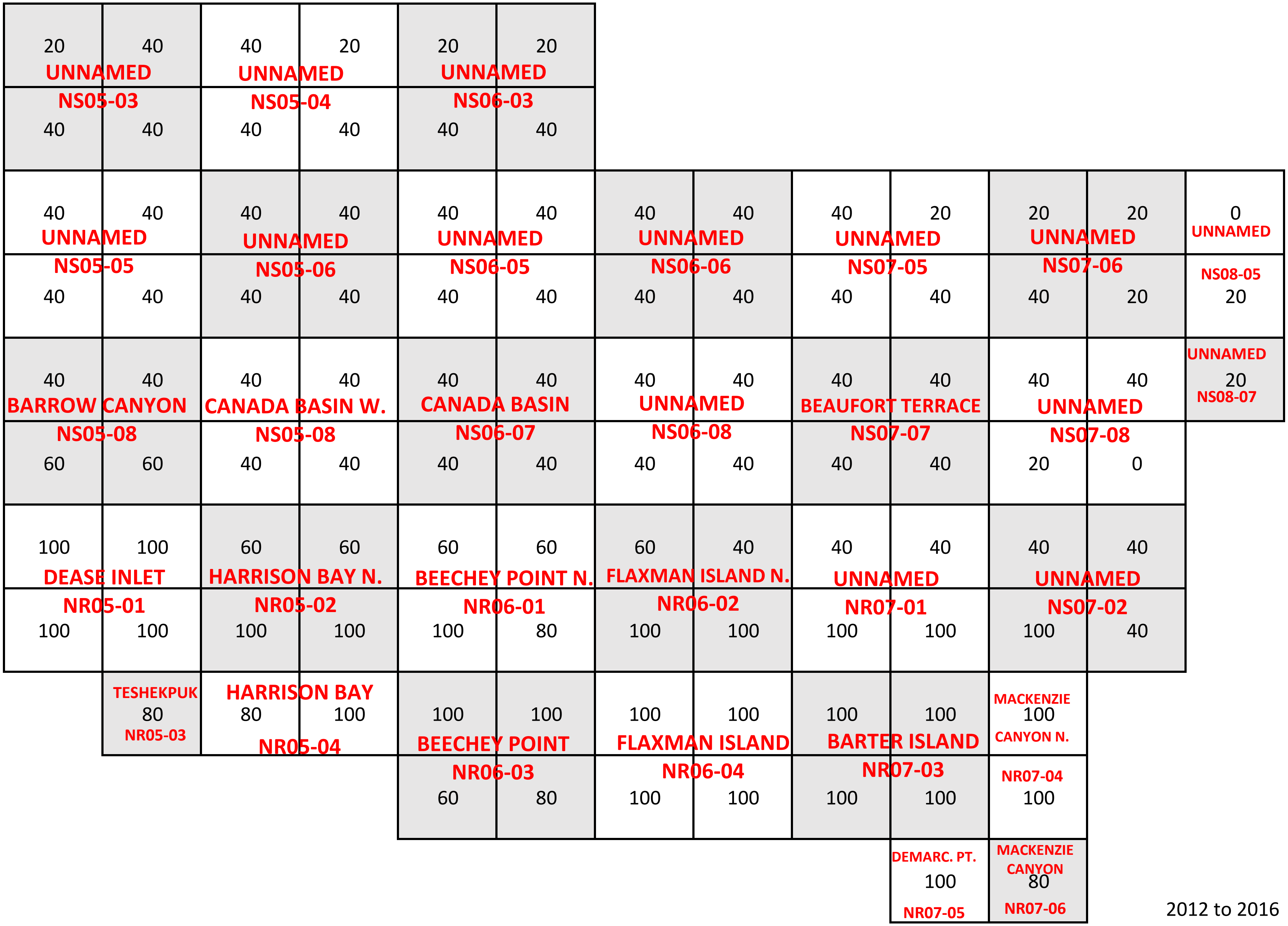
Sea Ice 6.4.13 Scenario 6.4: Percent probability of sea ice concentration from 0 to 7 tenths, Beaufort Sea. 1-Oct 10-Oct



UNNAMED	NS05-03	20	40	40	40
UNNAMED	NS05-04	60	60	40	40
UNNAMED	NS06-03	40	40	40	40
UNNAMED	NS05-05	40	40	40	60
UNNAMED	NS05-06	40	40	40	40
UNNAMED	NS06-05	40	40	40	40
UNNAMED	NS06-06	40	40	40	40
UNNAMED	NS07-05	40	40	40	40
UNNAMED	NS07-06	40	40	40	40
UNNAMED	NS08-05	20		40	
BARROW CANYON	NS05-08	80	80	100	100
CANADA BASIN W.	NS05-08	80	40	80	80
CANADA BASIN	NS06-07	40	40	100	60
UNNAMED	NS06-08	40	40	60	60
BEAUFORT TERRACE	NS07-07	40	40	40	60
UNNAMED	NS07-08	40	40	40	0
UNNAMED	NS08-07	40			
DEASE INLET	NR05-01	100	100	100	100
HARRISON BAY N.	NR05-02	100	100	100	100
BEECHEY POINT N.	NR06-01	100	100	100	100
FLAXMAN ISLAND N.	NR06-02	80	80	100	100
UNNAMED	NR07-01	80	60	80	100
UNNAMED	NS07-02	60	60	100	80
TESHEKPUK	NR05-03	80			
HARRISON BAY	NR05-04	100	100		
BEECHEY POINT	NR06-03	100	100	100	100
FLAXMAN ISLAND	NR06-04	100	100	100	100
BARTER ISLAND	NR07-03	100	100	100	100
MACKENZIE CANYON N.	NR07-04	100		100	
DEMARC. PT.	NR07-05	100			
MACKENZIE CANYON	NR07-06	100			

2012 to 2016

Sea Ice 6.4.14 Scenario 6.4: Percent probability of sea ice concentration from 0 to 7 tenths, Beaufort Sea. 11-Oct 20-Oct



20 40 UNNAMED NS05-03 40 40	40 20 UNNAMED NS05-04 40 40	20 20 UNNAMED NS06-03 40 40				
40 40 UNNAMED NS05-05 40 40	40 40 UNNAMED NS05-06 40 40	40 40 UNNAMED NS06-05 40 40	40 40 UNNAMED NS06-06 40 40	40 20 UNNAMED NS07-05 40 40	20 20 UNNAMED NS07-06 40 20	0 UNNAMED NS08-05 20
40 40 BARROW CANYON NS05-08 60 60	40 40 CANADA BASIN W. NS05-08 40 40	40 40 CANADA BASIN NS06-07 40 40	40 40 UNNAMED NS06-08 40 40	40 40 BEAUFORT TERRACE NS07-07 40 40	40 40 UNNAMED NS07-08 20 0	UNNAMED 20 NS08-07
100 100 DEASE INLET NR05-01 100 100	60 60 HARRISON BAY N. NR05-02 100 100	60 60 BEECHEY POINT N. NR06-01 100 80	60 40 FLAXMAN ISLAND N. NR06-02 100 100	40 40 UNNAMED NR07-01 100 100	40 40 UNNAMED NS07-02 100 40	
TESHEKPUK 80 NR05-03	HARRISON BAY 80 100 NR05-04	100 100 BEECHEY POINT NR06-03 60 80	100 100 FLAXMAN ISLAND NR06-04 100 100	100 100 BARTER ISLAND NR07-03 100 100	MACKENZIE 100 CANYON N. NR07-04 100	
				DEMARC. PT. 100 NR07-05	MACKENZIE CANYON 80 NR07-06	

2012 to 2016

Sea Ice 6.4.15 Scenario 6.4: Percent probability of sea ice concentration from 0 to 7 tenths, Beaufort Sea. 21-Oct 31-Oct

UNNAMED	NS05-03	0	0	0	0
UNNAMED	NS05-04	0	0	0	0
UNNAMED	NS06-03	0	0	0	0
UNNAMED	NS05-05	0	20	20	20
UNNAMED	NS05-06	0	0	20	20
UNNAMED	NS06-05	0	0	0	0
UNNAMED	NS06-06	0	0	0	0
UNNAMED	NS07-05	0	0	0	0
UNNAMED	NS07-06	0	0	0	0
UNNAMED	NS08-05	0		0	
BARROW CANYON	NS05-08	20	0	20	20
CANADA BASIN W.	NS05-08	0	0	0	0
CANADA BASIN	NS06-07	0	0	0	0
UNNAMED	NS06-08	0	0	0	20
BEAUFORT TERRACE	NS07-07	0	0	20	0
UNNAMED	NS07-08	0	0	0	0
UNNAMED	NS08-07	0			
DEASE INLET	NR05-01	20	40	40	40
HARRISON BAY N.	NR05-02	20	20	20	40
BEECHEY POINT N.	NR06-01	40	40	40	40
FLAXMAN ISLAND N.	NR06-02	20	20	40	40
UNNAMED	NR07-01	20	0	20	0
UNNAMED	NS07-02	0	0	0	0
TESHEKPUK	NR05-03	20			
HARRISON BAY	NR05-04	20	20		
BEECHEY POINT	NR06-03	20	40	0	20
FLAXMAN ISLAND	NR06-04	40	40	40	40
BARTER ISLAND	NR07-03	40	20	40	20
MACKENZIE CANYON N.	NR07-04	20		20	
DEMARC. PT.	NR07-05	60			
MACKENZIE CANYON	NR07-06	40			

2012 to 2016

Sea Ice 6.4.16 Scenario 6.4: Percent probability of sea ice concentration from 0 to 7 tenths, Beaufort Sea. 1-Nov 10-Nov

0 0 UNNAMED NS05-03 0 0	0 0 UNNAMED NS05-04 0 0	0 0 UNNAMED NS06-03 0 0				
0 0 UNNAMED NS05-05 0 0	0 0 UNNAMED NS05-06 0 0	0 0 UNNAMED NS06-05 0 0	0 0 UNNAMED NS06-06 0 0	0 0 UNNAMED NS07-05 0 0	0 0 UNNAMED NS07-06 0 0	0 UNNAMED NS08-05 0
0 0 BARROW CANYON NS05-08 20 0	0 0 CANADA BASIN W. NS05-08 0 0	0 0 CANADA BASIN NS06-07 0 0	0 0 UNNAMED NS06-08 0 0	0 0 BEAUFORT TERRACE NS07-07 0 0	0 0 UNNAMED NS07-08 0 0	UNNAMED 0 NS08-07
40 40 DEASE INLET NR05-01 20 40	0 0 HARRISON BAY N. NR05-02 20 0	0 0 BEECHEY POINT N. NR06-01 0 0	0 0 FLAXMAN ISLAND N. NR06-02 0 0	0 0 UNNAMED NR07-01 0 0	0 0 UNNAMED NS07-02 0 0	
TESHEKPUK 20 NR05-03	HARRISON BAY 0 20 NR05-04	0 0 BEECHEY POINT NR06-03 0 0	0 0 FLAXMAN ISLAND NR06-04 0 0	0 0 BARTER ISLAND NR07-03 20 20	MACKENZIE 0 CANYON N. NR07-04 20	
				DEMARC. PT. 20 NR07-05	MACKENZIE CANYON 20 NR07-06	

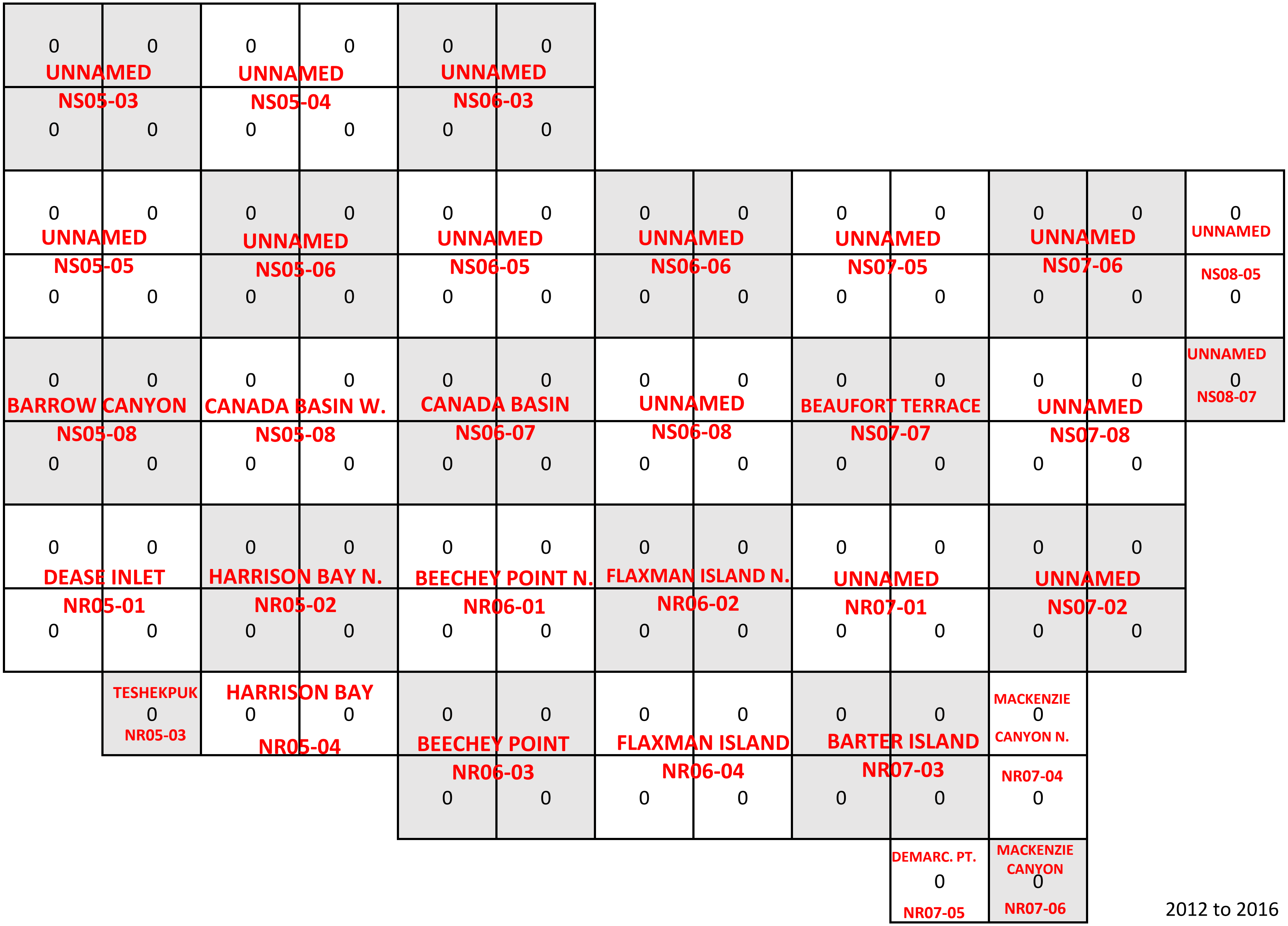
2012 to 2016

Sea Ice 6.4.17 Scenario 6.4: Percent probability of sea ice concentration from 0 to 7 tenths, Beaufort Sea. 11-Nov 20-Nov

0 0 UNNAMED NS05-03 0 0	0 0 UNNAMED NS05-04 0 0	0 0 UNNAMED NS06-03 0 0				
0 0 UNNAMED NS05-05 0 0	0 0 UNNAMED NS05-06 0 0	0 0 UNNAMED NS06-05 0 0	0 0 UNNAMED NS06-06 0 0	0 0 UNNAMED NS07-05 0 0	0 0 UNNAMED NS07-06 0 0	0 UNNAMED NS08-05 0
0 0 BARROW CANYON NS05-08 0 0	0 0 CANADA BASIN W. NS05-08 0 0	0 0 CANADA BASIN NS06-07 0 0	0 0 UNNAMED NS06-08 0 0	0 0 BEAUFORT TERRACE NS07-07 0 0	0 0 UNNAMED NS07-08 0 0	UNNAMED 0 NS08-07
0 0 DEASE INLET NR05-01 0 0	0 0 HARRISON BAY N. NR05-02 0 0	0 0 BEECHEY POINT N. NR06-01 0 0	0 0 FLAXMAN ISLAND N. NR06-02 0 0	0 0 UNNAMED NR07-01 0 0	0 0 UNNAMED NS07-02 0 0	
TESHEKPUK 0 NR05-03	HARRISON BAY 0 0 NR05-04	20 20 BEECHEY POINT NR06-03 0 0	20 0 FLAXMAN ISLAND NR06-04 20 20	0 0 BARTER ISLAND NR07-03 20 0	MACKENZIE 0 CANYON N. NR07-04 0	
				DEMARC. PT. 20 NR07-05	MACKENZIE CANYON 20 NR07-06	

2012 to 2016

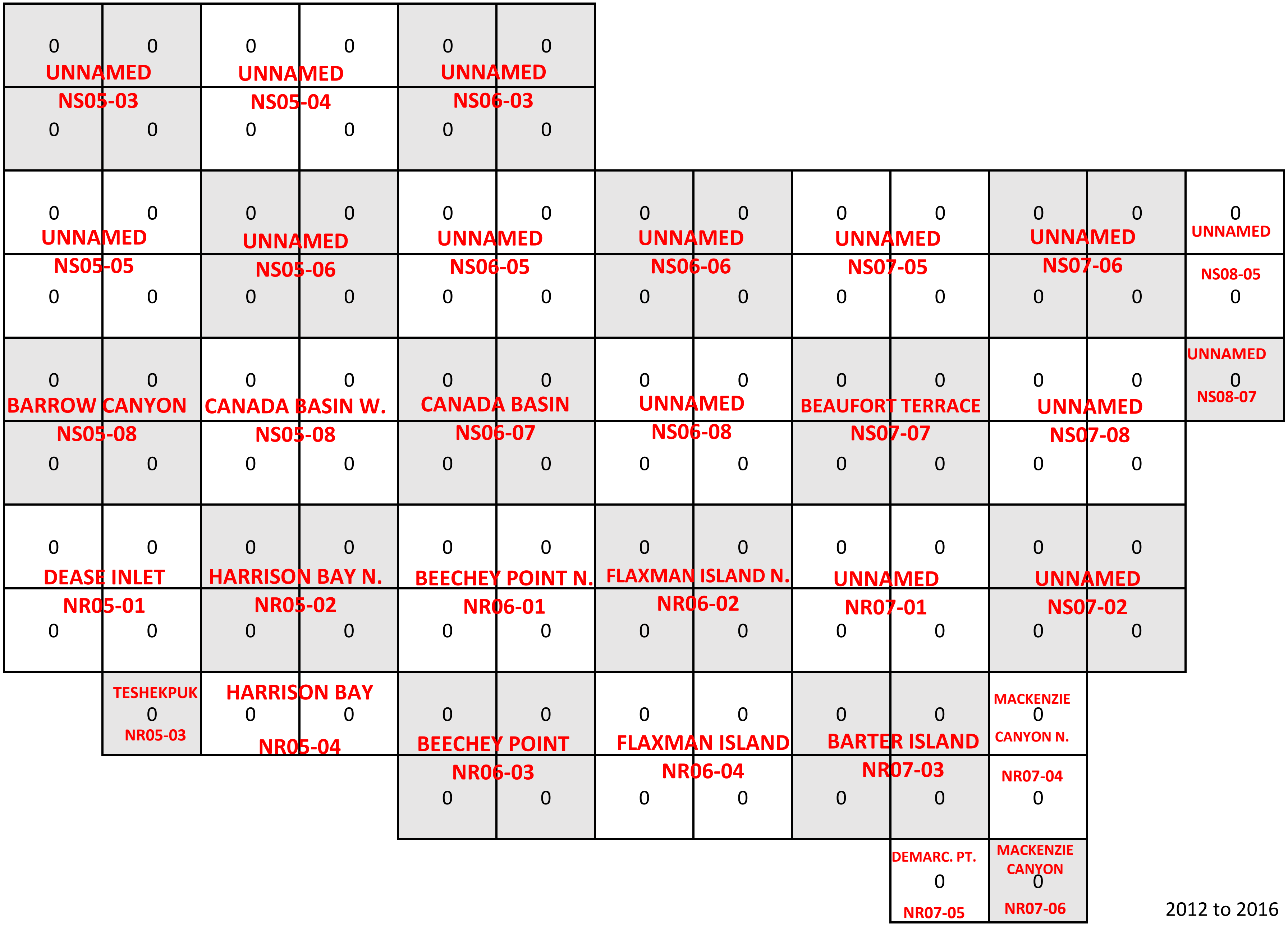
Sea Ice 6.4.18 Scenario 6.4: Percent probability of sea ice concentration from 0 to 7 tenths, Beaufort Sea. 21-Nov 30-Nov



0 0 UNNAMED NS05-03 0 0	0 0 UNNAMED NS05-04 0 0	0 0 UNNAMED NS06-03 0 0				
0 0 UNNAMED NS05-05 0 0	0 0 UNNAMED NS05-06 0 0	0 0 UNNAMED NS06-05 0 0	0 0 UNNAMED NS06-06 0 0	0 0 UNNAMED NS07-05 0 0	0 0 UNNAMED NS07-06 0 0	0 UNNAMED NS08-05 0
0 0 BARROW CANYON NS05-08 0 0	0 0 CANADA BASIN W. NS05-08 0 0	0 0 CANADA BASIN NS06-07 0 0	0 0 UNNAMED NS06-08 0 0	0 0 BEAUFORT TERRACE NS07-07 0 0	0 0 UNNAMED NS07-08 0 0	UNNAMED 0 NS08-07
0 0 DEASE INLET NR05-01 0 0	0 0 HARRISON BAY N. NR05-02 0 0	0 0 BEECHEY POINT N. NR06-01 0 0	0 0 FLAXMAN ISLAND N. NR06-02 0 0	0 0 UNNAMED NR07-01 0 0	0 0 UNNAMED NS07-02 0 0	
TESHEKPUK 0 NR05-03	HARRISON BAY 0 0 NR05-04	0 0 BEECHEY POINT NR06-03 0 0	0 0 FLAXMAN ISLAND NR06-04 0 0	0 0 BARTER ISLAND NR07-03 0 0	MACKENZIE 0 CANYON N. NR07-04 0	
				DEMARC. PT. 0 NR07-05	MACKENZIE CANYON 0 NR07-06	

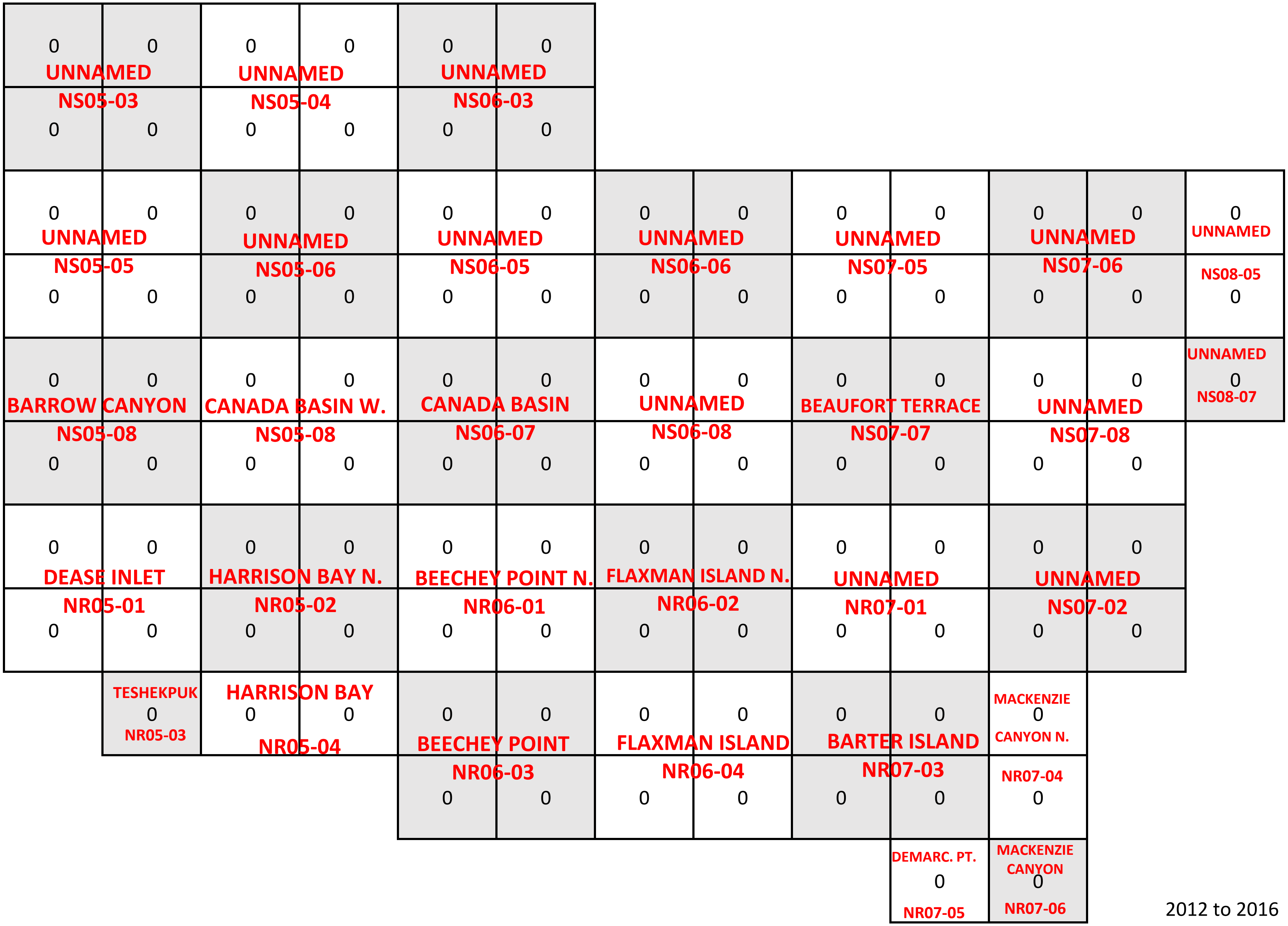
2012 to 2016

Sea Ice 6.4.19 Scenario 6.4: Percent probability of sea ice concentration from 0 to 7 tenths, Beaufort Sea. 1-Dec 10-Dec



2012 to 2016

Sea Ice 6.4.20 Scenario 6.4: Percent probability of sea ice concentration from 0 to 7 tenths, Beaufort Sea. 11-Dec 20-Dec



2012 to 2016

Sea Ice 6.4.21 Scenario 6.4: Percent probability of sea ice concentration from 0 to 7 tenths, Beaufort Sea. 21-Dec 31-Dec

Scenario 7.1:
Safe Open Water Relief Well Deployment in the Chukchi Sea.

Sea ice data for the probability of open water, within a 30 nautical mile ice free radius, for the period from June through December, 2012 to 2016, in the Chukchi Sea.

0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-04 0	NS03-03 0	0	NS03-04 0	0	NS04-03 0	0	NS04-04 0	0
0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-06 0	NS03-05 0	0	NS03-06 0	0	NS04-05 0	0	NS04-06 0	0
0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-08 0	NS03-07 0	0	NS03-038 0	0	NS04-07 0	0	NS04-08 0	0
0 TISON	0 KARO	0	0 POSEY	0	0 HANNA SHOAL	0	0 BARROW	0
NR02-02 0	NR03-01 0	0	NR03-02 0	0	NR04-01 0	0	NR04-02 0	0
0 STUDDS	0 COLBERT	0	0 SOLIVIK ISLAND	0	0 WAINWRIGHT	0	MEADE RIVER 0 NR04-04	
NR02-04 0	NR03-03 0	20	NR03-04 0	0	NR04-03 0			
0 CHUKCHI SEA	0 POINT LAY WEST	0	40 POINT LAY	20				
NR02-06 0	NR03-05 0	0	NR03-06 20	40				
0 PT. HOPE W.	0 POINT HOPE	0	DE LONG MTS. 40 NR03-08					
NR02-08 0	NR03-07 0	0						

2012 to 2016

1-Jun 10-Jun

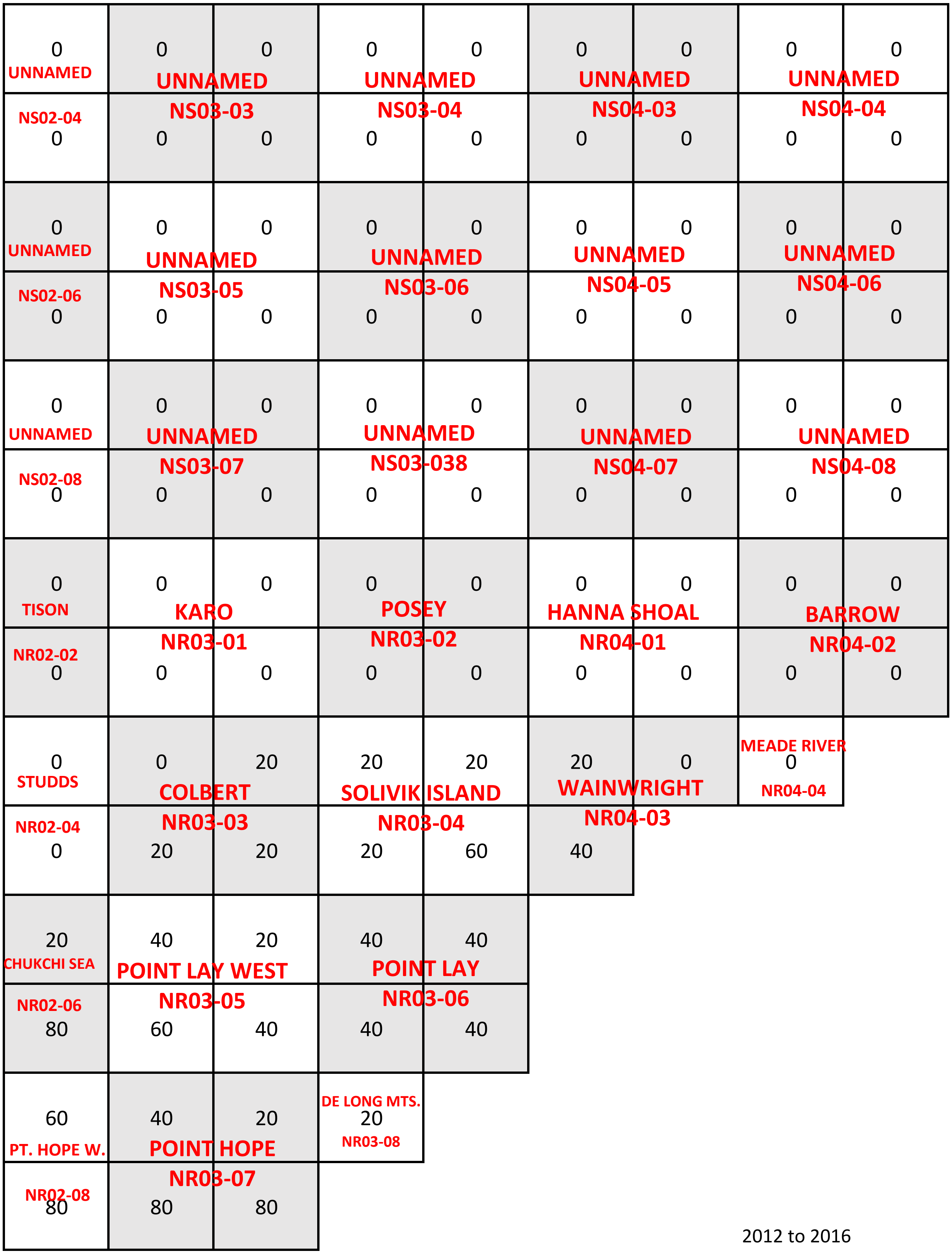
Sea Ice 7.1.1 Scenario 7.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-04 0	NS03-03 0	0	NS03-04 0	0	NS04-03 0	0	NS04-04 0	0
0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-06 0	NS03-05 0	0	NS03-06 0	0	NS04-05 0	0	NS04-06 0	0
0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-08 0	NS03-07 0	0	NS03-038 0	0	NS04-07 0	0	NS04-08 0	0
0 TISON	0 KARO	0	0 POSEY	0	0 HANNA SHOAL	0	0 BARROW	0
NR02-02 0	NR03-01 0	0	NR03-02 0	0	NR04-01 0	0	NR04-02 0	0
0 STUDDS	0 COLBERT	20	0 SOLIVIK ISLAND	0	0 WAINWRIGHT	0	MEADE RIVER 0 NR04-04	
NR02-04 0	NR03-03 0	20	NR03-04 20	0	NR04-03 0			
0 CHUKCHI SEA	0 POINT LAY WEST	20	20 POINT LAY	20				
NR02-06 20	NR03-05 20	20	NR03-06 0	20				
40 PT. HOPE W.	20 POINT HOPE	20	DE LONG MTS. 20 NR03-08					
NR02-08 40	NR03-07 40	40						

2012 to 2016

11-Jun 20-Jun

Sea Ice 7.1.2 Scenario 7.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

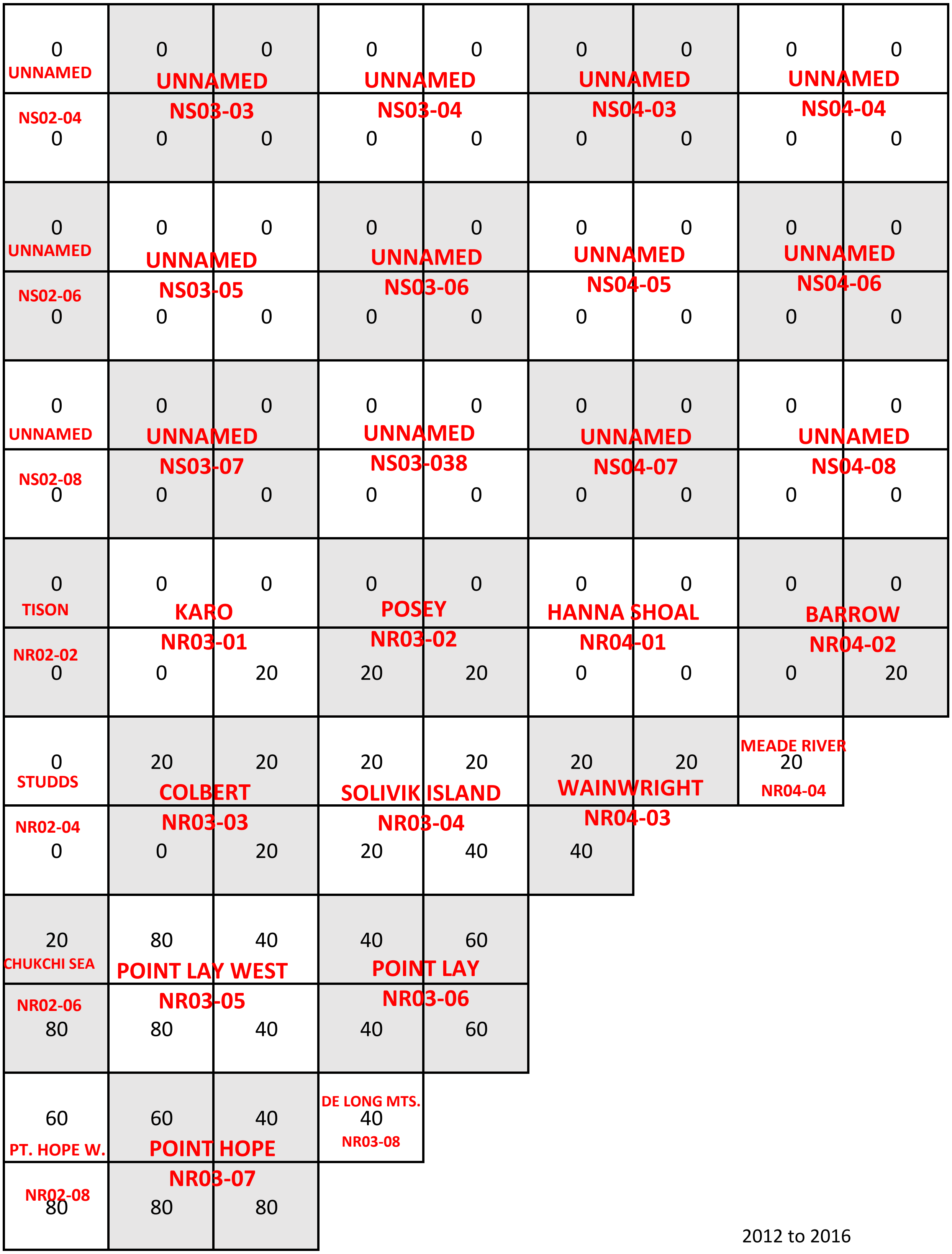


0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
0	0	0	0	0	0	0	0	0
0	0	20	20	20	20	0	MEADE RIVER 0	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		NR04-04	
NR02-04	NR03-03		NR03-04		NR04-03			
0	20	20	20	60	40			
20	40	20	40	40				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
80	60	40	40	40				
60	40	20	DE LONG MTS. 20					
PT. HOPE W.	POINT HOPE		NR03-08					
NR02-08	NR03-07							
80	80	80						

2012 to 2016

21-Jun 30-Jun

Sea Ice 7.1.3 Scenario 7.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.



0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
0	0	20	20	20	0	0	0	20
0	20	20	20	20	20	20	MEADE RIVER 20	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		NR04-04	
NR02-04	NR03-03		NR03-04		NR04-03			
0	0	20	20	40	40			
20	80	40	40	60				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
80	80	40	40	60				
60	60	40	DE LONG MTS. 40 NR03-08					
PT. HOPE W.	POINT HOPE							
NR02-08	NR03-07							
80	80	80						

2012 to 2016

1-Jul 10-Jul

Sea Ice 7.1.4 Scenario 7.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
0	0	0	0	0	0	0	0	0
20	20	20	0	0	0	0	0	0
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
20	40	20	20	0	0	0	20	0
40	60	20	20	20	0	40	MEADE RIVER	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		20	
NR02-04	NR03-03		NR03-04		NR04-03		NR04-04	
40	80	60	80	80	80			
60	100	100	100	100				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	100	100				
100	100	80	DE LONG MTS.					
PT. HOPE W.	POINT HOPE		80					
NR02-08	NR03-07		NR03-08					
100	100	100						

2012 to 2016

11-Jul 20-Jul

Sea Ice 7.1.5 Scenario 7.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
0	0	0	0	0	0	0	0	0
20	20	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
20	20	20	20	0	0	0	0	0
20	20	0	0	0	0	0	0	0
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
40	40	20	20	0	0	20	20	0
40	60	80	60	60	0	20	MEADE RIVER 40 NR04-04	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT			
NR02-04	NR03-03		NR03-04		NR04-03			
40	60	100	100	100	80			
60	80	100	100	100				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	100	100				
100	100	100	DE LONG MTS. 100 NR03-08					
PT. HOPE W.	POINT HOPE							
NR02-08	NR03-07							
100	100	100						

2012 to 2016

21-Jul 31-Jul

Sea Ice 7.1.6 Scenario 7.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

0	0	0	0	0	0	0	0	0
UNNAMED NS02-04	UNNAMED NS03-03		UNNAMED NS03-04		UNNAMED NS04-03		UNNAMED NS04-04	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED NS02-06	UNNAMED NS03-05		UNNAMED NS03-06		UNNAMED NS04-05		UNNAMED NS04-06	
0	0	0	0	0	0	0	0	0
20	20	20	20	0	0	0	0	0
UNNAMED NS02-08	UNNAMED NS03-07		UNNAMED NS03-038		UNNAMED NS04-07		UNNAMED NS04-08	
20	20	20	20	20	20	20	0	0
40	40	40	40	20	0	20	0	0
TISON NR02-02	KARO NR03-01		POSEY NR03-02		HANNA SHOAL NR04-01		BARROW NR04-02	
80	60	60	40	20	20	20	40	40
80	100	100	80	80	60	40	60	
STUDDS NR02-04	COLBERT NR03-03		SOLIVIK ISLAND NR03-04		WAINWRIGHT NR04-03		MEADE RIVER NR04-04	
80	80	100	100	100	100			
80	100	100	100	100				
CHUKCHI SEA NR02-06	POINT LAY WEST NR03-05		POINT LAY NR03-06					
100	100	100	100	100				
100	100	100	100					
PT. HOPE W. NR02-08	POINT HOPE NR03-07		DE LONG MTS. NR03-08					
100	100	100						

2012 to 2016

1-Aug 10-Aug

Sea Ice 7.1.7 Scenario 7.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
20	20	0	0	0	0	0	0	0
20	20	20	20	0	0	0	0	20
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
40	20	20	20	20	20	20	0	20
40	40	40	20	20	20	20	0	40
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
80	100	100	20	20	20	40	80	60
100	100	100	100	100	60	40	MEADE RIVER	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		80	
NR02-04	NR03-03		NR03-04		NR04-03		NR04-04	
100	100	100	100	100	100			
100	100	100	100	100				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	100	100				
100	100	100	DE LONG MTS.					
PT. HOPE W.	POINT HOPE		100					
NR02-08	NR03-07		NR03-08					
100	100	100						

2012 to 2016

11-Aug 20-Aug

Sea Ice 7.1.8 Scenario 7.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

0	0	0	40	20	20	20	20	20
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
0	0	20	20	40	40	20	20	20
0	20	20	20	60	40	40	20	20
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
20	20	20	20	20	100	60	80	40
40	40	20	20	20	20	40	100	80
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
60	60	60	60	20	20	20	80	100
80	80	60	40	40	20	40	60	100
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
100	80	80	60	40	60	40	80	100
100	100	100	80	80	80	100	MEADE RIVER 100	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		NR04-04	
NR02-04	NR03-03		NR03-04		NR04-03			
100	100	100	100	100	100			
100	100	100	100	100				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	100	100				
100	100	100	DE LONG MTS. 100					
PT. HOPE W.	POINT HOPE		NR03-08					
NR02-08	NR03-07							
100	100	100						

2012 to 2016

21-Aug 31-Aug

Sea Ice 7.1.9 Scenario 7.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

20	20	20	20	20	20	20	20	20
UNNAMED NS02-04	UNNAMED NS03-03		UNNAMED NS03-04		UNNAMED NS04-03		UNNAMED NS04-04	
40	40	40	40	40	40	20	20	20
40	20	40	60	80	40	40	20	20
UNNAMED NS02-06	UNNAMED NS03-05		UNNAMED NS03-06		UNNAMED NS04-05		UNNAMED NS04-06	
20	20	40	60	80	100	60	40	40
40	20	40	40	40	80	60	80	60
UNNAMED NS02-08	UNNAMED NS03-07		UNNAMED NS03-038		UNNAMED NS04-07		UNNAMED NS04-08	
80	60	60	60	60	80	80	100	80
100	80	80	60	40	80	80	80	100
TISON NR02-02	KARO NR03-01		POSEY NR03-02		HANNA SHOAL NR04-01		BARROW NR04-02	
100	80	80	40	40	80	80	80	100
100	100	100	100	100	80	80	100	
STUDDS NR02-04	COLBERT NR03-03		SOLIVIK ISLAND NR03-04		WAINWRIGHT NR04-03		MEADE RIVER NR04-04	
100	100	100	100	100	100			
100	100	100	100	100				
CHUKCHI SEA NR02-06	POINT LAY WEST NR03-05		POINT LAY NR03-06					
100	100	100	100	100				
100	100	100	100					
PT. HOPE W. NR02-08	POINT HOPE NR03-07		DE LONG MTS. NR03-08					
100	100	100						

2012 to 2016

1-Sep 10-Sep

Sea Ice 7.1.10 Scenario 7.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

UNNAMED	NS02-04	40		60	
UNNAMED	NS03-03	40	40	60	60
UNNAMED	NS03-04	40	60	40	40
UNNAMED	NS04-03	60	60	60	80
UNNAMED	NS04-04	60	40	80	60
UNNAMED	NS02-06	80		60	
UNNAMED	NS03-05	60	60	60	80
UNNAMED	NS03-06	60	60	60	60
UNNAMED	NS04-05	80	80	80	100
UNNAMED	NS04-06	80	80	80	80
UNNAMED	NS02-08	40		80	
UNNAMED	NS03-07	40	60	100	80
UNNAMED	NS03-038	60	60	80	60
UNNAMED	NS04-07	80	100	60	60
UNNAMED	NS04-08	100	100	80	100
TISON	NR02-02	100		100	
KARO	NR03-01	100	80	100	100
POSEY	NR03-02	80	60	80	60
HANNA SHOAL	NR04-01	60	60	80	80
BARROW	NR04-02	80	100	80	100
STUDDS	NR02-04	100		100	
COLBERT	NR03-03	100	100	100	100
SOLIVIK ISLAND	NR03-04	100	80	100	100
WAINWRIGHT	NR04-03	80	100	100	
MEADE RIVER	NR04-04	100			
CHUKCHI SEA	NR02-06	100		100	
POINT LAY WEST	NR03-05	100	100	100	100
POINT LAY	NR03-06	100	80	100	100
PT. HOPE W.	NR02-08	100		100	
POINT HOPE	NR03-07	100	100	100	100
DE LONG MTS.	NR03-08	100			

2012 to 2016

11-Sep 20-Sep

Sea Ice 7.1.11 Scenario 7.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

UNNAMED	NS02-04	40		60	
UNNAMED	NS03-03	40	40	60	60
UNNAMED	NS03-04	40	60	40	40
UNNAMED	NS04-03	60	40	60	60
UNNAMED	NS04-04	40	20	40	40
UNNAMED	NS02-06	100		80	
UNNAMED	NS03-05	80	80	80	100
UNNAMED	NS03-06	80	60	80	80
UNNAMED	NS04-05	60	60	60	80
UNNAMED	NS04-06	60	60	60	60
UNNAMED	NS02-08	80		100	
UNNAMED	NS03-07	80	80	100	100
UNNAMED	NS03-038	80	80	100	80
UNNAMED	NS04-07	80	80	80	80
UNNAMED	NS04-08	80	80	80	80
TISON	NR02-02	100		100	
KARO	NR03-01	100	100	100	100
POSEY	NR03-02	100	100	100	100
HANNA SHOAL	NR04-01	80	80	100	100
BARROW	NR04-02	80	100	100	100
STUDDS	NR02-04	100		100	
COLBERT	NR03-03	100	100	100	100
SOLIVIK ISLAND	NR03-04	100	100	100	100
WAINWRIGHT	NR04-03	100	100	100	
MEADE RIVER	NR04-04	100			
CHUKCHI SEA	NR02-06	100		100	
POINT LAY WEST	NR03-05	100	100	100	100
POINT LAY	NR03-06	100	80	100	100
PT. HOPE W.	NR02-08	100		100	
POINT HOPE	NR03-07	100	100	100	100
DE LONG MTS.	NR03-08	100			

2012 to 2016

21-Sep 30-Sep

Sea Ice 7.1.12 Scenario 7.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

80	60	80	80	40	40	40	40	40
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
80	80	80	80	60	60	60	40	40
80	80	100	100	100	100	100	40	40
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
60	60	80	100	80	100	100	60	40
80	100	100	100	100	80	100	100	100
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
100	100	100	100	100	80	80	100	100
100	100	100	100	100	100	100	100	100
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
100	100	100	100	100	100	100	100	100
100	100	100	100	100	100	100	MEADE RIVER 100 NR04-04	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT			
NR02-04	NR03-03		NR03-04		NR04-03			
100	100	100	100	100	100			
100	100	100	100	80				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	100	100				
100	100	100	DE LONG MTS. 100 NR03-08					
PT. HOPE W.	POINT HOPE							
NR02-08	NR03-07							
100	100	100						

2012 to 2016

1-Oct 10-Oct

Sea Ice 7.1.13 Scenario 7.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

40 UNNAMED	20 UNNAMED	20	20 UNNAMED	20	20 UNNAMED	20	20 UNNAMED	20
NS02-04 40	NS03-03 20	20	NS03-04 20	20	NS04-03 40	20	NS04-04 20	20
40 UNNAMED	40 UNNAMED	60	60 UNNAMED	40	40 UNNAMED	40	40 UNNAMED	40
NS02-06 60	NS03-05 60	80	NS03-06 80	100	NS04-05 60	60	NS04-06 40	40
60 UNNAMED	80 UNNAMED	80	80 UNNAMED	80	80 UNNAMED	80	60 UNNAMED	40
NS02-08 100	NS03-07 100	100	NS03-038 100	100	NS04-07 100	100	NS04-08 100	80
100 TISON	100 KARO	100	100 POSEY	100	100 HANNA SHOAL	100	100 BARROW	100
NR02-02 100	NR03-01 100	100	NR03-02 100	100	NR04-01 100	100	NR04-02 100	80
100 STUDDS	100 COLBERT	100	100 SOLIVIK ISLAND	100	100 WAINWRIGHT	80	MEADE RIVER 100 NR04-04	
NR02-04 100	NR03-03 100	100	NR03-04 100	100	NR04-03 100			
100 CHUKCHI SEA	100 POINT LAY WEST	100	100 POINT LAY	20				
NR02-06 100	NR03-05 100	100	NR03-06 100	80				
100 PT. HOPE W.	100 POINT HOPE	100	DE LONG MTS. 100 NR03-08					
NR02-08 100	NR03-07 100	100						

2012 to 2016

11-Oct 20-Oct

Sea Ice 7.1.14 Scenario 7.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

20	20	20	0	0	20	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
20	20	20	0	20	40	20	20	20
20	40	20	40	40	40	40	40	40
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
0	0	0	0	40	40	40	40	40
40	40	20	40	40	40	40	40	40
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
100	80	100	100	80	80	80	60	40
100	100	100	100	100	100	80	80	60
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
100	100	100	100	100	80	80	80	60
100	100	100	100	100	100	20	MEADE RIVER	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		80	
NR02-04	NR03-03		NR03-04		NR04-03		NR04-04	
100	100	100	100	80	80			
100	100	100	100	0				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	40	40				
100	100	100	DE LONG MTS.					
PT. HOPE W.	POINT HOPE		60					
NR02-08	NR03-07		NR03-08					
100	100	100						

2012 to 2016

21-Oct 31-Oct

Sea Ice 7.1.15 Scenario 7.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

0 UNNAMED NS02-04 0	0 0 UNNAMED NS03-03 0 0	0 0 UNNAMED NS03-04 0 0	0 0 UNNAMED NS04-03 0 0	0 0 UNNAMED NS04-04 0 0
0 UNNAMED NS02-06 0	0 0 UNNAMED NS03-05 0 0	0 0 UNNAMED NS03-06 0 0	0 0 UNNAMED NS04-05 0 0	0 0 UNNAMED NS04-06 0 0
20 UNNAMED NS02-08 60	20 20 UNNAMED NS03-07 40 40	0 0 UNNAMED NS03-038 0 0	0 0 UNNAMED NS04-07 20 0	0 0 UNNAMED NS04-08 0 0
60 TISON NR02-02 80	60 60 KARO NR03-01 80 60	40 40 POSEY NR03-02 40 40	20 0 HANNA SHOAL NR04-01 20 20	0 0 BARROW NR04-02 0 0
100 STUDDS NR02-04 100	80 60 COLBERT NR03-03 100 80	80 60 SOLIVIK ISLAND NR03-04 80 60	40 0 WAINWRIGHT NR04-03 40	MEADE RIVER 0 NR04-04
100 CHUKCHI SEA NR02-06 100	100 100 POINT LAY WEST NR03-05 100 60	80 0 POINT LAY NR03-06 0 0		
100 PT. HOPE W. NR02-08 100	80 20 POINT HOPE NR03-07 80 80	DE LONG MTS. 0 NR03-08		

2012 to 2016

1-Nov 10-Nov

Sea Ice 7.1.16 Scenario 7.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
0	40	20	20	0	0	0	0	0
40	40	40	20	0	0	0	0	0
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
40	40	40	40	0	0	0	0	0
60	60	60	40	40	40	0	0	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		MEADE RIVER	
NR02-04	NR03-03		NR03-04		NR04-03		NR04-04	
80	80	40	40	20	0			
80	80	60	40	0				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
80	40	40	0	0				
80	40	20	0					
PT. HOPE W.	POINT HOPE		DE LONG MTS.					
NR02-08	NR03-07		NR03-08					
60	40	60						

2012 to 2016

11-Nov 20-Nov

Sea Ice 7.1.17 Scenario 7.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

0 UNNAMED NS02-04 0	0 0 UNNAMED NS03-03 0 0	0 0 UNNAMED NS03-04 0 0	0 0 UNNAMED NS04-03 0 0	0 0 UNNAMED NS04-04 0 0
0 UNNAMED NS02-06 0	0 0 UNNAMED NS03-05 0 0	0 0 UNNAMED NS03-06 0 0	0 0 UNNAMED NS04-05 0 0	0 0 UNNAMED NS04-06 0 0
0 UNNAMED NS02-08 20	0 0 UNNAMED NS03-07 20 20	0 0 UNNAMED NS03-038 0 0	0 0 UNNAMED NS04-07 0 0	0 0 UNNAMED NS04-08 0 0
60 TISON NR02-02 60	20 20 KARO NR03-01 60 20	0 0 POSEY NR03-02 0 0	0 0 HANNA SHOAL NR04-01 0 0	0 0 BARROW NR04-02 0 0
60 STUDDS NR02-04 60	60 40 COLBERT NR03-03 60 40	40 20 SOLIVIK ISLAND NR03-04 20 0	0 0 WAINWRIGHT NR04-03 20	MEADE RIVER 0 NR04-04
60 CHUKCHI SEA NR02-06 60	60 20 POINT LAY WEST NR03-05 40 0	0 0 POINT LAY NR03-06 0 0		
40 PT. HOPE W. NR02-08 40	0 0 POINT HOPE NR03-07 40 40	DE LONG MTS. 0 NR03-08		

2012 to 2016

21-Nov 30-Nov

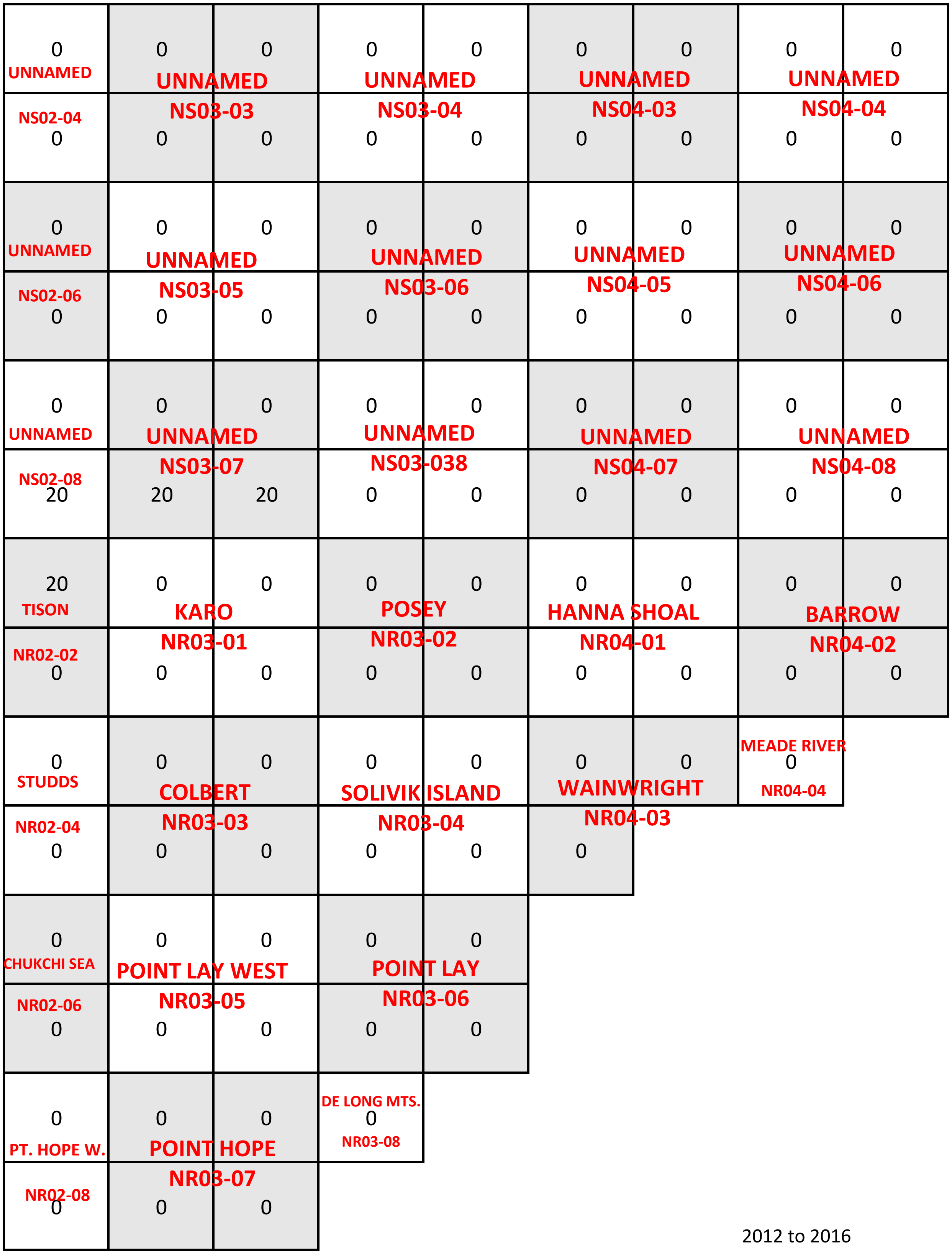
Sea Ice 7.1.18 Scenario 7.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

0 UNNAMED NS02-04 0	0 0 UNNAMED NS03-03 0 0	0 0 UNNAMED NS03-04 0 0	0 0 UNNAMED NS04-03 0 0	0 0 UNNAMED NS04-04 0 0
0 UNNAMED NS02-06 0	0 0 UNNAMED NS03-05 0 0	0 0 UNNAMED NS03-06 0 0	0 0 UNNAMED NS04-05 0 0	0 0 UNNAMED NS04-06 0 0
0 UNNAMED NS02-08 20	0 0 UNNAMED NS03-07 20 0	0 0 UNNAMED NS03-038 0 0	0 0 UNNAMED NS04-07 0 0	0 0 UNNAMED NS04-08 0 0
20 TISON NR02-02 20	20 0 KARO NR03-01 20 0	0 0 POSEY NR03-02 0 0	0 0 HANNA SHOAL NR04-01 0 0	0 0 BARROW NR04-02 0 0
20 STUDDS NR02-04 0	20 20 COLBERT NR03-03 0 0	20 0 SOLIVIK ISLAND NR03-04 0 0	0 0 WAINWRIGHT NR04-03 0	MEADE RIVER 0 NR04-04
20 CHUKCHI SEA NR02-06 40	20 0 POINT LAY WEST NR03-05 0 0	0 0 POINT LAY NR03-06 0 0		
40 PT. HOPE W. NR02-08 40	0 0 POINT HOPE NR03-07 0 0	DE LONG MTS. 0 NR03-08		

2012 to 2016

1-Dec 10-Dec

Sea Ice 7.1.19 Scenario 7.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.



2012 to 2016

11-Dec 20-Dec

Sea Ice 7.1.20 Scenario 7.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-04 0	NS03-03 0	0	NS03-04 0	0	NS04-03 0	0	NS04-04 0	0
0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-06 0	NS03-05 0	0	NS03-06 0	0	NS04-05 0	0	NS04-06 0	0
0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-08 20	NS03-07 0	0	NS03-038 0	0	NS04-07 0	0	NS04-08 0	0
20 TISON	0 KARO	0	0 POSEY	0	0 HANNA SHOAL	0	0 BARROW	0
NR02-02 20	NR03-01 0	0	NR03-02 0	0	NR04-01 0	0	NR04-02 0	0
0 STUDDS	0 COLBERT	0	0 SOLIVIK ISLAND	0	0 WAINWRIGHT	0	MEADE RIVER 0 NR04-04	
NR02-04 0	NR03-03 0	0	NR03-04 0	0	NR04-03 0			
0 CHUKCHI SEA	0 POINT LAY WEST	0	0 POINT LAY	0				
NR02-06 0	NR03-05 0	0	NR03-06 0	0				
0 PT. HOPE W.	0 POINT HOPE	0	DE LONG MTS. 0 NR03-08					
NR02-08 0	NR03-07 0	0						

2012 to 2016

21-Dec 31-Dec

Sea Ice 7.1.21 Scenario 7.1: Percent probability of open water, 30 NM ice free radius, Chukchi Sea.

Scenario 7.2:

Safe Relief Well Deployment with Sea Ice Operating Capability in the Chukchi Sea.

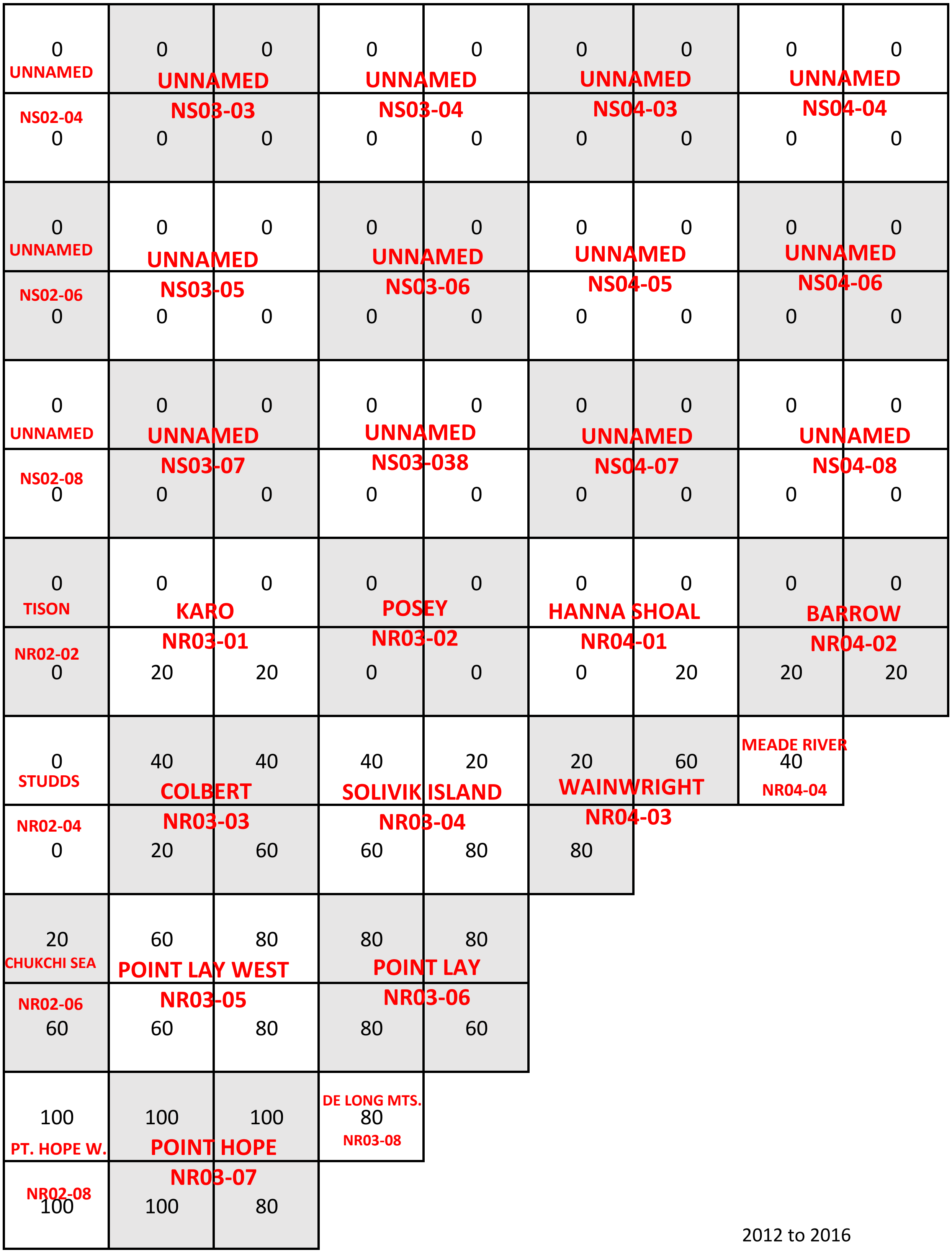
Sea ice data for the probability of sea ice concentration from 0 to 8 tenths, for the period from June through December, 2012 to 2016, in the Chukchi Sea.

0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	20	0
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
0	0	0	0	0	0	20	40	40
20	40	40	20	0	0	40	MEADE RIVER 80 NR04-04	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT			
NR02-04	NR03-03		NR03-04		NR04-03			
20	40	40	60	80	80			
0	40	60	80	60				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
40	40	80	80	40				
60	80	100	DE LONG MTS. 60 NR03-08					
PT. HOPE W.	POINT HOPE							
NR02-08	NR03-07							
80	100	80						

2012 to 2016

1-Jun 10-Jun

Sea Ice 7.2.1 Scenario 7.2: Percent probability of sea ice concentration from 0 to 8 tenths, Chukchi Sea.

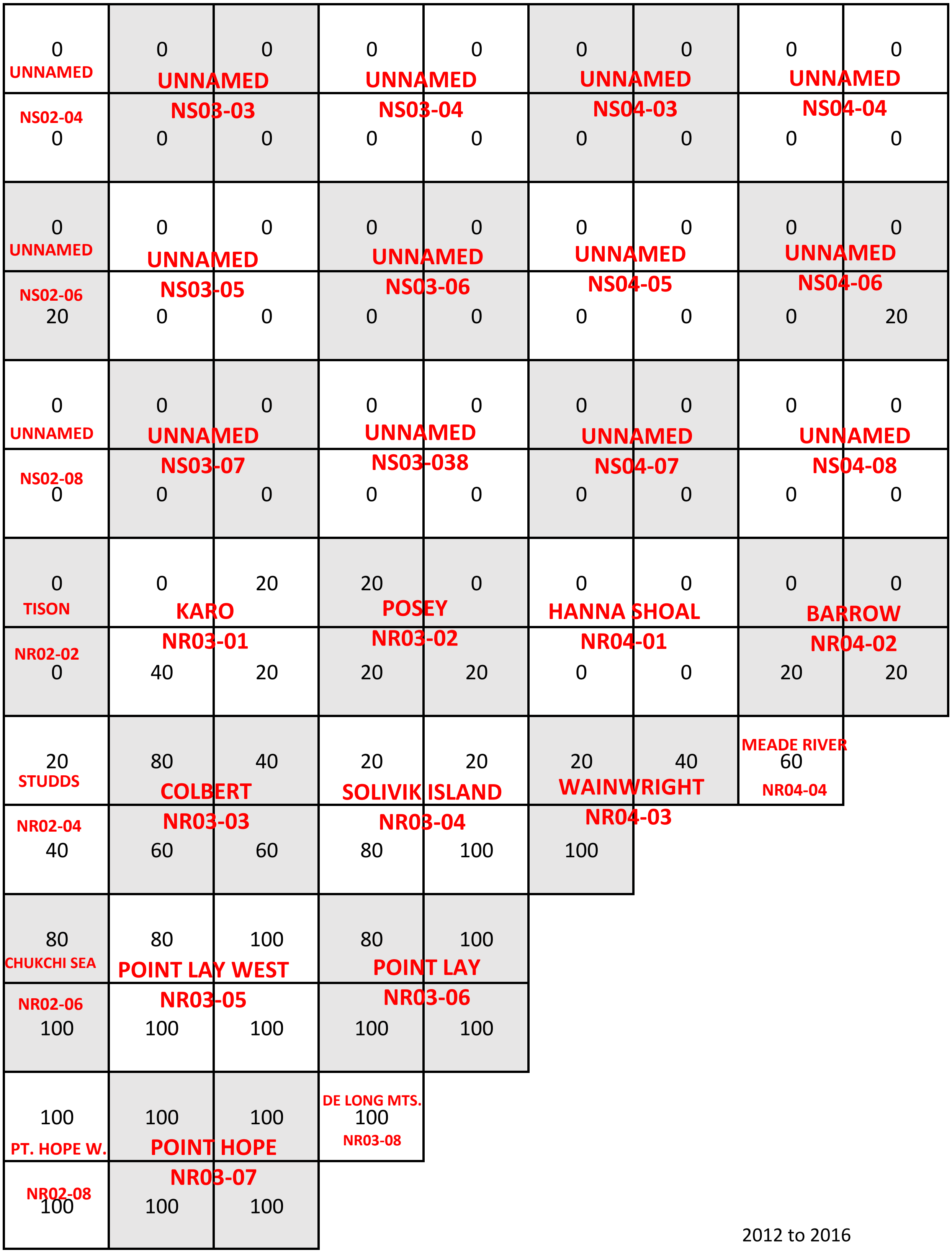


0	0	0	0	0	0	0	0	0
UNNAMED NS02-04	UNNAMED NS03-03		UNNAMED NS03-04		UNNAMED NS04-03		UNNAMED NS04-04	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED NS02-06	UNNAMED NS03-05		UNNAMED NS03-06		UNNAMED NS04-05		UNNAMED NS04-06	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED NS02-08	UNNAMED NS03-07		UNNAMED NS03-038		UNNAMED NS04-07		UNNAMED NS04-08	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
TISON NR02-02	KARO NR03-01		POSEY NR03-02		HANNA SHOAL NR04-01		BARROW NR04-02	
0	20	20	0	0	0	20	20	20
0	40	40	40	20	20	60	MEADE RIVER 40 NR04-04	
STUDDS NR02-04	COLBERT NR03-03		SOLIVIK ISLAND NR03-04		WAINWRIGHT NR04-03			
0	20	60	60	80	80			
20	60	80	80	80				
CHUKCHI SEA NR02-06	POINT LAY WEST NR03-05		POINT LAY NR03-06					
60	60	80	80	60				
100	100	100	DE LONG MTS. 80 NR03-08					
PT. HOPE W. NR02-08	POINT HOPE NR03-07							
100	100	80						

2012 to 2016

11-Jun 20-Jun

Sea Ice 7.2.2 Scenario 7.2: Percent probability of sea ice concentration from 0 to 8 tenths, Chukchi Sea.



0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
20	0	0	0	0	0	0	0	20
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
0	0	0	0	0	0	0	0	0
0	0	20	20	0	0	0	0	0
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
0	40	20	20	20	0	0	20	20
20	80	40	20	20	20	40	MEADE RIVER 60 NR04-04	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT			
NR02-04	NR03-03		NR03-04		NR04-03			
40	60	60	80	100	100			
80	80	100	80	100				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	100	100				
100	100	100	DE LONG MTS. 100 NR03-08					
PT. HOPE W.	POINT HOPE							
NR02-08	NR03-07							
100	100	100						

2012 to 2016

21-Jun 30-Jun

Sea Ice 7.2.3 Scenario 7.2: Percent probability of sea ice concentration from 0 to 8 tenths, Chukchi Sea.

0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
20	0	20	0	0	0	0	0	0
20	20	20	20	20	0	0	20	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
20	20	20	20	20	20	0	20	20
20	40	40	20	20	20	20	20	20
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
20	40	40	20	20	20	20	20	40
40	60	60	40	20	20	20	MEADE RIVER	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		40	
NR02-04	NR03-03		NR03-04		NR04-03		NR04-04	
20	80	80	80	100	100			
80	80	100	80	100				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	100	100				
100	100	100	DE LONG MTS.					
PT. HOPE W.	POINT HOPE		100					
NR02-08	NR03-07		NR03-08					
100	100	100						

2012 to 2016

1-Jul 10-Jul

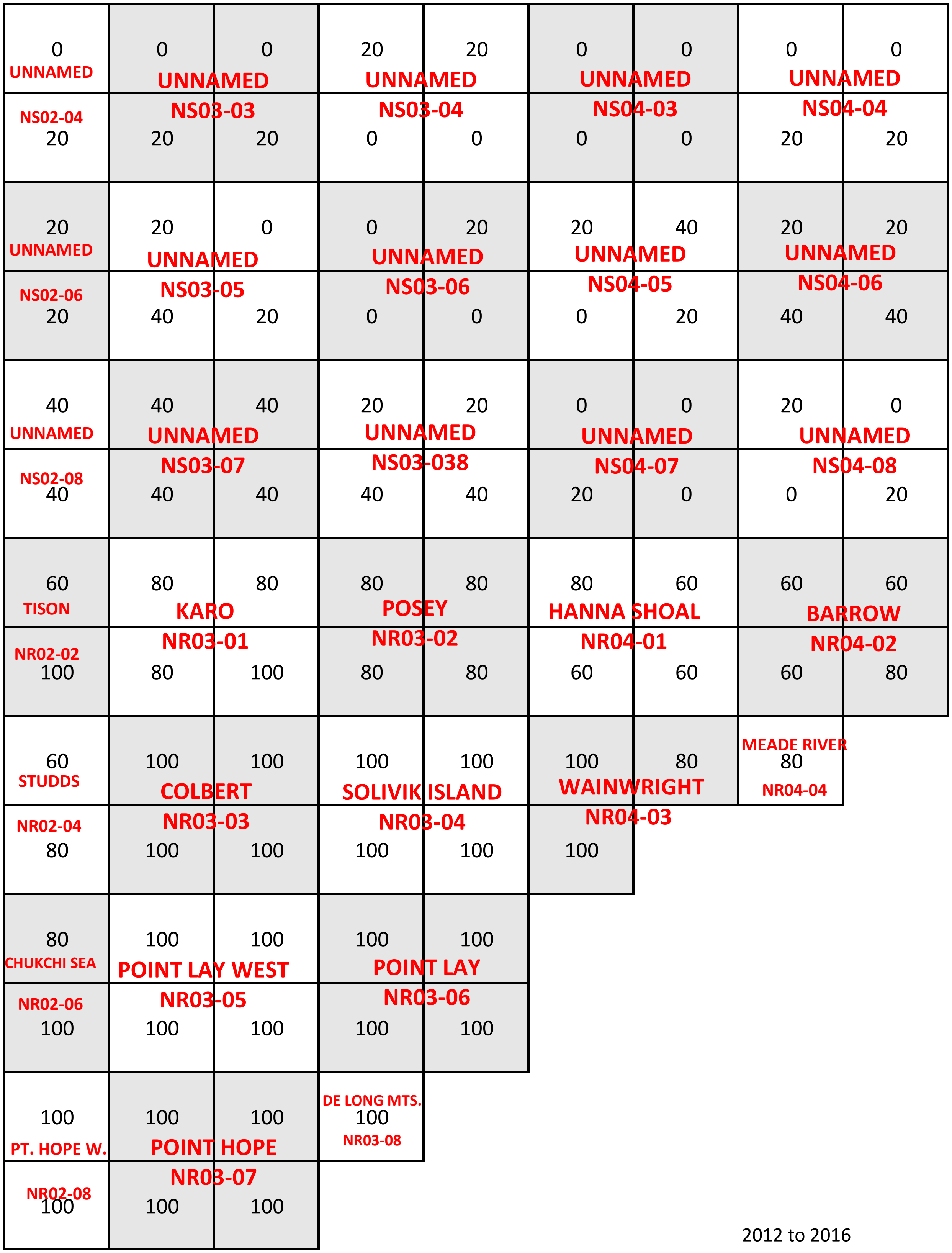
Sea Ice 7.2.4 Scenario 7.2: Percent probability of sea ice concentration from 0 to 8 tenths, Chukchi Sea.

0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	20 UNNAMED	20
NS02-04 0	NS03-03 0	0	NS03-04 0	0	NS04-03 0	0	NS04-04 20	20
0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-06 20	NS03-05 0	0	NS03-06 0	0	NS04-05 20	0	NS04-06 0	0
20 UNNAMED	20 UNNAMED	20	20 UNNAMED	20	20 UNNAMED	0	0 UNNAMED	0
NS02-08 20	NS03-07 60	60	NS03-038 60	60	NS04-07 20	0	NS04-08 20	20
80 TISON	80 KARO	60	40 POSEY	40	40 HANNA SHOAL	0	20 BARROW	40
NR02-02 80	NR03-01 80	80	NR03-02 40	40	NR04-01 20	60	NR04-02 40	80
80 STUDDS	80 COLBERT	80	60 SOLIVIK ISLAND	80	60 WAINWRIGHT	100	MEADE RIVER 100 NR04-04	
NR02-04 80	NR03-03 80	100	NR03-04 100	100	NR04-03 100			
80 CHUKCHI SEA	100 POINT LAY WEST	100	100 POINT LAY	100				
NR02-06 100	NR03-05 100	100	NR03-06 100	100				
100 PT. HOPE W.	100 POINT HOPE	80	DE LONG MTS. 80 NR03-08					
NR02-08 100	NR03-07 100	100						

2012 to 2016

11-Jul 20-Jul

Sea Ice 7.2.5 Scenario 7.2: Percent probability of sea ice concentration from 0 to 8 tenths, Chukchi Sea.



0	0	0	20	20	0	0	0	0	
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED		
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04		
20	20	20	0	0	0	0	20	20	
20	20	0	0	20	20	40	20	20	
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED		
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06		
20	40	20	0	0	0	20	40	40	
40	40	40	20	20	0	0	20	0	
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED		
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08		
40	40	40	40	40	20	0	0	20	
60	80	80	80	80	80	60	60	60	
TISON	KARO		POSEY		HANNA SHOAL		BARROW		
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02		
100	80	100	80	80	60	60	60	80	
60	100	100	100	100	100	80	MEADE RIVER 80 NR04-04		
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT				
NR02-04	NR03-03		NR03-04		NR04-03				
80	100	100	100	100	100				
80	100	100	100	100					
CHUKCHI SEA	POINT LAY WEST		POINT LAY						
NR02-06	NR03-05		NR03-06						
100	100	100	100	100					
100	100	100	DE LONG MTS. 100 NR03-08						
PT. HOPE W.	POINT HOPE								
NR02-08	NR03-07								
100	100	100							

2012 to 2016

21-Jul 31-Jul

Sea Ice 7.2.6 Scenario 7.2: Percent probability of sea ice concentration from 0 to 8 tenths, Chukchi Sea.

20	20	0	0	0	20	40	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
20	20	40	20	20	20	40	40	40
20	40	20	20	40	20	40	40	40
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
20	40	40	20	20	20	40	40	40
80	80	20	20	40	40	40	20	20
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
80	60	80	60	80	60	60	40	40
80	80	80	80	80	80	60	60	60
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
100	80	100	80	80	80	80	80	60
80	100	100	100	100	100	80	MEADE RIVER 100 NR04-04	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT			
NR02-04	NR03-03		NR03-04		NR04-03			
80	100	100	100	100	100			
100	100	100	100	100				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	100	100				
100	100	100	DE LONG MTS. 100 NR03-08					
PT. HOPE W.	POINT HOPE							
NR02-08	NR03-07							
100	100	100						

2012 to 2016

1-Aug 10-Aug

Sea Ice 7.2.7 Scenario 7.2: Percent probability of sea ice concentration from 0 to 8 tenths, Chukchi Sea.

40	40	0	0	0	0	20	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
40	20	20	0	20	20	20	20	20
20	20	40	40	20	20	40	20	40
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
20	40	60	60	40	60	40	40	40
80	80	40	20	40	60	60	40	40
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
80	80	80	60	60	60	60	80	60
80	80	80	80	60	80	80	80	80
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
100	100	100	100	100	80	80	80	100
100	100	100	100	100	100	100	MEADE RIVER	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		100	
NR02-04	NR03-03		NR03-04		NR04-03		NR04-04	
100	100	100	100	100	100			
100	100	100	100	100				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	100	100				
100	100	100	DE LONG MTS.					
PT. HOPE W.	POINT HOPE		100					
NR02-08	NR03-07		NR03-08					
100	100	100						

2012 to 2016

11-Aug 20-Aug

Sea Ice 7.2.8 Scenario 7.2: Percent probability of sea ice concentration from 0 to 8 tenths, Chukchi Sea.

20	40	40	40	40	40	20	40	60
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
20	40	40	40	60	80	40	60	40
40	40	60	40	80	60	60	60	100
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
60	60	20	40	60	100	80	80	60
60	80	40	60	40	60	100	100	80
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
80	80	100	80	80	40	80	80	100
100	100	100	100	60	100	80	100	100
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
100	80	80	100	100	100	100	100	100
100	100	100	80	100	100	100	MEADE RIVER 100	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		NR04-04	
NR02-04	NR03-03		NR03-04		NR04-03			
100	100	100	100	100	100			
100	100	100	100	100				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	100	100				
100	100	100	DE LONG MTS. 100 NR03-08					
PT. HOPE W.	POINT HOPE							
NR02-08	NR03-07							
100	100	100						

2012 to 2016

21-Aug 31-Aug

Sea Ice 7.2.9 Scenario 7.2: Percent probability of sea ice concentration from 0 to 8 tenths, Chukchi Sea.

40 UNNAMED	40 UNNAMED	40	40 UNNAMED	40	20 UNNAMED	20	40 UNNAMED	40
NS02-04 40	NS03-03 40	40	NS03-04 60	60	NS04-03 60	40	NS04-04 40	60
40 UNNAMED	60 UNNAMED	40	60 UNNAMED	80	60 UNNAMED	60	60 UNNAMED	40
NS02-06 60	NS03-05 60	60	NS03-06 60	80	NS04-05 100	60	NS04-06 60	60
40 UNNAMED	40 UNNAMED	80	80 UNNAMED	60	80 UNNAMED	60	80 UNNAMED	60
NS02-08 100	NS03-07 100	100	NS03-038 100	100	NS04-07 100	100	NS04-08 100	80
100 TISON	100 KARO	100	100 POSEY	80	100 HANNA SHOAL	100	100 BARROW	100
NR02-02 100	NR03-01 100	100	NR03-02 80	80	NR04-01 100	100	NR04-02 100	100
100 STUDDS	100 COLBERT	100	100 SOLIVIK ISLAND	100	100 WAINWRIGHT	100	MEADE RIVER 100 NR04-04	
NR02-04 100	NR03-03 100	100	NR03-04 100	100	NR04-03 100			
100 CHUKCHI SEA	100 POINT LAY WEST	100	100 POINT LAY	100				
NR02-06 100	NR03-05 100	100	NR03-06 100	100				
100 PT. HOPE W.	100 POINT HOPE	100	DE LONG MTS. 100 NR03-08					
NR02-08 100	NR03-07 100	100						

2012 to 2016

1-Sep 10-Sep

Sea Ice 7.2.10 Scenario 7.2: Percent probability of sea ice concentration from 0 to 8 tenths, Chukchi Sea.

80	60	60	40	60	60	60	60	40
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
60	60	60	60	60	80	80	80	80
80	60	80	60	60	100	100	100	80
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
80	60	80	60	60	80	100	100	100
60	40	60	60	60	80	100	100	100
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
100	100	100	80	60	60	60	100	100
100	100	80	80	60	80	60	100	100
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
100	100	100	80	60	80	80	80	100
100	100	100	100	80	80	100	MEADE RIVER 100	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		NR04-04	
NR02-04	NR03-03		NR03-04		NR04-03			
100	100	100	100	100	100			
100	100	100	100	100				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	100	100				
100	100	100	DE LONG MTS. 100					
PT. HOPE W.	POINT HOPE		NR03-08					
NR02-08	NR03-07							
100	100	100						

2012 to 2016

11-Sep 20-Sep

Sea Ice 7.2.11 Scenario 7.2: Percent probability of sea ice concentration from 0 to 8 tenths, Chukchi Sea.

60 UNNAMED	60 UNNAMED	60	60 UNNAMED	60	60 UNNAMED	40	40 UNNAMED	60
NS02-04 60	NS03-03 60	60	NS03-04 60	60	NS04-03 80	60	NS04-04 40	40
100 UNNAMED	80 UNNAMED	80	80 UNNAMED	60	80 UNNAMED	80	80 UNNAMED	60
NS02-06 100	NS03-05 100	100	NS03-06 80	100	NS04-05 60	80	NS04-06 80	80
100 UNNAMED	100 UNNAMED	100	100 UNNAMED	80	100 UNNAMED	80	80 UNNAMED	80
NS02-08 100	NS03-07 100	100	NS03-038 100	80	NS04-07 80	100	NS04-08 80	80
100 TISON	100 KARO	100	100 POSEY	100	80 HANNA SHOAL	100	80 BARROW	100
NR02-02 100	NR03-01 100	100	NR03-02 100	100	NR04-01 100	100	NR04-02 100	100
100 STUDDS	100 COLBERT	100	100 SOLIVIK ISLAND	100	100 WAINWRIGHT	100	MEADE RIVER 100 NR04-04	
NR02-04 100	NR03-03 100	100	NR03-04 100	100	NR04-03 100			
100 CHUKCHI SEA	100 POINT LAY WEST	100	100 POINT LAY	100				
NR02-06 100	NR03-05 100	100	NR03-06 100	100				
100 PT. HOPE W.	100 POINT HOPE	100	DE LONG MTS. 100 NR03-08					
NR02-08 100	NR03-07 100	100						

2012 to 2016

21-Sep 30-Sep

Sea Ice 7.2.12 Scenario 7.2: Percent probability of sea ice concentration from 0 to 8 tenths, Chukchi Sea.

100 UNNAMED NS02-04 100	100 100 UNNAMED NS03-03 100 80	80 80 UNNAMED NS03-04 80 80	100 80 UNNAMED NS04-03 100 100	60 80 UNNAMED NS04-04 100 60
100 UNNAMED NS02-06 80	100 100 UNNAMED NS03-05 80 80	100 100 UNNAMED NS03-06 100 80	100 100 UNNAMED NS04-05 100 100	100 100 UNNAMED NS04-06 80 80
80 UNNAMED NS02-08 100	100 100 UNNAMED NS03-07 100 100	100 100 UNNAMED NS03-038 100 100	80 100 UNNAMED NS04-07 80 80	100 100 UNNAMED NS04-08 100 100
100 TISON NR02-02 100	100 100 KARO NR03-01 100 100	100 100 POSEY NR03-02 100 100	100 100 HANNA SHOAL NR04-01 100 100	100 100 BARROW NR04-02 100 100
100 STUDDS NR02-04 100	100 100 COLBERT NR03-03 100 100	100 100 SOLIVIK ISLAND NR03-04 100 100	100 100 WAINWRIGHT NR04-03 100	MEADE RIVER 100 NR04-04
100 CHUKCHI SEA NR02-06 100	100 100 POINT LAY WEST NR03-05 100 100	100 100 POINT LAY NR03-06 100 100		
100 PT. HOPE W. NR02-08 100	100 100 POINT HOPE NR03-07 100 100	DE LONG MTS. 100 NR03-08		

2012 to 2016

1-Oct 10-Oct

Sea Ice 7.2.13 Scenario 7.2: Percent probability of sea ice concentration from 0 to 8 tenths, Chukchi Sea.

80	80	60	40	20	40	60	40	40
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
80	80	80	80	40	40	40	40	40
80	80	80	100	100	80	60	40	40
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
100	100	100	100	100	100	100	80	40
100	100	100	100	100	80	80	100	100
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
100	100	100	100	100	100	100	100	100
100	100	100	100	100	100	100	100	100
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
100	100	100	100	100	100	100	100	100
100	100	100	100	100	100	100	MEADE RIVER 100 NR04-04	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT			
NR02-04	NR03-03		NR03-04		NR04-03			
100	100	100	100	100	100			
100	100	100	100	100				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	100	100				
100	100	100	DE LONG MTS. 100 NR03-08					
PT. HOPE W.	POINT HOPE							
NR02-08	NR03-07							
100	100	100						

2012 to 2016

11-Oct 20-Oct

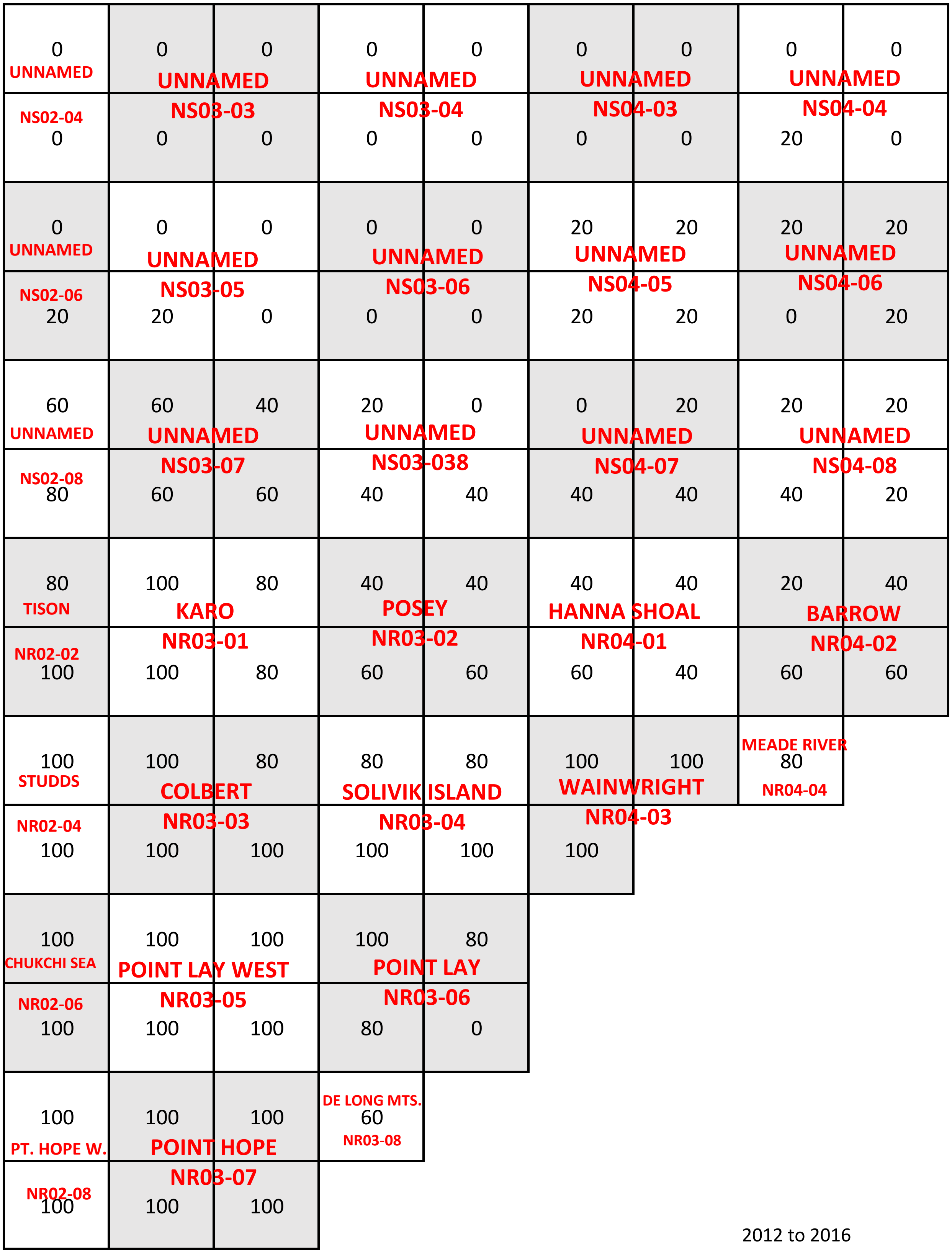
Sea Ice 7.2.14 Scenario 7.2: Percent probability of sea ice concentration from 0 to 8 tenths, Chukchi Sea.

40	40	40	40	20	40	40	40	40
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
40	40	40	40	40	40	40	40	40
40	40	60	60	40	40	40	40	40
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
40	60	60	60	60	40	40	40	40
60	80	100	80	80	80	80	40	40
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
100	100	100	100	100	80	80	80	60
100	100	100	100	100	100	100	100	80
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
100	100	100	100	100	100	100	100	100
100	100	100	100	100	100	100	MEADE RIVER 100	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		NR04-04	
NR02-04	NR03-03		NR03-04		NR04-03			
100	100	100	100	100	100			
100	100	100	100	100				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	100	80				
100	100	100	DE LONG MTS. 80					
PT. HOPE W.	POINT HOPE		NR03-08					
NR02-08	NR03-07							
100	100	100						

2012 to 2016

21-Oct 31-Oct

Sea Ice 7.2.15 Scenario 7.2: Percent probability of sea ice concentration from 0 to 8 tenths, Chukchi Sea.



0	0	0	0	0	0	0	0	0
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04	
0	0	0	0	0	0	0	20	0
0	0	0	0	0	20	20	20	20
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06	
20	20	0	0	0	20	20	0	20
60	60	40	20	0	0	20	20	20
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED	
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08	
80	60	60	40	40	40	40	40	20
80	100	80	40	40	40	40	20	40
TISON	KARO		POSEY		HANNA SHOAL		BARROW	
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02	
100	100	80	60	60	60	40	60	60
100	100	80	80	80	100	100	MEADE RIVER	
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		80	
NR02-04	NR03-03		NR03-04		NR04-03		NR04-04	
100	100	100	100	100	100			
100	100	100	100	80				
CHUKCHI SEA	POINT LAY WEST		POINT LAY					
NR02-06	NR03-05		NR03-06					
100	100	100	80	0				
100	100	100	DE LONG MTS.					
PT. HOPE W.	POINT HOPE		60					
NR02-08	NR03-07		NR03-08					
100	100	100						

2012 to 2016

1-Nov 10-Nov

Sea Ice 7.2.16 Scenario 7.2: Percent probability of sea ice concentration from 0 to 8 tenths, Chukchi Sea.

0	0	0	0	0	0	0	0	0		
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED			
NS02-04	NS03-03		NS03-04		NS04-03		NS04-04			
0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0		
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED			
NS02-06	NS03-05		NS03-06		NS04-05		NS04-06			
0	0	0	0	0	0	0	0	0		
40	40	40	20	0	0	0	0	0		
UNNAMED	UNNAMED		UNNAMED		UNNAMED		UNNAMED			
NS02-08	NS03-07		NS03-038		NS04-07		NS04-08			
80	60	60	40	20	0	0	20	20		
80	60	60	40	40	0	0	0	20		
TISON	KARO		POSEY		HANNA SHOAL		BARROW			
NR02-02	NR03-01		NR03-02		NR04-01		NR04-02			
80	80	80	60	40	40	40	40	40		
80	80	80	80	60	40	40	40			
STUDDS	COLBERT		SOLIVIK ISLAND		WAINWRIGHT		MEADE RIVER			
NR02-04	NR03-03		NR03-04		NR04-03		NR04-04			
80	80	80	60	40	60					
80	80	80	60	60						
CHUKCHI SEA	POINT LAY WEST		POINT LAY							
NR02-06	NR03-05		NR03-06							
100	100	100	60	20						
100	100	80	20							
PT. HOPE W.	POINT HOPE		DE LONG MTS.							
NR02-08	NR03-07		NR03-08							
100	100	100								

2012 to 2016

11-Nov 20-Nov

Sea Ice 7.2.17 Scenario 7.2: Percent probability of sea ice concentration from 0 to 8 tenths, Chukchi Sea.

0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-04 0	NS03-03 0	0	NS03-04 0	0	NS04-03 0	0	NS04-04 0	0
0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-06 0	NS03-05 0	0	NS03-06 0	0	NS04-05 0	0	NS04-06 0	0
20 UNNAMED	20 UNNAMED	20	0 UNNAMED	20	20 UNNAMED	0	0 UNNAMED	0
NS02-08 60	NS03-07 40	40	NS03-038 20	20	NS04-07 20	0	NS04-08 0	0
60 TISON	60 KARO	40	20 POSEY	0	0 HANNA SHOAL	0	0 BARROW	0
NR02-02 60	NR03-01 60	40	NR03-02 60	60	NR04-01 0	0	NR04-02 20	20
60 STUDDS	60 COLBERT	60	60 SOLIVIK ISLAND	60	20 WAINWRIGHT	20	MEADE RIVER 20 NR04-04	
NR02-04 60	NR03-03 60	60	NR03-04 60	20	NR04-03 20			
80 CHUKCHI SEA	80 POINT LAY WEST	60	20 POINT LAY	0				
NR02-06 80	NR03-05 60	40	NR03-06 0	0				
80 PT. HOPE W.	60 POINT HOPE	20	DE LONG MTS. 0 NR03-08					
NR02-08 80	NR03-07 60	60						

2012 to 2016

21-Nov 30-Nov

Sea Ice 7.2.18 Scenario 7.2: Percent probability of sea ice concentration from 0 to 8 tenths, Chukchi Sea.

0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-04 0	NS03-03 0	0	NS03-04 0	0	NS04-03 0	0	NS04-04 0	0
0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-06 0	NS03-05 0	0	NS03-06 0	0	NS04-05 0	0	NS04-06 0	0
0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-08 20	NS03-07 20	20	NS03-038 0	0	NS04-07 0	0	NS04-08 0	0
20 TISON	20 KARO	20	0 POSEY	0	0 HANNA SHOAL	0	0 BARROW	0
NR02-02 20	NR03-01 20	20	NR03-02 20	0	NR04-01 0	0	NR04-02 0	0
40 STUDDS	40 COLBERT	20	20 SOLIVIK ISLAND	40	40 WAINWRIGHT	0	MEADE RIVER 0 NR04-04	
NR02-04 40	NR03-03 60	40	NR03-04 40	40	NR04-03 0			
60 CHUKCHI SEA	60 POINT LAY WEST	40	20 POINT LAY	0				
NR02-06 60	NR03-05 60	0	NR03-06 0	0				
60 PT. HOPE W.	60 POINT HOPE	20	DE LONG MTS. 20 NR03-08					
NR02-08 60	NR03-07 40	20						

2012 to 2016

1-Dec 10-Dec

Sea Ice 7.2.19 Scenario 7.2: Percent probability of sea ice concentration from 0 to 8 tenths, Chukchi Sea.

0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-04 0	NS03-03 0	0	NS03-04 0	0	NS04-03 0	0	NS04-04 0	0
0 UNNAMED	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-06 0	NS03-05 0	0	NS03-06 0	0	NS04-05 0	0	NS04-06 0	0
0 UNNAMED	20 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0	0 UNNAMED	0
NS02-08 20	NS03-07 20	20	NS03-038 20	0	NS04-07 0	0	NS04-08 0	0
20 TISON	20 KARO	20	20 POSEY	0	0 HANNA SHOAL	0	0 BARROW	0
NR02-02 20	NR03-01 20	20	NR03-02 0	0	NR04-01 0	0	NR04-02 0	0
20 STUDDS	20 COLBERT	20	0 SOLIVIK ISLAND	0	0 WAINWRIGHT	0	MEADE RIVER 0 NR04-04	
NR02-04 20	NR03-03 20	20	NR03-04 0	0	NR04-03 0			
20 CHUKCHI SEA	20 POINT LAY WEST	0	0 POINT LAY	0				
NR02-06 20	NR03-05 0	0	NR03-06 0	0				
20 PT. HOPE W.	0 POINT HOPE	40	DE LONG MTS. 20 NR03-08					
NR02-08 20	NR03-07 0	0						

2012 to 2016

11-Dec 20-Dec

Sea Ice 7.2.20 Scenario 7.2: Percent probability of sea ice concentration from 0 to 8 tenths, Chukchi Sea.

0 UNNAMED NS02-04 0	0 0 UNNAMED NS03-03 0 0	0 0 UNNAMED NS03-04 0 0	0 0 UNNAMED NS04-03 0 0	0 0 UNNAMED NS04-04 0 0
0 UNNAMED NS02-06 0	0 0 UNNAMED NS03-05 0 0	0 0 UNNAMED NS03-06 0 0	0 0 UNNAMED NS04-05 0 0	0 0 UNNAMED NS04-06 0 0
20 UNNAMED NS02-08 20	20 0 UNNAMED NS03-07 20 20	0 0 UNNAMED NS03-038 0 0	0 0 UNNAMED NS04-07 0 0	0 0 UNNAMED NS04-08 0 0
20 TISON NR02-02 20	20 20 KARO NR03-01 20 20	0 0 POSEY NR03-02 0 0	0 0 HANNA SHOAL NR04-01 0 0	0 0 BARROW NR04-02 0 0
20 STUDDS NR02-04 20	20 20 COLBERT NR03-03 20 0	0 0 SOLIVIK ISLAND NR03-04 0 0	0 0 WAINWRIGHT NR04-03 0	MEADE RIVER 0 NR04-04
20 CHUKCHI SEA NR02-06 20	0 0 POINT LAY WEST NR03-05 0 0	0 0 POINT LAY NR03-06 0 0		
0 PT. HOPE W. NR02-08 0	0 0 POINT HOPE NR03-07 0 0	DE LONG MTS. 0 NR03-08		

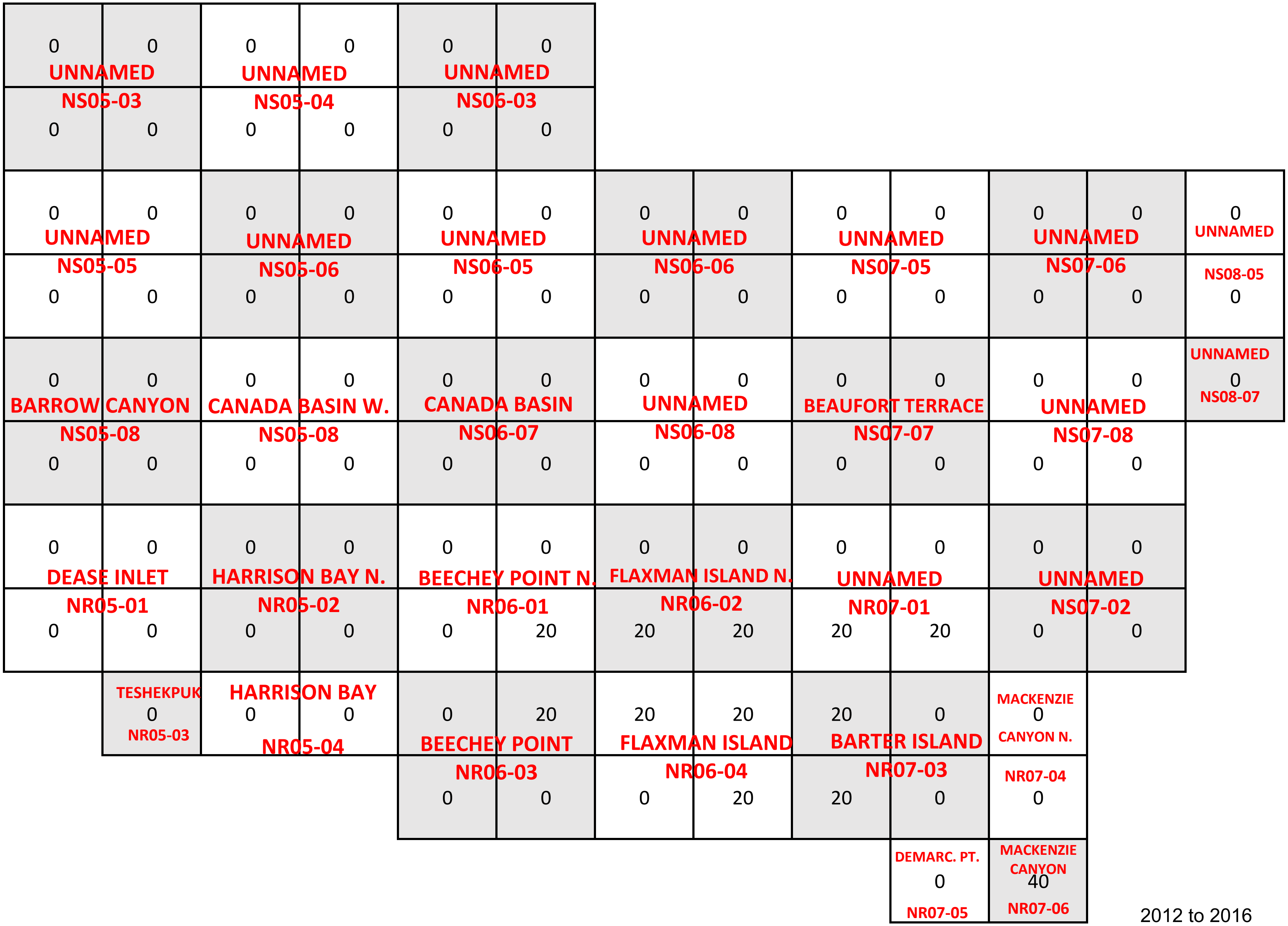
2012 to 2016

21-Dec 31-Dec

Sea Ice 7.2.21 Scenario 7.2: Percent probability of sea ice concentration from 0 to 8 tenths, Chukchi Sea.

Scenario 7.3:
Safe Open Water Relief Well Deployment in the Beaufort Sea.

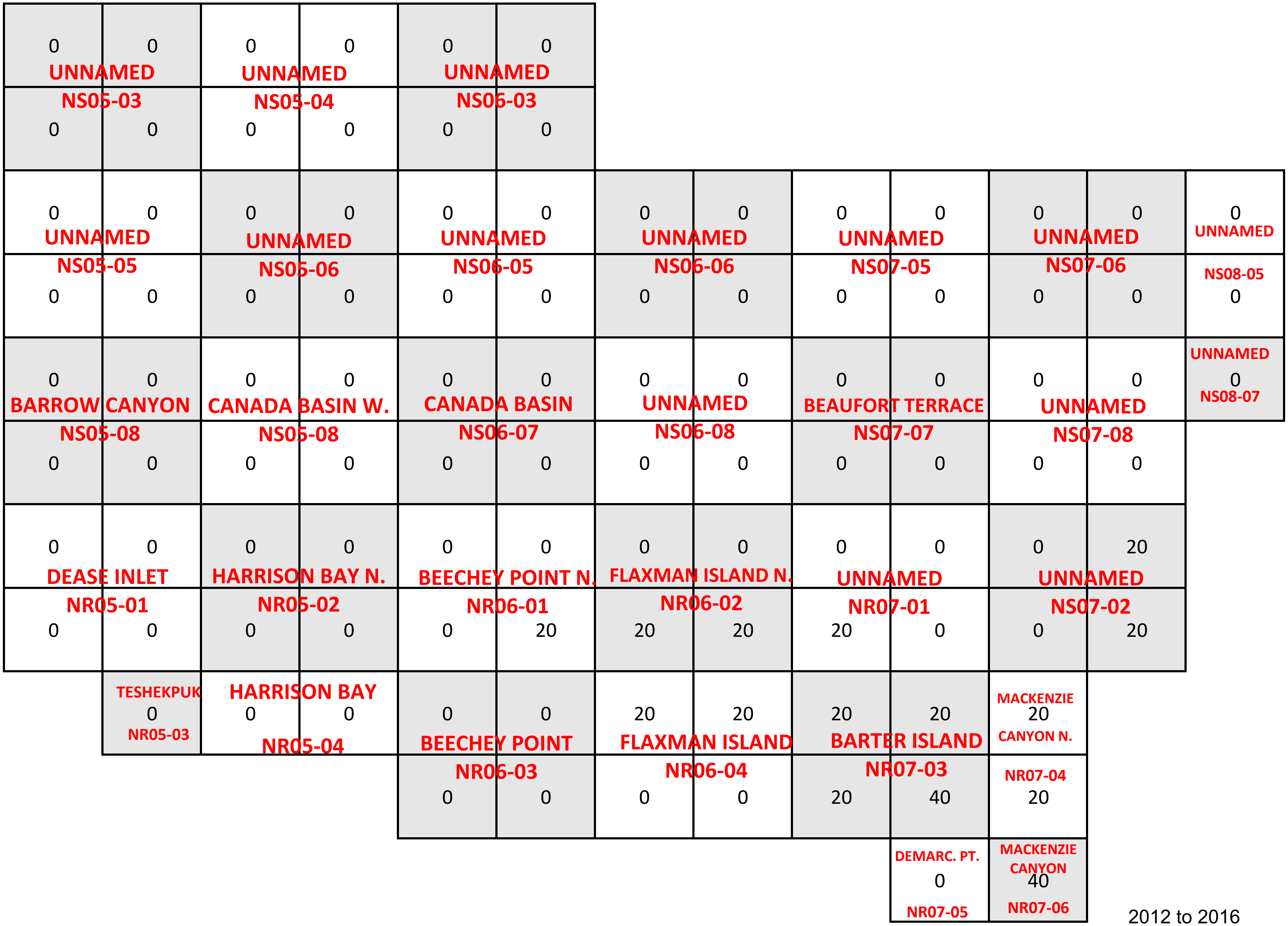
Sea ice data for the probability of open water, within a 30 nautical mile ice free radius, for the period from June through December, 2012 to 2016, in the Beaufort Sea.



UNNAMED	NS05-03	0	0	0	0
UNNAMED	NS05-04	0	0	0	0
UNNAMED	NS06-03	0	0	0	0
UNNAMED	NS05-05	0	0	0	0
UNNAMED	NS05-06	0	0	0	0
UNNAMED	NS06-05	0	0	0	0
UNNAMED	NS06-06	0	0	0	0
UNNAMED	NS07-05	0	0	0	0
UNNAMED	NS07-06	0	0	0	0
UNNAMED	NS08-05	0		0	
BARROW CANYON	NS05-08	0	0	0	0
CANADA BASIN W.	NS05-08	0	0	0	0
CANADA BASIN	NS06-07	0	0	0	0
UNNAMED	NS06-08	0	0	0	0
BEAUFORT TERRACE	NS07-07	0	0	0	0
UNNAMED	NS07-08	0	0	0	0
UNNAMED	NS08-07	0			
DEASE INLET	NR05-01	0	0	0	0
HARRISON BAY N.	NR05-02	0	0	0	0
BEECHEY POINT N.	NR06-01	0	0	0	20
FLAXMAN ISLAND N.	NR06-02	0	0	20	20
UNNAMED	NR07-01	0	0	20	20
UNNAMED	NS07-02	0	0	0	0
TESHEKPUK	NR05-03	0			
HARRISON BAY	NR05-04	0	0		
BEECHEY POINT	NR06-03	0	20	0	0
FLAXMAN ISLAND	NR06-04	20	20	0	20
BARTER ISLAND	NR07-03	20	0	20	0
MACKENZIE CANYON N.	NR07-04	0		0	
DEMARC. PT.	NR07-05	0			
MACKENZIE CANYON	NR07-06	40			

2012 to 2016

Sea Ice 7.3.1 Scenario 7.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea. 1-Jun 10-Jun



0 0 UNNAMED NS05-03 0 0	0 0 UNNAMED NS05-04 0 0	0 0 UNNAMED NS06-03 0 0				
0 0 UNNAMED NS05-05 0 0	0 0 UNNAMED NS05-06 0 0	0 0 UNNAMED NS06-05 0 0	0 0 UNNAMED NS06-06 0 0	0 0 UNNAMED NS07-05 0 0	0 0 UNNAMED NS07-06 0 0	0 UNNAMED NS08-05 0
0 0 BARROW CANYON NS05-08 0 0	0 0 CANADA BASIN W. NS05-08 0 0	0 0 CANADA BASIN NS06-07 0 0	0 0 UNNAMED NS06-08 0 0	0 0 BEAUFORT TERRACE NS07-07 0 0	0 0 UNNAMED NS07-08 0 0	UNNAMED 0 NS08-07
0 0 DEASE INLET NR05-01 0 0	0 0 HARRISON BAY N. NR05-02 0 0	0 0 BEECHEY POINT N. NR06-01 0 20	0 0 FLAXMAN ISLAND N. NR06-02 20 20	0 0 UNNAMED NR07-01 20 0	0 20 UNNAMED NS07-02 0 20	
TESHEKPUK 0 NR05-03	HARRISON BAY 0 0 NR05-04	0 0 BEECHEY POINT NR06-03 0 0	20 20 FLAXMAN ISLAND NR06-04 0 0	20 20 BARTER ISLAND NR07-03 20 40	MACKENZIE 20 CANYON N. NR07-04 20	
				DEMARC. PT. 0 NR07-05	MACKENZIE CANYON 40 NR07-06	

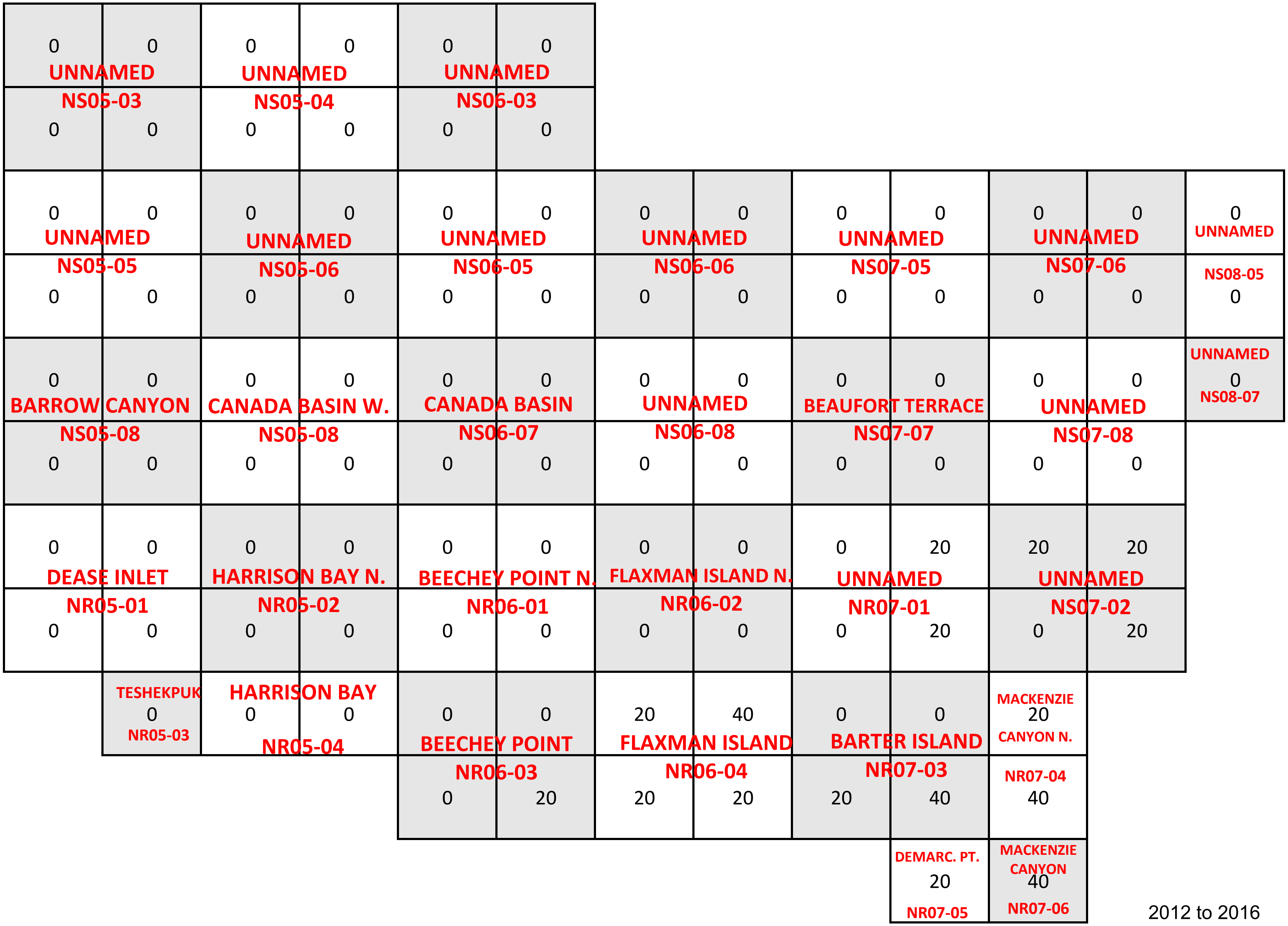
2012 to 2016
11-Jun 20-Jun

Sea Ice 7.3.2 Scenario 7.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea.

0 0 UNNAMED NS05-03 0 0	0 0 UNNAMED NS05-04 0 0	0 0 UNNAMED NS06-03 0 0				
0 0 UNNAMED NS05-05 0 0	0 0 UNNAMED NS05-06 0 0	0 0 UNNAMED NS06-05 0 0	0 0 UNNAMED NS06-06 0 0	0 0 UNNAMED NS07-05 0 0	0 0 UNNAMED NS07-06 0 0	0 UNNAMED NS08-05 0
0 0 BARROW CANYON NS05-08 0 0	0 0 CANADA BASIN W. NS05-08 0 0	0 0 CANADA BASIN NS06-07 0 0	0 0 UNNAMED NS06-08 0 0	0 0 BEAUFORT TERRACE NS07-07 0 0	0 0 UNNAMED NS07-08 0 0	UNNAMED 0 NS08-07
0 0 DEASE INLET NR05-01 0 0	0 0 HARRISON BAY N. NR05-02 0 0	0 0 BEECHEY POINT N. NR06-01 0 0	0 0 FLAXMAN ISLAND N. NR06-02 0 0	0 20 UNNAMED NR07-01 0 20	20 20 UNNAMED NS07-02 0 20	
TESHEKPUK 0 NR05-03	HARRISON BAY 0 0 NR05-04	0 0 BEECHEY POINT NR06-03 0 0	0 0 FLAXMAN ISLAND NR06-04 0 0	0 0 BARTER ISLAND NR07-03 0 0	MACKENZIE 20 CANYON N. NR07-04 20	
				DEMARC. PT. 0 NR07-05	MACKENZIE CANYON 20 NR07-06	

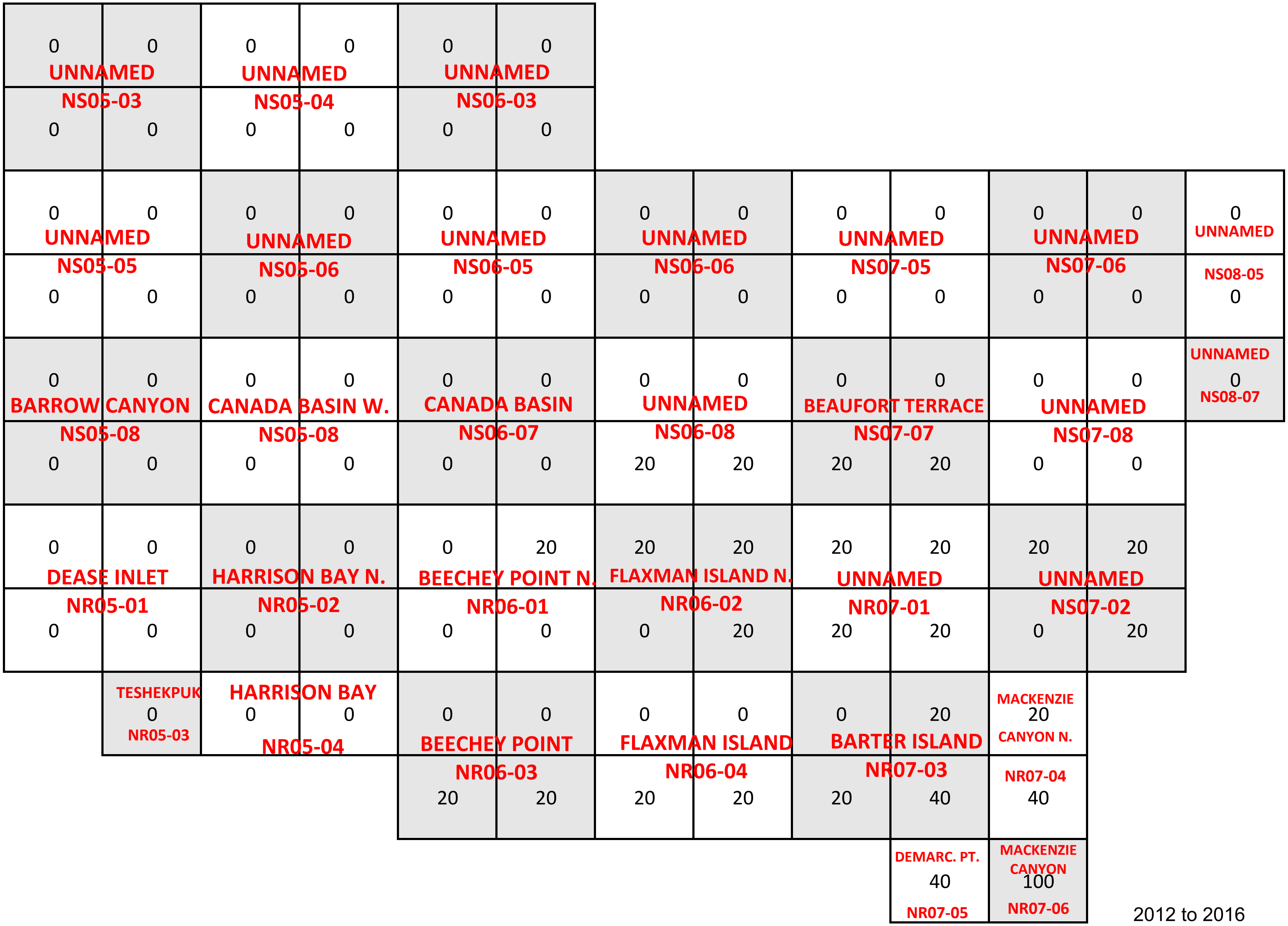
2012 to 2016

Sea Ice 7.3.3 Scenario 7.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea. 21-Jun 30-Jun



2012 to 2016

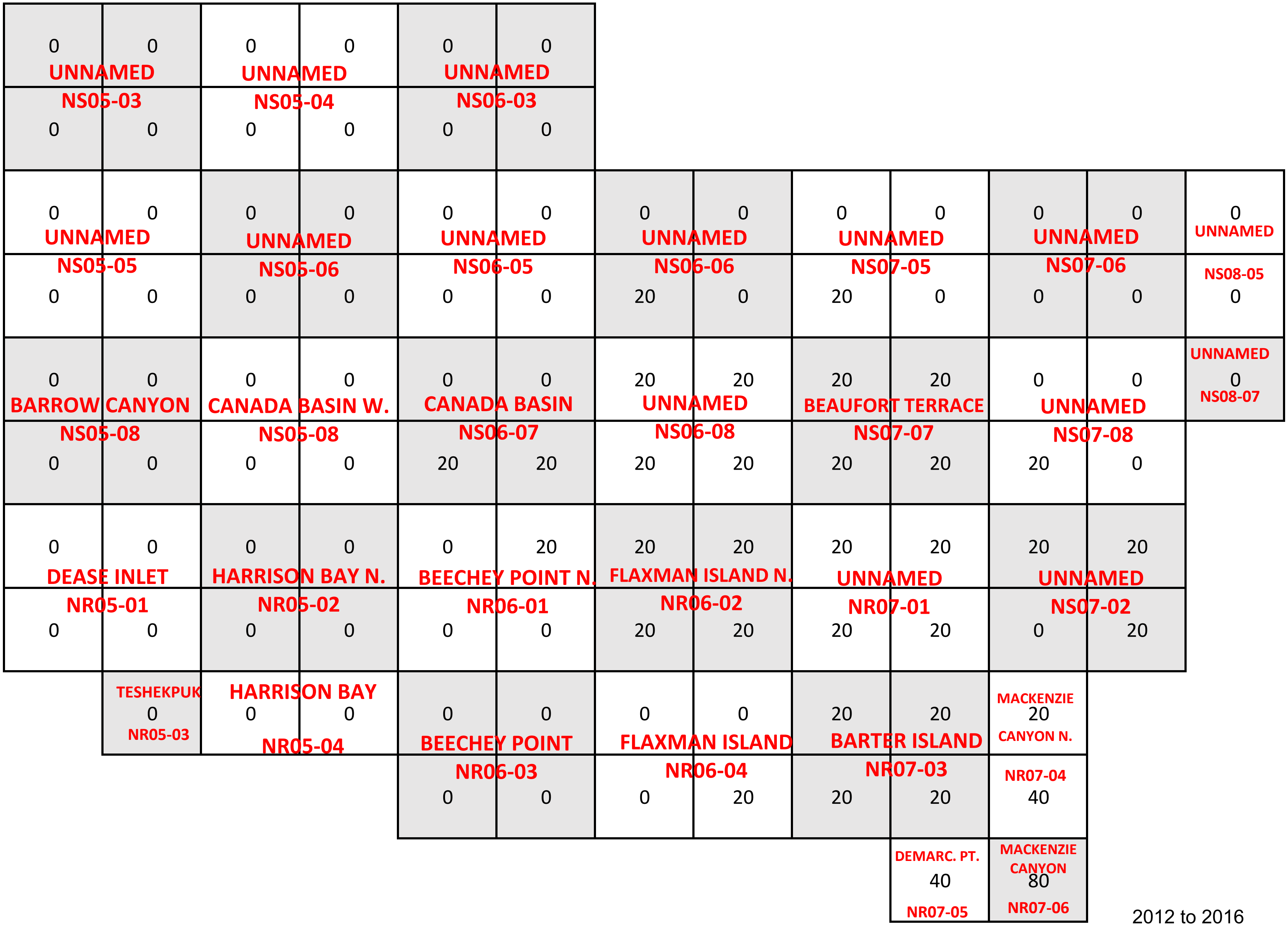
Sea Ice 7.3.4 Scenario 7.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea. 1-Jul 10-Jul



0 0 UNNAMED NS05-03 0 0	0 0 UNNAMED NS05-04 0 0	0 0 UNNAMED NS06-03 0 0				
0 0 UNNAMED NS05-05 0 0	0 0 UNNAMED NS05-06 0 0	0 0 UNNAMED NS06-05 0 0	0 0 UNNAMED NS06-06 0 0	0 0 UNNAMED NS07-05 0 0	0 0 UNNAMED NS07-06 0 0	0 UNNAMED NS08-05 0
0 0 BARROW CANYON NS05-08 0 0	0 0 CANADA BASIN W. NS05-08 0 0	0 0 CANADA BASIN NS06-07 0 0	0 0 UNNAMED NS06-08 20 20	0 0 BEAUFORT TERRACE NS07-07 20 20	0 0 UNNAMED NS07-08 0 0	UNNAMED 0 NS08-07
0 0 DEASE INLET NR05-01 0 0	0 0 HARRISON BAY N. NR05-02 0 0	0 20 BEECHEY POINT N. NR06-01 0 0	20 20 FLAXMAN ISLAND N. NR06-02 0 20	20 20 UNNAMED NR07-01 20 20	20 20 UNNAMED NS07-02 0 20	
TESHEKPUK 0 NR05-03	HARRISON BAY 0 0 NR05-04	0 0 BEECHEY POINT NR06-03 20 20	0 0 FLAXMAN ISLAND NR06-04 20 20	0 20 BARTER ISLAND NR07-03 20 40	MACKENZIE 20 CANYON N. NR07-04 40	
				DEMARC. PT. 40 NR07-05	MACKENZIE CANYON 100 NR07-06	

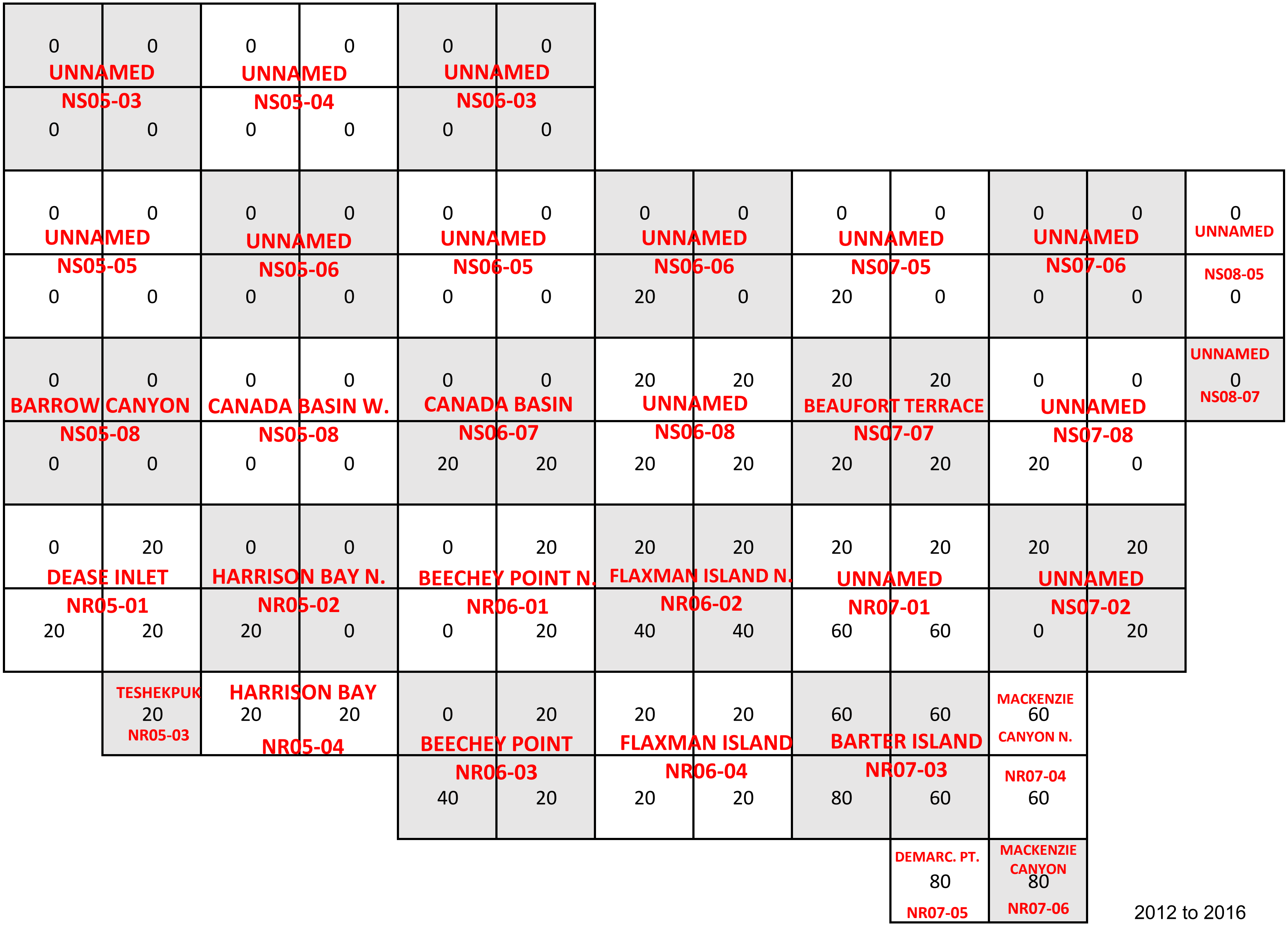
2012 to 2016

Sea Ice 7.3.5 Scenario 7.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea. 11-Jul 20-Jul



2012 to 2016
21-Jul 31-Jul

Sea Ice 7.3.6 Scenario 7.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea.



0 0 UNNAMED NS05-03 0 0	0 0 UNNAMED NS05-04 0 0	0 0 UNNAMED NS06-03 0 0				
0 0 UNNAMED NS05-05 0 0	0 0 UNNAMED NS05-06 0 0	0 0 UNNAMED NS06-05 0 0	0 0 UNNAMED NS06-06 20 0	0 0 UNNAMED NS07-05 20 0	0 0 UNNAMED NS07-06 0 0	0 UNNAMED NS08-05 0
0 0 BARROW CANYON NS05-08 0 0	0 0 CANADA BASIN W. NS05-08 0 0	0 0 CANADA BASIN NS06-07 20 20	20 20 UNNAMED NS06-08 20 20	20 20 BEAUFORT TERRACE NS07-07 20 20	0 0 UNNAMED NS07-08 20 0	UNNAMED 0 NS08-07
0 20 DEASE INLET NR05-01 20 20	0 0 HARRISON BAY N. NR05-02 20 0	0 20 BEECHEY POINT N. NR06-01 0 20	20 20 FLAXMAN ISLAND N. NR06-02 40 40	20 20 UNNAMED NR07-01 60 60	20 20 UNNAMED NS07-02 0 20	
TESHEKPUK 20 NR05-03	HARRISON BAY 20 20 NR05-04	0 20 BEECHEY POINT NR06-03 40 20	20 20 FLAXMAN ISLAND NR06-04 20 20	60 60 BARTER ISLAND NR07-03 80 60	MACKENZIE 60 CANYON N. NR07-04 60	
				DEMARC. PT. 80 NR07-05	MACKENZIE CANYON 80 NR07-06	

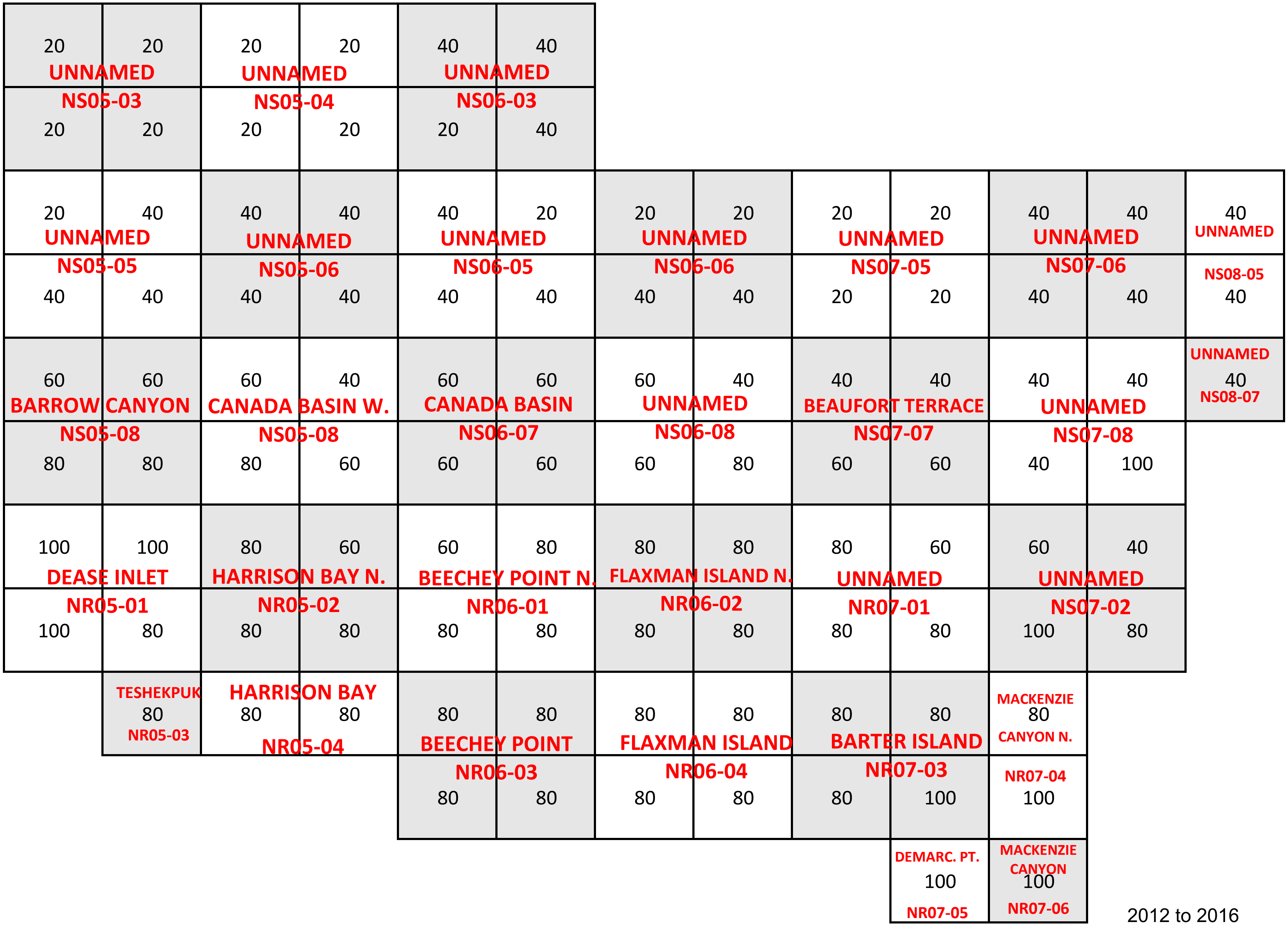
2012 to 2016

Sea Ice 7.3.7 Scenario 7.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea. 1-Aug 10-Aug

UNNAMED	NS05-03	0	0	0	0
UNNAMED	NS05-04	0	0	0	0
UNNAMED	NS06-03	0	0	0	20
UNNAMED	NS05-05	0	0	0	0
UNNAMED	NS05-06	0	0	0	0
UNNAMED	NS06-05	20	20	20	40
UNNAMED	NS06-06	20	20	20	20
UNNAMED	NS07-05	20	20	20	20
UNNAMED	NS07-06	40	20	20	40
UNNAMED	NS08-05	20		40	
BARROW CANYON	NS05-08	20	20	20	20
CANADA BASIN W.	NS05-08	0	0	20	40
CANADA BASIN	NS06-07	40	40	40	40
UNNAMED	NS06-08	40	20	40	20
BEAUFORT TERRACE	NS07-07	20	20	20	20
UNNAMED	NS07-08	20	0	20	0
UNNAMED	NS08-07	0			
DEASE INLET	NR05-01	40	40	40	40
HARRISON BAY N.	NR05-02	40	40	40	40
BEECHEY POINT N.	NR06-01	60	60	40	60
FLAXMAN ISLAND N.	NR06-02	60	60	60	60
UNNAMED	NR07-01	20	20	80	80
UNNAMED	NS07-02	20	20	0	20
TESHEKPUK	NR05-03	60			
HARRISON BAY	NR05-04	60	60		
BEECHEY POINT	NR06-03	40	60	60	60
FLAXMAN ISLAND	NR06-04	60	60	40	60
BARTER ISLAND	NR07-03	80	80	60	80
MACKENZIE CANYON N.	NR07-04	80		80	
DEMARC. PT.	NR07-05	80			
MACKENZIE CANYON	NR07-06	100			

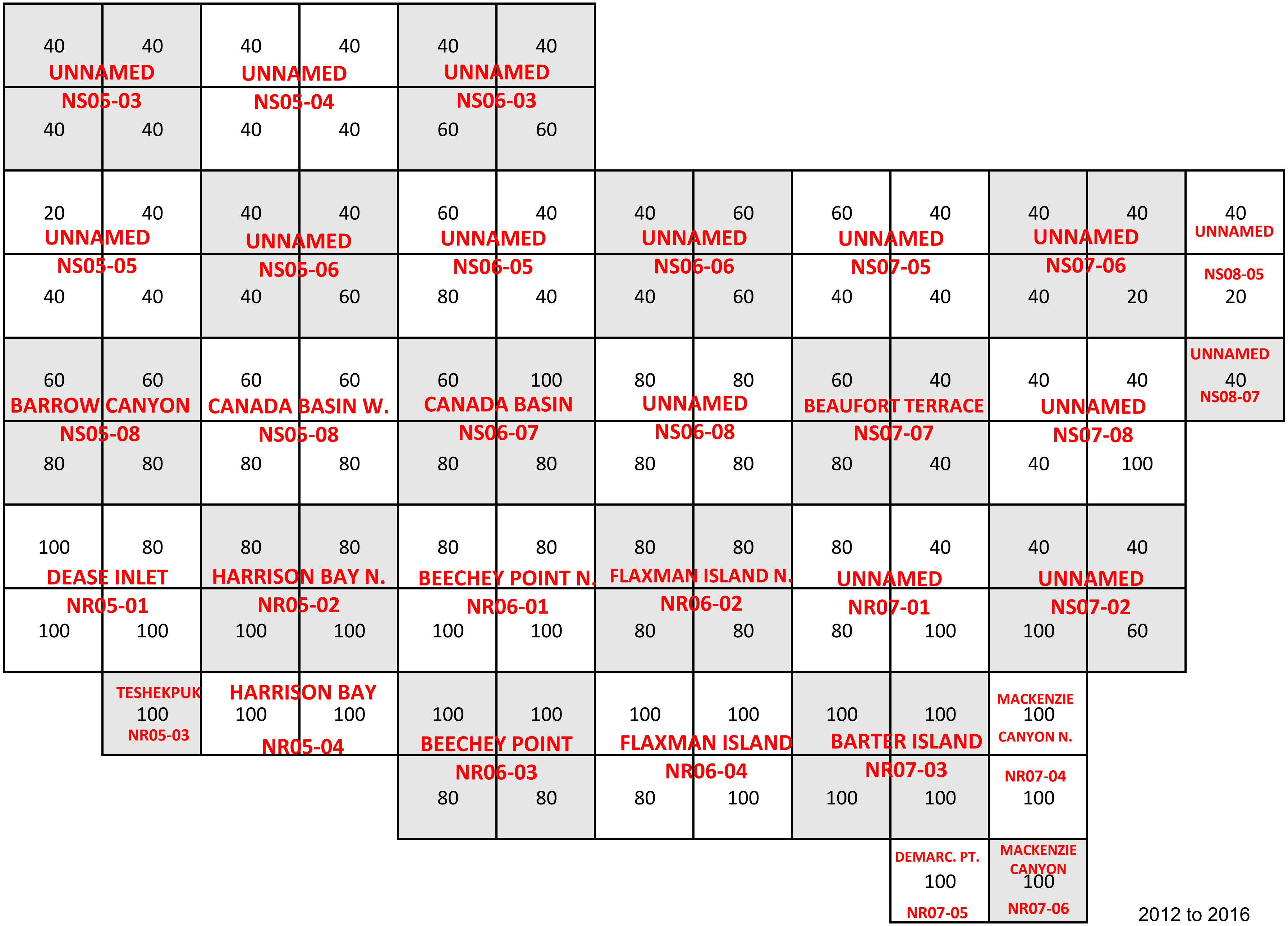
2012 to 2016
11-Aug 20-Aug

Sea Ice 7.3.8 Scenario 7.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea.



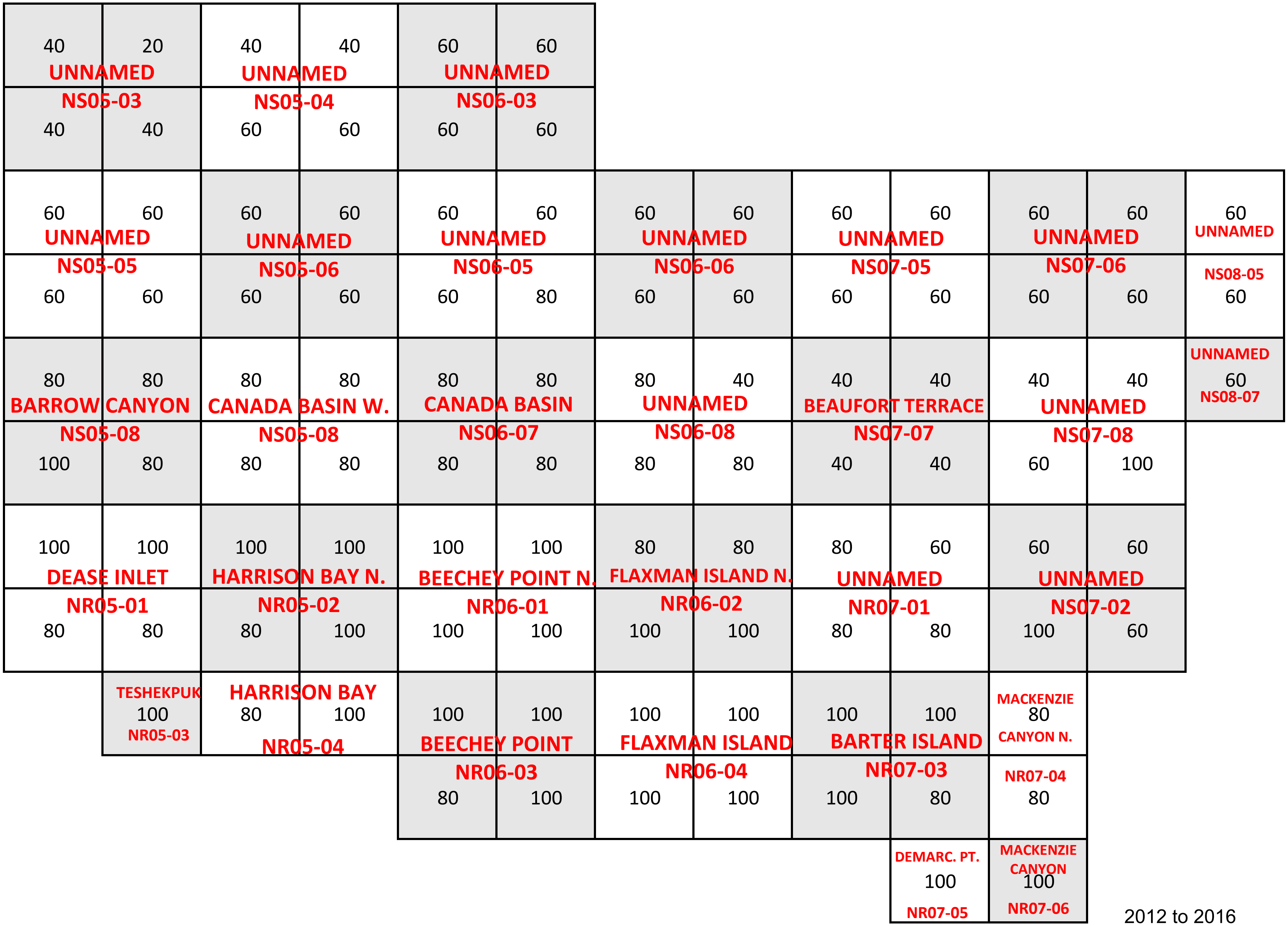
2012 to 2016
21-Aug 31-Aug

Sea Ice 7.3.9 Scenario 7.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea.



2012 to 2016
1-Sep 10-Sep

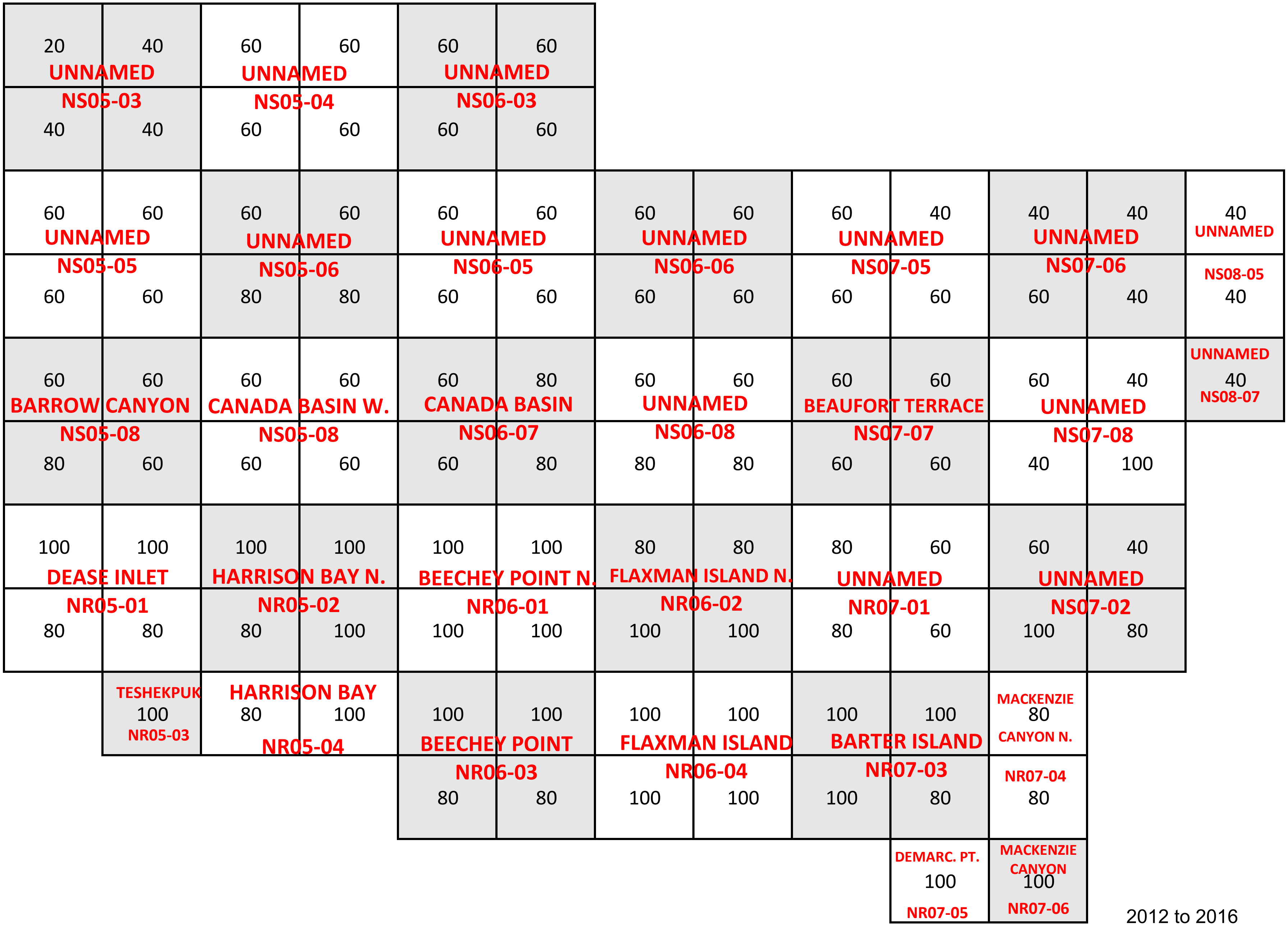
Sea Ice 7.3.10 Scenario 7.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea.



UNNAMED	NS05-03	40	20	40	40
UNNAMED	NS05-04	40	40	60	60
UNNAMED	NS06-03	60	60	60	60
UNNAMED	NS05-05	60	60	60	60
UNNAMED	NS05-06	60	60	60	60
UNNAMED	NS06-05	60	60	60	80
UNNAMED	NS06-06	60	60	60	60
UNNAMED	NS07-05	60	60	60	60
UNNAMED	NS07-06	60	60	60	60
UNNAMED	NS08-05	60		60	
BARROW CANYON	NS05-08	80	80	100	80
CANADA BASIN W.	NS05-08	80	80	80	80
CANADA BASIN	NS06-07	80	80	80	80
UNNAMED	NS06-08	80	40	80	80
BEAUFORT TERRACE	NS07-07	40	40	40	40
UNNAMED	NS07-08	40	40	60	100
UNNAMED	NS08-07	60			
DEASE INLET	NR05-01	100	100	80	80
HARRISON BAY N.	NR05-02	100	100	80	100
BEECHEY POINT N.	NR06-01	100	100	100	100
FLAXMAN ISLAND N.	NR06-02	80	80	100	100
UNNAMED	NR07-01	80	60	80	80
UNNAMED	NS07-02	60	60	100	60
TESHEKPUK	NR05-03		100		
HARRISON BAY	NR05-04	80	100		
BEECHEY POINT	NR06-03	100	100	80	100
FLAXMAN ISLAND	NR06-04	100	100	100	100
BARTER ISLAND	NR07-03	100	100	100	80
MACKENZIE CANYON N.	NR07-04	80		80	
DEMARC. PT.	NR07-05	100			
MACKENZIE CANYON	NR07-06	100			

2012 to 2016
11-Sep 20-Sep

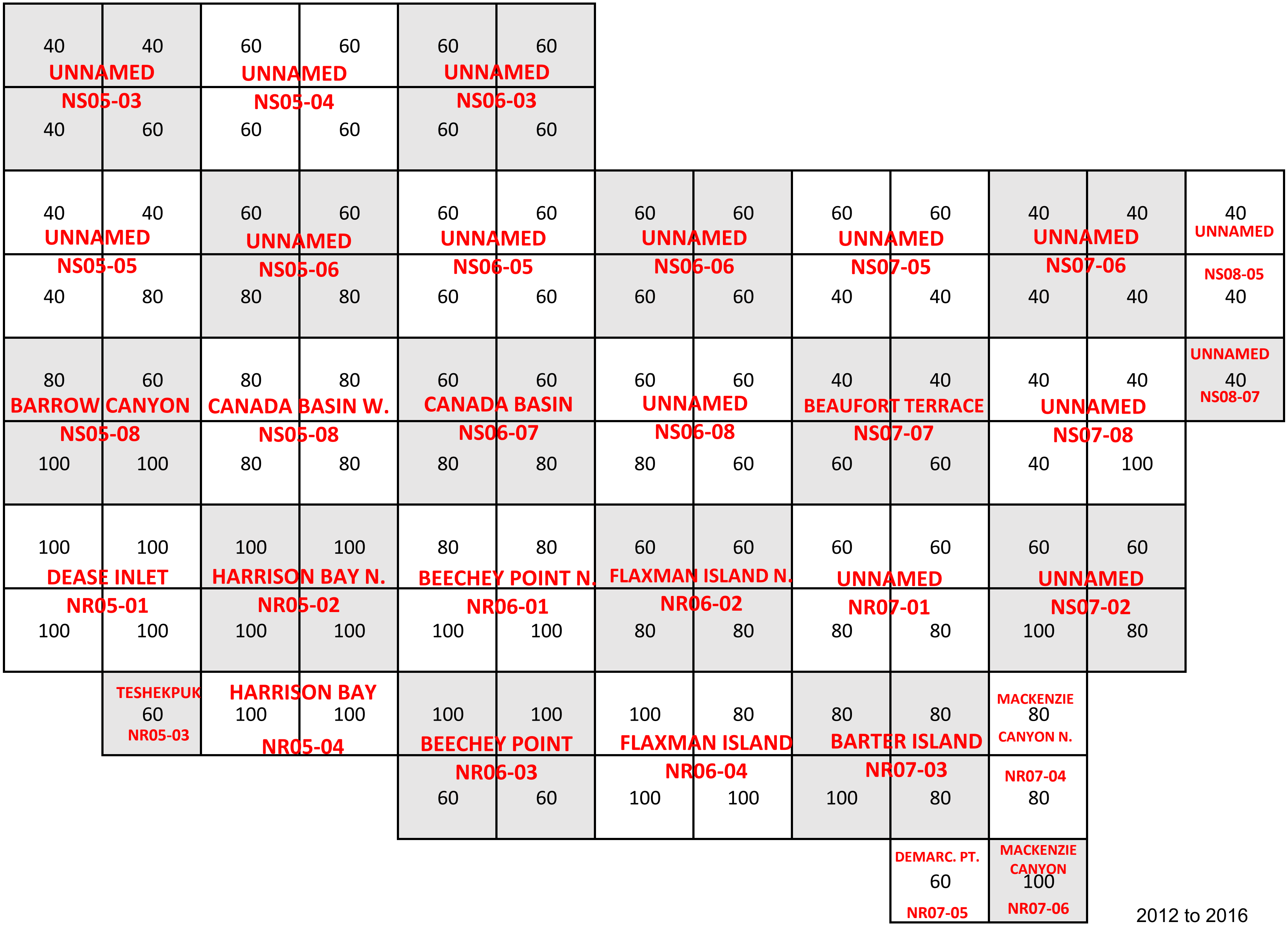
Sea Ice 7.3.11 Scenario 7.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea.



20 40 UNNAMED NS05-03 40 40	60 60 UNNAMED NS05-04 60 60	60 60 UNNAMED NS06-03 60 60				
60 60 UNNAMED NS05-05 60 60	60 60 UNNAMED NS05-06 80 80	60 60 UNNAMED NS06-05 60 60	60 60 UNNAMED NS06-06 60 60	60 40 UNNAMED NS07-05 60 60	40 40 UNNAMED NS07-06 60 40	40 UNNAMED NS08-05 40
60 60 BARROW CANYON NS05-08 80 60	60 60 CANADA BASIN W. NS05-08 60 60	60 80 CANADA BASIN NS06-07 60 80	60 60 UNNAMED NS06-08 80 80	60 60 BEAUFORT TERRACE NS07-07 60 60	60 40 UNNAMED NS07-08 40 100	UNNAMED 40 NS08-07
100 100 DEASE INLET NR05-01 80 80	100 100 HARRISON BAY N. NR05-02 80 100	100 100 BEECHEY POINT N. NR06-01 100 100	80 80 FLAXMAN ISLAND N. NR06-02 100 100	80 60 UNNAMED NR07-01 80 60	60 40 UNNAMED NS07-02 100 80	
TESHEPUK 100 NR05-03	HARRISON BAY 80 100 NR05-04	100 100 BEECHEY POINT NR06-03 80 80	100 100 FLAXMAN ISLAND NR06-04 100 100	100 100 BARTER ISLAND NR07-03 100 80	MACKENZIE 80 CANYON N. NR07-04 80	
				DEMARC. PT. 100 NR07-05	MACKENZIE CANYON 100 NR07-06	

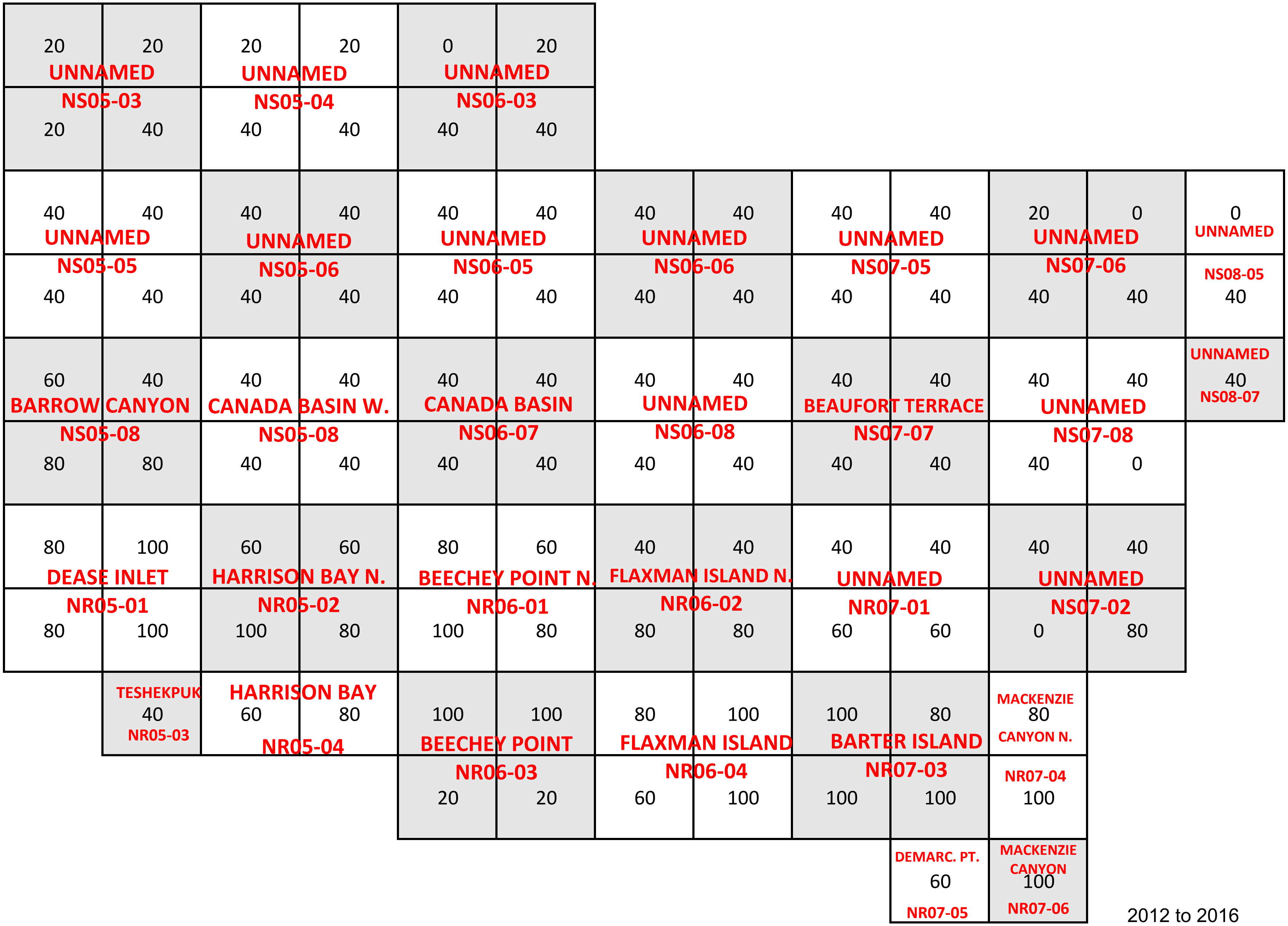
2012 to 2016

Sea Ice 7.3.12 Scenario 7.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea. 21-Sep 30-Sep



2012 to 2016
1-Oct 10-Oct

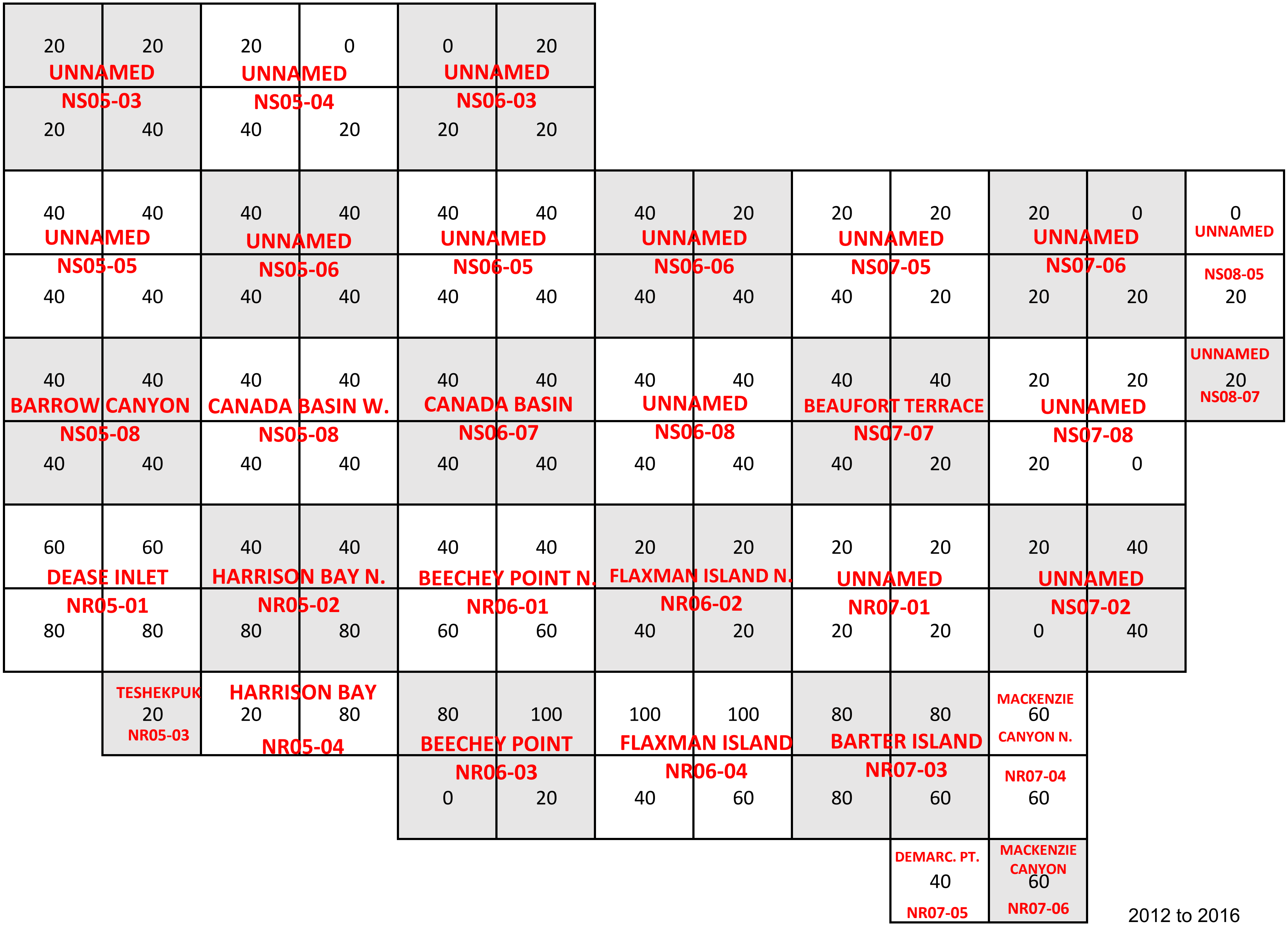
Sea Ice 7.3.13 Scenario 7.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea.



UNNAMED	NS05-03	20	20	20	40
UNNAMED	NS05-04	20	20	40	40
UNNAMED	NS06-03	0	20	40	40
UNNAMED	NS05-05	40	40	40	40
UNNAMED	NS05-06	40	40	40	40
UNNAMED	NS06-05	40	40	40	40
UNNAMED	NS06-06	40	40	40	40
UNNAMED	NS07-05	40	40	40	40
UNNAMED	NS07-06	20	0	40	40
UNNAMED	NS08-05	0		40	
BARROW CANYON	NS05-08	60	40	80	80
CANADA BASIN W.	NS05-08	40	40	40	40
CANADA BASIN	NS06-07	40	40	40	40
UNNAMED	NS06-08	40	40	40	40
BEAUFORT TERRACE	NS07-07	40	40	40	40
UNNAMED	NS07-08	40	40	40	0
UNNAMED	NS08-07	40			
DEASE INLET	NR05-01	80	100	80	100
HARRISON BAY N.	NR05-02	60	60	100	80
BEECHEY POINT N.	NR06-01	80	60	100	80
FLAXMAN ISLAND N.	NR06-02	40	40	80	80
UNNAMED	NR07-01	40	40	60	60
UNNAMED	NS07-02	40	40	0	80
TESHEKPUK	NR05-03	40			
HARRISON BAY	NR05-04	60	80		
BEECHEY POINT	NR06-03	100	100	20	20
FLAXMAN ISLAND	NR06-04	80	100	60	100
BARTER ISLAND	NR07-03	100	80	100	100
MACKENZIE CANYON N.	NR07-04	80		100	
DEMARC. PT.	NR07-05	60			
MACKENZIE CANYON	NR07-06	100			

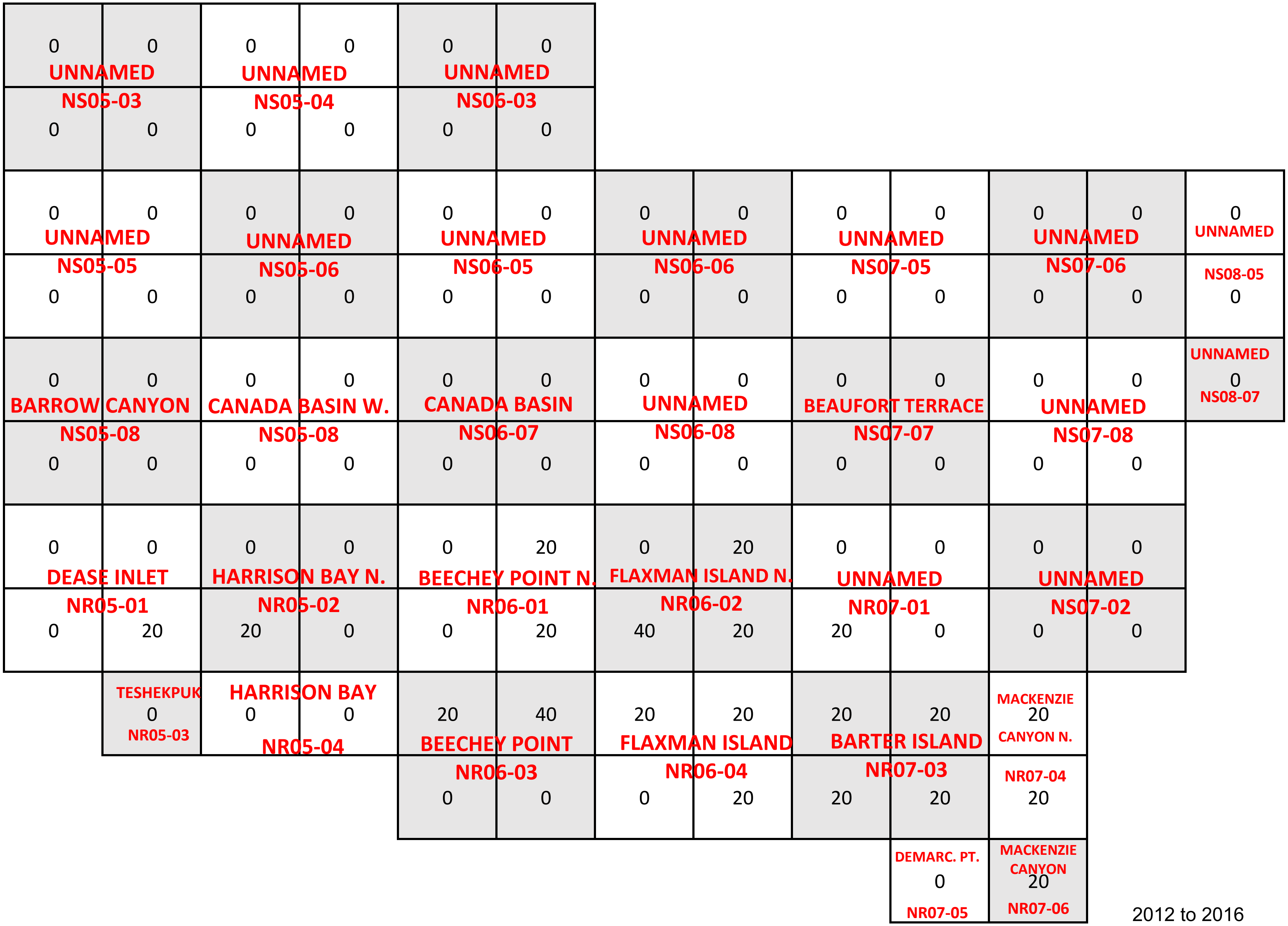
2012 to 2016

Sea Ice 7.3.14 Scenario 7.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea. 11-Oct 20-Oct



2012 to 2016

Sea Ice 7.3.15 Scenario 7.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea. 21-Oct 31-Oct



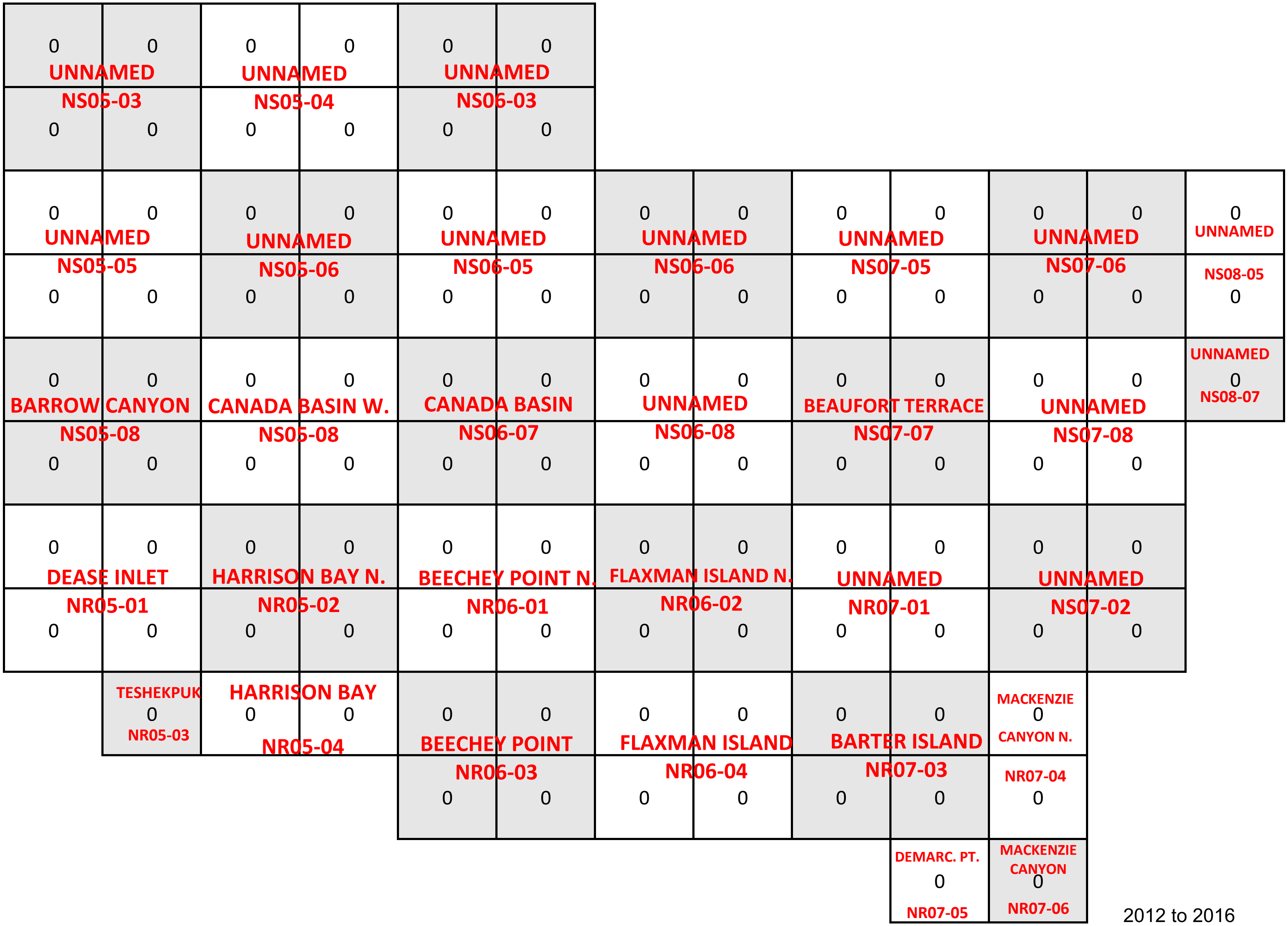
2012 to 2016
1-Nov 10-Nov

Sea Ice 7.3.16 Scenario 7.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea.

0 0 UNNAMED NS05-03 0 0	0 0 UNNAMED NS05-04 0 0	0 0 UNNAMED NS06-03 0 0				
0 0 UNNAMED NS05-05 0 0	0 0 UNNAMED NS05-06 0 0	0 0 UNNAMED NS06-05 0 0	0 0 UNNAMED NS06-06 0 0	0 0 UNNAMED NS07-05 0 0	0 0 UNNAMED NS07-06 0 0	0 UNNAMED NS08-05 0
0 0 BARROW CANYON NS05-08 0 0	0 0 CANADA BASIN W. NS05-08 0 0	0 0 CANADA BASIN NS06-07 0 0	0 0 UNNAMED NS06-08 0 0	0 0 BEAUFORT TERRACE NS07-07 0 0	0 0 UNNAMED NS07-08 0 0	UNNAMED 0 NS08-07
0 0 DEASE INLET NR05-01 0 0	0 0 HARRISON BAY N. NR05-02 0 0	0 0 BEECHEY POINT N. NR06-01 0 0	0 0 FLAXMAN ISLAND N. NR06-02 0 0	0 0 UNNAMED NR07-01 0 0	0 0 UNNAMED NS07-02 0 0	
TESHEKPUK 0 NR05-03	HARRISON BAY 0 0 NR05-04	0 0 BEECHEY POINT NR06-03 0 0	0 0 FLAXMAN ISLAND NR06-04 0 0	0 0 BARTER ISLAND NR07-03 0 0	MACKENZIE 0 CANYON N. NR07-04 0	
				DEMARC. PT. 0 NR07-05	MACKENZIE CANYON 0 NR07-06	

Sea Ice 7.3.17 Scenario 7.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea.

2012 to 2016
11-Nov 20-Nov



Sea Ice 7.3.18 Scenario 7.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea.

2012 to 2016
21-Nov 30-Nov

0 0 UNNAMED NS05-03 0 0	0 0 UNNAMED NS05-04 0 0	0 0 UNNAMED NS06-03 0 0				
0 0 UNNAMED NS05-05 0 0	0 0 UNNAMED NS05-06 0 0	0 0 UNNAMED NS06-05 0 0	0 0 UNNAMED NS06-06 0 0	0 0 UNNAMED NS07-05 0 0	0 0 UNNAMED NS07-06 0 0	0 UNNAMED NS08-05 0
0 0 BARROW CANYON NS05-08 0 0	0 0 CANADA BASIN W. NS05-08 0 0	0 0 CANADA BASIN NS06-07 0 0	0 0 UNNAMED NS06-08 0 0	0 0 BEAUFORT TERRACE NS07-07 0 0	0 0 UNNAMED NS07-08 0 0	UNNAMED 0 NS08-07
0 0 DEASE INLET NR05-01 0 0	0 0 HARRISON BAY N. NR05-02 0 0	0 0 BEECHEY POINT N. NR06-01 0 0	0 0 FLAXMAN ISLAND N. NR06-02 0 0	0 0 UNNAMED NR07-01 0 0	0 0 UNNAMED NS07-02 0 0	
TESHEKPUK 0 NR05-03	HARRISON BAY 0 NR05-04	0 0 BEECHEY POINT NR06-03 0 0	0 0 FLAXMAN ISLAND NR06-04 0 0	0 0 BARTER ISLAND NR07-03 0 0	MACKENZIE 0 CANYON N. NR07-04 0	
				DEMARC. PT. 0 NR07-05	MACKENZIE CANYON 0 NR07-06	

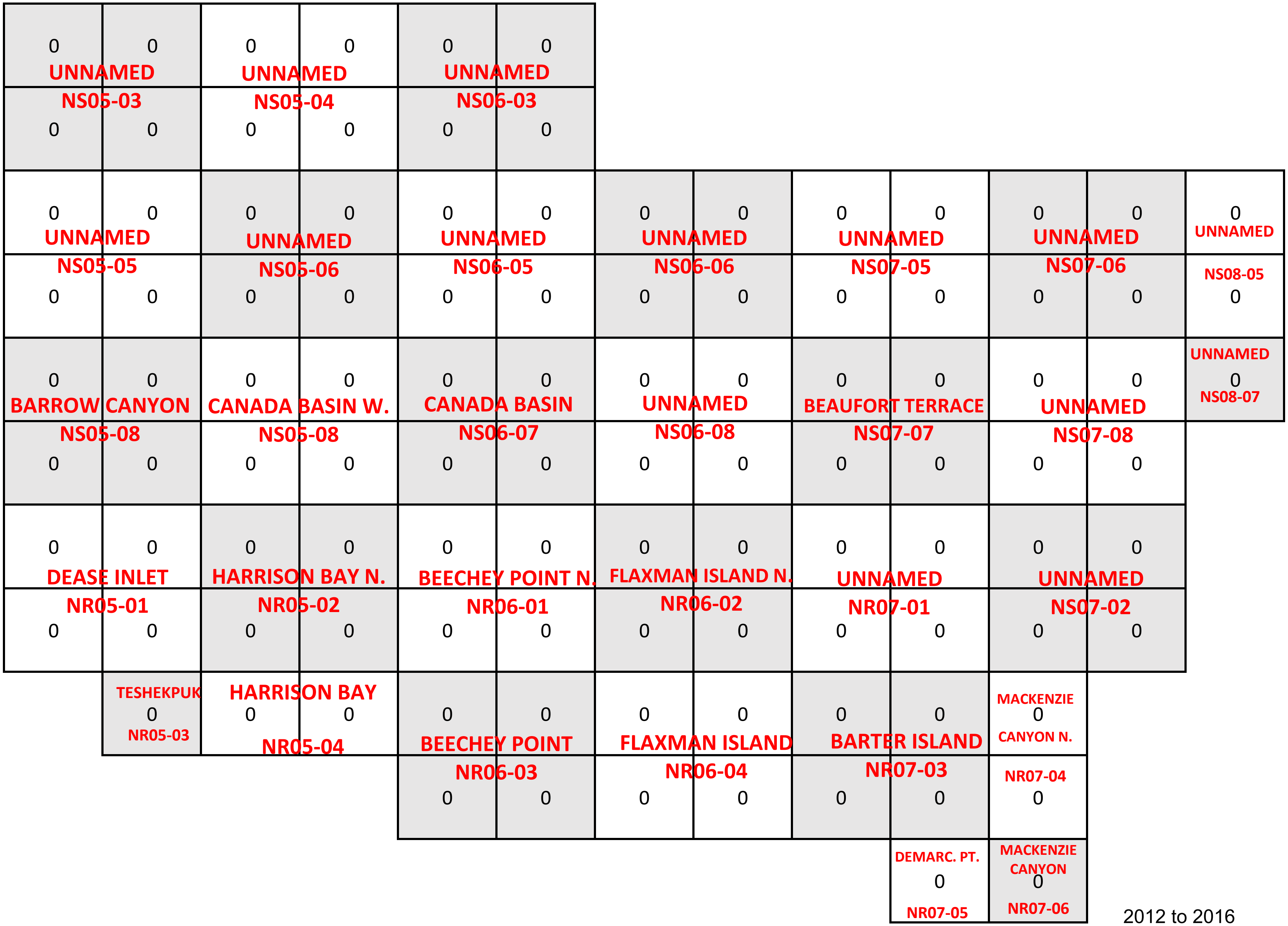
2012 to 2016
1-Dec 10-Dec

Sea Ice 7.3.19 Scenario 7.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea.

0 0 UNNAMED NS05-03 0 0	0 0 UNNAMED NS05-04 0 0	0 0 UNNAMED NS06-03 0 0				
0 0 UNNAMED NS05-05 0 0	0 0 UNNAMED NS05-06 0 0	0 0 UNNAMED NS06-05 0 0	0 0 UNNAMED NS06-06 0 0	0 0 UNNAMED NS07-05 0 0	0 0 UNNAMED NS07-06 0 0	0 UNNAMED NS08-05 0
0 0 BARROW CANYON NS05-08 0 0	0 0 CANADA BASIN W. NS05-08 0 0	0 0 CANADA BASIN NS06-07 0 0	0 0 UNNAMED NS06-08 0 0	0 0 BEAUFORT TERRACE NS07-07 0 0	0 0 UNNAMED NS07-08 0 0	UNNAMED 0 NS08-07
0 0 DEASE INLET NR05-01 0 0	0 0 HARRISON BAY N. NR05-02 0 0	0 0 BEECHEY POINT N. NR06-01 0 0	0 0 FLAXMAN ISLAND N. NR06-02 0 0	0 0 UNNAMED NR07-01 0 0	0 0 UNNAMED NS07-02 0 0	
TESHEKPUK 0 NR05-03	HARRISON BAY 0 0 NR05-04	0 0 BEECHEY POINT NR06-03 0 0	0 0 FLAXMAN ISLAND NR06-04 0 0	0 0 BARTER ISLAND NR07-03 0 0	MACKENZIE 0 CANYON N. NR07-04 0	
				DEMARC. PT. 0 NR07-05	MACKENZIE CANYON 0 NR07-06	

2012 to 2016

Sea Ice 7.3.20 Scenario 7.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea. 11-Dec 20-Dec

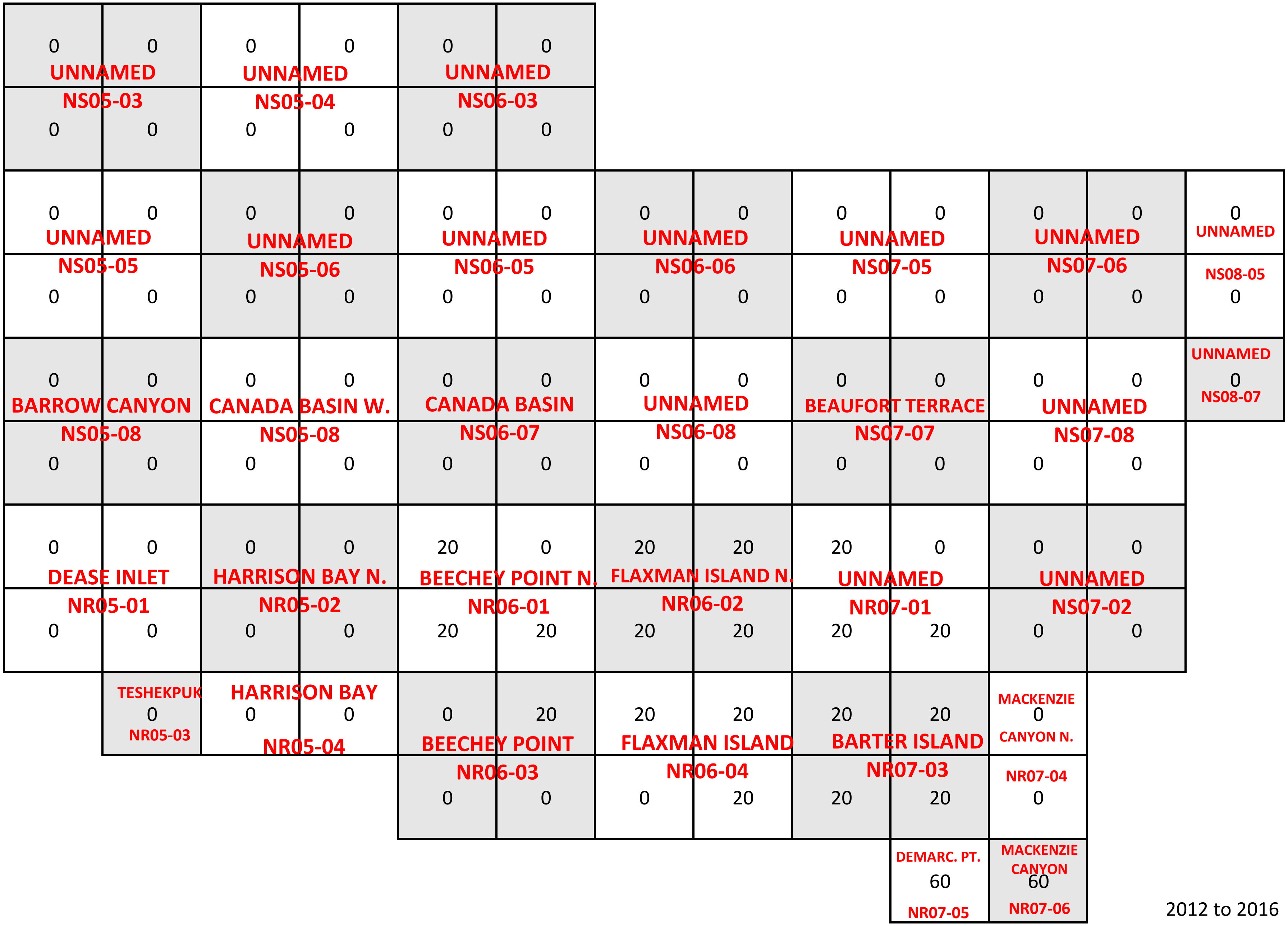


2012 to 2016

Sea Ice 7.3.21 Scenario 7.3: Percent probability of open water, 30 NM ice free radius, Beaufort Sea. 21-Dec 31-Dec

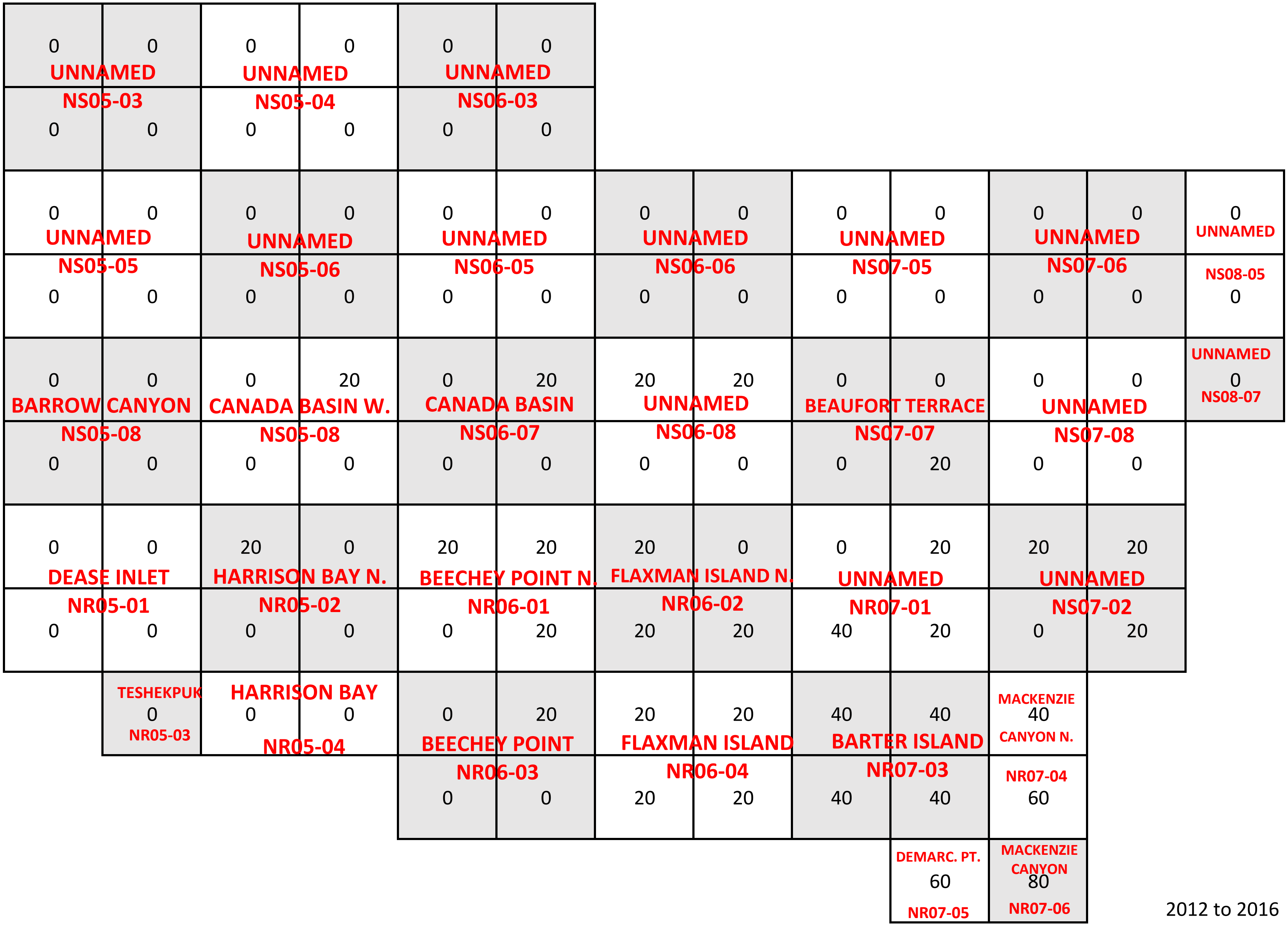
Scenario 7.4:
Safe Relief Well Deployment with Sea Ice Operating Capability in the Beaufort Sea.

Sea ice data for the probability of sea ice concentration from 0 to 8 tenths, for the period from June through December, 2012 to 2016, in the Beaufort Sea.



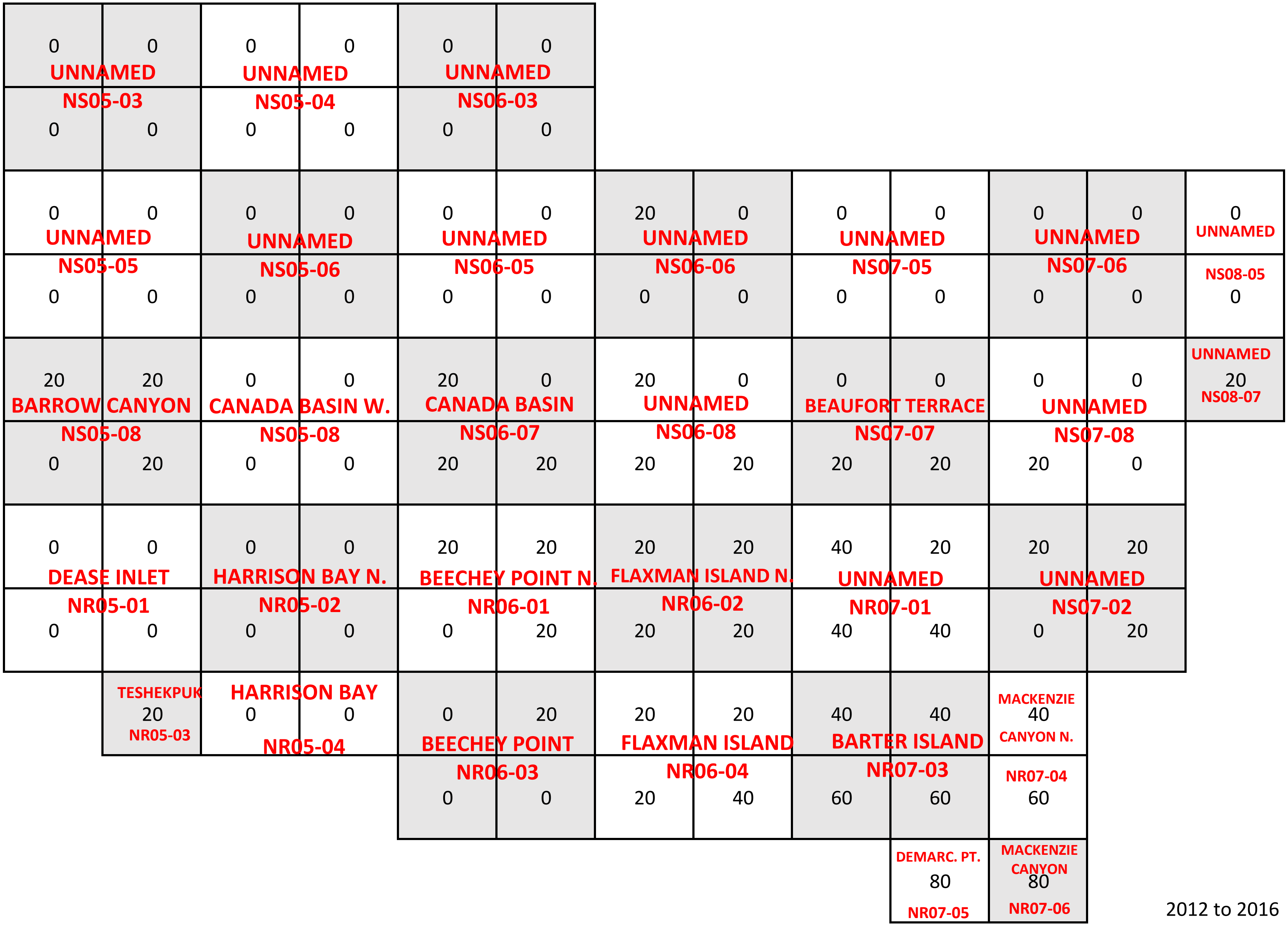
2012 to 2016

Sea Ice 7.4.1 Scenario 7.4: Percent probability of sea ice concentration from 0 to 8 tenths, Beaufort Sea. 1-Jun 10-Jun



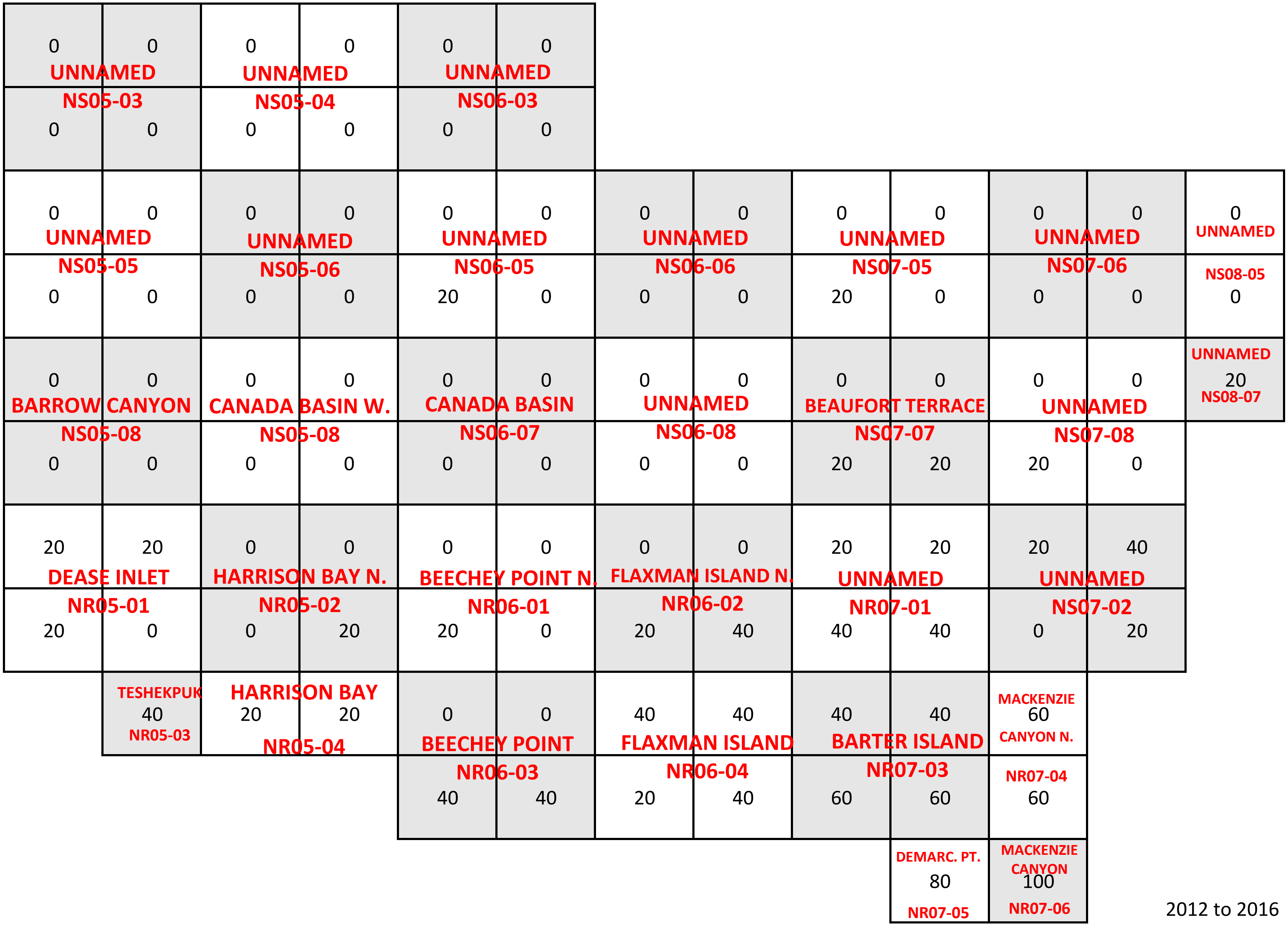
2012 to 2016

Sea Ice 7.4.2 Scenario 7.4: Percent probability of sea ice concentration from 0 to 8 tenths, Beaufort Sea. 11-Jun 20-Jun



2012 to 2016

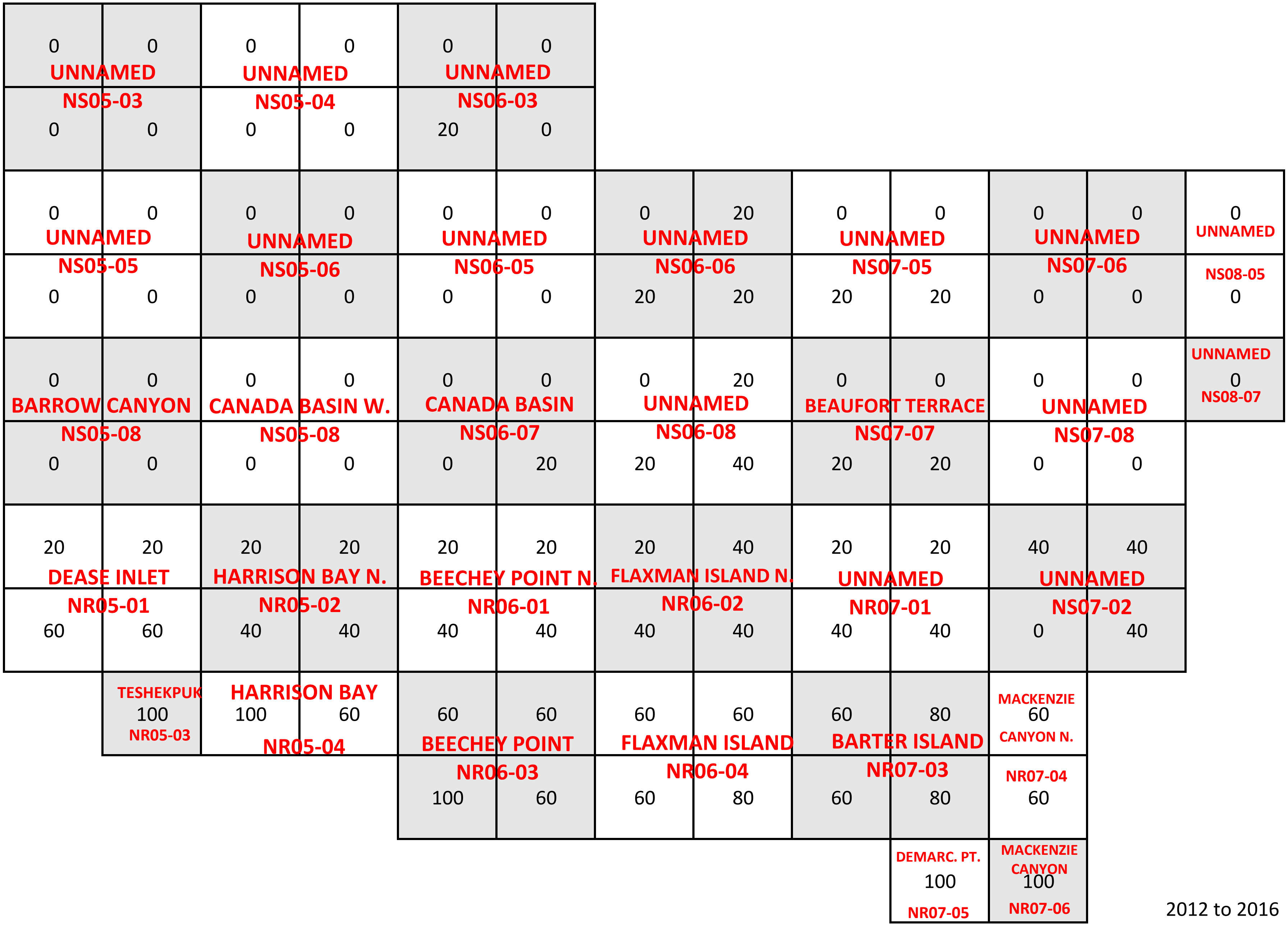
Sea Ice 7.4.3 Scenario 7.4: Percent probability of sea ice concentration from 0 to 8 tenths, Beaufort Sea. 21-Jun 30-Jun



UNNAMED	NS05-03	0	0	0	0
UNNAMED	NS05-04	0	0	0	0
UNNAMED	NS06-03	0	0	0	0
UNNAMED	NS05-05	0	0	0	0
UNNAMED	NS05-06	0	0	0	0
UNNAMED	NS06-05	0	0	20	0
UNNAMED	NS06-06	0	0	0	0
UNNAMED	NS07-05	0	0	20	0
UNNAMED	NS07-06	0	0	0	0
UNNAMED	NS08-05	0		0	
BARROW CANYON	NS05-08	0	0	0	0
CANADA BASIN W.	NS05-08	0	0	0	0
CANADA BASIN	NS06-07	0	0	0	0
UNNAMED	NS06-08	0	0	0	0
BEAUFORT TERRACE	NS07-07	0	0	20	20
UNNAMED	NS07-08	0	0	20	0
UNNAMED	NS08-07	20			
DEASE INLET	NR05-01	20	20	20	0
HARRISON BAY N.	NR05-02	0	0	0	20
BEECHEY POINT N.	NR06-01	0	0	20	0
FLAXMAN ISLAND N.	NR06-02	0	0	20	40
UNNAMED	NR07-01	20	20	40	40
UNNAMED	NS07-02	20	40	0	20
TESHEKPUK	NR05-03	40			
HARRISON BAY	NR05-04	20	20		
BEECHEY POINT	NR06-03	0	0	40	40
FLAXMAN ISLAND	NR06-04	40	40	20	40
BARTER ISLAND	NR07-03	40	40	60	60
MACKENZIE CANYON N.	NR07-04	60		60	
DEMARC. PT.	NR07-05	80			
MACKENZIE CANYON	NR07-06	100			

2012 to 2016

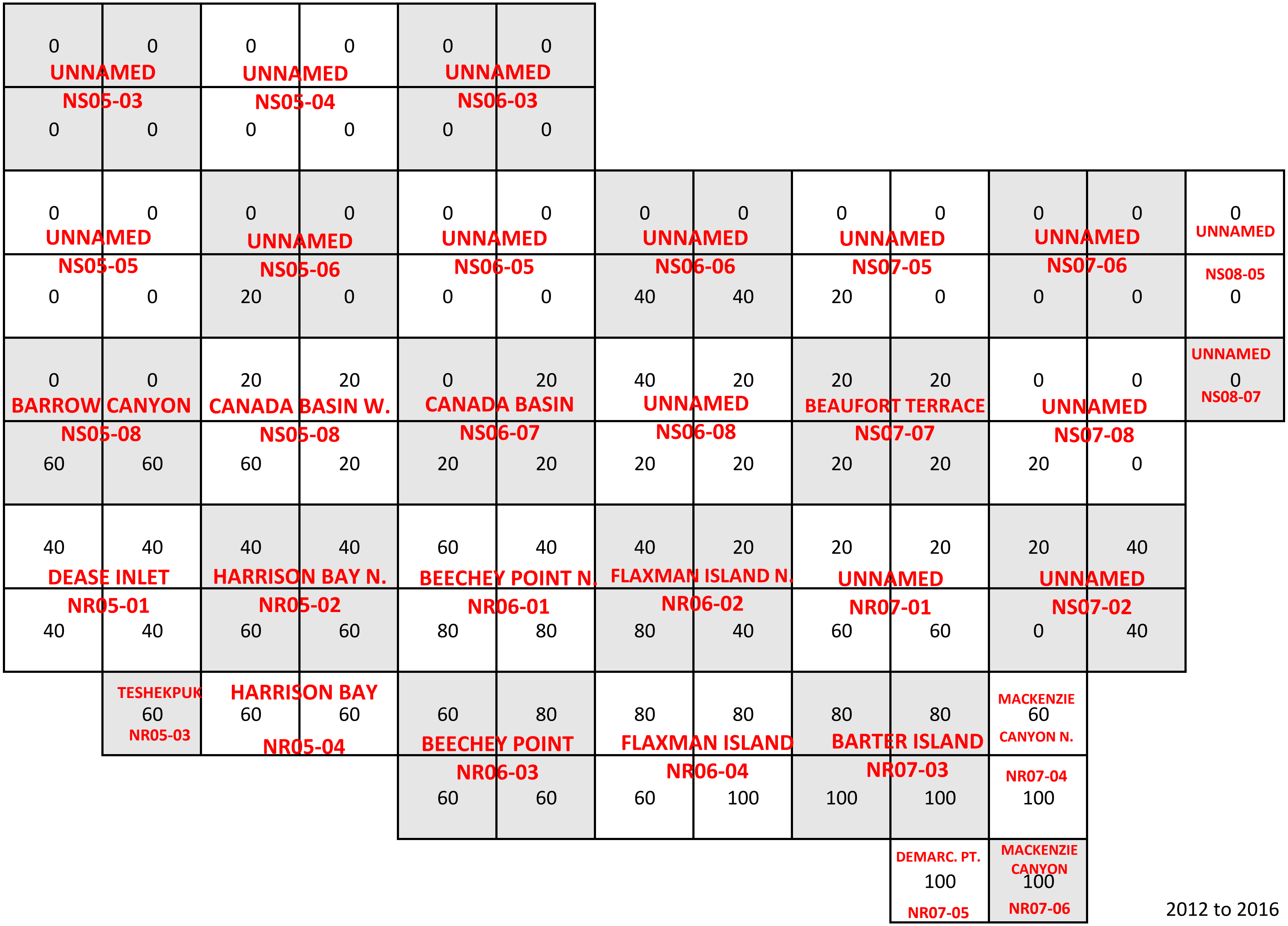
Sea Ice 7.4.4 Scenario 7.4: Percent probability of sea ice concentration from 0 to 8 tenths, Beaufort Sea. 1-Jul 10-Jul



UNNAMED	NS05-03	0	0	0	0
UNNAMED	NS05-04	0	0	0	0
UNNAMED	NS06-03	0	0	20	0
UNNAMED	NS05-05	0	0	0	0
UNNAMED	NS05-06	0	0	0	0
UNNAMED	NS06-05	0	0	0	0
UNNAMED	NS06-06	0	20	20	20
UNNAMED	NS07-05	0	0	20	20
UNNAMED	NS07-06	0	0	0	0
UNNAMED	NS08-05	0		0	
BARROW CANYON	NS05-08	0	0	0	0
CANADA BASIN W.	NS05-08	0	0	0	0
CANADA BASIN	NS06-07	0	0	0	20
UNNAMED	NS06-08	0	20	20	40
BEAUFORT TERRACE	NS07-07	0	0	20	20
UNNAMED	NS07-08	0	0	0	0
UNNAMED	NS08-07	0			
DEASE INLET	NR05-01	20	20	60	60
HARRISON BAY N.	NR05-02	20	20	40	40
BEECHEY POINT N.	NR06-01	20	20	40	40
FLAXMAN ISLAND N.	NR06-02	20	40	40	40
UNNAMED	NR07-01	20	20	40	40
UNNAMED	NS07-02	40	40	0	40
TESHEKPUK	NR05-03	100			
HARRISON BAY	NR05-04	100	60		
BEECHEY POINT	NR06-03	60	60	100	60
FLAXMAN ISLAND	NR06-04	60	60	60	80
BARTER ISLAND	NR07-03	60	80	60	80
MACKENZIE CANYON N.	NR07-04	60		60	
DEMARC. PT.	NR07-05	100			
MACKENZIE CANYON	NR07-06	100			

2012 to 2016

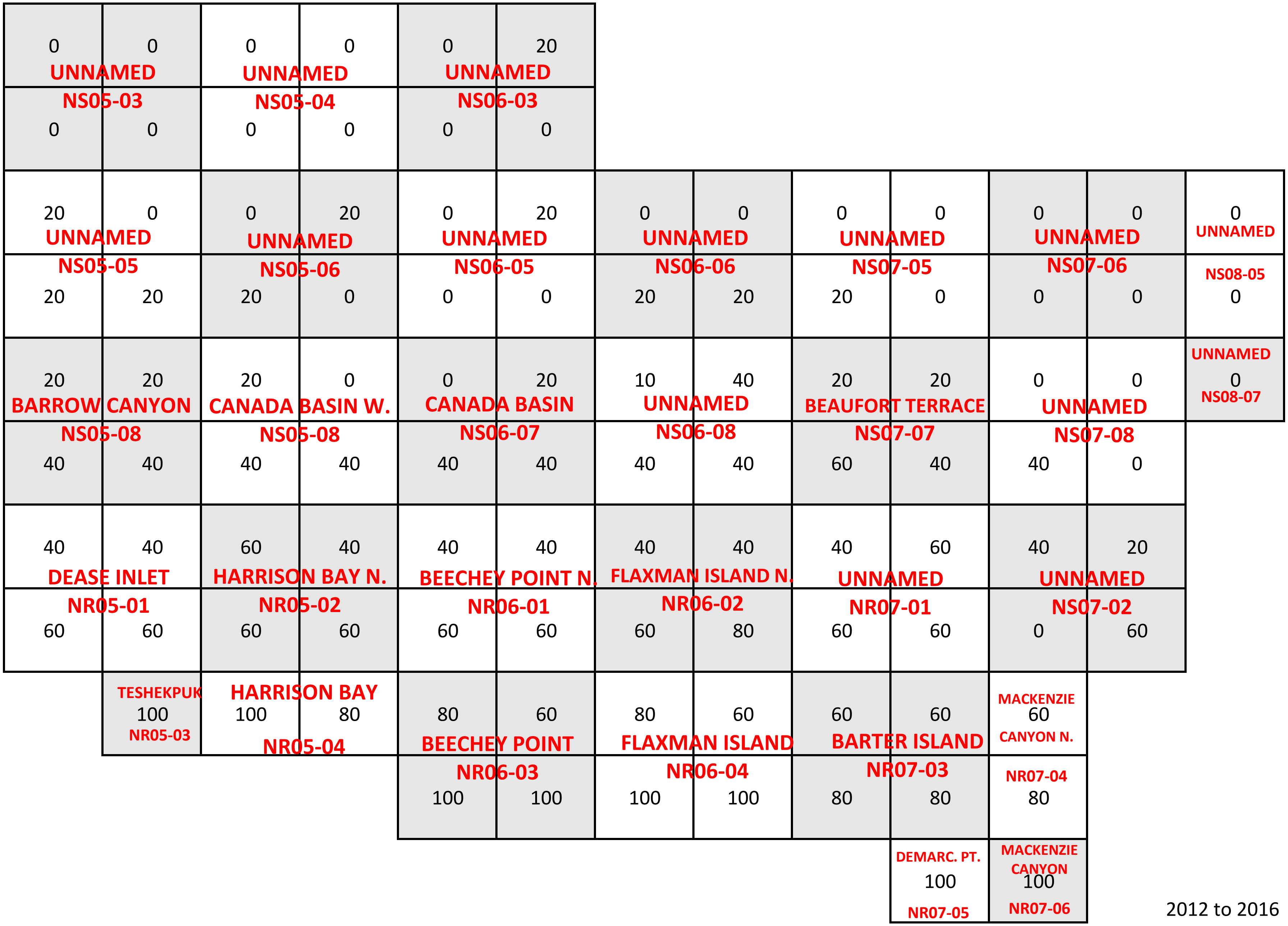
Sea Ice 7.4.5 Scenario 7.4: Percent probability of sea ice concentration from 0 to 8 tenths, Beaufort Sea. 11-Jul 20-Jul



0 0 UNNAMED NS05-03 0 0	0 0 UNNAMED NS05-04 0 0	0 0 UNNAMED NS06-03 0 0				
0 0 UNNAMED NS05-05 0 0	0 0 UNNAMED NS05-06 20 0	0 0 UNNAMED NS06-05 0 0	0 0 UNNAMED NS06-06 40 40	0 0 UNNAMED NS07-05 20 0	0 0 UNNAMED NS07-06 0 0	0 UNNAMED NS08-05 0
0 0 BARROW CANYON NS05-08 60 60	20 20 CANADA BASIN W. NS05-08 60 20	0 20 CANADA BASIN NS06-07 20 20	40 20 UNNAMED NS06-08 20 20	20 20 BEAUFORT TERRACE NS07-07 20 20	0 0 UNNAMED NS07-08 20 0	UNNAMED 0 NS08-07
40 40 DEASE INLET NR05-01 40 40	40 40 HARRISON BAY N. NR05-02 60 60	60 40 BEECHEY POINT N. NR06-01 80 80	40 20 FLAXMAN ISLAND N. NR06-02 80 40	20 20 UNNAMED NR07-01 60 60	20 40 UNNAMED NS07-02 0 40	
TESHEKPUK 60 NR05-03	HARRISON BAY 60 60 NR05-04	60 80 BEECHEY POINT NR06-03 60 60	80 80 FLAXMAN ISLAND NR06-04 60 100	80 80 BARTER ISLAND NR07-03 100 100	MACKENZIE 60 CANYON N. NR07-04 100	
				DEMARC. PT. 100 NR07-05	MACKENZIE CANYON 100 NR07-06	

2012 to 2016

Sea Ice 7.4.6 Scenario 7.4: Percent probability of sea ice concentration from 0 to 8 tenths, Beaufort Sea. 21-Jul 31-Jul



0 0 UNNAMED NS05-03 0 0	0 0 UNNAMED NS05-04 0 0	0 20 UNNAMED NS06-03 0 0				
20 0 UNNAMED NS05-05 20 20	0 20 UNNAMED NS05-06 20 0	0 20 UNNAMED NS06-05 0 0	0 0 UNNAMED NS06-06 20 20	0 0 UNNAMED NS07-05 20 0	0 0 UNNAMED NS07-06 0 0	0 UNNAMED NS08-05 0
20 20 BARROW CANYON NS05-08 40 40	20 0 CANADA BASIN W. NS05-08 40 40	0 20 CANADA BASIN NS06-07 40 40	10 40 UNNAMED NS06-08 40 40	20 20 BEAUFORT TERRACE NS07-07 60 40	0 0 UNNAMED NS07-08 40 0	UNNAMED 0 NS08-07
40 40 DEASE INLET NR05-01 60 60	60 40 HARRISON BAY N. NR05-02 60 60	40 40 BEECHEY POINT N. NR06-01 60 60	40 40 FLAXMAN ISLAND N. NR06-02 60 80	40 60 UNNAMED NR07-01 60 60	40 20 UNNAMED NS07-02 0 60	
TESHEKPUK 100 NR05-03	HARRISON BAY 100 80 NR05-04	80 60 BEECHEY POINT NR06-03 100 100	80 60 FLAXMAN ISLAND NR06-04 100 100	60 60 BARTER ISLAND NR07-03 80 80	MACKENZIE 60 CANYON N. NR07-04 80	
				DEMARC. PT. 100 NR07-05	MACKENZIE CANYON 100 NR07-06	

2012 to 2016

Sea Ice 7.4.7 Scenario 7.4: Percent probability of sea ice concentration from 0 to 8 tenths, Beaufort Sea. 1-Aug 10-Aug

0 0 UNNAMED NS05-03 0 0	0 0 UNNAMED NS05-04 0 0	0 0 UNNAMED NS06-03 20 20				
20 0 UNNAMED NS05-05 20 20	0 0 UNNAMED NS05-06 20 20	20 20 UNNAMED NS06-05 60 40	20 20 UNNAMED NS06-06 40 20	20 20 UNNAMED NS07-05 20 20	40 40 UNNAMED NS07-06 20 40	20 UNNAMED NS08-05 40
40 40 BARROW CANYON NS05-08 60 60	40 40 CANADA BASIN W. NS05-08 40 60	40 40 CANADA BASIN NS06-07 40 40	40 40 UNNAMED NS06-08 40 20	20 20 BEAUFORT TERRACE NS07-07 40 40	20 20 UNNAMED NS07-08 20 20	UNNAMED 20 NS08-07
80 60 DEASE INLET NR05-01 80 80	60 60 HARRISON BAY N. NR05-02 60 60	80 80 BEECHEY POINT N. NR06-01 60 80	80 80 FLAXMAN ISLAND N. NR06-02 80 80	80 60 UNNAMED NR07-01 80 100	20 40 UNNAMED NS07-02 40 40	
TESHEKPUK 100 NR05-03	HARRISON BAY 100 100 NR05-04	80 80 BEECHEY POINT NR06-03 100 80	80 80 FLAXMAN ISLAND NR06-04 80 100	80 80 BARTER ISLAND NR07-03 100 100	MACKENZIE 80 CANYON N. NR07-04 80	
				DEMARC. PT. 100 NR07-05	MACKENZIE CANYON 100 NR07-06	

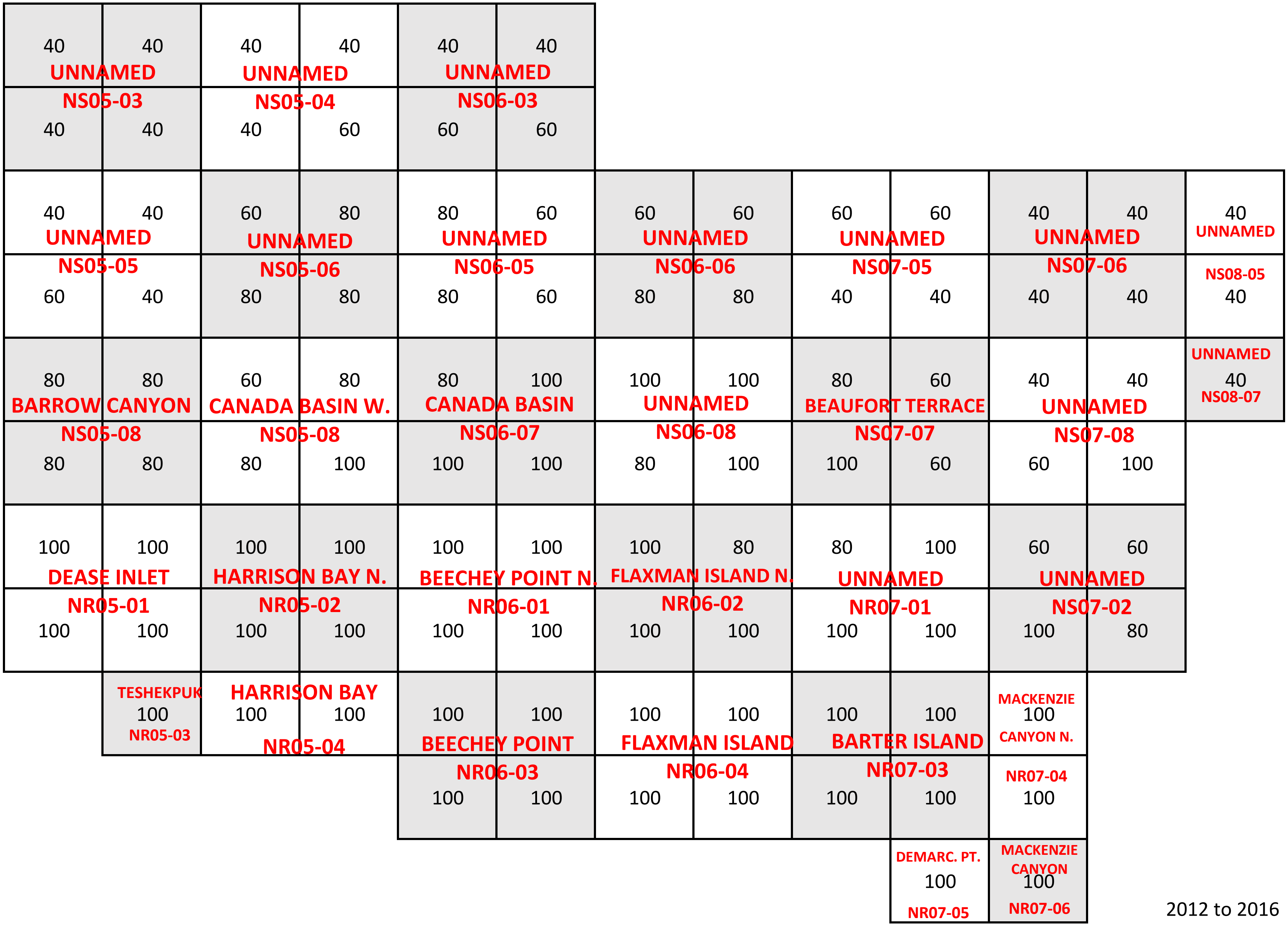
2012 to 2016

Sea Ice 7.4.8 Scenario 7.4: Percent probability of sea ice concentration from 0 to 8 tenths, Beaufort Sea. 11-Aug 20-Aug

UNNAMED	NS05-03	20	20	40	40
UNNAMED	NS05-04	20	40	40	20
UNNAMED	NS06-03	40	40	20	60
UNNAMED	NS05-05	40	40	60	40
UNNAMED	NS05-06	40	40	40	40
UNNAMED	NS06-05	40	20	40	40
UNNAMED	NS06-06	20	20	40	60
UNNAMED	NS07-05	20	20	40	20
UNNAMED	NS07-06	40	40	40	40
UNNAMED	NS08-05	40		40	
BARROW CANYON	NS05-08	80	80	100	80
CANADA BASIN W.	NS05-08	80	40	80	80
CANADA BASIN	NS06-07	60	60	60	60
UNNAMED	NS06-08	60	60	60	80
BEAUFORT TERRACE	NS07-07	40	40	60	60
UNNAMED	NS07-08	40	40	40	100
UNNAMED	NS08-07	40			
DEASE INLET	NR05-01	100	100	100	100
HARRISON BAY N.	NR05-02	100	80	100	80
BEECHEY POINT N.	NR06-01	80	80	80	80
FLAXMAN ISLAND N.	NR06-02	80	80	80	80
UNNAMED	NR07-01	80	60	80	80
UNNAMED	NS07-02	60	60	100	80
TESHEKPUK	NR05-03	100			
HARRISON BAY	NR05-04	100	100		
BEECHEY POINT	NR06-03	100	100	100	100
FLAXMAN ISLAND	NR06-04	100	100	100	100
BARTER ISLAND	NR07-03	100	80	100	100
MACKENZIE CANYON N.	NR07-04	80		100	
DEMARC. PT.	NR07-05	100			
MACKENZIE CANYON	NR07-06	100			

2012 to 2016

Sea Ice 7.4.9 Scenario 7.4: Percent probability of sea ice concentration from 0 to 8 tenths, Beaufort Sea. 21-Aug 31-Aug



UNNAMED	NS05-03	40	40	40	40
UNNAMED	NS05-04	40	40	40	60
UNNAMED	NS06-03	40	40	60	60
UNNAMED	NS05-05	40	40	60	40
UNNAMED	NS05-06	60	80	80	80
UNNAMED	NS06-05	80	60	80	60
UNNAMED	NS06-06	60	60	80	80
UNNAMED	NS07-05	60	60	40	40
UNNAMED	NS07-06	40	40	40	40
UNNAMED	NS08-05	40		40	
BARROW CANYON	NS05-08	80	80	80	80
CANADA BASIN W.	NS05-08	60	80	80	100
CANADA BASIN	NS06-07	80	100	100	100
UNNAMED	NS06-08	100	100	80	100
BEAUFORT TERRACE	NS07-07	80	60	100	60
UNNAMED	NS07-08	40	40	60	100
UNNAMED	NS08-07	40			
DEASE INLET	NR05-01	100	100	100	100
HARRISON BAY N.	NR05-02	100	100	100	100
BEECHEY POINT N.	NR06-01	100	100	100	100
FLAXMAN ISLAND N.	NR06-02	100	80	100	100
UNNAMED	NR07-01	80	100	100	100
UNNAMED	NS07-02	60	60	100	80
TESHEKPUK	NR05-03	100			
HARRISON BAY	NR05-04	100	100		
BEECHEY POINT	NR06-03	100	100	100	100
FLAXMAN ISLAND	NR06-04	100	100	100	100
BARTER ISLAND	NR07-03	100	100	100	100
MACKENZIE CANYON N.	NR07-04	100		100	
DEMARC. PT.	NR07-05	100			
MACKENZIE CANYON	NR07-06	100			

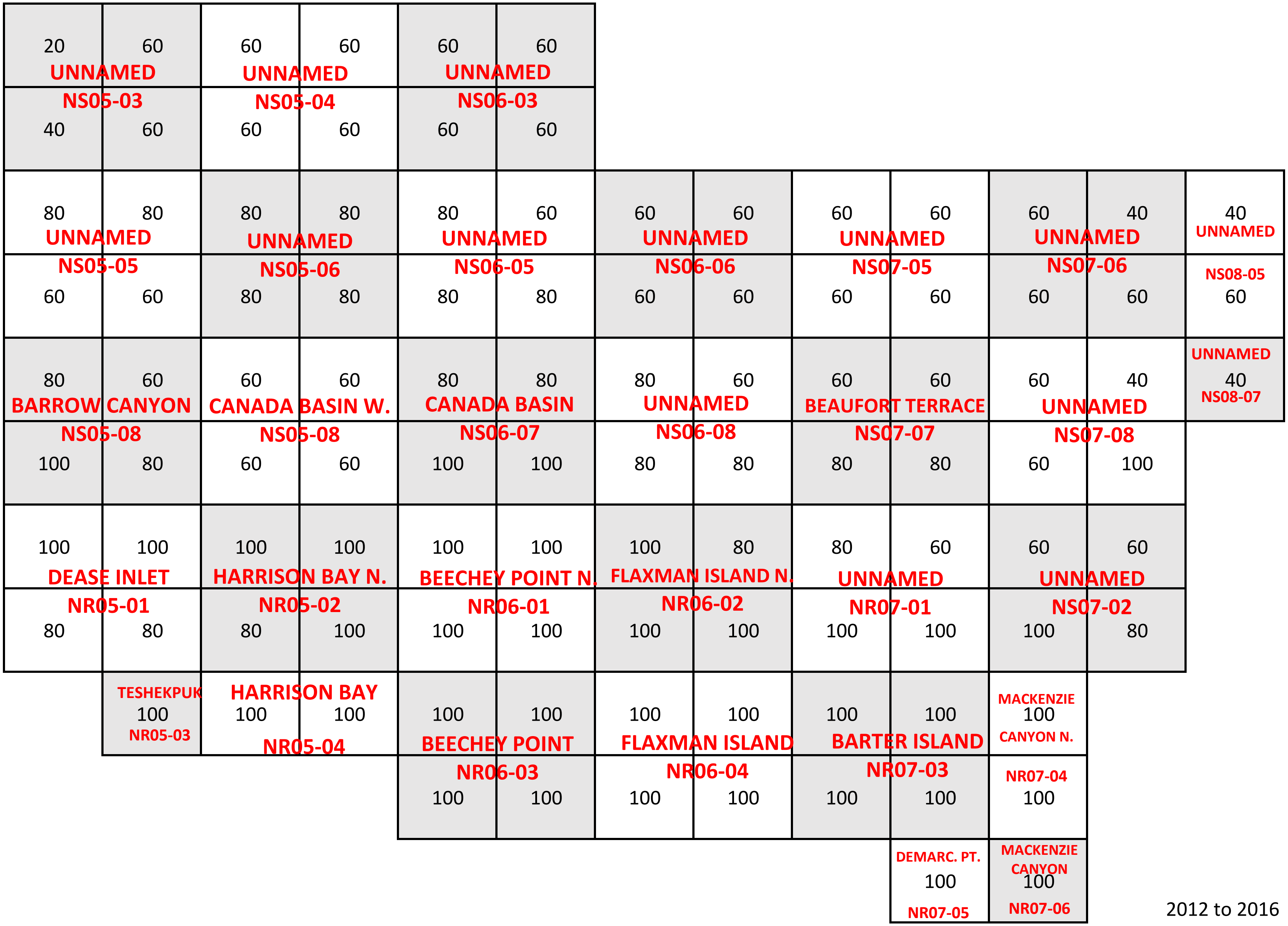
2012 to 2016

Sea Ice 7.4.10 Scenario 7.4: Percent probability of sea ice concentration from 0 to 8 tenths, Beaufort Sea. 1-Sep 10-Sep

UNNAMED	NS05-03	40	40	40	60
UNNAMED	NS05-04	40	40	60	60
UNNAMED	NS06-03	60	60	60	60
UNNAMED	NS05-05	60	60	80	80
UNNAMED	NS05-06	60	60	60	60
UNNAMED	NS06-05	60	60	80	80
UNNAMED	NS06-06	60	60	80	60
UNNAMED	NS07-05	60	60	60	60
UNNAMED	NS07-06	60	60	60	60
UNNAMED	NS08-05	60		60	
BARROW CANYON	NS05-08	100	80	100	100
CANADA BASIN W.	NS05-08	80	80	80	80
CANADA BASIN	NS06-07	80	80	100	100
UNNAMED	NS06-08	80	60	80	80
BEAUFORT TERRACE	NS07-07	40	60	60	60
UNNAMED	NS07-08	40	60	60	100
UNNAMED	NS08-07	60			
DEASE INLET	NR05-01	100	100	80	80
HARRISON BAY N.	NR05-02	100	100	80	100
BEECHEY POINT N.	NR06-01	100	100	100	100
FLAXMAN ISLAND N.	NR06-02	100	80	100	100
UNNAMED	NR07-01	80	80	100	100
UNNAMED	NS07-02	60	60	100	60
TESHEKPUK	NR05-03	100			
HARRISON BAY	NR05-04	100	100		
BEECHEY POINT	NR06-03	100	100	100	100
FLAXMAN ISLAND	NR06-04	100	100	100	100
BARTER ISLAND	NR07-03	100	100	100	100
MACKENZIE CANYON N.	NR07-04	100		100	
DEMARC. PT.	NR07-05	100			
MACKENZIE CANYON	NR07-06	100			

2012 to 2016

Sea Ice 7.4.11 Scenario 7.4: Percent probability of sea ice concentration from 0 to 8 tenths, Beaufort Sea. 11-Sep 20-Sep



20 60 UNNAMED NS05-03 40 60
60 60 UNNAMED NS05-04 60 60
60 60 UNNAMED NS06-03 60 60

80 80 UNNAMED NS05-05 60 60
80 80 UNNAMED NS05-06 80 80
80 60 UNNAMED NS06-05 80 80
60 60 UNNAMED NS06-06 60 60
60 60 UNNAMED NS07-05 60 60
60 40 UNNAMED NS07-06 60 60
40 UNNAMED NS08-05 60

80 60 BARROW CANYON NS05-08 100 80
60 60 CANADA BASIN W. NS05-08 60 60
80 80 CANADA BASIN NS06-07 100 100
80 60 UNNAMED NS06-08 80 80
60 60 BEAUFORT TERRACE NS07-07 80 80
60 40 UNNAMED NS07-08 60 100
UNNAMED 40 NS08-07

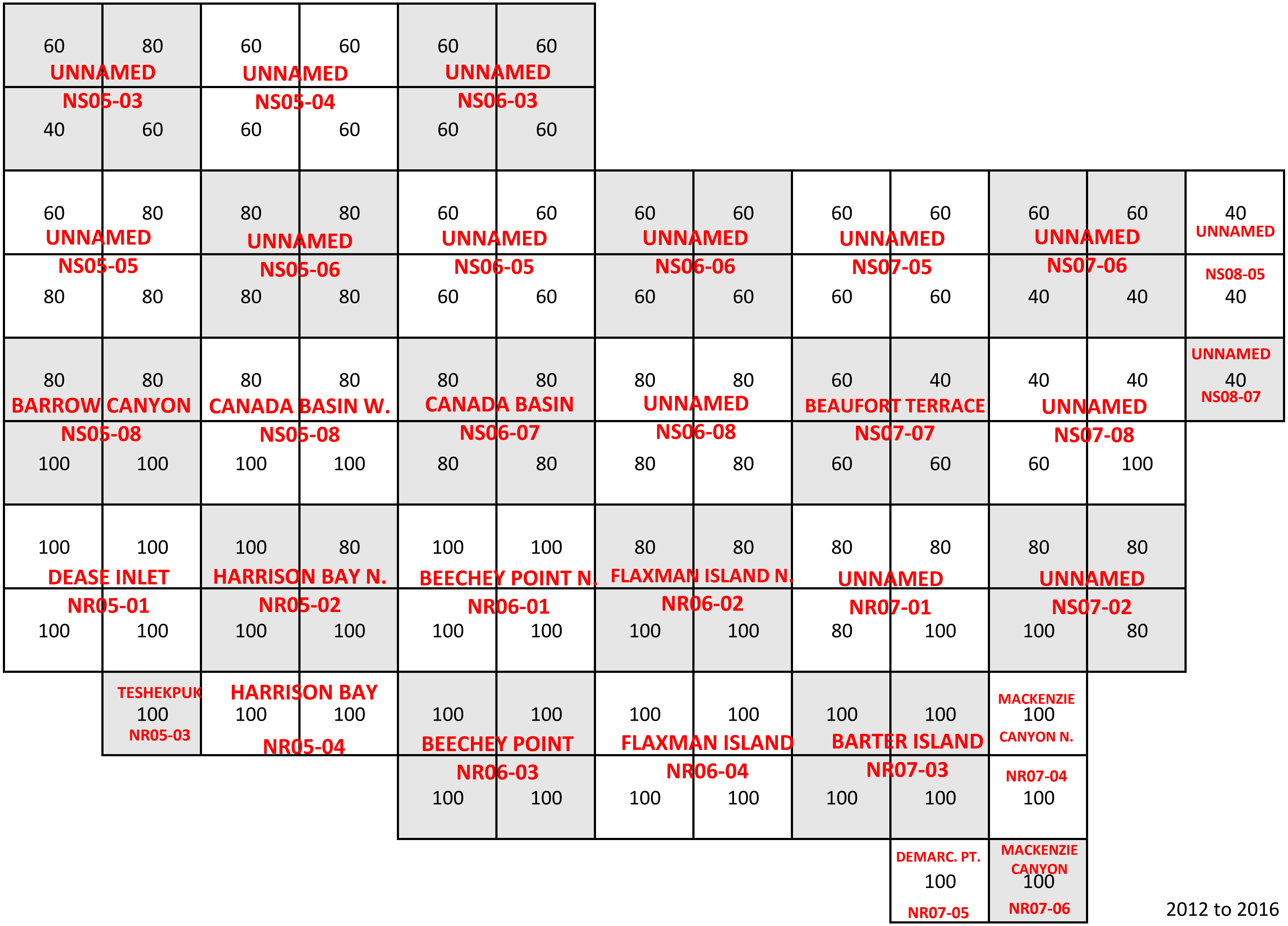
100 100 DEASE INLET NR05-01 80 80
100 100 HARRISON BAY N. NR05-02 80 100
100 100 BEECHEY POINT N. NR06-01 100 100
100 80 FLAXMAN ISLAND N. NR06-02 100 100
80 60 UNNAMED NR07-01 100 100
60 60 UNNAMED NS07-02 100 80

TESHEKPUK 100 NR05-03
HARRISON BAY 100 100 NR05-04
100 100 BEECHEY POINT NR06-03 100 100
100 100 FLAXMAN ISLAND NR06-04 100 100
100 100 BARTER ISLAND NR07-03 100 100
MACKENZIE 100 CANYON N. NR07-04 100

DEMARC. PT. 100 NR07-05
MACKENZIE CANYON 100 NR07-06

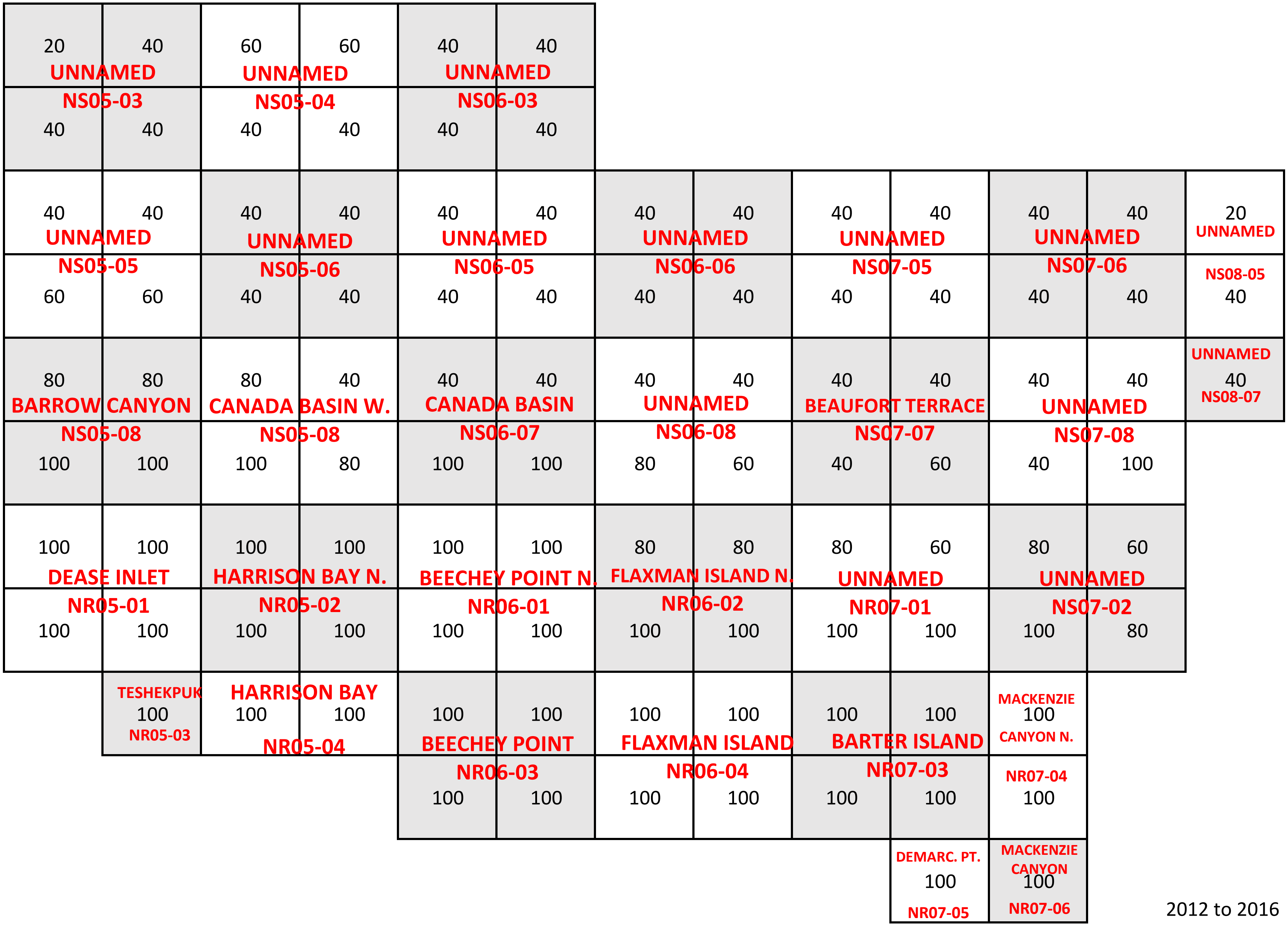
2012 to 2016

Sea Ice 7.4.12 Scenario 7.4: Percent probability of sea ice concentration from 0 to 8 tenths, Beaufort Sea. 21-Sep 30-Sep



2012 to 2016

Sea Ice 7.4.13 Scenario 7.4: Percent probability of sea ice concentration from 0 to 8 tenths, Beaufort Sea. 1-Oct 10-Oct



20 40 UNNAMED NS05-03 40 40

60 60 UNNAMED NS05-04 40 40

40 40 UNNAMED NS06-03 40 40

40 40 UNNAMED NS05-05 60 60

40 40 UNNAMED NS05-06 40 40

40 40 UNNAMED NS06-05 40 40

40 40 UNNAMED NS06-06 40 40

40 40 UNNAMED NS07-05 40 40

40 40 UNNAMED NS07-06 40 40

20 UNNAMED NS08-05 40

80 80 BARROW CANYON NS05-08 100 100

80 40 CANADA BASIN W. NS05-08 100 80

40 40 CANADA BASIN NS06-07 100 100

40 40 UNNAMED NS06-08 80 60

40 40 BEAUFORT TERRACE NS07-07 40 60

40 40 UNNAMED NS07-08 40 100

UNNAMED 40 NS08-07

100 100 DEASE INLET NR05-01 100 100

100 100 HARRISON BAY N. NR05-02 100 100

100 100 BEECHEY POINT N. NR06-01 100 100

80 80 FLAXMAN ISLAND N. NR06-02 100 100

80 60 UNNAMED NR07-01 100 100

80 60 UNNAMED NS07-02 100 80

TESHEKPUK 100 NR05-03

HARRISON BAY 100 100 NR05-04

100 100 BEECHEY POINT NR06-03 100 100

100 100 FLAXMAN ISLAND NR06-04 100 100

100 100 BARTER ISLAND NR07-03 100 100

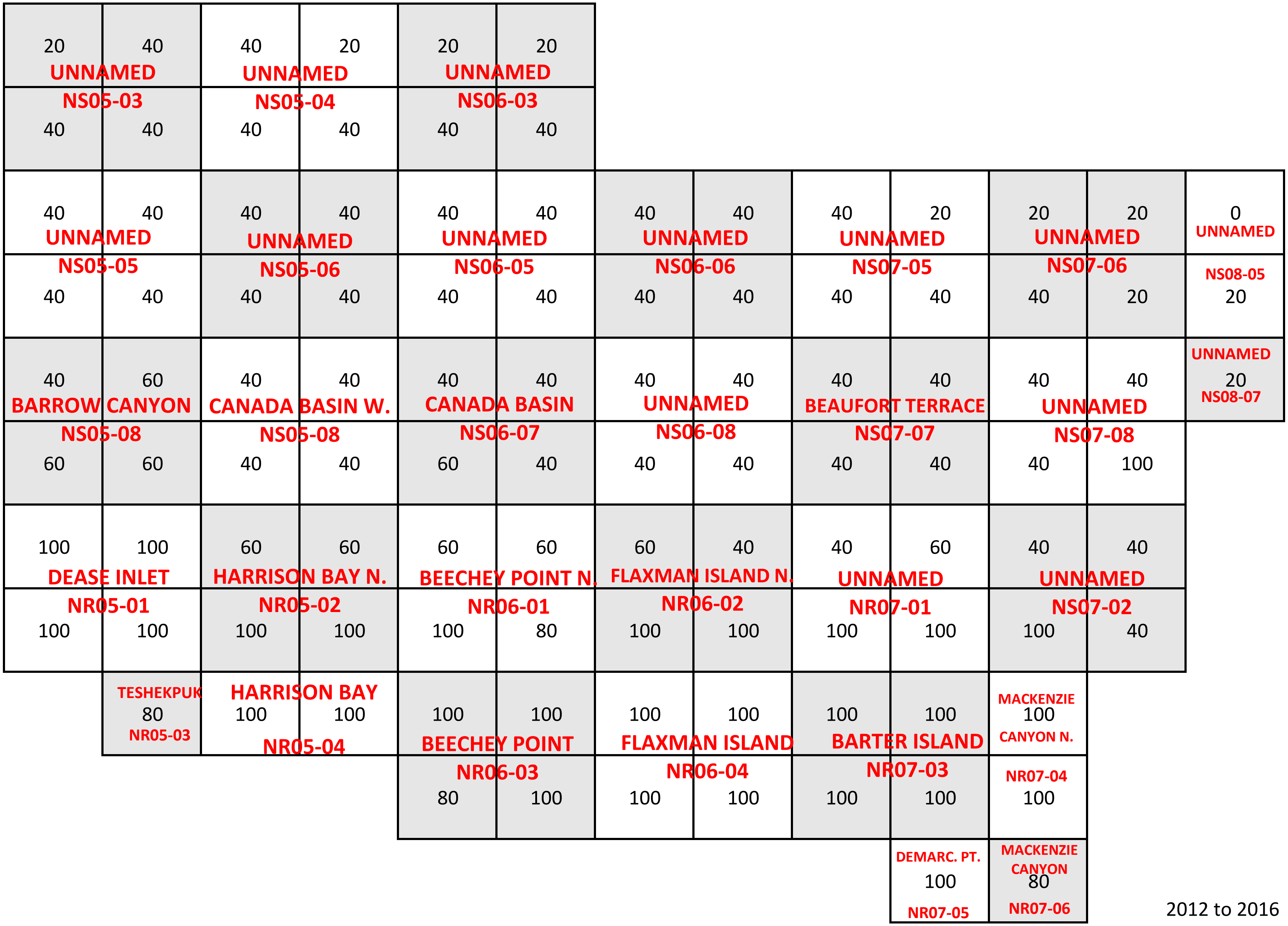
MACKENZIE 100 CANYON N. NR07-04 100

DEMARC. PT. 100 NR07-05

MACKENZIE CANYON 100 NR07-06

2012 to 2016

Sea Ice 7.4.14 Scenario 7.4: Percent probability of sea ice concentration from 0 to 8 tenths, Beaufort Sea. 11-Oct 20-Oct



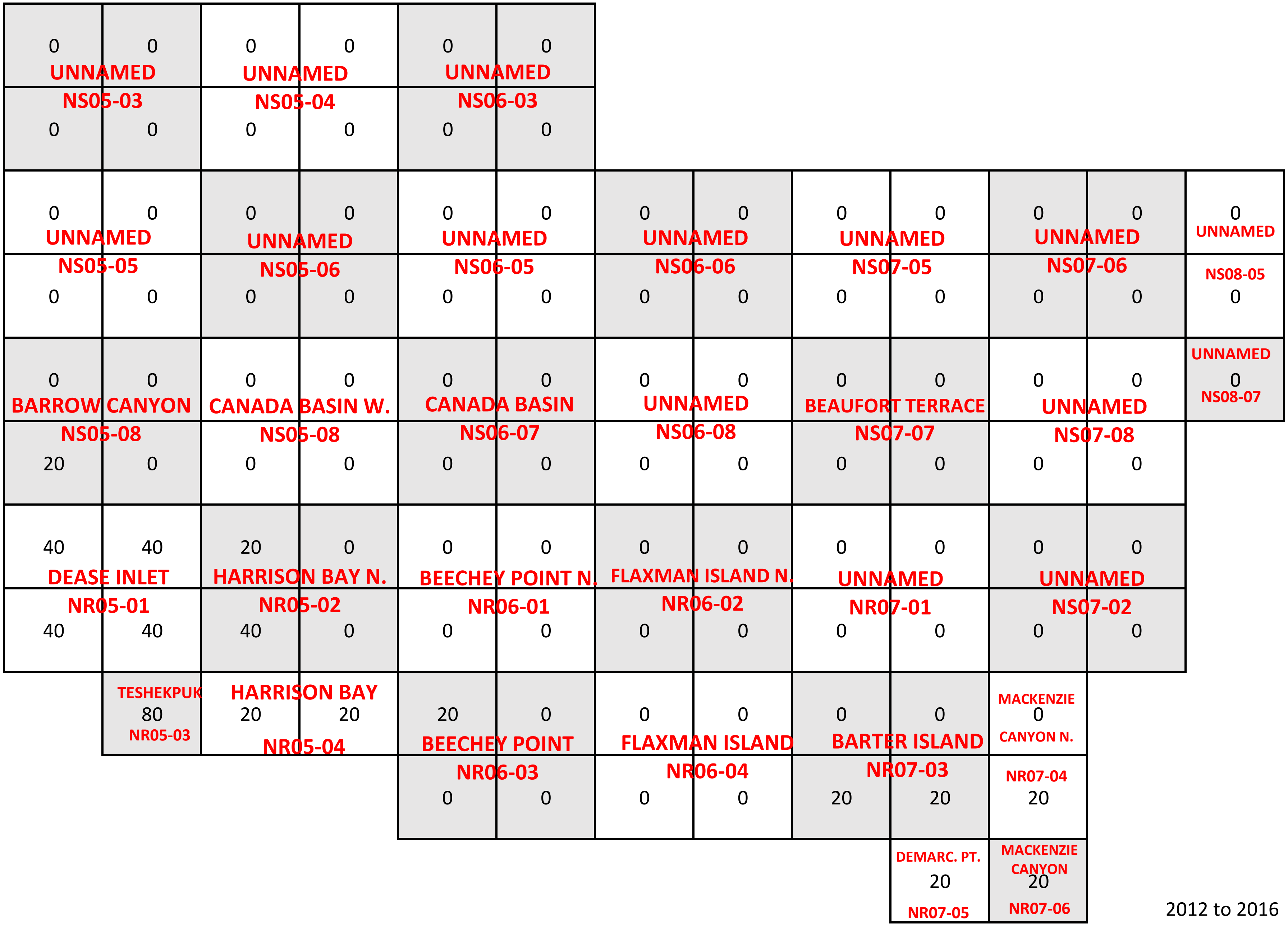
2012 to 2016

Sea Ice 7.4.15 Scenario 7.4: Percent probability of sea ice concentration from 0 to 8 tenths, Beaufort Sea. 21-Oct 31-Oct

UNNAMED	NS05-03	0	0	0	0
UNNAMED	NS05-04	0	0	0	0
UNNAMED	NS06-03	0	0	0	0
UNNAMED	NS05-05	0	20	20	20
UNNAMED	NS05-06	20	20	20	20
UNNAMED	NS06-05	0	0	0	0
UNNAMED	NS06-06	0	0	0	0
UNNAMED	NS07-05	0	0	0	0
UNNAMED	NS07-06	0	0	0	0
UNNAMED	NS08-05	0		0	
BARROW CANYON	NS05-08	20	0	20	20
CANADA BASIN W.	NS05-08	0	0	20	0
CANADA BASIN	NS06-07	0	0	0	0
UNNAMED	NS06-08	0	0	0	20
BEAUFORT TERRACE	NS07-07	0	0	20	0
UNNAMED	NS07-08	0	0	0	0
UNNAMED	NS08-07	0			
DEASE INLET	NR05-01	20	40	60	40
HARRISON BAY N.	NR05-02	20	40	40	40
BEECHEY POINT N.	NR06-01	40	40	40	40
FLAXMAN ISLAND N.	NR06-02	20	20	40	40
UNNAMED	NR07-01	20	0	40	0
UNNAMED	NS07-02	0	0	0	0
TESHEKPUK	NR05-03	60			
HARRISON BAY	NR05-04	20	20		
BEECHEY POINT	NR06-03	40	40	20	40
FLAXMAN ISLAND	NR06-04	40	40	40	40
BARTER ISLAND	NR07-03	40	40	40	20
MACKENZIE CANYON N.	NR07-04	20		20	
DEMARC. PT.	NR07-05	60			
MACKENZIE CANYON	NR07-06	40			

2012 to 2016

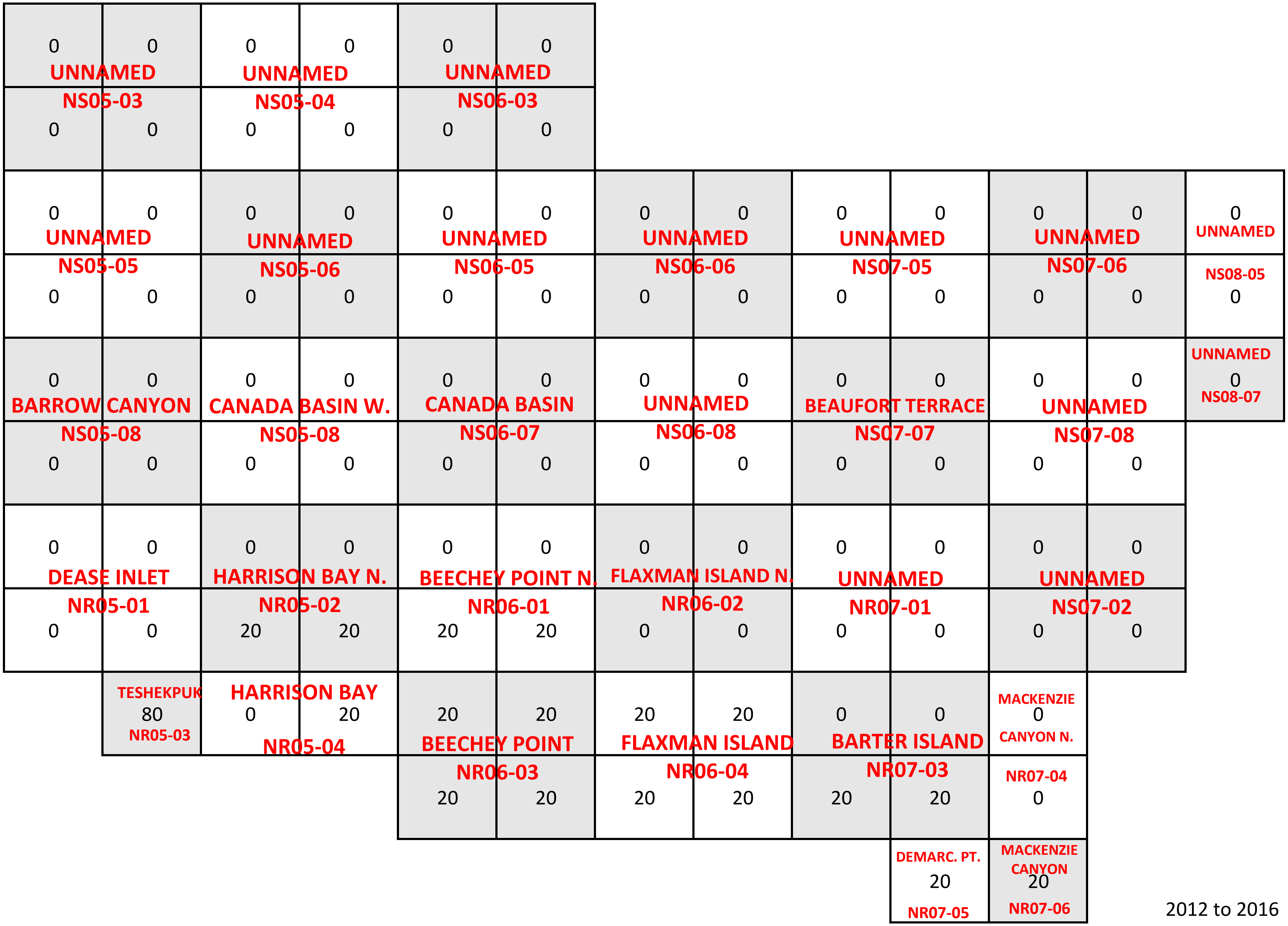
Sea Ice 7.4.16 Scenario 7.4: Percent probability of sea ice concentration from 0 to 8 tenths, Beaufort Sea. 1-Nov 10-Nov



UNNAMED	NS05-03	0	0	0	0
UNNAMED	NS05-04	0	0	0	0
UNNAMED	NS06-03	0	0	0	0
UNNAMED	NS05-05	0	0	0	0
UNNAMED	NS05-06	0	0	0	0
UNNAMED	NS06-05	0	0	0	0
UNNAMED	NS06-06	0	0	0	0
UNNAMED	NS07-05	0	0	0	0
UNNAMED	NS07-06	0	0	0	0
UNNAMED	NS08-05	0		0	
BARROW CANYON	NS05-08	0	0	20	0
CANADA BASIN W.	NS05-08	0	0	0	0
CANADA BASIN	NS06-07	0	0	0	0
UNNAMED	NS06-08	0	0	0	0
BEAUFORT TERRACE	NS07-07	0	0	0	0
UNNAMED	NS07-08	0	0	0	0
UNNAMED	NS08-07	0			
DEASE INLET	NR05-01	40	40	40	40
HARRISON BAY N.	NR05-02	20	0	40	0
BEECHEY POINT N.	NR06-01	0	0	0	0
FLAXMAN ISLAND N.	NR06-02	0	0	0	0
UNNAMED	NR07-01	0	0	0	0
UNNAMED	NS07-02	0	0	0	0
TESHEKPUK	NR05-03	80			
HARRISON BAY	NR05-04	20	20		
BEECHEY POINT	NR06-03	20	0	0	0
FLAXMAN ISLAND	NR06-04	0	0	0	0
BARTER ISLAND	NR07-03	0	0	20	20
MACKENZIE CANYON N.	NR07-04	0		20	
DEMARC. PT.	NR07-05	20			
MACKENZIE CANYON	NR07-06	20			

2012 to 2016

Sea Ice 7.4.17 Scenario 7.4: Percent probability of sea ice concentration from 0 to 8 tenths, Beaufort Sea. 11-Nov 20-Nov



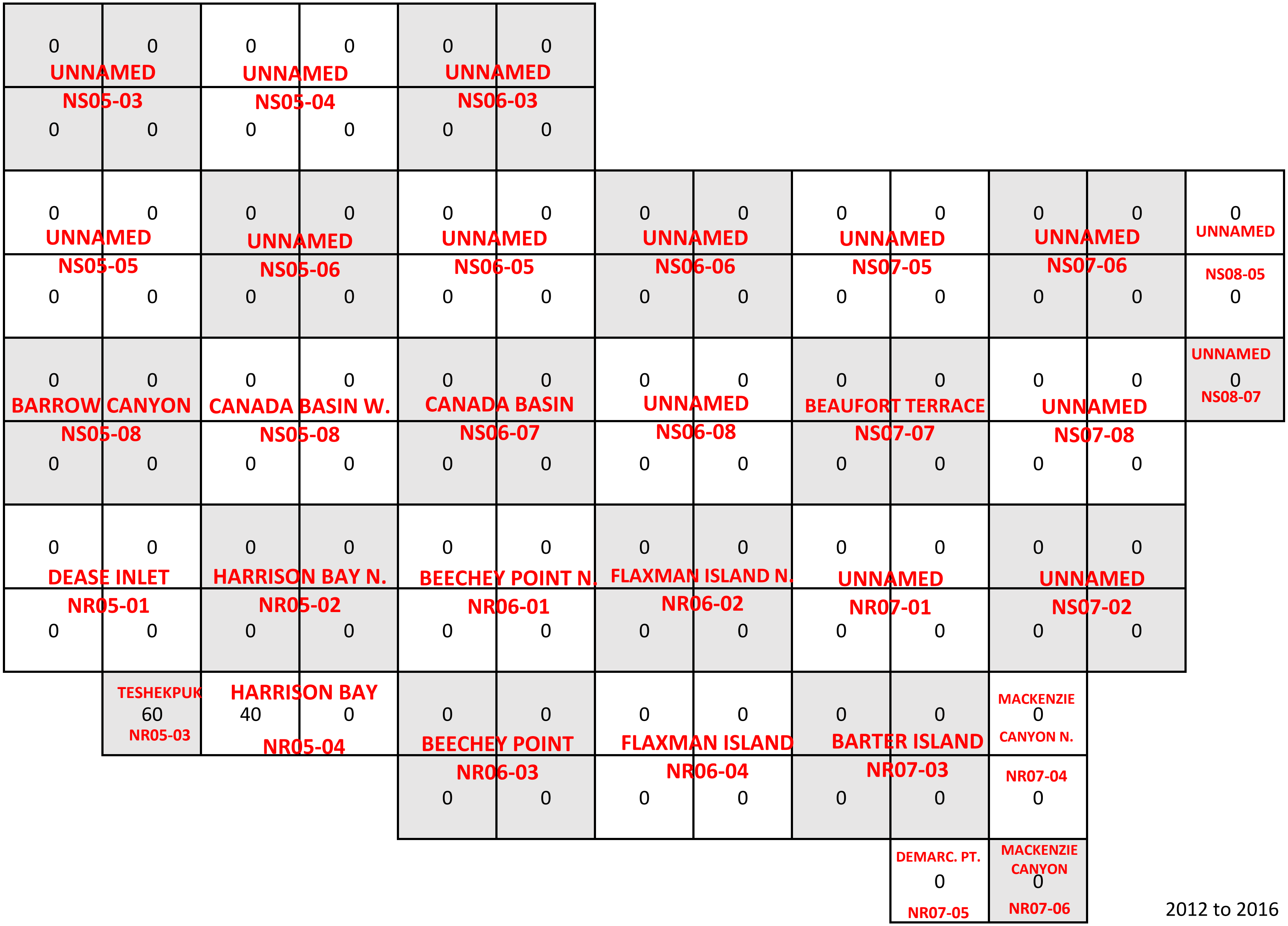
2012 to 2016

Sea Ice 7.4.18 Scenario 7.4: Percent probability of sea ice concentration from 0 to 8 tenths, Beaufort Sea. 21-Nov 30-Nov

0 0 UNNAMED NS05-03 0 0	0 0 UNNAMED NS05-04 0 0	0 0 UNNAMED NS06-03 0 0				
0 0 UNNAMED NS05-05 0 0	0 0 UNNAMED NS05-06 0 0	0 0 UNNAMED NS06-05 0 0	0 0 UNNAMED NS06-06 0 0	0 0 UNNAMED NS07-05 0 0	0 0 UNNAMED NS07-06 0 0	0 UNNAMED NS08-05 0
0 0 BARROW CANYON NS05-08 0 0	0 0 CANADA BASIN W. NS05-08 0 0	0 0 CANADA BASIN NS06-07 0 0	0 0 UNNAMED NS06-08 0 0	0 0 BEAUFORT TERRACE NS07-07 0 0	0 0 UNNAMED NS07-08 0 0	UNNAMED 0 NS08-07
0 0 DEASE INLET NR05-01 0 0	0 0 HARRISON BAY N. NR05-02 0 0	0 0 BEECHEY POINT N. NR06-01 0 0	0 0 FLAXMAN ISLAND N. NR06-02 0 0	0 0 UNNAMED NR07-01 0 0	0 0 UNNAMED NS07-02 0 0	
TESHEKPUK 80 NR05-03	HARRISON BAY 20 0 NR05-04	0 0 BEECHEY POINT NR06-03 0 0	0 0 FLAXMAN ISLAND NR06-04 0 0	0 0 BARTER ISLAND NR07-03 0 0	MACKENZIE 0 CANYON N. NR07-04 0	
				DEMARC. PT. 0 NR07-05	MACKENZIE CANYON 0 NR07-06	

2012 to 2016

Sea Ice 7.4.19 Scenario 7.4: Percent probability of sea ice concentration from 0 to 8 tenths, Beaufort Sea. 1-Dec 10-Dec



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UNNAMED	NS08-07	0			
DEASE INLET	NR05-01	0	0	0	0
HARRISON BAY N.	NR05-02	0	0	0	0
BEECHEY POINT N.	NR06-01	0	0	0	0
FLAXMAN ISLAND N.	NR06-02	0	0	0	0
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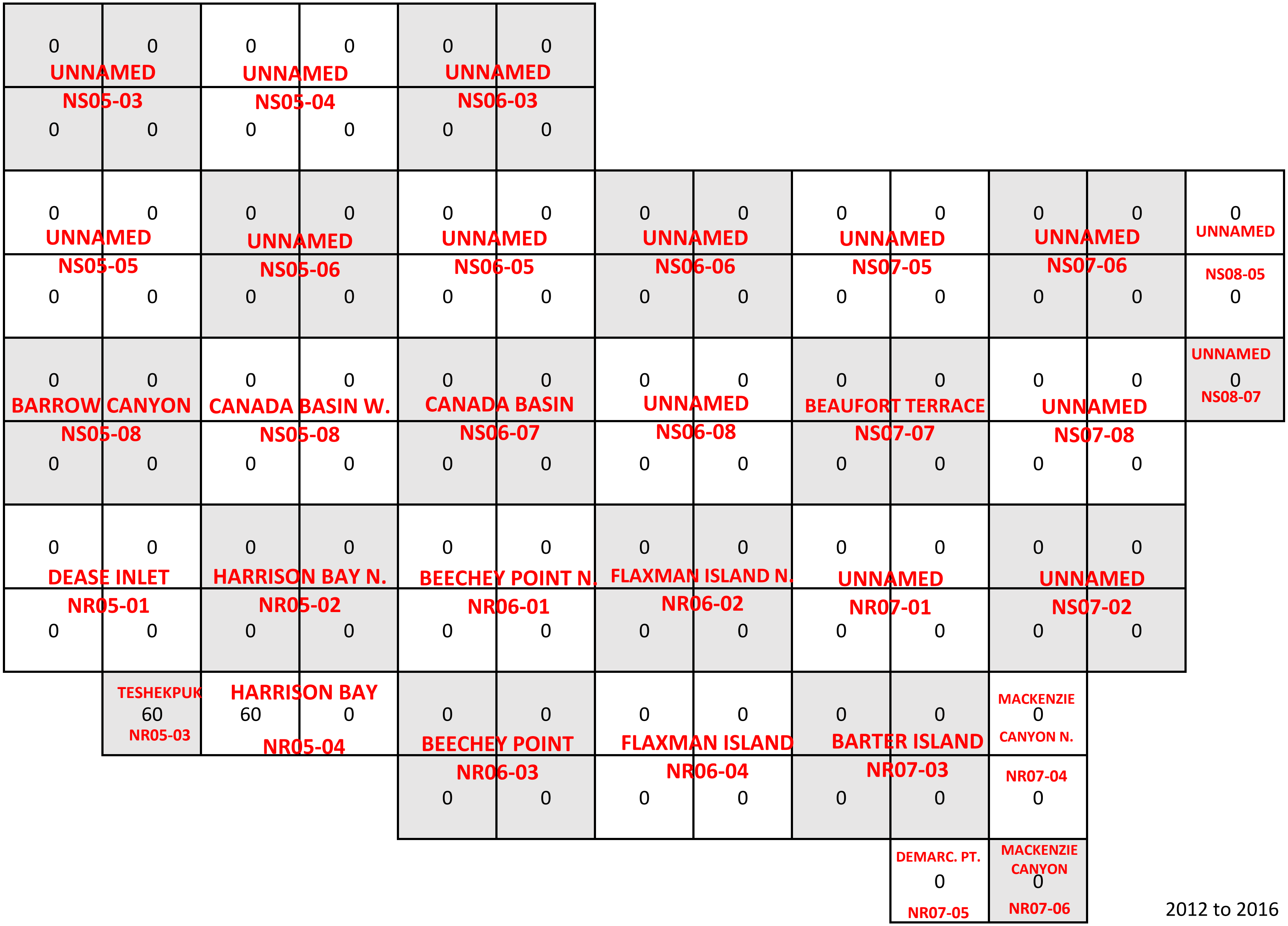
UNNAMED	NS07-02	0	0	0	0
TESHEKPUK	NR05-03	60			
HARRISON BAY	NR05-04	40	0		
BEECHEY POINT	NR06-03	0	0	0	0
FLAXMAN ISLAND	NR06-04	0	0	0	0
BARTER ISLAND	NR07-03	0	0	0	0
MACKENZIE CANYON N.	NR07-04	0		0	
DEMARC. PT.	NR07-05	0			
MACKENZIE CANYON	NR07-06	0			

2012 to 2016

Sea Ice 7.4.20 Scenario 7.4: Percent probability of sea ice concentration from 0 to 8 tenths, Beaufort Sea. 11-Dec 20-Dec



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TESHEKPUK 60 NR05-03

HARRISON BAY 60 0 NR05-04

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MACKENZIE 0 CANYON N. NR07-04 0

DEMARC. PT. 0 NR07-05

MACKENZIE CANYON 0 NR07-06

2012 to 2016

Sea Ice 7.4.21 Scenario 7.4: Percent probability of sea ice concentration from 0 to 8 tenths, Beaufort Sea. 21-Dec 31-Dec

APPENDIX C

Potential Environmental Concerns Related to SCCE and Relief Well Deployment

APPENDIX C

Potential Environmental Concerns Related to SCCE and Relief Well Deployment

Responding to and stopping a well blowout through deployment of SCCE or by drilling a relief well is, in itself, the primary focus of any blowout response and the most significant environmental concern in every blowout scenario. However, the use of deployment equipment, marine support vessels and aircraft and relief-well drilling programs also introduce some secondary environmental impacts. Thus, when choosing response options it is not only important that the chosen method be practicable and suited to site-specific conditions, it is also important to consider which method will stop the blowout the fastest to minimize petroleum loss from the well, which method will introduce the least risk of secondary oil spills, and which method will be the least disruptive to wildlife and their habitat. This section presents and compares secondary environmental impacts between the different response actions.

1.0 Petroleum Contamination

Additional petroleum contamination may occur during the process of stopping a blowout or cleaning up a spill. Petroleum contamination can cause acute injury or mortality to humans and marine biota, it can also cause longer-term, sublethal effects on marine species and/or degrade the marine habitat.

1.1 Relief Well Drilling

The act of drilling a second well introduces all the same risks that are associated with drilling the original well although the risk of blowout and well control loss are reduced due to the reservoir pressure and flow data gained from the blowing well (Shursen, personal communication). The relief well risks include the potential for large discharges (defined as > 1,000 barrels) from blowouts, other losses of well control, or accidents during loading, transport, and unloading of oil or gas from the drilling rig to shore via vessels or pipelines. Smaller discharges, spills and leaks of oil, gas, or other chemicals also can occur from storage tank accidents, transfer mishaps, or leaks from fuel tanks.

Relief well drilling, like any drilling program, also produces muds and cuttings that may be discharged under an NPDES permit, injected back into the subsurface or collected and disposed of off-site. Accidental discharges of drilling muds to the marine environment could potentially occur. Certain types of muds and cuttings can introduce heavy metals and other toxic materials into the marine ecosystem.

1.2 SCCE Deployment

Capping stacks, containment domes and SIDs provide a fast and, in most circumstances, an effective means to contain the hydrocarbons already being released by the blowout; the response time for capping stacks and containment domes will depend on how quickly the equipment can be brought to site, but a preinstalled SID is extremely expeditious and may be the most effective means of limiting oil loss from the well. Importantly, none of these SCCE options pose a threat of directly introducing any additional hydrocarbons to the environment.

1.3 Support Vessels

Support vessels are associated with relief-well operations and with most SCCE deployment. These vessels are generally diesel fueled and present a risk of spills and leaks typical to the operation of any other large marine vessel. Support vessels are used to manage sea ice, assist in the transport of a relief-well drilling rig to and from the site, in the transport of a capping stack and/or containment dome to and from the site, and in the deployment of a capping stack or containment dome. Petroleum contamination risks from support vessels are therefore generally similar whether drilling a relief well or deploying SCCE; the exception being the use of preinstalled SIDs which requires no direct vessel support for deployment.

2.0 Water Discharges

In general, vessel traffic, as may be associated with the transport of SCCE and/or a relief-well drilling rig, has minimal impact on water quality. NPDES-permitted discharges may include deck drainage, desalination unit wastes, sanitary wastes, BOP fluid, non-contact cooling water, excess cement slurry, water-based drilling fluids and other NPDES permitted wastes. These discharges could have minor short-term and temporary effects on water temperature, salinity, and pH, but would be expected to be negligible as permitted discharges covered in the NPDES permit associated with the drill plan (BOEM OCS Lease Plan Camden Bay 2012).

If transport, support vessels or relief-well drilling vessels utilize traditional anchors, placement and retrieval of the anchors will disturb the seafloor sediment and some sediment will be re-suspended in the water column during these processes; these sediment loads would be restricted to a very small area and would be expected to remain suspended for a very short time. With modern vessels that use DP, these concerns will no longer apply. The use of turret-mooring will also include anchoring impacts to the seafloor similar to those discussed above (Connelly). However, this concern should be considered within the context of natural impacts to the ocean floor from ice scour in shallow Arctic waters

Relief-well drilling will create drill cuttings and drilling muds which may be discharged under an NPDES permit or collected and transported out of the work area to an onshore disposal facility to minimize impacts on water quality. Any impacts on water quality from NPDES permitted discharges would be temporary and include a short-term increase in turbidity in the immediate area of the relief well BOEM OCS Lease Plan Camden Bay 2012).

Drilling of a relief well will also include the displacement of seafloor material and the discharge of sediments to the seafloor in the immediate vicinity of the wellhead. It is also possible that deployment of SCCE, and/or the removal of debris over a blown out well could result in some sediment displacement. A portion of the sediments would be suspended in the water column, resulting in a temporary plume with increased TSS, turbidity, and biological oxygen demand (BOD).

The increased activity of a relief-well increases the likelihood of water quality impacts over the deployment of SCCE, but overall the impact is generally accepted to be negligible and falls within the NPDES permitted discharges for the project.

3.0 Air Emissions

Marine transport and supply vessels, as well as relief-well drilling rigs are all typically diesel fueled. Operating the vessels' engines and the drilling equipment all result in the release of air emissions. Emissions generated from drilling, transport and deployment support vessels and ice management activities will likely include NOx, CO, and SOX, small diameter particulate matter such as PM10 and PM2.5, CO_2 and lead as well as lesser quantities of VOC, HAP, and ammonia (US BOEM OCS Lease Plan Camden Bay 2012).

Vessel traffic and drilling are the primary sources of related air emissions. While in transit, emissions from drillships and associated fleets will mostly be from power generated for propulsion and domestic use onboard. Emissions during drilling are primarily associated with power generation to support DP station keeping and drilling; secondary emissions include general purpose heating, transfer of materials about the deck, pumping of cement, incineration of (primarily) domestic waste, and other small emission sources. Support vessels (e.g., anchor handling, ice management and OSR vessels) will likely generate significant emissions; ice-management vessel activity generally accounts for most of the support vessels emissions.

Fixed-wing aircraft and helicopters used for ice management and to support relief-well drilling to bring in supplies and crews will emit criteria air pollutants, but in small quantities compared to the drilling rig and support vessels. The emissions from these aircraft are therefore expected to have only negligible and temporary impact on air quality.

The existing air quality in the Alaska Arctic OCS is good; emissions from relief-well drilling or the deployment of SCCE activities are not likely to significantly deteriorate the existing good air quality. EPA air permit requirements for drilling and related activities, including the deployment of SCCE, will help to ensure that emission levels remain low enough to comply with the national primary and secondary ambient air quality standards and to prevent harm to human health and the environment at all operating scenarios. Similarly, projected CO_2 emissions associated with drilling are expected to be insignificant in relationship to the Alaska total statewide and Alaska oil and gas industry GHG/CO_2 emissions based on Shell's 2011 Camden Bay Air Quality modeling (US BOEM OCS Lease Plan Camden Bay 2012). Commitments to use ultra-low sulfur fuel can also help keep impacts to air quality from vessels at negligible levels.

Transport of a capping stack or containment dome and transport to bring in a relief-well drilling rig are likely to result in similar vessel activity and associated air emissions. SID's are preinstalled and transported to site with the original drilling unit and therefore do not result in additional air emissions during the response to a blowout. Drilling a relief well will create additional air emissions that may continue for up to 45 days or longer. Ice management, which generates the most air emissions among the support vessel activity, may also cause an increase in emissions in the event additional marine support vessels and equipment are determined to be necessary for the emergency response.

4.0 Noise

Noise production associated with the deployment of a relief-well drilling rig may come from helicopters, AHTS vessels, and the relief-well drilling process itself. Noise generated from the support vessels is most evident when icebreakers come into direct contact with the ice as part of the ice management program (Connelly). Deploying and maneuvering the SCCE in the water column; the operation of SCCE is generally not noise producing once in place.

Some boat noise comes from engine noise vibrating through the hull, but most of the noise is related to propeller cavitation which produces large numbers of bubbles that emit noise when they collapse, these sounds are generally at a low frequency that can travel over large distances underwater (NRDC).

Noise impacts are most evident upon marine mammals but also extend to fish, migratory birds, and other organisms as well; however, because most available studies focus on marine mammals, this section only directly addresses effects on marine mammals. For example, marine mammal response to noise has been observed to range from minor to severe, depending on factors such as location, season, species, life-history, and type of noise. Impacts may include increased stress levels; avoidance of noisy areas which may include important feeding, or breeding, and calving grounds; changes in dive time, surface time, and/or swimming speed; and interference with the low frequency noises that many cetaceans use to communicate (National Research Council, 2003).

Studies on beluga whales show that the whales in the Canadian Arctic respond to icebreakers and other ships when they arrive in the spring. Possible explanations for this unique sensitivity to ship sounds are partial confinement of whales by heavy ice, good sound propagation conditions in the Arctic deep channels in the spring, and lack of prior exposure to ship noise in that year (LGL and Greenridge, 1986); these findings support that noise associated with relief-well drilling and support vessels could impact marine mammals. It has also been observed that marine mammals will avoid areas where hunting occurs (Malme 1989, Johnson et al 1989). However, other studies also indicate that belugas, and therefore possibly other marine mammals, will acclimate to ship noise over time. This was seen in studies of beluga in the St. Lawrence River in Quebec where the whales appear more tolerant of ship traffic (National Research Council, 2003). Similarly, beluga which generally disperse in response to small boat traffic in a river, appear to be habituated to small boat traffic in Bristol Bay, Alaska where they have been observed to continue to feed when surrounded by fishing vessels and resist dispersal even when purposely harassed by motorboats (Fish and Vance, 1971). Almost all the noise studies conducted so far have looked at only short-term effects of anthropogenic noise on marine mammals, leaving uncertainty on the likelihood of marine mammals to habituate to noise over time.

Mitigation measures for sound-generating activities from offshore operations may include what size and design of propellers are used, slowing vessel speeds and/or waiting until the area is clear of marine mammals prior to the startup of noise-producing operations; “soft starts” gradually increasing the intensity of the sound source to alert marine mammals that may be in the area so that they can move away, shutting down or powering down the sound source when marine mammals approach the area. Aircraft operating in a sensitive area may be required to fly above a certain altitude to avoid disturbing marine mammals. Proposed activities also may be prohibited in sensitive areas at specific times (such as during calving, breeding, feeding, or resting, or during subsistence hunting in Alaska) (US BOEM OCS Lease Plan Camden Bay 2012). General and site-specific mitigation measures are based, to the extent possible, on observations of animals exposed to various industrial activities and the animal’s hearing abilities and behavioral response. Nevertheless, the effectiveness of many mitigation measures has yet to be determined. Furthermore, these mitigation measures are not likely practical in a blowout emergency where the overwhelming hazard to marine life is the blowout discharge and efforts to deploy SCCE or a relief well are unlikely to be constrained by noise mitigation requirements. However, after the initial response has brought the well under control, mitigation measures may be implemented for ongoing well response and clean-up activities.

In determining the best response option to minimize noise impacts, it is the duration of exposure to noise that is likely to differ between the deployment of SCCE and the drilling of a relief well. SCCE deployment can be a relatively short-term operation compared to the drilling of a relief well. SCCE is expected to bring a well under control in the matter of hours, days or weeks, whereas a relief well will likely require 30 days or more before a well is brought back under control. During the drilling process there will be continued noise from support vessels and from the drillship itself. However, due to the uncertainty regarding noise habituation, it is difficult to determine if one method of blowout response has greater noise impact on marine species than the other. The exception to this comparison is the use of a SID. This device does not require the assistance of the ice management and support vessel fleet and is preinstalled such that it can be activated within a matter of minutes.

5.0 Vessel Strikes

Few vessel-strikes of marine mammals have been reported in the Beaufort Sea, and very few harvested marine mammals in the region have shown vessel-strike scars (George 2016). However, an increase in the number of vessels working in an area could increase the likelihood of a vessel striking a marine mammal. Marine mammal strikes usually occur from fast moving vessels that are difficult to avoid; the greatest risk of a drilling vessel or support vessel striking a whale would occur during transit operations when vessels travel at faster speeds as they approach or leave the region. Ice-management vessels do not generally operate at high speeds while conducting ice-management operations or when within the relief-well vicinity. Furthermore, ice management is a noisy process that is likely to alert any marine mammals of the vessel's presence (Connelly). Thus, ice-management vessels present a minimal risk of striking whales. To further minimize the probability of vessel strikes, vessels may be required to have marine-mammal observers on board; when observers spot an animal, they direct the vessel to slow down and avoid the animal by changing course within a certain closing distance (Shell used 900 feet) of marine mammals (Marine Mammals Commission 2018). Mitigation measures, including minimizing speed and changing course, are not likely to be employed until the primary focus of bringing the well under control has been accomplished and the vessels are engaged in ongoing operations to complete the response and cleanup activities. A ship strike, should one occur, would likely impact individual animals but would not likely affect animal populations in the project area unless the population was very small. (US BOEM OCS Lease Plan Camden Bay 2012)

The opportunity for vessel strikes is similar for the drilling of relief wells and the deployment of capping stacks and containment domes; all these activities require similar vessel activity related to transporting the SCCE or the relief-well drilling rig to and from the site and associated resupply operations. Once at the site, the majority of these vessels will generally stay in one area. Ice-management vessel activities are generally conducted at low speeds and will likely not create an increase in vessel strike risk. A pre-installed SID does not require additional vessel traffic for deployment and will not create any vessel strike risk to marine mammals.

6.0 Seafloor Sediments

As discussed above in section B, water discharges, drilling a relief well will have some potential to impact the seafloor sediments, depending on the type of anchoring systems used by the drilling vessel and other seafloor contacting operations. Impacts related to anchoring of a drilling vessel would depend on the anchoring system. An anchor and anchor chain system disturbs sediments and creates a depression in the seafloor with ridges of displaced sediment; the area of disturbance is often greater than the size of the anchor itself, because the anchor is dragged along the seafloor until it takes hold and sets (Connelly). After the anchors are removed, the disturbed areas eventually fill in from natural processes, such as ice gouging and natural migration of seafloor sediments. Time required for filling in the anchor scars will depend on currents, characteristics of the sea bottom sediments, and frequency and depth of ice gouging. Seafloor sediments would also be disturbed in the immediate vicinity of the relief well during installation of a recessed well (shallow water) cellar and possibly during the initial conductor casing installation.

The only available Arctic-class drilling vessels at this time are the Stena IceMAX and the Noble Bully I and II. These vessels use a DP system instead of anchors to maintain position that would have no impact on seafloor sediments when operating above 1,000 feet (300-meter) water depths. However, operation in the shallow waters of the Alaska Arctic OCS may also require modification of the Stena IceMAX to include a turret-mooring system with anchor lines that connect to seafloor anchors in a radial pattern and would result in the aforementioned anchor disturbances to the seafloor.

It is not anticipated that there would be any disturbance to the seafloor sediments caused by ice management and support vessels unless they dropped anchor to remain in one location and conserve fuel.

APPENDIX D

Gap Analysis and Matrix of Regulations, Standards, and Guidance

APPENDIX D

Gap Analysis and Matrix of Regulations, Standards and Guidance

1.0 Executive Summary

1.1 Objective

The objective of this Gap Analysis Report is to provide the Bureau of Safety and Environmental Enforcement (BSEE) Alaska Region with a comprehensive review and gap analysis of U.S. and international regulations, standards, recommended practices, specifications, technical reports and common industry methods regarding the safe deployment of Source Control and Containment Equipment (SCCE) versus a relief-well in Arctic conditions. The Gap Analysis Report is Task 5 of a multi-task scope of work requested by BSEE. In this scope of work, Task 5 is the result of research performed in Tasks 2 through 4. These Tasks are further defined below in section 2.0.

1.2 Method

To provide the basis for this review, U.S. and international regulations were researched along with international agreements, industry standards, and public and industry comments on regulatory concerns. Industry experts reviewed the material to ensure it addressed common industry methods. Pertinent sections of the regulations, standards and comments were compiled into a sortable matrix to enable an organized review of the material. This matrix is attached as Attachment A to this report.

An extensive review of the material was conducted and is summarized in Table 1, U.S. Regulations/Standards/Guidelines and Practices as Compared to Other International Arctic Countries and Agreements.

1.3 Results

The materials compiled in the matrix and discussed in this report are summarized in this section.

1.3.1 Relief Wells

Several countries specifically require relief wells, but regulations among countries differ in timing as listed below.

- Canada requires “same-season” relief well capacity.
- The U.S. requires the ability to bring in a relief-drilling rig and complete the plug and abandonment within 45 days.
- Norway and Greenland require a relief-drilling rig to be on site within 12 days.

1.3.2 Other SCCE Equipment

- Canada is the only country besides the U.S. that has specific SCCE requirements with respect to international SCCE requirements. Canada's requirements are less prescriptive than the U.S. requirements stating a more general requirement for "cap and containment methods and same-well intervention methods" as compared to the U.S. requirement for access to specific SCCE equipment within specified time periods.

1.3.3 Alternative Technology

- The U.S. and Canada have regulations that allow for the approval of alternative technology on a case by case basis, but the approval process is not well defined for either country. Other countries do not have SCCE regulations and therefore do not address approval of alternative technologies.

1.3.4 Contingency Plans

- All countries have some regulations and/or international agreements that reference contingency planning for loss of well control, but these requirements generally stop at requiring an operator to develop emergency response plans and lack specifics for relief wells, capping stacks, and/or containment domes.
- Canada is the only country that requires the submittal of site-specific contingency plans to address relief wells as well as capping and containment. These plans are required to accompany an application to drill offshore and ask for information on proposed site-specific loss of well-control response equipment, along with details on mobilization, deployment, and operation.
- The U.S. does not have site-specific plan requirements but does ask the applicant to address SCCE capability, access, and ability to deploy; additionally the Application to Drill permit approval process allows for the U.S to ask for additional detailed information as needed.

1.3.5 Sea-Ice and Metocean Data

- Sea-Ice and Metocean Data are critical to consider when planning for loss of well-control response, and it is necessary to support ice management during a response operation. The U.S. and Canada are the only two countries that require submittal of sea ice and metocean conditions.
- The U.S. requires Sea-Ice and Metocean Data in support of drilling operations but does not specifically address detailed information related to safe deployment of a relief-drilling rig or SCCE, or for ice management during a response event.

- Canada requires Sea-Ice and Metocean Data, along with proposed methods for tracking, modeling, and predicting ocean conditions, specifically related to contingency plan ice management systems.

1.4 Gap Analysis Conclusion

No regulations were located for any country regarding emergency relief-drilling rig or SCCE safe deployment practices. Through this review, it was determined that the definitive conclusion to this gap analysis is that there are no specific or prescriptive regulatory references in the U.S. or abroad that directly address safe deployment conditions or practices for either SCCE or relief-drilling rigs in Arctic waters.

Canada however does require applications for offshore drilling to include specific information that addresses mobilization, deployment and operation of relief-drilling rigs, capping, and containment; Canada also requires the submittal of Sea-Ice and Metocean Data. This information supports safe deployment of relief-drilling rigs and SCCE equipment and it supports the development of ice management systems. Canada’s contingency plan information requirements may be a useful reference for a comparative review and/or development of future Arctic OCS oil and gas drilling application requirements.

1.5 Gap Analysis Report - Considerations for Future SCCE Regulations

While the team’s research could not locate any regulations specifically related to safe deployment practices of SCCE and relief-drilling rigs, the team did compile an extensive repository of related regulations, standards and practices, industry methods, and public and industry concerns and comments. These materials provide important context for the use and safe deployment of SCCE and/or relief-drilling rigs. This additional research information is contained in the Gap Analysis Matrix; it also provides the main content of this report as it was determined that this information may be of use to BSEE for review and development of future Arctic offshore oil and gas regulations.

1.6 Gap Analysis Report Format

This Gap Analysis Report contains an Executive Summary, a Background section, Regulatory Requirements and Industry Standards for Use of Relief Wells and SCCE (main body of report) section, and a Gap Analysis Summary.

The Regulatory Requirements and Industry Standards for Use of Relief Wells and SCCE (main body of the report) is divided into the following subject sections:

- Relief Wells.
- SCCE Equipment: Capping Stacks, Containment Domes and Subsea Shut-in Devices.
- Approval of Alternative Technology.
- Submittal of Sea-Ice and Metocean Data.
- Contingency Plans for Well Response.

Each of the above-listed sections contains a presentation of relevant regulations and standards that may be used as references for future development of Arctic OCS oil exploration and production regulations.

Each of the above-listed sections also contains a summary of points raised through public and industry comment. These comments (BSEE, 2018) were submitted to BSEE in response to the Proposed Rule: “Oil and Gas and Sulphur Operations on the Outer Continental Shelf – Requirements for Exploratory Drilling on the Arctic Outer Continental Shelf” (Joint with BOEM) (1082-1100) 80 FR 9916 and 80 FR 21670). There are also citations taken from industry reports presented at the Annual Arctic Conference, published books on the Arctic, and industry expertise provided by Captain Don Connelly, Jerry Shursen, and Richard Carden of the BCE/Solsten Review Team. Each of these men has 40+ years of experience engineering and/or operating offshore drilling projects and specific expertise in blowout well control and Arctic operations. This report does not present a complete listing of all comments submitted, but a general representation of the breadth of comments that exist on these subjects. The full listing of comments can be found within the Gap Analysis Matrix in Attachment A.

1.6.1 Summary of Main Points Addressed within the Report

- The basic requirements to have access to relief-drilling rigs and specific types of SCCE, and how quickly to initiate a loss of well-control response, are compared across Arctic nations and various government agencies.
- Regulations, standards, and recommended practices are also addressed in the context of factors that may affect Arctic offshore operations, safety, and the environment. Relief wells and other forms of SCCE are addressed for various issues such as efficacy, feasibility, response time, added risk, impact on the drilling season, and overwintering.
- Important to relief well and SCCE regulations is an underlying intent of expediency in well-loss control (the greatest control factor over the volume of a spill), and efficiency. Both of these concerns are often closely tied to site-specific determinations for the most effective SCCE for individual operations.
- SCCE equipment is an evolving technology; prescriptive regulations may inadvertently exclude new and more effective equipment. To address this concern, regulations related to procedures for approval of alternative and newly developed technologies are also addressed in this report.
- Subsea isolation devices (SIDs) are a particularly important example of alternative SCCE as they are preinstalled and can be activated quickly and under circumstances that preclude the use of other SCCE.
- The collection, understanding and forecasting of sea-ice distribution, sea-ice concentration and metocean data is important for the development of an overall ice management and alert system to support the safe deployment of

relief-drilling rigs and SCCE. General requirements exist for the submittal of sea-ice distribution and metocean data for oil exploration and production activity within applications for a permit to drill, and/or as a part of oil spill contingency planning. These regulations and requirements contribute important data that may, by default, be useful for planning the safe deployment of relief-drilling rigs and SCCE. However, the regulations and requirements for collection of metocean and sea-ice data may also warrant a review to ensure they include information that is specifically relevant to a loss of well-control response.

- Contingency plan and/or deployment plan requirements and guidance are another regulatory avenue for minimizing pollution, stopping a discharge at its source, and addressing loss of well control. The explicitness of guidance on these topics is addressed along with policy and guidance regarding plan development and review.

2.0 Background

The following background material is copied from the BSEE RFQ for this project.

BSEE issued the final Arctic Rule, adding to and revising existing regulations in 30CFR 250.

As per 30 CFR 250.751, requirements for Arctic Alaskan Outer Continental Shelf (OCS) source control and containment; operators using a Mobile Offshore Drilling Unit (MODU) for drilling below or working below the surface casing must meet the following requirements.

- The operator must have access to a capping stack that can arrive at the well location within 24 hours after a loss of well control and can be deployed by direction of the Regional Supervisor.
- A cap and flow system must be positioned to ensure its arrival at the well location within 7 days after a loss of well control and can be deployed by direction of the Regional Supervisor.
- A containment dome must be positioned to ensure that it will arrive at the well location within 7 days after a loss of well control.

As per 30 CFR 250.472, Relief Rig Requirements for the Arctic OCS: in the event of a loss of well control, operators may be directed to drill a relief well using the relief-drilling rig described in the approved Application for Permit to Drill (APD). The relief rig must be staged in a location such that it can arrive on site, drill a relief well, kill and abandon the original well, and abandon the relief well prior to expected seasonal ice encroachments at the drill site, but no later than 45 days after the loss of well control.

Industry is concerned that current regulatory or permit requirements for same-season relief well capability do not recognize the more effective and lower environmental impact capabilities of capping and containment solutions. Additionally, they have stated that current well-control regulations do not account for the technological advancements made in capping and containment. Post-MACONDO, industry contends that the use of advanced control and containment technologies could prevent or significantly reduce the spill volume, when compared to a relief well which could take in excess of 30 days to be effective. Industry has estimated that under moderate weather conditions a successful relief well response action may take 30 days to 90 days, plus deployment time. In comparison, a capping stack could be implemented more quickly and a subsea shut-in device could be activated within minutes.

Therefore, the BSEE Alaska Region needs a comprehensive review and gap analysis of United States (U.S.) and international regulations, standards, recommended practices, specifications, technical reports and common industry methods regarding the safe deployment of SCCE versus a relief-well in Arctic conditions, and a historical statistical analysis of the Alaskan Arctic OCS drilling seasons over the past five years, in which metocean and operational conditions would support either or both methods.

This Gap Analysis Report addresses the Comprehensive Review and Gap Analysis request.

This Gap Analysis Report is attached as an appendix to the *BSEE Suitability of Source Control and Containment Equipment versus Same Season Relief Well in the Alaska OCS Region Final Report* with a separate attachment provided for the Gap Analysis Matrix file.

The scope for this Gap Analysis Report includes the following tasks.

- **Task 1** – Kick-off meeting requirement.
- **Task 2** - Conduct a comprehensive review of current U.S. and international regulations, standards, recommended practices, specifications, technical reports and common industry methods regarding the safe deployment of SCCE in response to a loss of well situation in Arctic conditions.
- **Task 3** - Conduct a comprehensive review of current U.S. and international regulations, standards, recommended practices, specifications, technical reports and common industry methods regarding the safe deployment of a relief-well [relief–drilling rig] in response to a loss of well situation in Arctic conditions.
- **Task 4** - Conduct a comprehensive review of the current 30 CFR 250 regarding the safe deployment of SCCE and relief wells [relief–drilling rigs] in response to a loss of wells situation in Arctic conditions.
- **Task 5** - Provide a gap analysis of the data obtained from Task 2, Task 3, and Task 4.
- **Additional tasks 6 – 10** requested within the same scope of work, are presented in the main body of the *BSEE Suitability of Source Control and Containment Equipment versus Same Season Relief Well in the Alaska OCS Region Final Report.*

Table 2-1. U.S. Regulations/Standards/Guidelines and Practices as Compared to Other International Arctic Countries and Agreements (summarized and condensed for generalized comparative formatting)

Country	**Relief Wells**				**Other SCCE**				**Contingency Plan**	**Alternative Technology**	**Sea-Ice and Metocean Data**	**Other Comments**
	Relief Well Required	**Access Time**	**Drilling Season Limit to Allow for Relief Well**	**Application Data to Address Relief Well**	**Other SCCE Required**	**Access Time**	**Seasonal Considerations**	**Application Data to Address SCCE**	**Loss of Well Control**	**Approval Process**	**Collection and Submittal**	
U.S. Code of Federal Regulations (API Industry Standards mentioned where applicable)	**Yes**	**Yes:** Ample time to arrive, drill, kill and plug the wells within 45 days of loss of well. (Wording stems from 30 CFR 250.472 (b) requirements)	**Implied:** Stop 45 days prior to end of ice season (Wording stems from a 30 CFR 250.472 requirement to have access to a relief well no later than 45 days after loss of well control and a seasonal ice-encroachment expectation as provided by BOEM in their response to the site Exploration Plan)	**Indirectly:** 30 CFR 250 lists application requirements but does not list out any specific information required to show compliance with relief well regulations	**Yes:** - Capping Stack - Containment Dome - Cap and Flow - Other SCCE to enable timely response	**Yes:** - Capping Stack within 24 hours - Containment Dome, Cap and Flow, within 7 days	**In Some Cases:** - Capping Stack Deployment can only occur during the ice-free season or with ice management with limited ice/ Operations can occur year-round - Subsea Intervention can be deployed and operated year round	**Indirectly:** 30 CFR 250 lists application requirements but does not list specific information required to show compliance with SCCE regulations	**Required:** - 40 CFR 112.11 Must meet discharge prevention and containment procedures - 18 AAC 75.408 Requires a blowout plan - API provides guidance to maintain and deploy SCCE	**Provided in Regulation:** - No defined process - No schedule or time frames	**Indirectly:** - Required in the Application for a Permit to Drill for Operations and Spill Response - Not specifically directed towards loss of well control - API also provides guidance	[In 2012] Shell deployed two drilling vessels and twenty support vessels to US waters north of Alaska The deployment of the two drill ships was consistent with past Shell practices dating back to 2007, but in 2012 Shell was specifically required by the US government to maintain a set distance between the two units during drilling operations
International Agreement UN Convention on Oil Pollution Prevention Response and Cooperation (OPRC) UN Convention of the Sea Arctic Council – Arctic Offshore Oil and Gas Guidelines	**Yes:** Arctic Council requires Emergency Response Plan to address relief well planning	**None Located**	**None Located**	**None Located**	**Not Directly**	**None Located**	**None Located**	**None Located**	**Required:** - OPRC requires measures for dealing with pollution incidents – oil spill equipment, cleanup plans, exercises - UN Convention of the Sea requires global cooperation for contingency plans - Arctic Council Requires Emergency Response Plan including loss of well control	**None Located**	**None Located**	

Country	Relief Wells				Other SCCE				Contingency Plan	Alternative Technology	Sea-Ice and Metocean Data	Other Comments
	Relief Well Required	Access Time	Drilling Season Limit to Allow for Relief Well	Application Data to Address Relief Well	Other SCCE Required	Access Time	Seasonal Considerations	Application Data to Address SCCE	Loss of Well Control	Approval Process	Collection and Submittal	
Canada Government of Canada National Energy Board National Energy Board Filing Requirements for Offshore Drilling In the Canadian Arctic	**Yes**	**Yes:** • Same-season (NEB SSRW Policy)	**Implied:** • Same-Season Relief Well Policy	**Yes:** Contingency plan must include a section for same-season relief well. • Identify drilling unit • Mobilization details • 2 suitable locations • Shallow seismic interpretation • Hazard assessment • Confirm prepared for same-season • Confirm availability of resources • Management systems, • Proof of financial responsibility, • Certificate of fitness • Operational reporting and notification. 2.1.1	**Yes:** • Capping and containment methods • Well intervention methods • Contingency plan must include a section for capping and containment for mobilization, deployment, and operation • Must provide information in plan for resources, redundancies, support systems and vessels, testing and certification of the capping/ containment system	**None Located**	**None Located**	**Yes:** Contingency Plan must include a section for Capping and Containment Methods • Proposed methods and systems • Plan for mobilization, deployment, and operation • Plan to clear debris • Execution Plan • Required Support Systems • Testing and Certification Process	**Required:** Plan must contain: • Relief-well plans • Time estimate to kill well • Intervention techniques (other SCCE) • Strategies • Preparedness	**Provided in Regulation:** • No defined process • No schedule or timeframes • One instance in practice where agreed to a two-phase review process (project suspended and review did not occur) 1.) The technology is reviewed for approval upfront and included in the APD Offshore 2.) Receives final review as part of total project approval process	**Required under Contingency Plan for Drilling Activity:** • Data for temperatures, darkness, polynas, ice cover, ice movement, sea state, currents, shoreline features, seafloor features • Detail to demonstrate adequacy of ice management and ice alert program for drilling activity and onboard operations including emergency disconnect, well completions, suspension, and abandonment • The threshold used to identify conditions and ice features that could be a hazard • How hazards will be predicted and tracked • Details on a robust ice alert system to manage ice hazards	The Super Shear and Seal System referred to as Alternative Well Kill (AWKS) has also been under development by industry as an alternative technology

Country	**Relief Wells**				**Other SCCE**				**Contingency Plan**	**Alternative Technology**	**Sea-Ice and Metocean Data**	**Other Comments**
	Relief Well Required	**Access Time**	**Drilling Season Limit to Allow for Relief Well**	**Application Data to Address Relief Well**	**Other SCCE Required**	**Access Time**	**Seasonal Considerations**	**Application Data to Address SCCE**	**Loss of Well Control**	**Approval Process**	**Collection and Submittal**	
Norway NORSOK STANDARDS Section 4.4 Revision 2, December 1998 Petroleum Safety Authority Norway Chapter IV Section 20	**Yes**	**Yes:** • Initiation of relief drilling at a relevant location shall commence no later than 12-days after the option is declared.	**None Located**	**None Located**	**None Located**	**None Located**	**None Located**	**None Located**	**Required:** Plan must contain: • Map suitable drilling location • Shallow seismic interpretation • Evaluation of blow-out scenarios and kill methods • Evaluation of relevant well profiles and casing program • Estimation of necessary pumping capacity • List of available equipment and time critical activities, including possible rigs or facilities for well intervention options as appropriate	**Provided in Regulation:** • Integral within permitting process		Requirement for standby vessels, including aircraft, to be stationed at facilities or vessels participating in the petroleum activities Requirements can include stipulations for the standby vessel functions The company's site specific ice management plan will drive the number, type, and capability of vessels
Denmark/ Greenland Greenland Bureau of Minerals and Petroleum (BMP) Exploration Drilling Guidelines Section 2.0	**Yes**	**None located in regulation - In practice:** • Cairn Energy maintained two drill ships in the area at all times	**Yes:** • Must stop at least two months before the sea freezes • No drilling during the sea-ice season (sea ice season as defined by Greenland BMP)	**None Located**	**None Located**	**None Located**	**None Located**	**None Located**	**Required:** Plan must contain: • Two relief well locations -surveyed for shallow hazards prior to operations • Relief well sites evaluated for current profiles, benthic character, seabed topography • Rig access plans evaluated for relief well • Pre-planned relief well design trajectories • A well-control drill conducted ahead of drilling	**None Located**	**Yes:** • Meteorological forecasts and a report on ice conditions are to be provided daily to the Bureau of Minerals and Petroleum	

Country	**Relief Wells**				**Other SCCE**				**Contingency Plan**	**Alternative Technology**	**Sea-Ice and Metocean Data**	**Other Comments**
Empty cell	**Relief Well Required**	**Access Time**	**Drilling Season Limit to Allow for Relief Well**	**Application Data to Address Relief Well**	**Other SCCE Required**	**Access Time**	**Seasonal Considerations**	**Application Data to Address SCCE**	**Loss of Well Control**	**Approval Process**	**Collection and Submittal**	Empty cell
Europe EN ISO 155444 (1) Amendment 1	**None Located**	**None Located**	**None Located**	**None Located**	**None Located**	**None Located**	**None Located**	**None Located**	**Required:** • Requires formation of an Emergency Response Strategy	**None Located**	**Guidance:** • Guidance for metocean data to consider	Equipment capable of remote control shall include emergency response and well control Examples: • ROV (Remote Operated Vehicle) for sub surface well-control operations • RAR (Remote Anchor Release) for the mooring wires for emergency release
Russia (Limited Access to Regulations)	**None Located**	**None Located**	**None Located**	**None Located**	**None Located**	**None Located**	**None Located**	**None Located**	**Required:** • Russia has treaties with U.S. and Norway for joint contingency plans and cooperative spill response	**None Located**	**None Located**	**2.1.2**

Sources for Table 2-1 are provided in the Gap Analysis Matrix (Attachment A)

3.0 Regulatory Requirements and Industry Standards for Use of Relief Wells and SCCE

3.1 Relief Wells

Relief wells are used in the oil and gas industry to respond to loss of well control. A drilling rig is brought to a blowout site to intersect an oil or gas well. The relief well will intersect the blowout well at a sufficient depth so that the kill fluid can be pumped into the blowout well; the density and frictional pressure losses from the kill fluid will exceed the flowing bottom-hole pressure and stop continued flow from the blowout well.

The relief-drilling rig is then also used to permanently plug and abandon both the original and the relief well as appropriate.

The first part of this section (subsection 3.1.1) reviews regulations that require operators to have accessibility to a relief-drilling rig, as well as other regulations that affect their mobilization, safe deployment and their operation.

The second part of this section (subsection 3.1.2) summarizes comments made by the public and by industry and submitted to BSEE in response to the Proposed Rulemaking: Oil and Gas and Sulphur Operations in the Outer Continental Shelf; Requirements for Drilling on the Outer Continental Shelf (Joint with BOEM) (1082-1100) 80 FR 9916 and 80 FR 21670 during the public comment period. These comments provide various perspectives on the benefits and concerns related to the use of relief wells as a contingency measure for offshore oil and gas drilling operations. Comments focus on usefulness, efficacy, feasibility, response time, environmental risks, impacts upon the drilling season, overwintering potential and the ability of some wells to self-seal or self-bridge due to their geology.

These regulations and these public comments, as submitted to BSEE, are provided as a source of information and public perspective for consideration in the development of future Arctic OCS regulations.

3.1.1 Regulations and Standards for a Same-Season Relief Well

Relief wells have long been relied upon as the required response to loss of well control. Canada, in 1976, was the first government to require relief wells. The requirement has since been adopted throughout most of the Arctic including key Arctic offshore nations; Canada, USA, Norway, and Greenland all require some form of demonstrated relief well capability either directly or via the contingency planning process. Russian regulations and standards could not be accessed to directly determine if there are any specific requirements for relief wells; however, books discussing Arctic international law state that no such requirements exist. Finland, having no oil and gas resources, also has no applicable regulations.

Both the State of Alaska and Canada require contingency plans to address the mobilization and operations of a relief-drilling rig; Canada provides applicants a more detailed list of what information is required to develop an acceptable plan.

3.1.1.1 U.S. Federal Regulations for Relief Wells

30 CFR 250.472 (a): *In the event of a loss of well control, the Regional Supervisor [BSEE] may direct you to drill a relief well using a relief-drilling rig able to kill and permanently plug an out-of-control well as described in your APD (Application for a Permit to Drill). Your relief-drilling rig must comply with all other requirements of this part pertaining to drill rig characteristics and capabilities, and it must be able to drill a relief well under anticipated Arctic OCS (Outer Continental Shelf) conditions.*

30 CFR 250.472 (b): *When you are drilling below or working below the surface casing during Arctic OCS exploratory drilling operations, you must have access to a relief rig, different from your primary drilling rig, staged in a location such that it can arrive on site, drill a relief well, kill and abandon the original well, and abandon the relief well prior to expected seasonal ice encroachment at the drill site, but no later than 45 days after the loss of well control.*

3.1.1.2 State of Alaska and Local Regulations for Relief Wells

18 AAC 75.425: Alaska state regulations do not currently specify a requirement for staging a relief-drilling rig in relation to a well site. However, there are contingency planning requirements, that require contingency plans for exploration facilities to include: a description of methods for responding to and controlling blowouts, the location and identification of oil spill cleanup equipment, the location and availability of suitable drilling equipment, <u>and an operations plan to mobilize and drill a relief well</u>. These regulations do not outline a specific timeframe for the use of the relief well; however, as discussed in the contingency planning section of this report, there are spill cleanup timeframe requirements that indirectly apply.

Title 20 Chapter 25 AOGCC: This state regulation addresses loss of well control, within spill contingency planning (discussed in a separate section). No specific regulations were listed for relief wells; the regulations were limited to primary and secondary well control including BOP requirements and drilling fluids control.

3.1.1.3 U.S. Industry Standards and Practices for Relief Wells

Alaska Department of Natural Resources, Division of Oil and Gas, Best Interest Finding for the Beaufort Sea Areawide Lease Sale (2009) Page 6-35: [State regulations do not require a same-season relief well. However, the Beaufort Sea Areawide Lease Sale Best Interest Finding references a historical industry practice of using relief wells for offshore winter season oil-drilling operations located in shallow State waters using ice islands or land-based drilling rigs.] The Best Interest Finding states, **"**If well control is lost…the operators consider mechanical surface control methods, they also begin planning to drill a relief well by assessing the situation and determining the location for the relief well. Additionally, a logistical plan to move another drill rig to the site is necessary. Conditions may require the construction of an ice or gravel pad and road. The operator will look for the closest appropriate drill rig. If the rig is in use, industry practice dictates that, when requested, the operator will release the rig for emergency use. Arranging for and drilling a relief well could take from 10-15 weeks depending on various factors." (Alaska Department of Natural Resources, 2009)

3.1.1.4 International Standards and Regulations for Relief Wells

Norway: NORSOK STANDARD Section 4.4 Revision 2, December 1998 Norwegian Technology Standards Institution (Industry Initiative): If a surface intervention cannot be performed on the blowing well, the blowing well shall be killed or plugged via a relief well. The objective of a relief well is to enter or get communication to dynamically kill and stabilize a blowing well. The following information shall, at a minimum, be covered for a relief well design.

- Mapping of suitable drilling locations, if appropriate including shallow seismic interpretation of the top section.
- Evaluation of blow-out scenarios and kill methods.
- Evaluation of relevant well profiles and the casing program.
- Estimation of necessary pumping capacity.
- Updated list of available equipment and time critical activities, including possible rigs or facilities for well-intervention options as appropriate. <u>Initiation of relief drilling at a relevant location shall commence no later than 12 days after the option is declared.</u>

International Regulations for Relief Wells

Canada: National Energy Board, Review of Offshore Drilling in the Canadian Arctic, 2015: Under the Canada Oil and Gas Drilling and Production Regulations, if the operator loses control of their well, they must have a contingency plan to regain well control. This plan could use various measures including drilling a relief well. The NEB states, "In the Canadian Arctic offshore … <u>the applicant must demonstrate, in its Contingency Plan, the capability to drill a relief well to kill an out-of-control well during the same drilling season.</u> This is the Same-Season Relief Well Policy. The intended outcome of the Same Season Relief Well Policy is to is to kill and out-of-control well in the same season in order to minimize harmful impacts on the environment." (Government of Canada, National Energy Board, 2011). An applicant must demonstrate this capability. A relief well is one contingency measure employed to respond to loss of well control. An operator is also expected to continue well intervention using all available means to bring into control a well blowout while designing, mobilizing, and undertaking a relief well operation.

Canada's NEB regulations also require a contingency plan with a specific section to address same-season relief well capability containing the following information.

- Relief well plans, procedures, technology, and competencies required to kill an out-of-control well during the same drilling season.
- Identification of the drilling unit that will be used, including mobilization details:
    - identification of a minimum of two suitable locations for drilling a same-season relief well, including shallow seismic interpretation of the top-hole section,
    - a hazard assessment for positioning the relief well close to the out-of-control well,
    - confirmation that the relief-well drilling unit, support craft, and supplies are available and can drill the relief well and kill the out-of-control well in the same drilling season, and
    - confirmation of the availability of well equipment and specialized equipment, personnel services, and consumables to kill the out-of-control well during the same drilling season.
- Contingency plans for the relief well.
- An estimate of the time that it would take to drill the relief well and kill the out-of-control well in the same drilling season.
- All available intervention techniques, in addition to a relief well, that will be used so that the flow from an out-of-control well can be stopped as quickly as possible.
- Related strategies and preparedness to drill a relief well using a second drilling unit including any advanced planning, preparation, and staging to reduce the time required to kill the out-of-control well.

Norway: International Law and the Arctic - Michael Byers Cambridge Studies in International and Comparative Law. /Norwegian Regulation: Michael Byers states, "Norway has some of the highest safety standards for offshore drilling of any country in the world, including, a long-standing requirement for the capability to initiate a relief well within twelve days of a blowout." (Byers, 2013).
Greenland: Naalakkersuisut Government of Greenland, Bureau of Minerals and Petroleum Website. https://www.govmin.gl/component/acymailing/listid-5/mailid-41-the-oil-spill-contingency-plan: First and foremost it is important to establish that drilling is not permitted in the sea-ice season in Greenland. <u>The drilling of wells in Greenland must stop at least 2-months before the sea freezes up so that there is time, if necessary, to drill a relief well and to abate and clean up after a potential oil spill.</u>

Greenland: International Law and the Arctic - Michael Byers Cambridge Studies in International and Comparative Law/Greenland Regulation: **“**Greenland has adopted Norway's high standards for offshore drilling. When Cairn Energy, a Scottish oil company, drilled a number of wells in Davis Strait in 2010 and 2011, two drill ships were required to be in the area at all times, leaving one available to drill a relief well if a blowout occurred. Several ’ice-management vessels’ were also kept on standby to tow threatening icebergs away” (Byers, 2013).

3.1.2 Comments and Concerns about Relief Wells

The gap analysis research yielded a variety of comments and concerns that have been submitted to BSEE by commenters to the proposed regulations (Proposed Rule: “Oil and Gas and Sulphur Operations on the Outer Continental Shelf – Requirements for Exploratory Drilling on the Arctic Outer Continental Shelf” (Joint with BOEM) (1082-1100) 80 FR 9916 and 80 FR 21670 during the public comment period. There are also some additional citations taken from industry reports presented at the Annual Arctic Conference or taken from published books on the Arctic. Information discussed also includes industry expertise provided by Captain Don Connelly, Jerry Shursen, and Richard Carden of the BCE/Solsten Review Team. These comments, citations, and information are summarized below under the related subject matter. This section is not a complete listing of all the public comments submitted to BSEE, but a general representation of the breadth of comments that were submitted regarding relief wells.

The following public comments address what may be seen as a paradox within the regulations, wherein the regulation language promotes expedient and efficient technology, but falls back on relief wells as a long-established source-control method. Review of the public comments shows that relief wells are not held in public or industry regard to be expedient or necessarily more effective than other source-control methods. Furthermore, relief wells are the only technology that introduces the risk of an additional discharge of oil to the environment. Various aspects of public and industry concern over relief wells are covered in the sections below.

3.1.2.1 Usefulness and Efficacy of Same-Season Relief Wells

Relief wells are considered by many to be unnecessary; commenters state that relief wells are seldom used for well-loss control because wells can be controlled through other means in less time than a relief well can be drilled. Several commenters referenced a MMS (Minerals Management Service) report, stating, “Since DOI began keeping comprehensive incident records in 1971, one of the more than 41,000 wells drilled over more than 40 years has depended on a relief well to control a blowout. Relief-drilling rigs have [only] been deployed to perform the final plug and abandonments. Although relief wells were initiated during several of the blowouts, all of the flowing wells were controlled by other means prior to completion of the relief wells." Sara Longhan, on behalf of the State of Alaska Department of Natural

Resources commenting to BSEE on the proposed rulemaking stated, “It is not made expressly clear where proven technology and application of same-season relief rigs have demonstrated enhanced well-control performance during a blowout event or incident using a relief rig, versus employing blowout preventer (BOP) or capping stacks and devices. Without this technical justification and explanation, it is difficult to ascertain whether the added cost, possible environmental impacts, and logistical challenges of requiring a same-season relief rig is rationally balanced with either real or perceived assumptions of practical use and effect” (BSEE comment file, 2018).

However, other members of the public state that relief rigs should be required as the last line of defense against a blowout. Concerns were listed by the Pew Charitable Trust that relief wells are necessary because other technologies are not successful 100 percent of the time, with well intervention failing five to 10 percent of the time (BSEE comment file, 2018). Arguments were also made by Lois Epstien representing a group of 15 ENGOs, that it is not always possible to cap or contain a blowout if the pressurized fluids are not coming up solely through the well bore, or [that] it may be unsafe to use capping or containment near certain blowouts (such as the Walter Well blowout in the Gulf of Mexico in July 2013, which took place in shallow water) (BSEE comment file, 2018). Industry has also stated that in the rare event of a rig fire and/or collapse, a relief well may be required (one such incident was the Montara well offshore Australia). Or, in the rare event that the formation pressure is unexpectedly higher than the estimates used in the design of the well casings, then it may not be possible to shut-in the well without the danger of rupturing the casing; then a relief well may be necessary (BSEE comment file, 2018).

3.1.2.2 Feasibility of Using Relief Wells in Deep Arctic Waters

The use of relief wells is considered by some industry members to be risky or infeasible as drilling moves into deeper water. Commenters, including Chevron, noted that there are more complex wells and more wells with challenging ice conditions than were experienced in the initial phase of Arctic OCS drilling in the Canadian Beaufort exploration 20 to 35 years ago (when relief-well regulations first appeared in Canada). Any late season relief well drilling will take place largely in limited daylight conditions, with growing ice thicknesses; later in the year, the extent of ridging and the type and roughness of ice cover increases the operational challenges. Relief well feasibility is a function of the well depth and complexity, late season ice conditions and the ice class and capability of the drillship and its support fleet (BSEE comment file, 2018).

3.1.2.3 Slow Response Associated with Relief Wells

The ability to respond quickly to a loss of well situation is key to minimizing environmental damage. Some commenters state that a timely response is best achieved through improved preventative measures versus response measures. In the unlikely event of the loss of well control, commenters are concerned that a reactive approach, such as a relief well, may result in a significant spill. Surface intervention or proactive approaches such as improved BOP designs, inspections, and well-control practice drills would represent a preventative method and as such, limit or reduce any spilled volume. To some commenters, it is a better use of resources to prevent a spill than to require costly relief wells to address a spill (BSEE comment file, 2018).

The timeliness of bringing a relief-drilling rig to site is another concern addressed in many comments as important for reducing the damage associated with the loss of well control. Some commenters are satisfied with the new U.S. regulations, some find them too onerous, while others prefer that a relief-drilling rig be staged on site or nearby; or, as once proposed in Alaska State legislation in 2010, that a relief well be drilled simultaneous to the principal well – a practice that could introduce additional drilling hazards (BSEE comment file, 2018).

While accessibility to a relief-drilling rig is one aspect of reducing spill response time, it does not address public and industry concerns about meeting the 45-day response and completion requirement to access and mobilize a drilling vessel, complete drilling, and to kill and abandon the two wells. It is estimated that it typically takes 30 – 90 days, under good weather conditions to control a well through the use of a relief-drilling rig. In some instances, this could be imposing a requirement to drill and complete a relief well in less time than it took to develop the original well.

Commenters also point out that other surface-intervention methods are capable of containing the spill at its source within hours, days or weeks (BSEE comment file, 2018). For instance, the SID, which sits on the subsea wellhead below the blowout preventer (BOP) uses rams to shear and seal the out-of-control well and is operated from an independent, offsite control system. Unlike a relief well, which can take weeks to drill, a SID is instantaneous. Some commenters do not agree with the need for a relief well, when other more expeditious technologies are available (BSEE comment file, 2018).

3.1.2.4 Introduced Environmental Risk Associated with an Additional Well

Drilling of a second well introduces additional spill risk through the potential loss of well control at the second well; this concern is the basis of some commenters' opposition to the relief well regulations. There are specific concerns if the relief well is being drilled simultaneously to the principal well; these concerns focus on the risk of the two wells drilling through a higher risk hydrocarbon zone at the same time. This risk could be minimized by managing the timing of drilling the relief well. However, even if the relief well drilling is managed for this risk, or even if it is not drilled until the onset of the loss of well control situation, it carries the same inherent spill risks as any principal well. As such, drilling a second well is perceived as increasing the risk of environmental damage while not necessarily providing a timely or effective method for regaining control of the first well.

3.1.2.5 Impact on the Drilling Season of Same-Season Requirement

As a result of the 45-day relief well requirement, the U.S. Arctic OCS drilling season is significantly reduced. This is a concern for several operators including Arctic Inupiat Offshore LLC. The proposed rule assumes an average 139-day drilling season on the Arctic OCS, " As the NPC (National Petroleum Council) study notes, the accessible season for drilling [in the western area of the Chukchi Sea] is July 1 to November 1, a total of 124 days. However, under the 45-day relief well rule, the drilling season is further shortened effectively requiring an operator in the Chukchi Sea to stop drilling after 80 days to build sufficient time into its drilling plan to comply with the rule. This is an effective reduction of approximately 35 to 45 percent (depending on the location and definition of the drilling season) of the Arctic drilling season. An extended drilling season is important to industry to increase competitiveness of Arctic resources in the global marketplace" (BSEE comment file, 2018).

It should also be noted that there are other public parties that strongly support the concept of a same-season relief well such as the Northwest Arctic Borough that states, "The permissible drilling permit duration should be limited to the total period of time the drilling rig is capable of working in Arctic conditions, minus the time required for oil spill cleanup and time required to cap and/or drill a relief well (whichever is longer)" (BSEE comment file, 2018).

3.1.2.6 Overwintering Suspended Wells

Regulations, in the U.S. and in other countries, are based on the assumption that a same-season relief well is necessary as it is not feasible to prevent uncontrolled flow during the ice season. Industry commenters assert that there are some source-control tools that can be safely overwintered; when these tools are available and well suited to the site, it should not be necessary to require a relief-drilling rig or to limit the operating season to accommodate plug and abandonment activity. The commenters also suggested that the regulations should address separately, and in a performance-based manner, the objective an operator must meet when making decisions to choose between source control versus the final kill of a well (BSEE comment file, 2018).

3.1.2.7 Safety Concerns with Late-Season Relief Wells

Industry commenters noted that the Chevron Arctic Centre conducted an extensive multi-year Canadian Arctic review that concluded operating a same-season relief well would not be safe in late-season environmental conditions due to ice hazards. The response capacity of late-season operations would also be diminished by significant down time that would likely be incurred due to ice system alerts and physical ice management requirements. Late season operations would also require special relief-drilling rigs and support vessels capable of working, at a minimum, in a first-year pack-ice regime under ice pressure (BSEE comment file, 2018).

Industry commenters reflected a preference for proactive SCCE technology such as capping stacks, Alternative Well Kill System (AWKS), containment technology, oil spill response techniques, and having the right marine support system should be incorporated in an overall plan to secure the well safely and to quickly reduce the hydrocarbon discharge. If a relief-well operation was still necessary to conduct a final kill of the well, particularly during the late-season, the report concludes that it would be preferable to delay that operation until there are more optimal conditions, likely leaving the relief-well operations to be conducted during the following season (BSEE comment file, 2018).

3.2 SCCE Equipment: Capping Stacks, Containment Domes and Subsea Shut-in Devices

Capping stacks are a subsea-intervention technology deployed to stop or redirect the flow of oil from a well that is otherwise out-of-control. Subsea shut-in devices are the seafloor counterpart of a capping stack; they are a similar capping device that is pre-installed at the seafloor on Mobile Offshore Drilling Units (MODUs). Containment domes are another source-control system that is deployed and held above a compromised well that uses mechanical means to contain and recover escaping oil, gas, and water into collection systems. These SCCE technologies are widely recognized as preferred emergency well-response efforts due to their expedience and general effectiveness.

The first part of this section (subsection 3.2.1) reviews regulations that require operators to have accessibility to capping stacks, containment domes and other SCCE equipment, as well as other regulations that affect their mobilization, safe deployment and operation.

The second part of this section (subsection 3.2.2) summarizes public comments submitted to BSEE the public and by industry that provide various perspectives on the benefits and concerns related to the use of SCCE equipment as a contingency measure for offshore oil and gas drilling operations. Comments focus on usefulness, efficacy, feasibility, response time, suitability for Arctic waters, issues related to the use of multiple response strategies, and comparability to the use of relief wells.

These regulations and these comments are provided as a source of information and public and industry perspective for consideration in the development of future Arctic OCS regulations.

3.2.1 Regulations and Standards for SCCE Equipment

SCCE equipment appears to be commonly used as a form of contingency source control for blowout wells in most Arctic countries where oil and gas exploration and production occur. However, regulations requiring its use seem to be confined to the U.S. and Canada. U.S. regulations are more prescriptive about accessibility, while Canadian regulations more specifically address the development of an SCCE contingency plan with detailed information about methods, mobilization, deployment, operations, and certification. API Industry standards provide important recommendations for the use of SCCE.

3.2.1.1 U.S. Federal Standards Regulations on SCCE Equipment

30 CFR 250.471 (a - h): U.S regulations require operators of offshore oil exploration and development wells to have SCCE (including proof of ownership, contracts, and inventory) to stop loss of well control at the source, in addition to the capability to bring in a relief-drilling rig and kill and abandon the wells within 45 days after the loss of well control. The requirements specifically include the following:

- Surface intervention using a <u>capping stack positioned to ensure that it will arrive at the well location within 24 hours </u>after a loss of well control.
- <u>A cap and flow system that can be accessed within 7 days</u>.
- <u>A containment dome that can be accessed within 7 days.</u>
- Additionally, the containment dome must have the capacity to pump fluids without relying on buoyancy.

30 CFR 250.462 (b) requires the ability to control or contain a blowout event at the sea floor through access to and the ability to deploy Source Control and Containment Equipment (SCCE) and all other necessary supporting and collocated equipment to regain control of the well. SCCE means the capping stack, cap-and-flow system, containment dome, and/or other subsea and surface devices, equipment, and vessels, which have the collective purpose to control a spill source and stop or contain the flow of fluids into the environment. SCCE, supporting equipment, and collocated equipment include subsea containment and capture equipment, hydraulic power sources, hydrate control equipment, collocated equipment including dispersant injection equipment, riser systems, ROVs, capture vessels, support vessels and storage facilities.

3.2.1.2 State of Alaska Regulations on SCCE Equipment

Title 20 Chapter 25 AOGCC: This is the only state regulation that directly addresses loss of well control, outside of references within spill contingency planning discussed in a separate section. No specific regulations were listed for SCCE such as capping; the regulations were limited to general BOP requirements and drilling fluids control for primary and secondary well control.

3.2.1.3 U.S. Industry Standards and Practices on SCCE Equipment

Because these technologies are unique unto themselves, there are extensive API standards and regulations to address their design, assembly, maintenance, ROV assessment of an incident well, deployment equipment, deployment support vessels, pre-deployment inspections and tests, recovery, and training for SCCE procedures. API standards also address subsea capping devices, including their transport. There were no standards located related to safe deployment weather, ice, or metocean conditions. (See API standards: API RP 17W 5.1, API RP 17W 5.4, API RP 17W 5.2, API RP 17W Annex B, API RP 17W 6)

Joint Industry (API/IADC/IPAA/NOIA/USOGA) Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13, 2012: This report included many recommendations for continued study; relevant recommended studies are listed below.

- Confirm that a Lower Marine Riser Package (LMRP) can be removed from the lower BOP using a surface intervention vessel and ROV. This should allow access to the mandrel on top of the BOP and the installation of subsea containment assembly (well cap). This assembly (well cap) should have full shut-in capability in addition to choked flow from flow wings. If well flow is necessary, it can be achieved by diverting flow to the capture vessels. The subsea containment assembly also allows vertical access to the well for intervention within the well if necessary. In almost all cases where there is no confidence in the integrity of the well design, the well can be shut-in and top kill procedures executed. Well "capping" capability is available now through use of a second BOP stack or equipment used in the MACONDO incident. Containment companies should expand this capability. Refer to API subcommittee on Drilling Well Control Equipment (SC16) and API RP Std. 53 for further discussion and analysis on LMRP release and ROV intervention requirements and testing.

- Logistics and Deployment Plans - Address details of airports and capacity to receive and service heavy-lift aircraft, customs clearance, availability of transportation resources, capacity of roads, bridges, tunnels, road permits issues and restrictions. Develop a load plan with crane capacities, trailer sites, permit loads, third party technical personnel required at site. Develop a deployment plan from receiving and handling at port of entry until the capping stack is deployed from a vessel and installed.

- Research and Development Capability – Ensure effective and non-damaging release of LMRP’s. High-angle-release connectors now exist. This recommendation is to evaluate current high-angle-release connectors to ensure they fully address high angle release without riser tension or without a riser. There may be no additional technical work required after this study. Additionally, the ability to reattach a capping stack to a BOP or wellhead housing that is not vertical should be evaluated. Straightening techniques are available but this would add another option.

- Establish long-term coordinated industry capability for owning and providing subsea well containment technology and capability.
- The containment companies should procure, construct, and test the needed equipment. This includes testing effectiveness over time through drills and readiness reviews. The containment companies should also conduct research into enhanced methods and equipment for subsea well control and containment.
- Ensure effective methods to release LMRPs are included in BOP stack designs. This should include release with no vertical tension is available as when rig is drifting without power. Releases should not damage the BOP or BOP connections. There are tools and techniques available now such as LMRP jacks but new methods should be considered.
- Containment companies should design and construct subsea connectors to fully seal, connect and contain damaged connector profiles and casing stubs. Also, consideration should be given to inside well connectors such as packers.

3.2.1.4 International Regulations on SCCE Equipment

International standards on SCCE deployment, outside of spill contingency planning, were not located during our research. However Statoil, in their comments on the Arctic OCS rule, noted that performance based regulations are applied in various modern offshore regimes, including UK and Norway, as areas of established offshore exploration and production for more than 50 years. Norway's OCS extends from the North Sea, the Norwegian Sea up to the Arctic Barents Sea, in areas far offshore, with seasonal darkness, and where icing and sea-ice can occur. One set of risk-based regulations applies, but activities, drilling equipment and support vessels have to be adjusted to the specific environmental and meteorological conditions in the exact area and the exact period of time for which the activity is planned.

Canada: National Energy Board Filing Requirements for Offshore Drilling in the Canadian Arctic – 2015: Contingency plans for offshore drilling in the Canadian Arctic require the following information specific to capping and containment:

- A description of capping and containment methods and systems proposed to appropriately respond to the worst-case scenario.

- A plan for mobilization, deployment, and operation of the capping and containment system, including any clearance of debris or damaged pieces of sub-sea systems.
- A description of the execution plan, resources, reliability, and redundancies of the capping and containment system in the unique Arctic environment.
- A description of the required support systems, including vessels, icebreakers, riser system, and remotely operated underwater vehicles (ROV).
- A description of the testing and certification process of the capping and containment system, including qualification of new technology where applicable.

3.2.2 Comments and Concerns about SCCE Equipment

The gap analysis research yielded a variety of comments and concerns that have been submitted to BSEE by commenters to the proposed regulations (Proposed Rule: Oil and Gas and Sulphur Operations on the Outer Continental Shelf – Requirements for Exploratory Drilling on the Arctic Outer Continental Shelf (Joint with BOEM) (1082-1100) 80 FR 9916 and 80 FR 21670) during the public comment period (BSEE comment file, 2018). There may be some additional citations taken from industry reports presented at the Annual Arctic Conference or taken from published books on the Arctic. Information discussed also includes industry expertise provided by Captain Don Connelly, Jerry Shursen, and Richard Carden of the BCE/Solsten Review Team. These comments, citations, and information are summarized below under the related subject matter. This section is not a complete listing of all public comments submitted to BSEE, but a general representation of the breadth of comments that were submitted on SCCE.

3.2.2.1 Usefulness and Efficacy of SCCE (Capping Systems, Cap and Flow Systems, Containment Domes and Subsea Isolation Devices)

There is general acceptance by most parties that commented on the BSEE regulation that capping stacks and SIDs are the best available source control technologies for controlling a blowout. SCCE technology is estimated by the Pew Trust to be capable of controlling a blowout situation 90 to 95 percent of the time. Industry comments that it is important to consider the well-control capability for combined or redundant SCCE options. When SCCE technologies are combined, it is expected that the capability to control a blowout closely approaches 100 percent of the time (BSEE comment file, 2018).

As noted in the relief well section, some commenters view relief well capability as a necessary last line of defense for the situations that may not be able to be controlled by SCCE; their concern is supported by citing the occasional circumstances when capping stacks, containment domes, and other forms of SCCE cannot be safely deployed due to site hazards. These instances may include a blowout where pressurized fluids are not coming up solely through the well bore; situations where the rig catches fire or collapses on top of the well (such as the Montara well offshore Australia); operations that are constrained due to shallow waters; or in the rare event that the formation pressure is unexpectedly higher than the estimates used in the design of the well casings, then it may not be possible to shut-in the well without the danger of rupturing the casing and continued loss of well control (BSEE comment file, 2018).

However, as further detailed in the SID section below, industry experts stated that a preinstalled SID that is placed on a well designed to accommodate a full shut-in on the casing strings-set in the well, and that can be remotely operated from an offsite location, is likely to be capable of safely responding and killing a well under most of these extenuating circumstances. While the SID, as a response tool, is likely to be highly successful there could be situations in which a SID could fail, and a relief well could still be required to bring the well under control. (Shursen, 2018)

It is important to consider that by combining a capping stack with a properly designed, preinstalled SID, the 90 to 95 percent probability of containing a blowout with SCCE will increase significantly and more closely approach 100 percent. The use of a preinstalled SID could provide a faster, safer second line of defense for a blowout than a relief well.

3.2.2.2 Response Time for SCCE

Commenters on the proposed BSEE regulations also stated that SCCE technologies offer a dramatic reduction in worst-case discharge volumes because they are designed to stem the flow of oil in a matter of minutes, hours, or days versus weeks or months and they are independent of the controls on the drilling rig (BSEE comment file, 2018). Capping stacks are deployed by an intervention vessel after an incident to stop the flow from the well and are used on floating MODUs which are not well suited for subsea shut in devices. Whereas jack-up MODUs are not well suited to capping stacks due to the jack-up vessel's rig structure over the well and the use of surface BOPs, pre- SIDs on a jack-up can provide the advantage of the SID being in place prior to the loss of well control for immediate response, if the well has been designed to accommodate a full shut-in of the casing string set.

3.2.2.3 Feasibility of Using Capping Systems in Arctic Waters

Alternative response technologies like SIDs and capping stacks are being utilized in frontier areas around the globe. For example, ExxonMobil and Rosneft have employed SIDs in the Kara Sea in the Russian Arctic, while Royal Dutch Shell relied on a capping stack during its summer 2015 exploratory drilling operations in the Chukchi Sea.

The feasibility of a subsea-capping operation will largely depend on the ability of vessels to work safely above or near the blowing well, especially in shallow water. For a subsea blowout, the gas plume may become entrained in the water column. The plume could theoretically reduce stability and cause a vessel to capsize or sink. Surface accumulation of released gasses such as hydrogen sulfide, hydrocarbons, and carbon dioxide may be hazardous for personnel and introduce a risk of explosion. The shallow waters in the Arctic OCS allow less opportunity for the gas plume to be transported away by local currents, increasing this concern at some Arctic locations.

Capping stacks and subsea isolation devices can also be safely overwintered on the seafloor in areas with no known ice gouging, or in a mud line cellar in areas where ice gouging and scour may be a concern. Under these circumstances, if an operator felt that the final plugging and abandonment of the well would be better addressed through a relief well versus re-entering the capping stack, they could cap the well, leave the capping device in place over the winter and return the following season with a relief rig. This would allow relief-well operations to occur early in the next drilling season when there are fewer ice and metocean hazards and negate the need to stage a relief rig on site throughout operations.

3.2.2.4 Containment Domes are Best Suited for Floating Vessels in Deep Water

Many of these regulations are written for floating MODU operations, and that further consideration is required to address manmade gravel and ice islands or bottom grounded vessels such as jack-ups or submersible drilling vessels. Wells in the shallow waters of Beaufort Sea have been safely drilled in the past with bottom-founded submersible vessels, but such rigs may not be able to accommodate a containment dome so this type of rig would likely be precluded by the proposed rules.

The use of containment domes in shallow waters (less than 300 feet in particular) was also raised as a concern by several commenters. There is concern that containment domes have not been tested in shallow waters (such as exist in the Arctic OCS) and their use may be better suited for ultra-deep waters such as the Gulf of Mexico. Additionally, jack-up rigs, which are utilized in shallow waters up to 400 feet deep, are supported by legs that may impose hazards when setting the containment dome. Particular concern was raised by Craig Wilson stating, “The safety and technical issues of installing a containment dome between the legs of a bottom-founded rig are sufficient to dismiss the use of a containment dome out-of-hand in most situations” (BSEE comment file, 2018)

Alaska’s nearshore and OCS waters are commonly less than 300 feet deep; given the diversity of physical conditions in the Arctic, as well as the variety of rig types available, containment domes may not always be well suited for the particular conditions facing an operator. For these reasons, there was significant opposition to the prescribed and mandated use of containment domes as well-control equipment. Richard Ranger at the API Institute for 21st Century Energy and National Ocean Industries Association (NOIA) stated concern in his comments to the BSEE regulation that, “The system [containment dome] is a step forward in terms of technology, but the use of a containment dome should not be enshrined in regulation while other tools are being developed and new technology is being considered. (BSEE comment file, 2018).

3.2.2.5 Subsea Isolation Devices (SID)

SIDs can be pre-installed on a well, and remotely operated from an offsite location. If designed to accommodate a full shut-in of the last casing string set, they can kill a well and provide effective plug and abandonment. Remote operation ensures that the SID can be deployed in instances where site hazards make it unsafe or inaccessible to deploy other types of SCCE. These instances may include a blowout with pressurized fluids coming up solely through the well bore, situations where the rig catches fire or collapses on top of the well, or operations that are constrained due to very shallow waters.

Devon, in conjunction with Cameron/Schlumberger, designed a promising SID which included a supershear and seal system referred to as the AWKS which was installed and field-tested on the Steel Drilling Caisson (SDC) vessel for the Paktoa well in the Canadian Beaufort Sea at the conclusion of its 2005 / 2006 program. They proposed that the National Energy Board of Canada consider the use of AWKS as an alternative technology to the Canadian same-season relief well requirement. However, research and development delays prevented the system from being completed in time to both meet the approval process timelines and meet shipping deadlines required for timely implementation of the unit at site (it needed to be onsite prior to the minimum construction schedule required for building an ice island to support a relief-well event). Chevron has since taken over ownership of the AWKS from Devon and has continued the research and development process. In addition, ExxonMobil and Rosneft have employed SIDs in the Kara Sea in the Russian Arctic. Industry has commented that SIDs are an additional option that should be considered when regulating SCCE.

3.2.2.6 Risk of Simultaneous Well Response Operations

ExxonMobil noted in their comments submitted to BSEE that the benefits of staging and operating multiple SCCE units, including a relief rig, may be offset by the risks associated with complex simultaneous operations (BSEE comment file, 2018). For instance, containment domes and capping stacks are not complementary barriers in shallow water, especially when utilized in conjunction with a bottom-founded structure. Requiring the use of both types of technology could be counterproductive.

With multiple forms of SCCE being required by law, operators must have access to a capping stack that can be mobilized to location within 24 hours and access to a cap and flow system and a containment dome within 7 days. This will require equipment to be stored in the field or staged offshore in the nearest available safe harbor. As a result, a strain will be placed on the effective storage capability of an existing marine fleet or, more likely, additional vessels will be required. The incremental vessels will complicate SIMOPS issues and require careful management to avoid impact on critical path operations. Furthermore, the required mobilization duration for a containment dome and for the cap and flow system will likely drive the need to stage equipment in less sheltered waters, increasing risk to the personnel dedicated to maintaining and operating the equipment.

3.3 Approval of Alternative Technology

U.S. regulations allow for potential substitution of relief-drilling rigs and/or other prescribed SCCE procedures or equipment to stop and/or capture the flow of an out-of-control well. This allowance for alternative technology provides some accommodation for unique conditions when relief-drilling rigs and/or other required SCCE are not suitable, safe, or are cost-prohibitive. They also accommodate new innovative technology that may not have been invented or available at the time the regulations were drafted.

Regulations regarding the approval process for alternative technology are listed in subsection 3.3.1.

Public and industry comments submitted to BSEE regarding the importance, clarity and timeliness of the alternative technology approval process are summarized in subsection 3.3.2.

3.3.1 Regulations Allowing for Alternative or Equivalent Procedures or Equipment

Regulations that allow for approval of alternative technology also exist in Canada and Norway. In the U.S. and Canada, this provision is separate from the usual prescriptive permitting process; approval of the use of alternative technology is based on an undefined performance–based review process. However, in Norway where the overall permit process is performance based, the review and acceptance of alternative technologies is integral and does not require a separate process.

3.3.1.1 U.S. Federal Regulations on Approval of Alternative Technology

- **30 CFR 250.472 (c):** Operators may request approval of alternative compliance measures to the relief-rig requirement in accordance with § 250.141. The operator must show and document that the alternate compliance measure will meet or exceed the level of safety and environmental protection required by BSEE regulations, including demonstrating that the alternate compliance measure will be able to kill and permanently plug an out-of-control well.

- **30 CFR 250.471 (i):** Operators may request approval of alternate procedures or equipment to the SCCE requirements of sub paragraph (a) of this section in accordance with § 250.141. The operator must show and document that the alternate procedures or equipment will provide a level of safety and environmental protection that will meet or exceed the level of safety and environmental protection required by BSEE regulations, including demonstrating that the alternate procedures or equipment will be capable of stopping or capturing the flow of an out-of-control well.
- **30 CFR 250.141 (a)** Any alternate procedures or equipment that you propose to use must provide a level of safety and environmental protection that equals or surpasses current BSEE requirements.
- **30 CFR 250.141 (b)** You must receive the District Manager's or Regional Supervisor's written approval before you can use alternate procedures or equipment.
- **30 CFR 250.141 (c):**. . To receive approval, you must either submit information or give an oral presentation to the appropriate Regional Supervisor. Your presentation must describe the site-specific application(s), performance characteristics, and safety features of the proposed procedure or equipment.

3.3.1.2 International Regulations on Approval of Alternative Technology

- **Canada: National Energy Board. SSRW Technical Proceedings 2016-12-19:** The intended outcome of the Same-Season Relief Well Policy is to kill an out-of-control well in the same season in order to minimize harmful impacts on the environment. We will continue to require that any company applying for an offshore drilling authorization provides us with specific details as to how they will meet this policy. We will continue to require an operator to use all intervention techniques available, in addition to a relief well, so that the flow from an out-of-control well can be stopped as quickly as possible. <u>We acknowledge that there is a continual evolution of technology worldwide, including the technology needed to kill an out-of-control well. We are open to changing and evolving technology. An applicant wishing to depart from our policy would have to demonstrate how they would meet or exceed the intended outcome of our policy.</u> It would be up to us to determine, on a case-by-case basis, which tools are appropriate for meeting or exceeding the intended outcome of the Same-Season Relief Well Policy.
- **Canada: National Energy Board, Review of offshore drilling in the Canadian Arctic December 2011 Rob Powell - Director, Mackenzie River Basin, Albert, Alberta:** <u>"An equivalent to SSRW capability would, in our view, be an Arctic-proven alternative method to both control and kill a blowout before the end of the operating season.</u> It would provide an alternative to same well intervention methods where these are either not available or not

applicable...Finally; of course, it has to be capable of killing the well once it is under control. Anything less, we believe, could expose the Beaufort Sea to a blowout that could last through the winter." (Government of Canada, National Energy Board, 2011)

- **Canada: National Energy Board, Equivalency Review Precedent – NEB agrees to ruling on a proposed review approach to determine if a proposed well-control system would meet the intended outcome of the SSRW Policy (Imperial Oil Resource Ventures Limited (Imperial Oil) and Chevron in 2014)**

  The NEB endorsed the approach of a two-phase process, applied on a case-by-case basis, starting with projects by Imperial Oil and Chevron. In Phase I, the NEB would address the equivalency determination and rule on whether an alternative well-secure system is the same as, or better than, the SSRW Policy. If the NEB determined that a proposal satisfied the intended outcome of the SSRW Policy, the company would then be in a position to prepare its detailed application for all required drilling authorizations based on the alternative well-secure system. In Phase II, the detailed application would be submitted to regulatory authorities and subject to a full technical, economic, environmental and socio-economic assessment to determine whether approval of the whole drilling program is in the public interest. Each phase would be treated as a separate application and would follow the standard NEB review process. The NEB determined that issuing advanced rulings on equivalency was in the public interest in a situation where it is appropriate to do so. (The projects were suspended and the review was never completed.)

  The NEB established a list of issues to consider during the review:

  - What criteria and risks should be considered in determining whether the intent of the SSRW Policy has been satisfied by the tools and techniques proposed to respond to an out-of-control well.
  - How the tools and techniques proposed would meet the criteria and address risks in the circumstances of a worst case scenario.
  - How the tools and techniques proposed would address the challenges of the unique Arctic environment.
  - The terms and conditions, if any, that should be considered at the project application stage if the departure from the SSRW Policy is granted.
  - Implications of the Board accepting a departure from the SSRW Policy.

- **Norway:** Norway's regulations are less prescriptive and generally inherently adaptable without setting up a separate procedure for approval of alternative technology.

3.3.2 Comments and Concerns about the Alternative Technology Approval Process

The gap analysis research yielded a variety of comments and concerns that have been submitted to BSEE by commenters to the proposed regulations (Proposed Rule: Oil and Gas and Sulphur Operations on the Outer Continental Shelf – Requirements for Exploratory Drilling on the Arctic Outer Continental Shelf (Joint with BOEM) (1082-1100) 80 FR 9916 and 80 FR 21670) during the public comment period. There may be some additional citations taken from industry reports presented at the Annual Arctic Conference or taken from published books on the Arctic. Information discussed also includes industry expertise provided by Captain Don Connelly, Jerry Shursen, and Richard Carden of the BCE/Solsten Review Team. These comments, citations and information are summarized below under the related subject matter. This section is not a complete listing of all the public comments, but a general representation of the breadth of comments that were submitted on the alternative technology approval process.

3.3.2.1 Clarity and Definition of the Alternative Technology Approval Process

The public recognizes and values the accommodation within the regulations that include procedures for approving alternative technology. In particular, it was noted that this provision is necessary as the regulations already require equipment that is likely to be poorly suited to some applications, such as the containment dome. Industry also agrees with this need to accommodate alternative SCCE as stated by the Chevron Arctic Center: "Technology, by its very nature, is always evolving. As such, the requirement for flexible regulatory systems is essential to facilitate the levels of economic viability and environmental stewardship/sustainability that are desired by all stakeholders" (BSEE comment file, 2018).

It is important that the provisions allowing for review and approval of alternative technology be clear; in the current form, many feel that the regulations are too vague. There is concern that the proposed rules do not define a workable process to describe how an operator should demonstrate equivalency to BSEE to obtain approval for the use of an alternative to a same-season relief well or other prescribed SCCE. This lack of a defined process could prevent operators from being able to adapt their programs to utilize the safest and most effective technologies as they become available. If the best, most effective SCCE technologies cannot be approved in a workable manner, then operators will necessarily default to approved SCCE which if poorly suited or less efficient will inherently risk causing unnecessary harm to the environment.

Suggestions to improve the alternative technology approval process include the following.

- Set clear performance-based standards.
- Set a method to measure the perceived risk-reduction benefit, which is critical to establishing the baseline expectation.
- Require the applicant to explain how site-specific environmental factors in the Arctic, including extreme temperatures, darkness, polynyas, ice cover, ice movement, sea state, currents, shoreline features and seafloor features, could potentially affect the use and deployment of alternative SCCE.
- Require the applicant to explain how the proposed alternative SCCE is suited for the drilling rig equipment that will be used at the site.
- Review the proposed technology in the context of the worst-case scenario for the specific project, including the estimated flow rate, total volumes of fluids, oil properties, and maximum duration of a potential blowout and the measures available to regain well control.

3.3.2.2 Timeliness of the Approval of Alternative Technology Process

It is important to commenters that the regulations include assurance of a reasonable time frame for the review process to ensure that the approval process will be completed with enough time for the applicant to plan their well-operations season accordingly. As written, there are no set time periods in the regulations for acceptance of a proposal, review of the proposal, or for issuing a final decision.

Developing an alternative well-secure system requires companies to invest in design, engineering, construction and testing of new technology, all actions which require material, upfront-capital commitments. Companies are limited in their ability to make these commitments if they do not have timely confirmation that their proposed well-secure system is going to be approved by the governing agency. The risk of having new technology rejected at the end of the permitting process creates a considerable economic disincentive for companies and influences ultimate investment decisions.

One approach to address this issue is a staged approval process such as the one described above under Canadian NEB regulations for the Imperial Oil and Chevron projects. While these projects were suspended and the review was never completed, this example provides a potential model for future efficiencies in the regulatory process. Approving a proposed alternative technology prior to submittal of the APD, results in an APD project description that addresses all aspects of the project, including integration of the alternative SCCE. This two-phased approach enables two things; first, companies can make a timely investment in new and innovative well-control systems with less financial risk, and second this approach supports a full agency and public review of the project and of the new technology within a site-specific context.

3.4 Submittal of Sea-Ice and Metocean Data

The diverse and often extreme Arctic conditions have the potential to affect the safety and the effectiveness of SCCE and/or relief-drilling rig deployment, as well as to affect the determination of which SCCE methods are appropriate for each individual situation. Sea-ice and metocean data are particularly relevant to the conditions which allow for the safe deployment of relief-drilling rigs and SCCE equipment, as well as being important data to support the ice-management systems that are necessary to ensure safe and effective emergency operations in Arctic offshore waters when ice is present.

The technology for collecting, tracking, modeling and predicting metocean conditions and sea-ice data are continually advancing and evolving, it is important to consider if regulations requiring the collection and analysis of this data are adequate and whether they may or may not require to be adjusted according to technological advances. Regulations related to the collection of sea-ice and metocean data are listed in section 3.4.1.

Public and Industry comments regarding the importance of Sea-Ice and Metocean Data and the changing technology are summarized in section 3.4.2

3.4.1 Regulations to Submit Sea-Ice and Metocean Data

At present, there are no direct U.S. regulations that require sea-ice and metocean data be submitted as part of relief-drilling rig or SCCE deployment procedures or plans. These data are however required to be submitted in the APD as part of the general operations information, and are also required to be submitted within general spill contingency plan requirements. API recommendations, listed below in section 3.4.1.2, provide more extensive guidance for the collection and use of sea-ice and metocean data.

While the U.S. and Canada do require some sea-ice and metocean data be submitted with the application and contingency plans, they do not require data updates throughout the drilling operation. Greenland is the only country where it was noted that operators may be required to submit daily meteorological forecasts and ice conditions updates.

3.4.1.1 U.S. Federal Regulations for Ice and Metocean Data

- **30 CFR 250.470:** In addition to complying with all other applicable requirements included in this part, you must provide with your APD all of the following information pertaining to your proposed Arctic OCS exploratory drilling:
    - **(a)** A detailed description of (1) the environmental, meteorological, and oceanic conditions you expect to encounter at the well site(s).

  - **(d):** A detailed description of your weather and ice forecasting capability for all phases of the drilling operation, including:
    1. how you will ensure your continuous awareness of potential weather and ice hazards at, and during transition between, wells;
    2. your plans for managing ice hazards and responding to weather events; and
    3. verification that you have the capabilities described in your BOEM-approved Exploration Plan.
- **30 CFR 250.418 (f):** In areas subject to subfreezing conditions, evidence that the drilling equipment, BOP systems and components, diverter systems, and other associated equipment and materials are suitable for operating under such conditions.
- **30 CFR 250.472 (a):** In the event of a loss of well control, the Regional Supervisor [BSEE] may direct you to drill a relief well using a relief [rig able to kill and permanently plug an out-of-control well as described in your APD [Application for a Permit to Drill]. Your relief rig must comply with all other requirements of this part pertaining to drill rig characteristics and capabilities, and it must be able to drill a relief well under <u>anticipated Arctic OCS conditions.</u>

3.4.1.2 U.S. Industry Standards for Sea-Ice and Metocean Data

API Recommended Practice 2N provides extensive recommendations for the collection of sea-ice and metocean data and for how that data may be applied to determine safe operating conditions at a site including the following data.

- Ice coverage and the occurrence of grounded ice features, operational procedures for ice mitigation and management including how to alter the ice regime through decreases in flow size and the destruction or removal of potentially hazardous ice features, and through local reduction in ice coverage.
- Air temperature and associated actions that can also lead to a marine icing event.
- Factors affecting visibility (e.g. fog, blowing snow, daylight hours) polar lows including, the use of satellite remote sensing to be considered as part of the normal meteorological forecast service.
- Water depth at the site, including its variation.
- Wind, waves, current, and thermal expansion that affects ice movement and pack ice pressure. Interannual and seasonal variations in ice presence, polynas, and physical parameters shall be considered.
- Evaluation of minimal draft limitations shall be performed for all regions through which the structure can be transported in order to reach its final

destination. Contingency planning for all critical offshore activities shall be included to ensure safe transportation and installation.
- The varying amount of daylight hours in arctic regions.
- Where seismic events are a design concern, appropriate analyses shall be carried out.

3.4.1.3 International Industry Standards for Sea-Ice and Metocean Data

- **Canada:** Canada Oil and Gas Drilling and Production Regulations (SOR/2009-315 Part 11, 78). Meteorological Observations - The operator of an offshore installation shall ensure that:
    - the installation is equipped with facilities and equipment for observing, measuring and recording physical environmental conditions and that a comprehensive record of observations of physical environmental conditions is maintained onboard the installation; and
    - forecasts of meteorological conditions, sea states and ice movements are obtained and recorded each day and each time during the day that they change substantially from those forecasted.
- **Canada: National Energy Board - Filing Requirements for Offshore Drilling in the Canadian Arctic – 2015.** Canada requires that applicants to drill offshore provide data that address how factors in the Arctic, including extreme temperatures, darkness, polynas, ice cover, ice movement, sea state, currents, shoreline features, and seafloor features could potentially affect the project. Applicants must specifically include the following information:
    - Design or selection of the drilling unit, drilling rig, equipment, and working conditions.
    - Well design and drilling operations, including emergency disconnect.
    - Well completions, suspension, and abandonment.

  Applicants to drill offshore are also required to describe the ice management program with enough detail to demonstrate: the adequacy and effectiveness of the program in support of the proposed drilling activity; that the drilling system (the drilling platform and any supporting vessels) is able to stay at the drilling location so that drilling and related operations can be carried out safely; and that there is sufficient time to secure and suspend or abandon well operations properly in the event that the drilling system or personnel have to move away from the drilling location.

  Filing Requirements:

    - The design and operating limits of the drilling system in the anticipated ice-ocean-atmosphere conditions in the operating area and at the

  drilling location. Information on how the limits were established and validated should be included.
  - Conditions and ice features that would constitute hazards to the drilling system and its ability to stay at location. Provide information on the threshold used to identify conditions and ice features that could be a hazard, and a description of the conditions and ice features that would be at or above this threshold for the drilling system.
  - A description of how hazards will be identified and located. Provide information on ice-detection systems and capabilities and their effective range.
  - A description of how ice hazards will be predicted and tracked. Provide specifications of the forecasting and tracking systems that would be used. Provide information on system capabilities, reliability, and frequency of forecasting and tracking updates.
  - A description of how ice hazards will be managed. Provide information on ice-management system capabilities, reliability, and contingencies.
  - Describe how the drilling unit and well operations would be managed when ice hazards are predicted to exceed the ice management capability.
- **Europe: EN ISO 19901-1 Petroleum and Natural Gas Industries** - specific requirements for offshore structures - part 1 metocean design and operating conditions. 2015: These European recommended standards are informative on types of metocean conditions to consider and data that are particularly helpful for certain regions including Canada. No specific references to loss of well control or SCCE deployment**.**
- **Greenland: Bureau of Minerals and Petroleum (BMP) Exploration Drilling Guidelines Section 3.1 Weather Forecasts and Ice Reports:** The BMP request that a copy of the site-specific meteorological forecast and a report of ice conditions are to be provided daily to ensure the BMP is fully informed of the status of conditions in the event of an alert or an emergency situation.

3.4.2 Comments and Concerns for Sea-Ice and Metocean Data

The gap analysis research yielded a variety of comments and concerns that have been brought forward by commenters to the proposed regulations (Proposed Rule: Oil and Gas and Sulphur Operations on the Outer Continental Shelf – Requirements for Exploratory Drilling on the Arctic Outer Continental Shelf (Joint with BOEM) (1082-1100) 80 FR 9916 and 80 FR 21670). There may be some additional comments taken from industry reports presented at the Annual Arctic Conference or taken from published books on the Arctic. Comments also include industry expertise provided by Captain Don Connelly, Jerry Shursen, and Richard Carden of the BCE/Solsten Review Team. These comments are summarized below under the related subject matter. This section is not a complete listing of comments, but a general representation of the breadth of comments that exist on collection of sea-ice and metocean data.

3.4.2.1 Importance of Sea-Ice and Metocean Data

The Arctic OCS environment is prone to changing ice conditions, strong currents, stretches of 24-hour darkness, extreme cold and high winds. It is important for Arctic OCS regulations to include research, monitoring and forecasting of ice and metocean conditions to minimize the risk of loss of well control and to inform contingency planning for the transportation and deployment of a relief-drilling rig, capping stack, containment dome and other SCCE equipment. Safe operations and SCCE deployment will require some form of an ice- management system. The ice-management system for each operation will need to be designed to meet site-specific physical ice-management needs, if any, and operational time requirements on the MODU. The site-specific design should include an understanding of typical ice and metocean conditions for planning purposes, systems for real-time ice and weather forecasting, detection, and monitoring; an ice-alert system; and support vessel(s) for conducting physical ice management. The conditions at the site will drive, among many things, the number and capability of support vessels.

The overall ice-management system and area of operation will drive season lengths for floating systems, in part based on allowing for the required 45-day relief-well program. To enable an effective relief-well drilling program and the deployment of SCCE, the ice-management system should be able to provide safe ice-management support much longer than the intended exploration period. New technology including GPS transponders allows highly effective live tracking of ice floes and ice bergs without relying completely on helicopter or fixed-wing ice reconnaissance that is often limited by visibility and weather conditions.

3.4.2.2 Changing Technology for Collection and Evaluation of Sea-Ice and Metocean Data

Technology to measure and forecast ice and metocean conditions are constantly evolving. As a result, it will be important for any future regulations on this topic to consider a means for providing a clear and timely process to ensure the regulations remain inclusive of new technologies. As always, requiring specific technologies is a balance of availability, feasibility, cost, and appropriately fitting the depth and precision of the required data collection and forecasting to the application. It is important that the requirements can be adapted as appropriate to a project or situation.

3.5 Contingency Plans for Well Response

Contingency plan requirements cover many topics related to pollution prevention and spill control, most of which are outside of the scope of safe deployment of relief-drilling rigs and

SCCE equipment. However, within the contingency plan requirements there are some references to control of pollution at its source, and some references to loss of well control and relief wells that are pertinent to this review.

Requirements within contingency plan regulations that directly or indirectly affect an operator's responsibilities to use relief wells and other SCCE are listed in section 3.5.1. API industry standards also provide extensive detail and recommendations for contingency planning.

Public and industry comments address the adequacy of contingency planning requirements, development of well-specific capping plans and the sharing of response equipment. These comments are summarized in section 3.5.2.

3.5.1 Regulations for Contingency Planning

State of Alaska regulations are more explicit on loss of well-control contingency planning than U.S. federal regulations. It should be noted that the State of Alaska Department of Natural Resources and BSEE regulations have different response time requirements. BSEE regulations default to a spill response plan that address cleanup within 30 days, and completion of a relief-well drilling program within 45 days, while ADEC regulations address action that must be addressed within 72 hours and within 15 days after oil is discharged. These regulations are not necessarily equivalent response requirements, but there is room for confusion. Clarification of timing-response requirements may be necessary to ensure operators and the public understand their timing requirements.

3.5.1.1 U.S. Federal Regulations for Contingency Planning

- **40 CFR 112.11 (EPA):** If you are the owner or operator of an offshore oil drilling, production, or workover facility you must: meet the requirements listed under 112.7 and also meet the specific discharge prevention and containment procedures listed under this section. (This regulation includes various references such as a well-control system, but there are no direct references within this regulation regarding the ability to stop the discharge at its source or requirements related to contingency plans addressing the deployment of SCEE or relief-drilling rigs.)

3.5.1.2 Alaska State and Local Regulations for Contingency Planning

- **ADEC Prevention, Preparedness, and Response Program Oil Discharge Prevention and Contingency Plan (ODPCP) Application Package and Review Guidance Document Rev 1 2016 Chapter 3 Section 1.9.1 Well Blowout Control:** The [contingency plan] scenario for an exploration or production facility illustrates the methods, equipment, logistics, and associated timeframes for mobilization and deployment employed to control a well blowout. Exploration or production facilities must maintain a separate blowout contingency plan. The blowout contingency plan is not part of the [ODPCP] plan application package required under 18 AAC 75.408, but must be made available to the department prior to [ODPCP] plan approval and for inspection upon request under 18 AAC 75.480. The department may consult with AOGCC or other agencies to determine the adequacy of the planned methods, equipment, logistics, and timeframes for the control of a well blowout. (This regulation does not address what to do is the blowout prevention plan fails.)

- **Alaska Department of Natural Resources, Beaufort Sea Areawide Oil and Lease Sale, Final Finding of the Director /18 AAC 75.425 and AS 46.04.030 (o):** The Response Planning Standard Section of the current statute allows the sharing of oil spill response equipment, materials, and personnel among plan holders. (This could extend to relief-drilling rigs or other SCCE.)
- **Alaska Department of Natural Resources, Beaufort Sea Areawide Oil and Lease Sale, Final Finding of the Director /18 AAC 75.425/AS 46.04.030 (2) (c) (E)/18 AAC 75.485 (a) and (d):** The statute requires the plan holder to "successfully demonstrate the ability to carry out the [blowout contingency] plan when required by ADEC. ADEC requires that exercises be conducted to test the adequacy and execution of the [blowout] contingency plan. Two exercises are required annually. The plan must include a summary of methods, equipment, logistics and time frames proposed to be employed to control a well blowout within 15 days.
- **Alaska Department of Natural Resources, Beaufort Sea Areawide Oil and Lease Sale, Final Finding of the Director/18 AAC 75.425**: The [required] Response Action Plan must include an emergency action check list of immediate steps to be taken if a discharge occurs. (The checklist includes many items, such as “specific actions to stop a discharge at its source”, but again the regulation does not clearly include or exclude actions involving SCCE or relief-well requirements.)
- **Alaska Department of Natural Resources, Beaufort Sea Areawide Oil and Lease Sale, Final Finding of the Director (2009):** Regardless of the nature or location of a spill, the North Slope Subarea Plan sets these objectives for all response actions.
    - Ensure safety of responders and the public.
    - Stop the source of the spill.
    - Deploy equipment to contain and recover the spilled product.
    - Protect sensitive areas (environmental, historic, and human use).
    - Track the extent of the spill and identify affected areas.
    - Clean up contaminated areas and properly dispose of wastes.
    - Notify and update the public.

3.5.1.3 U.S. Industry Standards for Contingency Planning

Extensive API industry standards provide detailed recommendations to ensure that SCCE equipment is well maintained and ready for use, and that there is a detailed deployment plan. These standards complement the state and federal regulations that require access to and deployment of SCCE in the event of the loss of well control.

- **API RP 17W Subchapter 6.4 American Petroleum Institute Recommended Practice for Subsea Capping Stacks - Preservation:** Preservation to ensure that the SCCE equipment is maintained in a constant state of readiness. Periodic drills to ensure personnel are capable of reacting quickly and efficiently to potential situations requiring SCCE use.
- **API RP 17W Subchapters 6.1.2.5.3 and 6.1.2.6 - 6.1.2.12 American Petroleum Institute Recommended Practice for Subsea Capping Stacks - Testing:** Testing for multiple items including subsea capping stacks - hydraulic chamber testing, drift tests, ram tests, valve tests, choke tests, test fluids, test pressure measurement devices. Test documentation is also covered in these recommendations.
- **API RP 17W Subchapter 6.2 American Petroleum Institute Recommended Practice for Subsea Capping Stacks - Maintenance:** Maintenance practices include ensuring the subsea capping stack is ready for mobilization when required, at any time with no need for additional maintenance or repair.
- **API RP 17W Annex A American Petroleum Institute Recommended Practice for Subsea Capping Stacks – Subsea Well Capping Contingency Procedures:** Develop a set of Subsea Well Capping Contingency Procedures that address subsea debris and failed equipment removal including a recommended list of equipment for immediate callout, and where the equipment is retained.
- **API RP 17W Subchapter 5.7 American Petroleum Institute Recommended Practice for Subsea Capping Stacks – Logistics and Deployment Plans:** Address details of airports and capacity to receive and service heavy-lift aircraft, customs clearance, availability of transportation resources, capacity of roads, bridges, tunnels, road permits issues and restrictions. Develop a load plan with crane capacities, trailer sites, permit loads, third party technical personnel required at site. Develop a deployment plan from receiving and handling at port-of-entry until the capping stack is deployed from a vessel and installed.
- **API RP 17W Subchapter 6.3 American Petroleum Institute Recommended Practice for Subsea Capping Stacks – Inspections:** Include an inspection schedule to ensure it [SCCE] is maintained in a constant state of readiness.

3.5.1.4 International Regulations for Contingency Planning

International Policies for Contingency Planning

This section is included as it is the international underpinning of all other spill-response requirements including the loss of well control. However, these agreements are not so specific as to address requirements for same-season relief wells or SCCE deployment. The U.S. is a participating party in the 1990 Convention on Oil Pollution and Cooperation, the United Nations Convention of the Sea and the Arctic Council which all require the ability to directly and/or indirectly address the loss of well control.

- **1990 Convention on Oil Pollution Prevention Response and Cooperation (OPRC), a Treaty Negotiated within the Framework of the International Maritime Organization:** Parties to OPRC are required to establish measures for dealing with pollution incidents; these include the stockpiling of oil spill equipment, the development of clean-up plans and the holding of exercises. This convention also specifies the requirements of mutual assistance in international cooperation. The OPRC is considered to be: "probably the most important international legal document that regulates pollution of the marine environment resulting from offshore oil and gas activities”. (Spicer, 2012).
- **United Nations Convention of the Sea - Part XII Protection and Preservation of the Marine Environment:** Contains general statements about contingency plans. In particular, Article 197: States shall cooperate on a global basis and, as appropriate, on a regional basis, directly or through competent international organizations, in formulating and elaborating international rules, standards and recommended practices and procedures consistent with this Convention for the protection and preservation of the marine environment, taking into account characteristic regional features.
- **Arctic Council “Arctic Offshore Oil and Gas Guidelines" Updated in 1997/2002/2009: United Nations Convention of the Sea - Part XII Protection and Preservation of the Marine Environment:** These guidelines contain general statements about preventing, minimizing and controlling pollution, and about liability and enforcement; there is also a strong focus on improving communication and coordination between operators when accidents occur. Promotes regional consultations, coordination, and cooperation since there is currently no legally binding, multilateral marine oil pollution response instrument specific to the Arctic.
- **Arctic Council Arctic Offshore Oil and Gas Guidelines 2009:** Arctic states that are party to the International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC 1990) and/or the International Convention for the Prevention of Pollution from Ships

(MARPOL 1973/1978, Annex I) are required to ensure that operators have oil pollution emergency plans and that these plans are carried onboard installations.

- **Arctic Council Arctic Offshore Oil and Gas Guidelines 2009: "**Operators should establish and maintain emergency preparedness so that the mitigation of an incident will be carried out without delay in a controlled, organized, and safe manner. Risk analysis should be carried out in order to identify the accidental events that may occur and the consequences of such accidental events. An analysis should be carried out to design the emergency-preparedness requirements so as to meet the specific circumstances of the operation. The contingency-planning process is one of the key best management practices for evaluating the environmental effects of the response operation. Response options can be fully evaluated under varying weather and ice conditions to decide ahead of time which options may be most successful in minimizing the effects of a spill and subsequent clean-up operations. Emergency response plans should address abnormal conditions and emergencies that can be anticipated during the oil and gas operation being carried out including...loss of well control." (Arctic Council 2009)
- **International Law and the Arctic - Michael Byers Cambridge Studies in International and Comparative Law. 2013, p. 208:** Russia has treaties with its neighbors concerning cooperation in the event of an oil spill. In 1989, the Soviet Union and the U.S. concluded an agreement called Cooperation in Combatting Pollution in the Bering and Chukchi Seas in Emergency Situations. Under the agreement, the two countries undertake to: render assistance to each other in combatting pollution incidents regardless of where such incidents may occur, to develop a joint contingency plan and to periodically conduct joint pollution response exercise. In 1994, Russia and Norway signed an agreement on oil spill response in the Barents Sea. The agreement requires the two countries also to develop a joint contingency plan and to notify each other in the event of a spill.

International Industry Standards for Contingency Planning

- **Europe: EN ISO 155444 (1) Petroleum and Natural Gas Industries - Offshore Production Installations - Requirements and Guidelines for Emergency Response:** This international standard describes objectives, functional requirements and guidelines for emergency response measures on installations used for the development of offshore hydrocarbons resources. The standard is applicable to fixed offshore structures for floating production, storage and off-take systems. The standard requires a framework of emergency response and risk management and reduction that includes formation of an emergency-response strategy based on an assessment of the events that can arise and an Emergency Response Plan. Various guidelines are provided for competency, testing, emergency-response equipment and maintenance, communications, escape/evacuation, medical response, handling of oil spills, drills, and detection.

- **Norway: NORSOK STANDARD Section 4.4 Revision 2, December 1998 Norwegian Technology Standards Institution (Industry Initiative):** The Blowout Contingency Plan shall be developed to meet the Norwegian Petroleum Directorate legislation as well as operator internal requirements. The document shall be regularly updated to ensure that relevant information is available in case of loss of well control. It shall include mobilization plans for the necessary emergency equipment, personnel, and services; kill methods in the case of a blowout occurrence; a description of suitable locations for drilling a relief well; and measures for limiting the amount of the damage from the hazard or accident.
- **Norway: Petroleum Safety Authority Norway Chapter IV Section 21 Offshore Emergency Preparedness Cooperation:** The operator shall cooperate with operators of other production licenses to ensure necessary emergency preparedness in the areas of health, safety and the environment. When special circumstances so warrant, the Petroleum Safety Authority Norway and the Norwegian Environment Agency can issue and stipulate conditions for such cooperation, including an order to the effect that the financing of the response effort shall be a joint responsibility. In the scope of the Pollution Control Act and the Product Control Act or in connection with establishing management systems for follow-up of the Product Control Act, no standards or recognized norms are referenced. It is the responsible party's task to assess how required environmental requirements best can be achieved, and implement measures to fulfill these requirements.

International Regulations for Contingency Planning

- **Greenland: Bureau of Minerals and Petroleum Exploration Drilling Guidelines Section 1.0:** Prior to authorizing and issuing an Approval to Drill, the BMP has a duty to ensure that the operator shall present the application to drill with a dual drilling-rig vessel presence policy which allows for fast contingency response in case of severe well-control issues. Prior to authorizing and issuing Approval to Drill, the BMP has a duty to ensure that the plan includes the following elements.
  - Requirements for license and financial responsibility.
  - The operator shall present the Application to Drill with a dual drilling rig vessel presence policy which allows for fast contingency response in case of severe well-control issues. If more than one operator applies for

  drilling, a co-operation between the operators may be granted by BMP in sharing the responsibility for dual rig policy by entering into rig sharing agreements. If such agreement is proposed, BMP shall review such an agreement prior to a potential approval.
  - The operator shall present contingency plans for; major personnel accident, oil pollution, ice management and relief well drilling.
  - Suitable standby vessel(s), ice breakers and other support vessels will be provided complete with certification of fitness.
  - Additional requirements for safety, drill program submittal, environmental assessment, social assessment, and insurance not related to well control.
  - BMP may impose seasonal restrictions to the operations based on environmental sensitivity and/or weather/climate conditions.
  - The following contingency plans must be submitted and presented as a minimum to BMP for approval: emergency preparedness plan, oil spill and pollution plan, relief well drilling plan and program, and ice management plan. In the case where more than one operator applies for drilling, co-operations between the operators may be granted by BMP in sharing the responsibility for the different contingency plans by entering into sharing agreements and responsibilities. If such agreement is proposed, BMP shall review such agreements prior to a potential approval of the sharing agreements.
- **Canada: National Energy Board Filing Requirements for Offshore Drilling In the Canadian Arctic Chapter 4.17 b.** Capping and Containment Contingency Plan September 2015 requires that offshore drilling containment and contingency plans describe the following plan elements.
  - Describe the capping and containment methods and system proposed to appropriately respond to the worst-case scenario.
  - Describe the plan for mobilization, deployment, and operation of the capping and containment system, including any clearance of debris or damaged pieces of sub-sea systems.
  - Describe the execution plan, resources, reliability, and redundancies of the capping and containment system in the unique Arctic environment.
  - Describe the required support systems, including vessels, icebreakers, riser system, and remotely operated underwater vehicles (ROV).
  - Describe the testing and certification process of the capping and containment system, including qualification of new technology where applicable.

3.5.2 Comments and Concerns for Contingency Planning

The gap analysis research yielded a variety of comments and concerns that have been brought forward by commenters to the proposed regulations (Proposed Rule: Oil and Gas and Sulphur Operations on the Outer Continental Shelf – Requirements for Exploratory Drilling on the Arctic Outer Continental Shelf (Joint with BOEM) (1082-1100) 80 FR 9916 and 80 FR 21670). There may be some additional comments taken from industry reports presented at the Annual Arctic Conference or taken from published books on the Arctic. These comments are summarized below under the related subject matter. This section is not a complete listing of comments, but a general representation of the breadth of comments that exist on contingency planning.

3.5.2.1 State of Alaska Plan Development and Approval Process

The State of Alaska does specifically require a well blow-out response plan but does not provide specifics on content such as safe deployment practices and suitable deployment conditions. Local agencies such as the Northwest Arctic Borough recommend that the State also specifically require relief-well rig pre-planning, rather than waiting until an emergency situation. They state that they believe relief-well rig pre-planning will expedite relief-well design, permitting, and safe deployment.

Commenters such as the Northwest Arctic Borough are concerned that while drilling operators typically have emergency well-control plans, there are concerns that the plans are not adequately reviewed and/or subject to a well-defined approval process. They believe the plan should cover the primary rig, well capping and containment equipment, secondary relief-well rigs and additional well barriers. The plan should also be subject to rigorous examination to ensure the agency is familiar with the operator's response methods, thereby expediting the well control and relief-well drilling approvals needed during an emergency.

3.5.2.2 Development of a Well-Specific Capping Plan

Commenters noted that it may be important to develop a well-specific capping plan. They noted that the development of a well-specific capping plan would require site-specific and well-specific information such as an engineering analysis of the feasibility of deploying a capping stack from a floating vessel, the weight and stability of the capping stack to overcome the force of the blowout jet, and dynamic-flow simulations of closing the capping-stack outlets without loss of well integrity.

Computational-Fluid-Dynamics (CFD) simulations were suggested by one commenter as a method that could be used to determine if a capping stack can be landed and installed for a specific well and blowout scenario. The commenter also suggested that CFD simulations could be run for a wide range of blowout scenarios to identify an acceptable operating envelope, which would be unique for every subsea capping stack, depending on its weight and configuration. If it is found that a capping-stack landing may be challenging, the commenter suggested that it may be possible to use devices such as funnels and guide wires to aid in centering the stack and keeping it stable.

3.5.2.3 Sharing Response Equipment

Arctic countries such as Norway, Denmark/Greenland, and Canada have specific regulatory provisions for the sharing of a relief-well drilling and other SCCE between operators. There are also several international agreements and policies that include the U.S. and other Arctic countries that include similar provisions. Similar practices also exist through private agreements amongst oil companies in Alaska and elsewhere.

After the MACONDO incident, the Joint Industry (API/IADC/IPAA/NOIA/USOGA) Subsea Well Control and Containment Task Force produced a final report called "Industry Recommendations to Improve Subsea Well Control and Containment", dated March 13, 2012. Within this report were several recommendations (#1, #2, and #21) related to coordinated industry capability and commercial availability of well- containment equipment. These provisions, similar to the international regulations and agreements, can provide significant financial relief to the operators. However, when drilling in remote areas of the Arctic OCS, distances between operations may be too great to be of timely assistance or offshore drilling operations may be limited to a single operator during a given season.

4.0 Gap Analysis Summary

No regulations were located in any country regarding specific emergency relief-well or SCCE safe deployment practices. Through this review, it was determined that the definitive conclusion to this gap analysis is that there are no specific or prescriptive regulatory references in the U.S. or abroad that directly address safe deployment practices for either SCCE or relief-drilling rigs in Arctic waters.

While the team's research did not uncover any regulations specifically related to safe deployment practices of SCCE and relief-drilling rigs, the team did compile an extensive repository of related regulations, industry standards and practices, industry methods, and public and industry concerns and comments that provide important context for the use and safe deployment of SCCE and/or relief-drilling rigs. This additional research information is contained in the Gap Analysis Matrix, and has also been summarized and discussed throughout this report as it was determined that it may be of use to BSEE for review and development of future Arctic offshore oil and gas regulations.

The following sections summarize the key findings within this report related to safe deployment and operation of emergency-response equipment as contingency measures for well-loss control at its source.

4.1 Relief Wells

Summary findings related to requirements for access to relief-drilling rigs as well as their safe deployment and operation are listed below in section 4.1.1. A summary of key public and industry comments is provided in sections 4.1.2 through 4.4.4.

4.1.1 Regulatory Gap Analysis

- Relief wells have long been relied upon as the required response to loss of well control. Canada, in 1976, was the first government to require relief wells. The requirement has since been adopted throughout most of the Arctic including key arctic offshore nations; Canada, USA, Norway, and Greenland all require some form of demonstrated relief-well capability either directly or via the contingency planning process. Russian regulations and standards could not be accessed to directly determine if there are any specific requirements for relief wells; however, books discussing Arctic international law state that no such requirements exist. Finland, having no oil and gas resources, also has no applicable regulations. In the United States regulations are generally similar to other Arctic OCS countries in that they effectively require the use of a same-season relief well, by requiring that a relief-drilling rig be staged at a location that it can arrive at the well site to drill a relief well, and kill and abandon both the original well and the relief well, within 45 days after the loss of well control under expected seasonal ice conditions. Differences in the regulations center on how quickly an operator is required to be able to bring a relief-drilling rig on site after a loss of well control incident.

- Design and operating standards for relief-drilling rigs are generally covered by the same regulations that apply to primary drilling rigs and well development; as a result there are few explicit regulations or standards that address the specific design, operation or safe deployment of relief-drilling rigs. Regulations that address oil spill contingency planning make references, both directly and indirectly, for relief wells, loss control plans, and other response directives.

4.1.2 Efficacy and Usefulness of Relief Wells

- Commenters from the public and industry sectors assert that relief wells are seldom needed or used for well-loss control; capping stacks and other SCCE are the preferred technology for their efficacy and expediency.
- Commenters from the public and industry sectors also assert that relief wells represent a last line of defense that may be employed to address an estimated 5 to 10 percent probability of a well-loss situation that cannot be controlled through other forms of SCCE (BSEE comment file, 2018).

4.1.3 Associated Risks of Relief Wells

- Relief wells introduce additional environment risk through the development of a second well.

4.1.4 Impact of Relief Wells on the Drilling Season

- The requirement in 30 CFR 250.472 (b) to have access to a relief-drilling rig staged to arrive on site and to drill a relief well, kill and abandon the original and the relief wells within 45 days, as noted by the National Petroleum Council, this effectively reduces the drilling season by approximately 35 to 45 percent (depending on the well depth and geology, the ice management capability of the marine support vessels, and the defined Arctic drilling season for the specific location) (BSEE comment file, 2018).

4.2 SCCE

Summary findings related to requirements for access to capping stacks, containment domes and other SCCE equipment, as well as their safe deployment and operation, are listed below in section 4.2.1. A summary of key public and industry comments is provided in section 4.2.2.

4.2.1 Regulatory Gap Analysis

- U.S. regulations specifically require Arctic OCS operations to have capping stacks available within 24 hours and cap and flow systems and containment domes available within a 7-day time period. Review of other nations' Arctic offshore regulations did not show other countries prescribing similar SCCE requirements. Comments from operators in those areas, however, do indicate that regulations in these other countries tend to be performance based versus prescriptive allowing the operators to develop SCCE plans that are designed for their site-specific conditions.
- U.S. industry standards do provide detailed recommendations for SCCE equipment, support vessels and testing. However, they do not delineate recommended appropriate or inappropriate icing or metocean conditions for safe deployment.
- The source of the most direct and technologically specific guidance for the safe use and deployment of SCCE and relief-drilling rigs lies within industry standards. This source lacks a basis of enforcement, but by that very nature, it also allows the most fluid process to adjust guidance to include new technology and the evolution of practical knowledge.

4.2.2 Efficacy and Usefulness of SCCE

- SCCE technologies offer a dramatic reduction in worst-case discharge volumes because they are designed to stem the flow of oil in a matter of minutes, hours, or days versus weeks or months and they are independent of the controls on the drilling rig.
- A SID that is pre-installed on a well that has been designed to accommodate a full shut-in of the last casing string set, and that can be remotely operated from an offsite location, is likely to be capable of safely responding to a blowout and killing a well under the occasional conditions that preclude deployment of other forms of SCCE. While the SID, as a response tool, is likely to be highly successful, there could be situations in which a SID could fail and a relief well could still be required to bring the well under control. It is important to consider that by combining a capping stack with a properly designed, preinstalled SID, the 90 – 95 percent probability of containing a blowout with SCCE will increase significantly and more closely approach 100 percent. The use of a preinstalled SID could provide a faster, safer second line of defense for a blowout than a relief well resulting in smaller discharges to the environment.
- Response technologies like capping stacks are being utilized in frontier areas around the globe. The feasibility of a subsea capping operation will largely depend on the ability of vessels to work safely above or near the spill zone.

- SIDs, enhanced BOP, and other technologies may be better suited for some situations such as in shallow waters or when bottom-founded drilling vessels are present on the blowing well.
- Capping stacks can often be overwintered negating the need to plug and abandon within the same season.
- Containment domes may not always be suited for Alaskan Arctic OCS conditions; they are unproven in shallow waters (less than 300 feet), and may not be feasible for use with jack-up MODUs, gravel islands, or bottom–founded submersible vessels.

4.3 Alternative Technology Approval Process

Summary findings related to requirements for the approval of alternative loss of well response equipment are listed below in section 4.3.1. A summary of key public and industry comments is provided in sections 4.3.2 – 4.3.3.

4.3.1 Regulatory Gap Analysis

- U.S. regulation allows for use of alternative technology as a potential substitution for relief-drilling rigs and/or other prescribed SCCE procedures or equipment used to stop and/or capture the flow of an out-of-control well. These regulations provide some accommodation for unique conditions when relief-drilling rigs and/or other required SCCE are not suitable, safe, or are cost-prohibitive. They thereby also accommodate new innovative technology that may not have been invented or available at the time the regulations were drafted.
- Regulations that allow for approval of alternative technology also exist in Canada and Norway. In the U.S. and Canada, this provision is separate from the usual prescriptive permitting process; approval of the use of alternative technology is based on an undefined performance–based review process. However, in Norway the overall permit process is performance based; the review and acceptance of alternative technologies is integral and does not require a separate process.
- A two-phased review process, approved but never utilized in Canada, could provide a timely and efficient model for approval of new SCCE technologies. In this approach, the proposed alternative technology is approved prior to submittal of the APD. The APD then includes a project description that addresses all aspects of the project, including integration of the alternative SCCE. This two-phased approach enables two things; first, companies can make a timely investment in new and innovative well-control systems with less financial risk, and second, this approach supports a full agency and public review of the new technology within the context of the overall project and site-specific conditions.

4.3.2 Clarity of Alternative Technology Approval Process

- The approval process could be improved through: setting clear performance standards, setting methods to measure risk-reduction benefit, incorporating adequate site specific environmental factors, considering fit-for-purpose technology for the drilling equipment, and reviewing technology in the context of a worst-case scenario.

4.3.3 Timeliness of Alternative Technology Approval Process

- The approval process could be improved by incorporating set time periods for: acceptance of a proposal, review of the proposal, and for issuing a final decision.
- A timely approval process would encourage operators to request the use of the most effective technology for their operation.

4.4 Submittal of Sea-Ice and Metocean Data

Listed below in section 4.4.1 are the summary findings related to requirements for collection, modeling, tracking and predicting sea-ice and metocean conditions. These data are necessary for planning emergency-response deployment of relief-drilling rigs and SCCE and for supporting ice-management systems that enable safe operations when ice is present in Arctic offshore waters. A summary of key public and industry comments is provided in section 4.4.2.

4.4.1 Regulatory Gap Analysis

- At present, there are no direct regulations that required sea-ice and metocean data be submitted as part of relief-drilling rig or SCCE deployment procedures or plans. Ice and metocean data are however required to be submitted in the APD as part of the conditions for general operations, and are also required to be submitted within spill contingency plan requirements. These data may or may not address all the issues that affect safe deployment of relief-drilling rigs or SCCE equipment.
- API Recommended Practice 2N provides extensive recommendations for the collection of sea-ice and metocean data and guidance for how that data may be applied to determine safe operating conditions at a site.
- Sea-ice and metocean data requirements for Canada are listed within the National Energy Board - Filing Requirements for Offshore Drilling in the Canadian Arctic – 2015. The requirements center on supporting ice-management systems and could serve as a meaningful reference for the development of U.S. regulations.
- Greenland also has regulations regarding sea-ice and metocean data but they are limited to a requirement that operators submit daily meteorological forecasts and ice-condition updates.

4.4.2 Importance of Sea-Ice and Metocean Data

- Diverse and extreme Arctic conditions have the potential to affect the safety and the effectiveness of SCCE and/or relief-drilling rig deployment, as well as to affect the determination of which SCCE methods are appropriate for each individual situation.
- Information collected from satellite, aircraft and ice-management marine vessels feed into an alert system which in turn drives the alert level which drives operational decisions on the well site ranging from normal drilling operations to initiating and drilling a relief well. Marine vessels are also used for ice reconnaissance to inform operation personnel if their available ice-management vessels are capable of breaking the ice features down to a non-hazardous condition in time to prevent impacts to the MODU.
- New technology is constantly evolving. Current developments in technology such as GPS transponders are highly effective for live tracking of ice floes and ice bergs without relying completely on helicopter, fixed-wing and UAV/UAS-drone ice reconnaissance, methods that are often limited by visibility and weather conditions. However, marine-reconnaissance vessels will likely continue to be necessary to physically go to an ice feature that satellite technology (or aircraft) has labeled as potentially hazardous to conduct a “taste-test”. This test is used to determine the manageability of the ice feature and to set a management timeline to determine the alert level and impact on a T-Time (time to secure the well). Any future technology regulations would need to consider flexibility regarding ice-data collection methods to allow inclusion of new and existing ice-reconnaissance methods as appropriate.

4.5 Contingency Plans

Summary findings related to requirements for developing contingency plans to address loss of well control situations are listed below in section 4.5.1. A summary of key public and industry comments is provided in section 4.5.2.

4.5.1 Regulatory Gap Analysis

Within the contingency plan requirements, there are references to the minimization of pollution, control of pollution at its source, and some references to well-loss control and relief wells. State of Alaska regulations are more explicit on loss of well-control contingency planning than U.S. federal regulations.

- The U.S. is a participating party in several international agreements, the 1990 Convention on Oil Pollution Prevention Response and Cooperation (OPRC), a treaty negotiated within the framework of the International Maritime Organization, the United Nations Convention of the Sea and the Arctic Council

"Arctic offshore oil and gas guidelines", all of these agreements require the ability to directly and/or indirectly address loss of well control.

- U.S. regulations in 40 CFR 112.11 require owners and operators of offshore oil drilling, production, or workover facilities to meet specific discharge prevention and containment procedures; this regulation includes various references such as a well-control system, but there are no direct references regarding the ability to stop the discharge at its source or requirements related to contingency plans addressing the deployment of SCEE or relief-drilling rigs.
- The State of Alaska (18 AAC 75.425) requires an exploration or production facility to submit a spill plan that includes methods to stop a discharge at its source and to control a well blowout within 15 days based on an approved estimated volume under typical summer environmental conditions. This is a general oil-facility requirement that does not specifically address offshore drilling.
- Extensive API industry standards provide detailed recommendations to ensure that SCCE equipment is ready for use, and that there is a detailed deployment plan. These standards complement the state and federal regulations that require access to and deployment of SCCE in the event of the loss of well control.
- International regulations in Canada, Norway, and Greenland all address contingency planning, as do European Industry standards. Russia has agreements with its neighbors to cooperate on spill planning in its border areas.
- Arctic countries such as Norway, Denmark/Greenland, and Canada and several international agreements all include provisions for allowing the sharing of a relief-drilling rig and other SCCE. After the MACONDO incident, the Joint Industry (API/IADC/IPAA/NOIA/USOGA) Subsea Well Control and Containment Task Force recommended improvements to coordinated industry capability and commercial availability of well-containment equipment. However, when drilling in remote areas of the Arctic OCS, distances between operations may at times be too great to be of timely assistance; or offshore drilling operations may be limited to a single operator during a given season.

4.5.2 Contingency Plan Development

- The U.S. government does not require a blowout contingency plan. The State of Alaska does require a blowout contingency plan but does not provide specifics on content such as safe deployment practices of relief-drilling rigs and SCCE, or on suitable deployment conditions. However, regardless of regulatory requirements, it is generally an industry practice for offshore operators to develop a policy requiring blowout contingency plans for all exploration and development wells.

- Industry standards provide guidance for capping and containing a blowing subsea well, but commenters note that capping plans may not lend themselves to prescriptive content as they vary based on site-specific and well-specific information.
- Commenters have raised concerns that the Alaska regulations do not provide a well-defined approval process for contingency plans.

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ID	Source	Category - regulation, standard, comment	Action	Subject 1	Subject 2
1	30 CFR 250.471 (a)(1)	Regulation US	Must have access to a capping stack, positioned to ensure that it will arrive at the well location within 24 hours after a loss of well control and can be deployed as directed by the Regional Supervisor.	Capping Stack/Systems	
2	30 CFR 250.471 (a)(2)	Regulation US	A cap and flow system, positioned to ensure that it will arrive at the well location within 7 days after a loss of well control and can be deployed as directed by the Regional Supervisor pursuant to paragraph (h) of this section. The cap and flow system must be designed to capture at least the amount of hydrocarbons equivalent to the calculated worst case discharge rate referenced in your BOEM-approved EP.	Capping Stack/Systems	
3	30 CFR 250.471 (a)(3)	Regulation US	A containment dome, positioned to ensure that it will arrive at the well location within 7 days after a loss of well control and can be deployed as directed by the Regional Supervisor. The containment dome must have the capacity to pump fluids without relying on buoyancy.	Containment Dome	
4	30 CFR 250.471 (b)	Regulation US	You must conduct a monthly stump test of dry-stored capping stacks. If you use a pre-positioned capping stack, you must conduct a stump test prior to each installation on each well.	Capping Stack/Systems	
5	30 CFR 250.471 (c)	Regulation US	As required by § 250.465(a), if you propose to change your well design, you must submit an APM. For Arctic OCS operations, your APM must include a reevaluation of your SCCE capabilities for any new Worst Case Discharge (WCD) rate, and a demonstration that your SCCE capabilities will meet the criteria in § 250.470(f) under the changed well design.	SCCE Generalized Well Control	
6	30 CFR 250.471(d)	Regulation US	You must conduct tests or exercises of your SCCE, including deployment of your SCCE, when directed by the Regional Supervisor.	SCCE Generalized Well Control	
7	30 CFR 250.471 (e)	Regulation US	You must maintain records pertaining to testing, inspection, and maintenance of your SCCE for at least 10 years and make the records available to any authorized BSEE representative upon request.	SCCE Generalized Well Control	
8	30 CFR 250.471 (f)	Regulation US	You must maintain records pertaining to the use of your SCCE during testing, training, and deployment activities for at least 3 years and make the records available to any authorized BSEE representative upon request.	SCCE Generalized Well Control	
9	30 CFR 250.471 (g)	Regulation US	Upon a loss of well control, you must initiate transit of all SCCE identified in paragraph (a) of this section to the well.	SCCE Generalized Well Control	
10	30 CFR 250.471 (h)	Regulation US	You must deploy and use SCCE when directed by the Regional Supervisor.	SCCE Generalized Well Control	

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11	30 CFR 250.471 (i)	Regulation US	Operators may request approval of alternate procedures or equipment to the SCCE requirements of sub paragraph (a) of this section in accordance with § 250.141. The operator must show and document that the alternate procedures or equipment will provide a level of safety and environmental protection that will meet or exceed the level of safety and environmental protection required by BSEE regulations, including demonstrating that the alternate procedures or equipment will be capable of stopping or capturing the flow of an out-of-control well.	SCCE Generalized Well Control	
12	30 CFR 250.472 (a)	Regulation US	In the event of a loss of well control, the Regional Supervisor may direct you to drill a relief well using the relief rig able to kill and permanently plug an out-of-control well as described in your APD. Your relief rig must comply with all other requirements of this part pertaining to drill rig characteristics and capabilities, and it must be able to drill a relief well under anticipated Arctic OCS conditions.	Relief Well	
13	30 CFR 250.472 (b)	Regulation US	When you are drilling below or working below the surface casing during Arctic OCS exploratory drilling operations, you must have access to a relief rig, different from your primary drilling rig, staged in a location such that it can arrive on site, drill a relief well, kill and abandon the original well, and abandon the relief well prior to expected seasonal ice encroachment at the drill site, but no later than 45 days after the loss of well control.	Relief Well	
14	30 CFR 250.472 (c)	Regulation US	Operators may request approval of alternative compliance measures to the relief rig requirement in accordance with § 250.141. The operator must show and document that the alternate compliance measure will meet or exceed the level of safety and environmental protection required by BSEE regulations, including demonstrating that the alternate compliance measure will be able to kill and permanently plug an out-of-control well.	Relief Well	Approval process
15	30 CFR 250.141 (a)(b)(c)	Regulation US	Any alternate procedures or equipment that you propose to use must provide a level of safety and environmental protection that equals or surpasses current BSEE requirements. You must receive the District Manager's or Regional Supervisor's written approval before you can use alternate procedures or equipment. To receive approval, you must either submit information or give an oral presentation to the appropriate Regional Supervisor. Your presentation must describe the site-specific application(s), performance characteristics, and safety features of the proposed procedure or equipment.	SCCE Generalized Well Control	Approval process
16	30 CFR 250.470 (a)	Regulation US	In addition to complying with all other applicable requirements included in this part, you must provide with your APD all of the following information pertaining to your proposed Arctic OCS exploratory drilling: A detailed description of (1) the environmental, meteorological, and oceanic conditions you expect to encounter at the well site.	General Application Information	Ice and metocean data

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17	30 CFR 250.470 (a)	Regulation US	In addition to complying with all other applicable requirements included in this part, you must provide with your APD all of the following information pertaining to your proposed Arctic OCS exploratory drilling: (2) How you will prepare your equipment, materials, and drilling unit for service in the conditions identified in paragraph (a)(1) of this section, and how your drilling unit will be in compliance with the requirements of § 250.713.	General Application Information	
18	30 CFR 250.470 (b)	Regulation US	In addition to complying with all other applicable requirements included in this part, you must provide with your APD all of the following information pertaining to your proposed Arctic OCS exploratory drilling: A detailed description of all operations necessary in Arctic OCS conditions to transition the rig from being under way to conducting drilling operations and from ending drilling operations to being under way, as well as any anticipated repair and maintenance plans for the drilling unit and equipment. You should include, among other things, a description of how you plan to: (1) Recover the subsea equipment, including the marine riser and the lower marine riser package; (2) Recover the BOP; (3) Recover the auxiliary sub-sea controls and template; (4) Lay down the drill pipe and secure the drill pipe and marine riser; (5) Secure the drilling equipment; (6) Transfer the fluids for transport or disposal; (7) Secure ancillary equipment like the draw works and lines; (8) Refuel or transfer fuel; (9) Offload waste; (10) Recover the Remotely Operated Vehicles; (11) Pick up the oil spill prevention booms and equipment; and (12) Offload the drilling crew.	General Application Information	

ID	Source	Category - regulation, standard, comment	Action	Subject 1	Subject 2
19	30 CFR 250.470 (c)	Regulation US	In addition to complying with all other applicable requirements included in this part, you must provide with your APD all of the following information pertaining to your proposed Arctic OCS exploratory drilling: A description of well-specific drilling objectives, timelines, and updated contingency plans for temporary abandonment of the well, including but not limited to the following: (1) When you will spud the particular well (i.e., begin drilling operations at the well site) identified in the APD; (2) How long you will take to drill the well; (3) Anticipated depths and geologic targets, with timelines; (4) When you expect to set and cement each string of casing; (5) When and how you would log the well; (6) Your plans to test the well; (7) When and how you intend to abandon the well, including specifically addressing your plans for how to move the rig off location and how you will meet the requirements of § 250.720(c); (8) A description of what equipment and vessels will be involved in the process of temporarily abandoning the well due to ice; and (9) An explanation of how you will integrate these elements into your overall program.	General Application Information	
20	30 CFR 250.470 (d)	Regulation US	In addition to complying with all other applicable requirements included in this part, you must provide with your APD all of the following information pertaining to your proposed Arctic OCS exploratory drilling: A detailed description of your weather and ice forecasting capability for all phases of the drilling operation, including: (1) How you will ensure your continuous awareness of potential weather and ice hazards at, and during transition between, wells; (2) Your plans for managing ice hazards and responding to weather events; and (3) Verification that you have the capabilities described in your BOEM-approved EP.	General Application Information	Ice and metocean data
21	30 CFR 250.470 (e)	Regulation US	In addition to complying with all other applicable requirements included in this part, you must provide with your APD all of the following information pertaining to your proposed Arctic OCS exploratory drilling: A detailed description of how you will comply with the requirements of § 250.472.	General Application Information	

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22	30 CFR 250.470 (f)	Regulation US	In addition to complying with all other applicable requirements included in this part, you must provide with your APD all of the following information pertaining to your proposed Arctic OCS exploratory drilling: A statement that you own, or have a contract with a provider for, source control and containment equipment (SCCE), which is capable of controlling and/or containing a worst case discharge, as described in your BOEM-approved EP, when proposing to use a MODU to conduct exploratory drilling operations on the Arctic OCS. The following information must be included in your SCCE submittal: (1) A detailed description of your or your contractor's SCCE capability to stop or contain flow from an out-of-control well, including your operating assumptions and limitations; your access to and ability to deploy, in accordance with § 250.471, all necessary SCCE; and your ability to evaluate the performance of the well design to determine how you can achieve a full shut-in without having reservoir fluids discharged into the environment; (2) An inventory of the local and regional SCCE, supplies, and services that you own or for which you have a contract with a provider. You must identify each supplier of such equipment and services and provide their locations and telephone numbers; (3) Where applicable, proof of contracts or membership agreements with cooperatives, service providers, or other contractors who will provide you with the necessary SCCE or related supplies and services if you do not possess them. The contract or membership agreement must include provisions for ensuring the availability of the personnel and/or equipment on a 24-hour per day basis while you are drilling below or working below the surface casing; (4) A detailed description of the procedures you plan to use to inspect, test, and maintain your SCCE; and (5) A detailed description of your plan to ensure that all members of your operating team, who are responsible for operating the SCCE, have received the necessary training to deploy and operate such equipment in Arctic OCS conditions and demonstrate ongoing proficiency in source control	General Application Information	SCCE Generalized Well Control

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23	30 CFR 250.470 (g)	Regulation US	In addition to complying with all other applicable requirements included in this part, you must provide with your APD all of the following information pertaining to your proposed Arctic OCS exploratory drilling: Where it does not conflict with other requirements of this subpart, and except as provided in paragraphs (g)(1) through (11) of this section, you must comply with the requirements of API RP 2N, Third Edition “Planning, Designing, and Constructing Structures and Pipelines for Arctic Conditions” (incorporated by reference as specified in § 250.198), and provide a detailed description of how you will utilize the best practices included in API RP 2N during your exploratory drilling operations. You are not required to incorporate the following sections of API RP 2N into your drilling operations: (1) Sections 6.6.3 through 6.6.4; (2) The foundation recommendations in Section 8.4; (3) Section 9.6; (4) The recommendations for permanently moored systems in Section 9.7; (5) The recommendations for pile foundations in Section 9.10; (6) Section 12; (7) Section 13.2.1; (8) Sections 13.8.1.1, 13.8.2.1, 13.8.2.2, 13.8.2.4 through 13.8.2.7; (9) Sections 13.9.1, 13.9.2, 13.9.4 through 13.9.8; (10) Sections 14 through 16; and (11) Section 18.	General Application Information	
24	30 CFR 250.713 (a)	Regulation US	If you plan to use a MODU for well operations, you must provide: (a)Fitness requirements. Information and data to demonstrate the MODU's capability to perform at the proposed location. This information must include the maximum environmental and operational conditions that the MODU is designed to withstand, including the minimum air gap necessary for both hurricane and non-hurricane seasons. If sufficient environmental information and data are not available at the time you submit your APD or APM, the District Manager may approve your APD or APM, but require you to collect and report this information during operations. Under this circumstance, the District Manager may revoke the approval of the APD or APM if information collected during operations shows that the MODU is not capable of performing at the proposed location.	General Application Information	

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25	30 CFR 250.713 (b)	Regulation US	If you plan to use a MODU for well operations, you must provide: Foundation requirements. Information to show that site-specific soil and oceanographic conditions are capable of supporting the proposed bottom-founded MODU. If you provided sufficient site-specific information in your EP, DPP, or DOCD submitted to BOEM for that well location and conditions, you may reference that information. The District Manager may require you to conduct additional surveys and soil borings before approving the APD or APM if additional information is needed to make a determination that the conditions are capable of supporting the MODU, or equipment installed on a subsea wellhead. For a moored rig, you must submit a plat of the rig's anchor pattern approved in your EP, DPP, or DOCD in your APD or APM.	General Application Information	
26	30 CFR 250.713 (c)	Regulation US	If you plan to use a MODU for well operations, you must provide: For frontier areas. (1) If the design of the MODU you plan to use in a frontier area is unique or has not been proven for use in the proposed environment, the District Manager may require you to submit a third-party review of the MODU design. If required, you must obtain a third-party review of your MODU similar to the process outlined in §§ 250.915 through 250.918. You may submit this information before submitting an APD or APM. (2) If you plan to conduct operations in a frontier area, you must have a contingency plan that addresses design and operating limitations of the MODU. Your plan must identify the actions necessary to maintain safety and prevent damage to the environment. Actions must include the suspension, curtailment, or modification of operations to remedy various operational or environmental situations (e.g., vessel motion, riser offset, anchor tensions, wind speed, wave height, currents, icing or ice-loading, settling, tilt or lateral movement, resupply capability).	General Application Information	
27	30 CFR 250.713 (d)	Regulation US	If you plan to use a MODU for well operations, you must provide: Additional documentation. You must provide the current Certificate of Inspection (for U.S.-flag vessels) or Certificate of Compliance (for foreign-flag vessels) from the USCG and Certificate of Classification. You must also provide current documentation of any operational limitations imposed by an appropriate classification society.	General Application Information	

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28	30 CFR 250.713 (e)	Regulation US	If you plan to use a MODU for well operations, you must provide: Dynamically positioned MODU. If you use a dynamically positioned MODU, you must include in your APD or APM your contingency plan for moving off location in an emergency situation. At a minimum, your plan must address emergency events caused by storms, currents, station-keeping failures, power failures, and losses of well control. The District Manager may require your plan to include additional events that may require movement of the MODU and other information needed to clarify or further address how the MODU will respond to emergencies or other events.	General Application Information	
29	30 CFR 250.713 (f)	Regulation US	If you plan to use a MODU for well operations, you must provide: Inspection of MODU. The MODU must be available for inspection by the District Manager before commencing operations and at any time during operations.	General Application Information	
30	30 CFR 250.713 (g)	Regulation US	If you plan to use a MODU for well operations, you must provide: Current monitoring. For water depths greater than 400 meters (1,312 feet), you must include in your APD or APM: (1) A description of the specific current speeds that will cause you to implement rig shutdown, move-off procedures, or both; and (2) A discussion of the specific measures you will take to curtail rig operations and move off location when such currents are encountered. You may use criteria, such as current velocities, riser angles, watch circles, and remaining rig power to describe when these procedures or measures will be implemented.	General Application Information	
31	Beaufort Sea Best Interest Finding (2009) Page 6-35	Industry Standard Practice Alaska	If well control is lost…the operators consider mechanical surface control methods, they also begin planning to drill a relief well by assessing the situation and determining the location for the relief well. Additionally, the logistical plan to move another drill rig to the site are necessary. Conditions may require the construction of an ice or gravel pad and road. **The operator will look for the closest appropriate drill rig. If the rig is in use, industry practice dictates that, when requested, the operator will release the rig for emergency use.** Arranging for and drilling a relief well could take from 10 - 15 weeks depending on various factors.	Relief Well	

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32	Beaufort Sea Best Interest Finding (2009) Page 6-40	Guideline Alaska State or Local	Regardless of the nature or location of a spill, t**he North Slope Subarea Plan** sets these objectives for all response actions: - Ensure safety of responders and the public - **Stop the source of the spill** - **Deploy equipment to contain and recover the spilled product** - Protect sensitive areas (environmental, historic, and human use) - Track the extent of the spill and identify affected areas. - Clean up contaminated areas and properly dispose of wastes. - Notify and update the public.	SCCE Generalized Well Control	
33	Beaufort Sea Best Interest Finding 18 AAC 75.425	Regulation Alaska State or Local	C-Plans for exploration facilities must include a description of methods for responding to and c**ontrolling blowouts**, the location and identification of oil spill cleanup equipment, **the location and availability of suitable drilling equipment, and an operations plan to mobilize and drill a relief well.**	Relief Well	Contingency Plan
34	Beaufort Sea Best Interest Finding 18 AAC 75.425	Regulation Alaska State or Local	The [required] Response Action Plan must include an emergency action check list of immediate steps to be taken if a discharge occurs. The checklist must include:…Specific Actions to **stop a discharge at its source**…	SCCE Generalized Well Control	Contingency Plan
35	Beaufort Sea Best Interest Finding 18 AAC 75.425 and AS 46.04.030 (o)	Regulation Alaska State or Local	The Response Planning Standard Section current statue **allows the sharing of oil spill response equipment**, materials, and personnel among plan holders. ADEC determines by regulation the maximum amount of material, equipment, and personnel that can be transferred and the time allowed for the return of those resources to the original plan holder.	SCCE Generalized Well Control	Contingency Plan
36	Beaufort Sea Best Interest Finding 18 AAC 75.425 AS 46.04.030 ®(2)(E) 18 AAC 75.485 (a) and (d)	Regulation Alaska State or Local	The statute also requires the plan holders to "successfully demonstrate the ability to carry out the plan" when required by ADEC. ADEC requires that exercises (announced or unannounced) be conducted to test the adequacy and execution of the contingency plan. No more than two exercises are required annually, unless the plan proves inadequate. ADEC may, at its discretion, consider regularly scheduled training exercises as discharge exercises.	SCCE Generalized Well Control	Contingency Plan
37	40 CFR 112.11 (EPA)	Regulation US	If you are the owner or operator of an offshore oil drilling, production, or workover facility you must: Meet the requirements listed under 112.7 and also meet the specific discharge prevention and containment procedures listed under this section. (various including BOP assembly and well control system. (No references in this regulation to being able to stop the discharge at its source or deployment of SCEE or Relief wells.)	SCCE Generalized Well Control	BOP
38	33 CFR 153-158 (USCG)	Regulation US	No pertinent regulations apparent.		

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39	Senate Bill S.B 3492 (2010) House Bill H.R, 5666 (2010)	Regulation US Proposed	Any exploratory drilling conducted under a lease shall be accompanied by the concurrent drilling at least 1 emergency relief well subject to any applicable requirements established by the Secretary. The secretary, in consultation with the Administrator of the EPA and the Secretary of Commerce may require, as an alternative to the emergency relief well requirement under paragraph (3) measures that the Secretary, after a period of notice and public comment, determines would be at least as effective at stopping a major release from a proposed well as the measures required under that paragraph.	Relief Well	
40	30 CFR 250.462 (a) BSEE	Regulation US	For drilling operations using a subsea BOP on surface or on a floating facility, you must have the ability to control or contain a blowout event at the sea floor. (a) to determine your required source control and containment capabilities you must do the following: (1) Consider the scenario of the wellbore fully evacuated to reservoir fluids, with no restrictions in the well. (2) Evaluate the performance of the well as design to determine if a full shut-in can be achieved without having reservoir fluids broach to the sea floor. If your evaluation indicates that the well can only be partially shut-in, then you must determine your ability to flow and capture the residual fluids to a surface production and storage system.	BOP	
41	30 CFR 250.462 (b) BSEE	Regulation US	For drilling operations using a subsea BOP on surface or on a floating facility, you must have the ability to control or contain a blowout event at the sea floor. (b) You must have access to and the ability to deploy Source Control and Containment Equipment (SCCE) and all other necessary supporting and collocated equipment to regain control of the well. SCCE means the capping stack, cap-and-flow system, containment dome, and/or other subsea and surface devices, equipment, and vessels, which have the collective purpose to control a spill source and stop the flow of fluids into the environment or to contain fluids escaping into the environment. This SCCE, supporting equipment, and collocated equipment must include but is not limited to, the following: (1) Subsea containment and capture equipment, including containment domes and capping stacks; (2) Subsea utility equipment including hydraulic power sources and hydrate control equipment; (3) Collocated equipment including dispersant injection equipment; (4) Riser systems; (5) Remotely operated vehicles (ROVs) (6) Capture vessels; (7) Support vessels; (8) Storage facilities.	SCCE Generalized Well Control	BOP

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42	30 CFR 250.462 (c) BSEE	Regulation US	For drilling operations using a subsea BOP or surface or on a floating facility, you must have the ability to control or contain a blowout event at the sea floor. (c) You must submit a description of your SCCE capabilities to the Regional Supervisor and receive approval before BSEE will approve your APD Form BSEE-0123. The description of your containment capabilities must contain the following: (1) Your SCCE capabilities fro controlling and containing a blowout event at the seafloor; (2) A discussion of the determination required in paragraph (a) of this section; (3) Information showing that you have access to and the ability to deploy all equipment required by paragraph (b) of this section.	SCCE Generalized Well Control	BOP
43	30 CFR 250.462 d) BSEE	Regulation US	For drilling operations using a subsea BOP or surface or on a floating facility, you must have the ability to control or contain a blowout event at the sea floor. (d) You must contact the District Manager and Regional Supervisor for reevaluation of your SCCE capabilities if your: (1) well design changes; (2) Approved SCCE is out of service.	SCCE Generalized Well Control	BOP
44	30 CFR 250.462 (e)	Regulation US	For drilling operations using a subsea BOP on surface or on a floating facility, you must have the ability to control or contain a blowout event at the sea floor. (e) You must maintain, test, and inspect the SCCE and collocated equipment identified in the following table according to these requirements. (See table - includes: Test for capping stacks, production safety systems used for flow and capture operations, subsea utility equipment, collocated equipment)	SCCE Generalized Well Control	BOP
45	NWAB Letter to AOGCC 9/14/11	Concern or Comment Public	Arctic Well Capping and Containments Systems for an offshore Subsea Well Blowout and Capping System for an Onshore Surface Well Blowout. A subsea arctic well capping system has not yet been built for Chukchi or Beaufort Sea offshore drilling operations…There is limited well capping equipment located on the North Slope for wells, onshore, or offshore, with surface BOPs; however, most well capping plans rely on part of all of the required capping equipment being transported in from Texas or overseas, delaying response time. AOGCC should require operators to have an appropriate arctic well capping and containment system on contract. AOGCC should set specific construction and operation performance standards for this equipment. This system should be located in the Arctic, outfitted with necessary supplies and equipment, and staffed with trained and qualified personnel capable of initiating a well capping operation within 24 hours. The arctic well capping and containment system or capping system should be built to arctic engineering specifications and physically tested in the arctic conditions in which the applicant plans to operate. The amount of hydrocarbon development on the North Slope, and the unique nature of Arctic well capping operations warrant a full set of well capping equipment for surface BOPs and another for subsurface BOPs to provide immediate well control.	Capping Stack/Systems	

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46	NWAB Letter to AOGCC 9/14/11	Concern or Comment Public	Relief Well Capability: AOGCC should adopt new regulations or amend existing regulations to specify that before a permit-to-drill application is approved, the operator must identify a second relief well drilling rig by name, demonstrate that the relief well rig is on contract, located in the Arctic, outfitted with necessary supplies and equipment to conduct relief well drilling operations and staffed with trained and qualified personnel who are capable of initiating relief well operations within 24 hours. The second relief well rig should be at least of equivalent capability as the primary drilling rig.	Relief Well	
47	NWAB Letter to AOGCC 9/14/11	Concern or Comment Public	The size of a well blowout and the amount of oil spilled into the environment will be a function of the time required to transport a relief well rig to the drilling site and the time required to drill the relief well. To expedite relief well operations and reduce the spill size the relief well rig must be located close-by and immediately available. To ensure that the relief well rig is immediately available and capable of meeting the 24-hour response period, the relief well drilling rig must be located near the primary drilling rig to ensure a 24-hour transit time, including time to stop drilling and suspend[end the well if it is drilling.	Relief Well	
48	NWAB Letter to AOGCC 9/14/11	Concern or Comment Public	Relief well rig operations should be timed to ensure that it is not drilling through a higher risk hydrocarbon zone at the same time that the primary drilling rig is drilling through a hydrocarbon zone, AOGCC regulations should require the relief well rig to postpone or suspend drilling operations until the primary drilling rig has confirmed it has safely accessed the zone of interest.	Relief Well	
49	NWAB Letter to AOGCC 9/14/11	Industry Standard European or Scandinavian	Relief well rig operations should be timed to ensure that it is not drilling through a higher risk hydrocarbon zone at the same time that the primary drilling rig is drilling through a hydrocarbon zone, - the relief well rig to postpone or suspend drilling operations until the primary drilling rig has confirmed it has safely accessed the zone of interest. Cairn Company Plans - Greenland	Relief Well	
50	NWAB Letter to AOGCC 9/14/11	Concern or Comment Public	Relief Well Rig Pre-Planning: Planning for a relief well prior to drilling, rather than waiting until an emergency situation, will expedite relief well design, permitting and planning. While additional permitting and review may be required prior to drilling the actual relief well, pre-planning will expedite the process especially for offshore wells. AOGCC should require operators to prepare a relief well plan prior to drilling and AOGCC should review and approve the process especially for offshore wells. AOGCC should require operators to prepare a relief well plan prior to drilling, and AOGCC should review and approve this plan.	Relief Well	Contingency Plan

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51	NWAB Letter to AOGCC 9/14/11	Industry Standard European or Scandinavian	Relief Well Pre-Planning: The following recommendations reflect standards met by operators drilling offshore wells in Greenland: (1) Two alternate relief well locations should be fully identified, permitted and surveyed for shallow gas prior to operations commencing on the primary well site. (2) Relief well sites should be evaluated to ensure the current profiles, benthic character, seabed topography, and rig access plans are fully suitable for relief well operations. (3) Pre-planned relief well design trajectories should be approved by AOGCC based on various well blowout scenarios, final well design trajectories should be approved prior to actual relief well drilling. (4) A well control drill should be conducted ahead of the drilling season to test an operator's relief well plan and well-capping strategy.	Relief Well	Contingency Plan
52	NWAB Letter to AOGCC 9/14/11	Concern or Comment Government	BOP Redundancy - Redundant BOPs provide an additional level of emergency control capability, which is especially important for remote offshore drilling operations where transportation of a back-up BOP could result in significant delays in emergency will control operations. Some operators have proposed the use of redundant BOPS as an added oil spill prevention measure; we agree. AOGCC should require redundant BOP systems for all floating offshore drilling rigs that use subsea BOPS.	BOP	
53	NWAB Letter to AOGCC 9/14/11	Concern or Comment Government	Alternate Well Kill Systems: Best Available and Safest Technology (BAST) should be used for Arctic BOP systems. AOGCC should consider adding BAST requirements for subsea BOP systems.	SCCE Generalized Well Control	
54	NWAB Letter to AOGCC 9/14/11 See 30 CFR 250.420 clarifying the minimum number of well control barriers)	Concern or Comment Government	Two barrier Well Control Systems. After the 2010 Maconda well blowout and 2009 Montara well blowout, BOEM and a number of states re-examined and clarified their well barrier regulations to clearly require a minimum of two barriers - a primary and a back-up be installed to control wells at all times. AOGCC regulations should take a similar approach and unambiguously require that at least two independent well control barriers are in place at all times. Both barriers should be routinely tested and at least one barrier should be mechanical.	BOP	

ID	Source	Category - regulation, standard, comment	Action	Subject 1	Subject 2
55	NWAB Letter to AOGCC 9/14/11	Concern or Comment Government	Well Control Experts: Most operators indicate they have contracted with a well control expert, and that the expert can be flown in (usually from Texas) to assist in a well blowout. Transiting from the Lower 48 puts the expert out of touch for almost a day. And, companies are not required to show evidence of an actual contract, nor are there specific performance standards to ensure that the well control expert is trained, qualified, and experienced in arctic well control operations. This is important because arctic well control operations have unique challenges. Operators should be required to have a signed contract with a certified expert well control company that has demonstrated to AOGCC's satisfaction it has sufficient Arctic well control experience, qualifications, trained personnel and equipment. Evidence of this contract should be submitted in the permit-to-drill application. AOGCC should establish criteria in regulation for certifying arctic well control experts, develop a review and approval process to certify those experts, and maintain a list of certified experts on its website. AOGCC should require that the certified well control experts be present on the site during drilling of all offshore and ultra-extended reach wells to provide additional expert support to the operator. At a minimum, AOGCC should require well control experts be onboard while drilling through hydrocarbon zones on production wells and during all drilling operations for exploration wells.	SCCE Generalized Well Control	
56	NWAB Letter to AOGCC 9/14/11	Concern or Comment Government	Emergency Well Control Plan: While drilling operators typically have emergency well control plans, those plans are not currently subject to detailed AOGCC review and approval, nor are there specific performance criteria and standards for these plans in Alaska Regulation. There would be merit in AOGCC establishing plan standards and conducting a technical review of these plans to provide the public with the assurance that a quality plan is in place and that AOGCC is familiar with that plan. A comprehensive written Emergency Well Control Plan should be required as part of the application for a permit to drill. The plan should cover the primary rig, well capping and containment equipment, secondary relief well rigs and additional well barriers. AOGCC's approval of this plan should be subject to rigorous examination. In the event a well blowout occurs, this process will ensure that AOGCC is already familiar with the operator's response methods, expediting the well control and relief well drilling approvals needed during an emergency.	Contingency Plan	

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57	NWAB Letter to AOGCC 9/14/11 National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling Report January 11, 2011	Concern or Comment Government	Source Control Plans should be required as part of both oil spill response plans and applications for permit to drill.	Contingency Plan	
58	NWAB Letter to AOGCC 9/14/11	Concern or Comment Government	Seasonal Drilling Duration: Arctic environmental conditions - including darkness, sea ice, and extreme cold - prevent exploratory drilling operations during significant portions of the year and present unique challenges for oil spill clean-up operations. Routine drilling operations that extend to the very last day that it is safe to drill and clean up spilled oil do not allow time to respond to a well control event To ensure there is sufficient time left in the safe operating season to cap a blow out well, drill a relief well and clean up spilled oil, AOGCC should only permit operations that have a margin of safety built into their proposed plan of operations. The permissible drilling permit duration should be limited to the total period of time the drilling rig is capable of working in Arctic conditions, minus the time required for oil spill cleanup and time required to cap and/or drill a relief well (whichever is longer).	SCCE Generalized Well Control	Contingency Plan
59	https://www.govmin.gl/component/acymailing/listid-5/mailid-41-the-oil-spill-contingency-plan	Regulation Greenland	First and foremost it is important to establish that drilling is not permitted in the sea ice season in Greenland. The drilling of wells in Greenland must stop at least two months before the sea freezes up so that there is time, if necessary, to drill a relief well and to abate and clean up after a potential oil spill.	Relief Well	

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60	BOOK - International Law and the Arctic Section 7.4 Cambridge Studies in International and Comparative Law. Michael Byers Cambridge University Press 2013 Norsk Standard D-010 Rev 3 (Well Integrity in Drilling and Well Operations) August 2004, sec 4.8.2 available at standard.no/Page Files/1315/D-010r.3.pdf	Regulation Norway	Norway has some of the highest safety standards for offshore drilling of any country in the world, including, a long standing requirement for the capability to initiate a relief well within twelve days of a blowout.	Relief Well	
61	BOOK - International Law and the Arctic Section 7.4 Cambridge Studies in International and Comparative Law. Michael Byers Cambridge University Press 2013	Concern or Comment Public	In 1997, the Arctic Council adopted a set of "Arctic offshore oil and gas guidelines" which it updated in 2002, and 2009. Second, the [guidelines] avoided some of the more difficult and important issues such as whether oil companies should be required to maintain a same-season relief well capability.	Relief Well	

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62	18 AAC 75.425 d.1.I	Regulation Alaska State or Local	The Plan must include a summary of methods, equipment, logistics and time frames proposed to be employed to control a well blowout within 15 days. (I) response scenario for an exploration or production facility - if the facility is an exploration or production facility, a response scenario that, in addition to complying with (F) of this paragraph, includes as part of the response strategies a summary of planned methods, equipment, logistics, and time frames proposed to be employed to control a well blowout within 15 days; the plan holder shall certify that the plan holder maintains a separate blowout contingency plan; the blowout contingency plan is not part of an application required under 18 AAC 75.410 - 18 AAC 75.420, but must be made available to the department for inspection upon request under 18 AAC 75.480; a plan holder may use for development of a response scenario the July 1997 S.L. Ross oil deposition model for surface oil well blowouts, or another oil deposition model approved by the department for surface oil well blowouts; if required by the department to account for variations in seasonal conditions, a plan holder must provide a response scenario for a discharge of the applicable response planning standard volume under typical summer environmental conditions and typical winter environmental conditions; if the information required by this subparagraph is contained within a separate document developed by the plan holder or the plan holder's primary response action contractor identified in (3)(H) of this subsection, the plan holder may incorporate the information by reference upon obtaining the department's approval; for purposes of this subparagraph,	Contingency Plan	
63	Title 20 Chapter 25 AOGCC	Regulation Alaska State or Local	No specific regulations listed for relief wells or SCCE such as capping - mostly addresses BOP and fluids control	SCCE Generalized Well Control	
64	NORSOK STANDARD Section 4.4 Revision 2, December 1998 Norwegian Technology Standards Institution (Industry Initiative)	Industry Standard European or Scandinavian	The Blowout Contingency Plan shall be developed to meet the NPD legislation as well as Operator internal requirements. The document shall be regularly updated to assure that relevant information is available in case of well control. It shall contain the following: 1. **Mobilization of necessary emergency equipment,** personnel, services 2. Kill methods in the case of a blowout occurrence, 3. **Description of suitable locations for drilling a relief well** 4. Measures for limiting the amount of the damage from the hazard or accident 5. Guidelines for mobilization of the operation.	Contingency Plan	Relief Well

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65	NORSOK STANDARD Section 4.4 Revision 2, December 1998 Norwegian Technology Standards Institution (Industry Initiative)	Industry Standard European or Scandinavian	Relief Well: If a surface intervention cannot be performed on the blowing well, the blowing shall be killed or plugged via a relief well. The objective of a relief well is to enter or get communication to dynamically kill and stabilize a blowing well. The following shall as a minimum be covered for a relief well design: 1. Mapping of suitable drilling locations if appropriate including shallow seismic interpretation of the top section 2. Evaluation of blow-out scenarios and kill methods 3. Evaluation of relevant well profiles and casing programme 4. Estimation of necessary pumping capacity 5. Updated list of available equipment and time critical activities, including possible rigs or facilities for well intervention options as appropriate. initiation of relief drilling at a relevant location shall commence no later than 12-days after the option is declared.	Contingency Plan	Relief Well
66	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#1: Establish coordinated industry capability for owning and providing subsea well containment technology and capability. Immediate containment capability will exist via acquiring and refurbishing capability used by BP, contracting GOM contractors with immediate existing containment capability, and acquiring containment equipment available off the shelf from suppliers. This immediate containment capability will be provided via containment companies and cooperatives.	SCCE Generalized Well Control	Relief Well
68	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#2. Establish long-term coordinated industry capability for owning and providing subsea well containment technology and capability. This recommendation and action can be addressed by the MWCC, HWCG or by other containment companies with suitable capabilities and support that are established in the GOM. All containment companies and systems will make use of best practices and lessons learned from the Macondo response.	SCCE Generalized Well Control	

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69	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#3 Well containment systems should deliver a flexible, adaptable, and rapidly deployable tool kit of containment equipment. The equipment should be purpose-designed and constructed for rapid deployment and successful subsea containment. It should fully contain the oil by complete mechanical connection to the well or the sea floor *(states further design review currently show mechanical connection concepts to the seafloor technology to be technically infeasible as a result of the inability to carefully control the low pressures with the device. Modest positive pressure within the device would destroy any seal. And the device, if feasible, would cover too small an area to address broaching events. States currently, containment companies are developing direct mechanical devices to casing stubs at the seafloor as an alternative. Also that 'open water capture' devices that containment companies already can provide could be used above broaches. However, this still would address only a small area. R&D ongoing within some companies.)*	SCCE Generalized Well Control	
70	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	The containment companies should procure, construct, and test the needed equipment. This includes testing effectiveness over time through drills and readiness reviews. The containment companies should also do research into enhanced methods and equipment for subsea well control and containment.	SCCE Generalized Well Control	

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71	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#4. Confirm Lower Marine Riser Package (LMRP) can be removed from lower BOP using a surface intervention vessel and ROV. This should allow access to the mandrel on top of the BOP and the installation of subsea containment assembly (well cap). This assembly (well cap) should have full shut-in capability in addition to choked flow from flow wings. If well flow is necessary, it can be achieved by diverting flow to the capture vessels. The subsea containment assembly also allows vertical access to the well for intervention within the well if necessary. In almost all cases where there is no confidence in the integrity of the well design, the well can be shut-in and top kill procedures executed. Well "capping" capability is available now through use of a second BOP stack or equipment used in the Macondo incident. Containment companies should expand this capability. Refer to API subcommittee on Drilling Well Control Equipment (SC16) and API RP/std. 53) for further discussion and analysis on LMRP release and ROV intervention requirements and testing. An API wok group has formed to address design requirements and functionality of subsea capping stacks (new/proposed API Document 17-W)	Capping Stack/Systems	SCCE Generalized Well Control
72	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#5: Ensure effective methods to release LMRP's are included in BOP stack designs. This should include release with no vertical tension is available as when rig is drifting without power. Releases should not damage the BOP or BOP connections. There are tools and techniques available now such as LMRP jacks but new methods should be considered.	BOP	

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73	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#6: R&D Capability – Ensure effective and non-damaging release of LMRP's. High angle release connectors now exist. This recommendation is to evaluate current high angle release connectors to ensure they fully address high angle release without riser tension or without a riser. There may be no additional technical work required after this study. Additionally the ability to reattach a capping stack to a BOP or wellhead housing that is not vertical should be evaluated. Straightening techniques are available but this would add another option.	Capping Stack/Systems	BOP
74	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#7: R&D Capability – Develop new quick release that can be installed in the lower riser sections to enable quick release and reconnect of the riser when the LMRP does not release in the emergency sequence. *Status: Determined by the JITF to be of low total benefit with high technical complexity. The recommendation is to not pursue at this time. This recommendation is documented and should be reevaluated to determine possible need/solution at a later date. This can be done by the Federal Government and/or Industry.*	BOP	
75	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#8: Remove damaged BOP stack to allow installation of a new BOP on the wellhead housing, or a subsea containment assembly (well cap). With well designs that meet the capability of being capped, the well can be shut-in from release to the external environment via a well cap. This will protect the external environment until the well is killed. This capability is available now through use of a second BOP or well cap from a containment company or other contractor. The containment companies should expand this capability and ensure a sufficient variety of well caps designed specifically for potential future events. *Status: Future - The containment companies and the cooperatives are addressing this issue and JITF recommendation, but should continue their technical assessments to understand future well containment needs.*	Capping Stack/Systems	BOP

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76	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#9: If a similar failure scenario to Macondo occurs in which the rig has released from the BOP stack but the LMRP is in place and there is no control connection to the pods and/or the pods are not operative – it might be possible to regain full BOP stack control without ROV intervention. Research & Develop Capability: Evaluate possibilities to regain full control over all important BOP functions in the above noted situation. *BOP manufacturers are pursuing improved reliability and operability based on Industry and API input and by their own technical analysis. Additionally, API Std. 53 requires regular testing and enhancements of external ROV interfaces on BOP's. As a result it is recommended that this recommendation not be pursued further.*	BOP	
77	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#10 The containment companies should acquire and maintain a full set of crossover spools, connectors, and hub combinations for connecting to common BOP's. *Status: As part of the permitting process and NTL, the operator must demonstrate that they have the capability to respond during a containment event. This includes identifying all equipment to be used (e.g., adapters, crossovers, etc.). Standardizing and ensuring proper sizing of ROV stabs is being addressed within API. Thus this recommendation is being fully addressed.*	BOP	
78	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#11: The containment companies should design and construct subsea connectors to fully seal, connect and contain on damaged connector profiles and casing stubs. Also, consideration should be given to inside well connectors such as packers. *Well containment companies and cooperatives are addressing this recommendation.*	BOP	

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79	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#12: Coordinate with the Equipment Task Force to ensure methods and equipment are providing effectiveness and reliability in delivery of control fluids and control to BOP's and ROV's. Considerations should include an evaluation of methods other than shuttle valves for the ROV intervention plumbing. *Status: The revision of API RP 53 Blowout Prevention Equipment Systems for Drilling Wells (soon to be Standard (Std.) 53, 4th edition) is addressing this recommendation. Methods other than shuttle valves have not been found to enhance the reliability.* ***NA***	BOP	
80	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#13: R&D Capability – Review existing methods and number of connection points on existing BOP's. Determine if more outlets or different connections would enhance containment capability. *Status: Refer to API SC16, API Subcommittee on Subsea production Equipment (SC17), and the RP/Std. 53 workgroup to see if it is necessary to develop new a RP or to revise existing RP. It is unlikely that this is necessary to achieve containment and kill. There are already sufficient connect/disconnect points. Additional connections would likely reduce reliability.* ***NA***	BOP	
81	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#14: R&D Capability - Assess industry capability and conduct in-situ testing to determine what new technology and capability needs to be developed to remove a debris field and cut equipment like risers. Develop new equipment and capability as determined by testing. *Status: Commercial capabilities currently exist to address this recommendation. Well Control Companies, ROV Manufacturers and Subsea Service Vessels are all addressing this recommendation.* ***NA***	BOP	

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82	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#15: Coordinate with API RP 96 and ensure deep-water well design includes a system evaluation of the design and material for subsea well head support (e.g., templates, structural pipe etc.) and the release control methodology of the LMRP. *Status: Industry is addressing this issue with further consideration by the Blowout Risk Assessment (BORA) Joint Industry Project (JIP). Each company should make their own decisions on well design based on individual needs and API RP 96 Deepwater Well Design and Construction.* ***NA***	Subsea isolation device	
83	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#16: R&D Capability - Survey Industry for feasibility of developing subsea snubbing technology or consider proposal to Joint Industry Groups to develop preliminary designs for subsea snubbing equipment *No longer a recommendation: This option is no longer necessary. Once a subsea well is secured with a capping device, options such as pumping in to bullhead kill, or planning and drilling a relief well would be evaluated.* ***NA***	Subsea isolation device	
84	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#17: R&D Capability - Seek opportunities to accelerate development of subsea coil tubing deployment systems and make them available for subsea well intervention on damaged wells and BOP's. Consider all possibilities such as deep-water pipe-lay technologies for deploying pipe larger than conventional coil tubing. *No longer a recommendation: It is felt that using top kill or relief wells are better and safer options.* ***NA***	BOP	

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85	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#18: R&D Capability - Survey industry experience, conduct research into basic science if necessary, and undertake field testing to develop industry capability for establishing and maintaining an ”ice plug“ to provide subsea well containment while avoiding detrimental effects to the BOP operation. *No longer a recommendation: This is not technically feasible in the deep-water environment or in the characteristics of deep-water wells.* ***NA***	BOP	
86	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#19: R&D Capability - The top kill method should be considered when the subsea well is contained by the subsea containment assembly or the BOP. This requires well integrity and containment integrity sufficient for the top kill. This effort should include a survey of capability, and development of supporting technologies for converting fluids into barriers in-situ, augmenting bridging if desired, and pumping procedures and planning including hydrate management. *Ongoing: Conventional junkshot can work under certain well situations; however, R&D has shown that junkshot is not generally feasible under high flow rate conditions. It is not feasible to expand junkshot capability. Other kill and control solutions are available and preferred. Top kill capability must be addressed as part of NTL 10. The capability exists to pump into the well on most available well caps. This pump in capability will be addressed in API RP17W.*	BOP	
87	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#20: The Task Force will coordinate with API RP 96 Deepwater Well Design team to ensure they understand the importance of full shut-in capability to the containment capabilities. *Complete: Transferred to the RP 96 task group under the Offshore Operational Procedures JITF. The RP should fully address and consider shut-in and capping design as required in the BSEE Well containment Check Sheet.* ***NA***		

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88	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#21: The Containment Company will deliver a modular solution for capturing, processing, and transporting production from subsea wells that need to be produced until well control is complete. Such a system should be adaptable to deep-water metocean and water depths up to 10,000 feet. Riser systems should be readily deployable and able to accommodate a variety of operational conditions. Processing facilities and capability should be able to be rapidly deployed and easily made functional. All the equipment should be designed to address all the flow scenarios from the IPR work done for NTL-10 as well as pre-constructed, and held on ready stand-by. Any concepts forwarded through BOEMRE’s Alternative Response Technologies Program should be evaluated, researched, and included if they enhance capability. *Complete: Addressed by Well Containment Companies and Cooperatives. Enhanced systems will* *have full 10,000 feet capability. Components of currently available systems can achieve 10,000 feet.*	SCCE Generalized Well Control	
89	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#22: R&D Capability – The Containment Company will develop, test, and have available technology to provide full containment via seafloor connection of devices intended to fully cover BOP’s or well stubs. This system should allow connection of a Subsea containment Assembly so well production can flow to the production and processing system. Such systems should include chemical injection for hydrate mitigation. The sea floor connected containment system would be used for oil capture until a relief well was drilled. *Complete: This was technically evaluated by the Industry and containment companies and determined to not be technically feasible at this time. The focus will be on connecting to damaged wellheads/BOP/s or casing stubs.*	BOP	Relief Well
90	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#23: R&D Capability – As the next phase of the JITF, evaluate extension of containment concepts, equipment, and capabilities to subsea production operations including production from templates. Make recommendations for enhancing current practices as necessary and appropriate. *Complete: Capabilities currently exist in well containment companies and cooperatives. New capabilities are being developed as necessary.* ***NA***	SCCE Generalized Well Control	

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91	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#24: NA - Education		
92	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#25: NA - Continue R&D in general.		
93	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#26: Via focused workshops, determine and make a recommendation on the most effective methods and information that should be included in well plans regarding relief well drilling planning. Ensure full coordination and eliminate duplication with other groups' initiatives. *Complete: It is not recommended to develop additional requirements beyond those currently in BSEE regulations and requirements.*	Relief Well	

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94	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#27: Complete: Undertake desk research to revisit published work on relief wells. *A short white paper was completed by the JITF on this subject. No other work is now recommended. If there are other opportunities they should be identified and developed by the containment Subcommittee under OESAC (in combination with recommendation #24).* **NA**	Relief Well	
95	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#28: R&D Capability – Conduct focused interviews with experts and vendors of specialized equipment (ranging tools, etc.), Understand and support, as necessary, plans for developing magnetic ranging tools that don't require tripping the drilling assembly and other equipment that should enhance relief well capability. *Complete: This capability was developed during the Macondo response.* **NA**	SCCE Generalized Well Control	
96	Joint Industry (API/IADC/IPAA/NOIA/USOGA)Subsea Well Control and Containment Task Force: Final Report on Industry Recommendations to Improve Subsea Well Control and Containment March 13 2012	Industry Standard - US	#29: Immediate Action: Write a white paper on relief wells that evaluates the feasibility and desirability of pre-drilling relief wells. *Complete: Please see Experience, Role, and Limitations of Relief Wells* ***NA***	Relief Well	
97	Petroleum Safety Authority Norway Chapter IV Section 20 Coordination of offshore emergency preparedness	Industry Standard European or Scandinavian	The Petroleum Safety Authority Norway and the Norwegian Environment Agency can, within their respective jurisdictions, stipulate a requirement that standby vessels, including aircraft, shall be stationed at facilities or vessels participating in the petroleum activities. Requirements can be stipulated as regards the functions that a standby vessel shall be able to perform.	SCCE Generalized Well Control	

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98	Petroleum Safety Authority Norway Chapter IV Section 21 Offshore emergency preparedness cooperation	Industry Standard European or Scandinavian	The operator shall cooperate with operators of other production licenses to ensure necessary emergency preparedness in the areas of health, safety and the environment. When special circumstances so warrant, the Petroleum Safety Authority Norway and the Norwegian Environment Agency can issue and stipulate conditions for such cooperation, including an order to the effect that the financing shall be a joint responsibility. **NA**		
99	Petroleum Safely Authority Norway Chapter IX Section 64 Establishment of emergency preparedness	Industry Standard European or Scandinavian	Regulation specifies onshore facilities		
100	Petroleum Safety Authority Norway	Industry Standard European or Scandinavian	No references in the regulations to source control, well interception, relief wells, capping of well loss.		
101	Norwegian Petroleum Directorate Act 29 November 1996 No. 72 relating to petroleum activities, amended June 2011	Industry Standard European or Scandinavian	No references in the regulations to source control, well interception, relief wells, capping of well loss.		
102	Petroleum Safety Authority Norway	Industry Standard European or Scandinavian	The Scope of the Pollution Control Act and the Product Control Act or in connection with establishing management systems for follow-up of the Product Control Act, no standards or recognized norms are referenced. It is the responsible party's task to assess how required environmental requirements best can be achieved, and implement measures to fulfill these requirements.		

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103	Greenland Bureau of Minerals and Petroleum (BMP) Exploration Drilling Guidelines Section 1.0	Industry Standard European or Scandinavian	Prior to authorizing and issuing Approval to Drill, the Bureau of Minerals and Petroleum (BMP) has a duty to ensure that: [requirements for license and financial responsibility], The operator shall present the application to drill with a dual drilling rig vessel presence policy which allows for fast contingency response in case of severe well control issues. If more than one operator applies for drilling, a co-operation between the operators may be granted by BMP in sharing the responsibility for dual rig policy by entering into rig sharing agreements. If such agreement is proposed, BMP shall review such an agreement prior to a potential approval. The operator shall present contingency plans for; major personnel accident, oil pollution, ice management and **relief well drilling.** A valid Certificate of Fitness has been obtained for the drilling installation Suitable standby vessel(s) will be provided complete with certification of fitness Ice breakers and other support vessels to be nominated have certification of fitness [additional requirements for safety, drill programme submittal, Environmental Assessment, Social Assessment, insurance not related to well control] BMP may impose seasonal restrictions to the operations based on environmental sensitivity and/or weather/climate conditions.	Contingency Plan	Relief Well

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104	Greenland Bureau of Minerals and Petroleum (BMP) Exploration Drilling Guidelines Section 1.1	Industry Standard European or Scandinavian	Prior to authorizing and issuing Approval to Drill, the Bureau of Minerals and Petroleum (BMP) has a duty to ensure that: [requirements for license and financial responsibility], The operator shall present the application to drill with a dual drilling rig vessel presence policy which allows for fast contingency response in case of severe well control issues. If more than one operator applies for drilling, a co-operation between the operators may be granted by BMP in sharing the responsibility for dual rig policy by entering into rig sharing agreements. If such agreement is proposed, BMP shall review such an agreement prior to a potential approval. The operator shall present contingency plans for; major personnel accident, oil pollution, ice management and **relief well drilling.** A valid Certificate of Fitness has been obtained for the drilling installation Suitable standby vessel(s) will be provided complete with certification of fitness Ice breakers and other support vessels to be nominated have certification of fitness [additional requirements for safety, drill programme submittal, Environmental Assessment, Social Assessment, insurance not related to well control] BMP may impose seasonal restrictions to the operations based on environmental sensitivity and/or weather/climate conditions.	Contingency Plan	Relief Well
105	Greenland Bureau of Minerals and Petroleum (BMP) Exploration Drilling Guidelines Section 1.2 HSE Assessment	Industry Standard European or Scandinavian	The following contingency plans must be submitted and presented as a minimum to BMP for approval: Emergency preparedness plan, oil spill and pollution plan, relief well drilling plan and programme, Ice management plan. In the case where more than one operator applies for drilling, co-operations between the operators may be granted by BMP in sharing the responsibility for the different contingency plans by entering into sharing agreements and responsibilities. If such agreement is proposed, BMP shall review such agreements prior to a potential approval of the sharing agreements.	Contingency Plan	

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105	Greenland Bureau of Minerals and Petroleum (BMP) Exploration Drilling Guidelines Section 2.0 Seabed Site Survey	Industry Standard European or Scandinavian	As part of the EIA (Environmental Assessment) and site survey requirements, the Drilling Application submission is preceded or accompanied by documentation showing that the operator has investigated the nature of the seafloor and underlying sediments to identify any potential surface or subsurface hazards such as shallow gas. These surveys are usually conducted using geophysical methods. An application to undertake such surveys should be made to the BMP at least 6-weeks in advance of any Well Site Survey. As a general principle, due to limited offset data from other wells and limited exploration wells having been drilled in Greenlandic territory, a small diameter Pilot hole may vary from location to location, but shall determine non presence/hazards of shallow gas, and establish safe foundation and setting depths fro the surface casings. The seismic/geographical survey data shall as a general principle cover a radius of minimum 500-meters from the proposed well center. Plans for relief well shall be in accordance with section 4.8.2 in NORSOK standard D-010. The relief well locations must be surveyed and evaluated to same extent as the primary well location. The site surveys shall include collection of specific Environmental Data as determined by BMP. The requirements for Environmental Site Survey Data may vary for different license blocks and well locations. The site survey with respect to drilling operations safety shall as a minimum determine: Foundation stability and anchor suitability, limitations on well positioning with respect to avoid or reduce unnecessary impact to the environment, limitations on positioning and anchoring do drilling MODUs and auxiliary crafts to avoid damage to pipelines, cables, etc., as well as unnecessary drilling risks, possible presence of objects which might affect the drilling operation, possibility of penetrating gas bearing zones, possibility of penetrating particularly weak zones, possibility of penetrating zones with abnormal pressures.	Relief Well	Contingency Plan
106	Greenland Bureau of Minerals and Petroleum (BMP) Exploration Drilling Guidelines Section 3.1 Weather Forecasts and Ice Reports	Industry Standard European or Scandinavian	The BMP request that a copy of the site-specific meteorological forecast and a report of ice conditions are to be provided daily to ensure the BMP is fully informed of the status of conditions in the event of an alert or an emergency situation.	Ice and metocean data	

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107	highlights of paper SPE 181393, "How To Develop a Well-Specific Blowout Contingency Plan That Covers Engineering Analysis of the Deployment, Installation, and Soft Shut-In of a Subsea Capping Operation," by Ray T. Oskarsen, SPE, Morten H. Emilsen, SPE, and Amir S. Paknejad, Add Energy; Mike Cargol, Trendsetter Engineering; and Kwee Choong See, SPE, Shell International Exploration and Production, prepared for the 2016 SPE Annual Technical Conference and Exhibition, Dubai, 26–28 September.	Concern or Comment Public	Relief-well contingency planning has been standard practice in parts of the world for decades, and there are many available guidelines detailing a planning process. In comparison, the post--Macondo subsea-capping stacks are a relatively new technology and source-control plans that cover the associated equipment and operations are a recent requirement. Industry standards and guidelines cover a lot of general information on the equipment, connections, and interfaces needed for capping and containing a blowing subsea well. However, there is little or no information available on how to develop a well-specific capping plan that covers engineering analysis of the feasibility of deploying a capping stack from a floating vessel, the weight and stability of the capping stack to overcome the force of the blowout jet, and dynamic-flow simulations of closing the capping-stack outlets without loss of well integrity.	Capping Stack/Systems	Contingency Plan
108	How to Develop a Well Contingency Blowout Plan… Ray T Oskarsen	Technological Explanation	Computational-Fluid-Dynamics (CFD) simulations may be used to determine if a capping stack can be landed and installed for a specific well and blowout scenario. They may also be run for a wide range of blowout scenarios to identify an acceptable operating envelope, which will be unique for every subsea capping stack, depending on its weight and configuration. If it is found that a capping-stack landing may be challenging, it may be possible to use devices such as funnels and guide wires to aid in centering the stack and keeping it stable.	Capping Stack/Systems	
109	United Nations Convention of the Sea - Article 81 Drilling on the Continental Shelf	Agreement International	The coastal State shall have the exclusive right to authorize and regulate drilling on the continental shelf for all purposes. (This was the extent of the conventions comments on drilling regulations)		

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110	United Nations Convention of the Sea - Part XII Protection and Preservation of the Marine Environment	Agreement International	(General statements about preventing, minimizing and controlling pollution, having contingency plans, liability and enforcement - no specific guidelines or practices for drilling activity.) Article 197: States shall cooperate on a global basis and, as appropriate, on a regional basis, directly or through competent international organizations, in formulating and elaborating international rules, standards and recommended practices and procedures consistent with this Convention for the protection and preservation of the marine environment, taking into account characteristic regional features.	Contingency Plan	
111	United Nations Convention of the Sea - Annex III Basic Conditions of Prospecting, Exploration and Exploitation.	Agreement International	General statements about prospecting rights, transfer of technology, approval of work plans, mining, and general protection of the environment)		
112	ASTM Petroleum Standards	Industry Standard - International	No standards on drilling activity		
113	ASTM Environmental Stds.	Industry Standard - International	No standards on drilling activity		
114	ISO 16530-1:2017 Petroleum and Gas industries - Well Integrity	Industry Standard - International	ISO 16530-1:2017 is not applicable to well control. Well control refers to activities implemented to prevent or mitigate unintentional release of formation fluids from the well to its surroundings during drilling, completion, intervention and well abandonment operations, and involves dynamic elements, i.e. BOPs, mud pumps, mud systems, etc.		
115	ISO 28781:2010 Petroleum and Gas Industries - Subsurface barrier valves and related equipment	Industry Standard - International	Limited to subsurface valves that are not designed as emergency of fail-safe flow controlling safety device		
116	ISO 13628-6:2006 Petroleum and Gas Industries - Subsea Production Control Systems	Industry Standard - International	Design, fabrication, testing ,installation and operation of surface control systems - does not appear to address emergency control systems in standard description		

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117	Sara Longhan State of Alaska ADNR Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Government	It is not made expressly clear where proven technology and application of same season relief rigs have demonstrated enhanced well control performance during a blowout event or incident using a relief rig, versus employing blowout preventer (BOP) or capping stacks and devices. Without this technical justification and explanation, it is difficult to ascertain whether the added cost, possible environmental impacts, and logistical challenges of requiring a same season relief rig is rationally balanced with either real or perceived assumptions of practical use and effect.	Relief Well	
118	Sara Longhan State of Alaska ADNR Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Government	In addition, the proposed rule should adequately describe technical findings or actual application success rates of containment dome systems used in OCS water less than 300 feet, which is commonly found in Alaska's nearshore and OCS waters.	Containment Dome	
119	Sara Longhan State of Alaska ADNR Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Government	In particular, we are unaware if containment domes have ever safely been deployed in shallow water under a jack-up rig where leg placement may impose hazards when setting the containment dome. If there is no acceptable proven technology to support including this requirement in the proposed rule, we question the validation and justification BOEM and BSEE deemed sufficient to include unproven technology in the proposed rule.	Containment Dome	
120	Sara Longhan State of Alaska ADNR Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Government	Existing BSEE regulations default to a spill response plan that address cleanup within 30 days while ADEC regulations address action that must be addressed within 72 hour and within 15 days after oil is discharged.	Contingency Plan	
121	Sara Longhan State of Alaska ADNR Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Government	State regulations require a summary of methods to control a well blowout within 15 days, which currently is addressed by surface control (well capping) for offshore drilling in State waters (Cook Inlet) using a jack-up rig. ADEC's regulations do not currently require the SCCE described in this rulemaking.	Capping Stack/Systems	
122	Exxon Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	MMS studies of OCS blowouts showed relief wells were not used to regain well control • Documented in two papers; Assessed activity from 1971-1991 and 1992-2006 Excluding natural formation bridging, surface intervention has been most effective method of regaining well control • Surface intervention includes use of BOPs, capping devices, pumping weighted fluids Prepositioned capping devices can secure wells more quickly and safely than relief wells	Relief Well	SCCE Generalized Well Control

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123	Exxon Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	Proposed requirements could prevent the use of the most effective tools • Requires "Cap and Flow" capability without consideration of proven well design mitigations • Prescribes availability of a Containment Dome (an unproven technology for the proposed application)	SCCE Generalized Well Control	
124	Exxon Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	Well is designed to enable shut-in on a full column of hydrocarbons without loss of integrity • Allows time for detailed risk assessment and planning of next steps "Cap and Flow" approach utilizes a capping device to flow the well to facilities • Utilized when well design or formation integrity does not enable shut-in on a full hydrocarbon column • Additional infrastructure installation time; Operability is challenged by weather and SIMOPS • May result in discharge directly to the ocean in the event of any system failure • Unable to operate in ice; Ice impact risk to subsea components, ice flows prevent flow line connection	Capping Stack/Systems	
125	Cully Corporation Comments on Arctic OCS Rule	Concern or Comment Industry	The draft Arctic Regulations do not define a workable process pursuant to which an operator can apply to use equivalent technology to a same season relief rig. The lack of a defined process for the approval of equivalent technology will likely prevent operators from being able to adapt their programs as new technologies become available.	SCCE Generalized Well Control	Relief Well
126	Center for Regulatory Effectiveness Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	BSEE's proposed rules do not have an administrative record that supports them. The absence of a record is particularly true for the proposed same season response well ("SSRW") rules. There is no administrative record demonstrating the feasibility of SSRW in severe arctic conditions, and there is no record demonstrating SSRW's superiority to other containment and response methods.	Relief Well	
127	Center for Regulatory Effectiveness Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	The National Petroleum Council's recent report ARCTIC POTENTIAL—REALIZING THE IMPORTANCE OF U.S. ARCTIC OIL AND GAS RESOURCES ("Arctic Report") provides extensive evidence against SSRW in the Arctic. BSEE should reconsider its proposed rules and their Cost Benefit Analysis in light of the Arctic Report, including the Report's conclusion that SSRW rules would create severe impediments to Arctic oil and gas activity.	Relief Well	
128	Center for Regulatory Effectiveness Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	The Arctic Report explains that there are "Recent Technical Advances in Source Control. Additional well control devices and techniques are now available that are independent of the controls on the drilling rig. Examples of these devices are capping stacks that are deployed after an incident to stop the flow from the well and subsea isolation devices installed before the well encounters potential hydrocarbon-bearing zones in addition to standard BOP. These systems offer a dramatic reduction in worst case discharge volumes because they are designed to stem the flow of oil in a matter of minutes, hours, or days versus weeks or months. Consequently, they can provide a superior alternative to the requirement for same season relief well and/or oil spill containment systems." 2	Capping Stack/Systems	

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129	Center for Regulatory Effectiveness Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	The Arctic Report further explains that harsh Arctic conditions could render SSRW impracticable: "In Arctic environments, it may be more prudent from an environmental standpoint to focus on prevention and alternate methods than on a relief well plan. Prevention through prudent well design and operations should be the primary method for containment. Alternate methods such as capping stacks or subsea shutoff devices are a secondary method of spill mitigation and containment. A relief well under good weather conditions may take 30 to 90 days plus rig mobilization, whereas a capping stack could be installed significantly sooner, and a subsea shut-in device could be activated in minutes."3	Relief Well	SCCE Generalized Well Control
130	Center for Regulatory Effectiveness Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	The Arctic Report notes that even in much milder climates like the Gulf of Mexico, relief wells do not have a history of success: "The Minerals Management Services published two papers (Izon, 2007; Danenberg, 1993) on statistical data for blowout wells in the outer continental shelf of the United States. These studies covered the 35 years from 1971 to 2006. These reports state, 'Although relief wells were initiated during several of the blowouts, all of the flowing wells were controlled by other means prior to completion of the relief wells.'"4	Relief Well	
131	Center for Regulatory Effectiveness Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	The Arctic Report warns that SSRW requirements could inhibit oil and gas activities in the Arctic: "There are several policy and regulatory challenges that inhibit prudent development of the offshore Arctic. Offshore drilling season not based on drilling system capability – The prescriptive provision for a same season relief well with drilling limited to the open water season currently defines the latest date that the hydrocarbon bearing zone can be entered, which further challenges the lease terms."	Relief Well	
132	Center for Regulatory Effectiveness Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	"Two areas that the industry has identified as impediments to prudent development of the offshore Arctic are the requirements for a same season relief well (SSRW) and the need to have oil spill response capability equal to a worst-case discharge scenario."7	Relief Well	Contingency Plan

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133	Center for Regulatory Effectiveness Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	The National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling (2011) mentions relief wells a number of times, but they are not mentioned in the "recommendations" section. Moreover, the Macondo well was eventually controlled through a static kill, and not a relief well. And this report actually criticized reliance on a relief well strategy: The Need to Strengthen Industry's Spill Preparedness Beyond Attempting to Close the Blowout Preventer Stack, no proven options for rapid source control in deepwater existed when the blowout occurred. BP's Initial Exploration Plan for the area that included the Macondo prospect identified only one response option by name: a relief well, which would take months to drill. Although BP was able to develop new source-control technologies in a compressed timeframe, the containment effort would have benefited from prior preparation and contingency planning."	Relief Well	Contingency Plan
134	Center for Regulatory Effectiveness Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	The Ocean Energy Safety Advisory Committee Recommendations (2013) cautions that: "Regarding scenario planning, the environmental conditions in the Arctic OCS may limit the applicability and effectiveness of containment options (i.e., capping stacks, domes and relief wells) available in the deepwater GOM."	SCCE Generalized Well Control	
135	Center for Regulatory Effectiveness Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	"There are technologies available to substantially extend the useful annual drilling season while maintaining operational safety and enhancing environmental protection. These technologies fall into two broad categories: Advanced Well Control and Oil Spill Response. As discussed in Key Finding 7 on oil spill prevention and response, technologies have been developed that can offer superior protection with shorter implementation time than a relief well. These technologies include subsea isolation devices and capping stacks. Furthermore, there have been advances in oil spill response techniques designed for operations in ice. Page 30, at http://www.npcarcticpotentialreport.org/pdf/AR Exec Summary.pdf .	SCCE Generalized Well Control	Relief Well
136	Center for Regulatory Effectiveness Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	Alternatives include subsea shut-in devices independent of the standard blowout preventer. These alternatives could prevent or significantly reduce the amount of spilled oil compared to a relief well, which could take a month or more to be effective. This assessment should consider the benefits and risks of leaving the well secured using these technologies over the winter season.	SCCE Generalized Well Control	

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137	Center for Regulatory Effectiveness Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	Technological advances, as discussed in Chapter 8, that could be used as alternatives to a SSRW include capping stacks (the device ultimately used to stop the flow of oil from the Macondo well) and subsea isolation devices. The use of these technologies can significantly reduce the amount of spilled hydrocarbons, compared to a relief well as they can be implemented in a matter of hours, days, or weeks upon the loss of well control, compared to a relief well, which can take more than a month. Extending the drilling season would be based on the capability of these systems to operate safely and reliably in an Arctic environment. 11 Furthermore, post-Macondo, the DOI has issued NTL 2010-1012 which requires that wells must be designed to be capped, and if not, contained. Additionally, if these technologies can be used to safely extend the drilling season length the resulting increase in cost effectiveness provides greater incentive for companies to invest as the longer drilling season provides a greater likelihood of completing the necessary exploration and appraisal program required to advance the project to the development phase.	SCCE Generalized Well Control	Subsea isolation device
138	Center for Regulatory Effectiveness Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	"Additional well control devices and techniques are now available that are independent of the controls on the drilling rig. Combined with performance-based risk assessment, these systems offer a dramatic reduction in worst-case discharge volumes and form a superior alternative to the requirement for same season relief well and/or oil spill containment systems. Such measures do not provide ultimate well kill and may not obviate the need for a relief well, but they do reduce urgency such that there is no net risk benefit to killing the well in the same season. Examples of these devices are capping stacks that that can be quickly deployed after an incident and subsea shut-in devices that are installed on the well during the drilling process.	Capping Stack/Systems	Subsea isolation device
139	Center for Regulatory Effectiveness Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	Multiple spill prevention measures and barriers are currently designed into the wells, and these barriers are defined and specified in API/ISO standards and U.S. offshore regulations. Drilling fluid, casing design, cement, and other well components are the primary barriers and the blowout preventers (multiple redundancies) are the secondary barriers to prevent a release to the external environment."	BOP	
140	Center for Regulatory Effectiveness Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	Prevention through prudent well design and operations should be the primary method for containment. Alternate methods such as capping stacks or subsea shutoff devices are a secondary method of spill mitigation and containment. A relief well under good weather conditions may take 30 to 90 days plus rig mobilization, whereas a capping stack could be installed significantly sooner, and a subsea shut-in device could be activated in minutes. Some regions of the world (e.g., Canada) specify a same season relief well (SSRW) capability for Arctic drilling.	Capping Stack/Systems	Subsea isolation device

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141	Center for Regulatory Effectiveness Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	In the Arctic, a similar, and in some cases higher, level of protection to a SSRW may be achieved with appropriate well designs which are executed with the right equipment, best available technology, and utilizing proven drilling practices by personnel who are trained and competent. Both Chevron Canada and Imperial Oil Resources have requested an equivalent approach to the SSRW for the Canadian Beaufort Sea that includes incident prevention as well as securing the well and response plans." Page 8-19 at http://www.npcarcticpotentialreport.org/pdf/Arctic_Potential_Part_2.pdf .	SCCE Generalized Well Control	Relief Well
142	Statoil Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	Statoil notes that the proposed Arctic rule set takes a prescriptive rather than risk or performance based approach to requirements. Sections that are particularly relevant are Sections 30 CFR 250.471, 30 CFR.472. Performance based regulations set out the objectives that must be achieved, but allow flexibility in the choice of methods or equipment that may be used by companies to meet their statutory obligations. The recognized advantage of this approach is to foster innovation and continuous improvement whilst ensuring acceptable levels of performance based on science and fact. Performance based regulations are applied in various modern offshore regimes, including UK and Norway, as areas of established offshore exploration and production for more than 50 years. After major accidents in the 1980's, both these regions successfully overhauled their offshore safety regimes to focus on understanding and mitigating risks directly rather than application of prescriptive requirements. Norway's OCS extends from the North Sea, the Norwegian Sea up to the Arctic Barents Sea, in areas far offshore, with seasonal darkness, and where icing and sea-ice can occur. One set of risk based regulations applies, but activities have to be adjusted to the specific environmental and meteorological conditions in the exact area and the exact period of time for which the activity is planned. One of the key advantages of risk based regulations is adaptability to complex activities and operating environments. There is evidence (1 ref) that performance based regulation leads to improved safety, and that the "safety case" approach is one of the most effective ways of managing major hazard industries. The ultimate responsibility for safety offshore is more clearly transferred from the regulator to the operator, and sets the basis for increased health and safety understanding and competence by all parties. One of the key findings from The National Commission Report on the BP Oil Spill2 was that the Department of the Interior should develop a proactive, risk- based performance approach specific to individual facilities, operations and environments, similar to the "safety case" approach in the North Sea. It is not clear that DOI has included input from such safety case offshore regulators when drafting the proposed regulations. With respect to implementing the above recommendation, Statoil considers that where regulations are set up to meet DOI goals, then it	SCCE Generalized Well Control	Risk -based and fit for purpose solutions

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143	Statoil Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	The regulations address specific loss of well control risk concerns through integrating very prescriptive requirements of compliance measures. Requirements include individual equipment items which may have been used by an operator in the past, but which should not be assumed to be the appropriate or best choice of future operators. A preferable approach to open for innovation and improvement would be that the regulation itself is more adaptive and risk based, e.g. operator to provide source control to limit environmental risk to an acceptable level. Taking due respect to concerns for the transition phase to a performance based approach. The regulator can reference certain standards or practices as guidelines to fulfill regulations and clear risk goals, but these are not restrictive as the only way to achieve compliance. This also enables standards and best practices to be updated without the need to update regulations.	SCCE Generalized Well Control	Risk -based and fit for purpose solutions
144	Statoil Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	There is a statement that the proposed regulations will not “prevent” activity in the US Arctic OCS. International operators believe that the Arctic has significant hydrocarbon resources but DOI should recognize that Alaska is a high cost region that competes against numerous other regions in the global resource base. Competitiveness in the future will depend on operator ability and motivation to look for new solutions that meet societal goals for acceptable risk whilst delivering economic benefit, i.e. for prudent development. This subject is the focus of the NPC Arctic Potential report . It should be recognized that the application of inappropriately prescriptive requirements will reduce motivation of operators seeking cost and risk effective innovations, and will reduce competitiveness of Alaska as an offshore region. In effect it curbs motivation to improve safety whilst increasing the bar height to achieve economic viability. GENERAL RECOMMENDATION: Statoil recommends that the regulations include more evidence towards openness and opportunities for cost and risk effective solutions which can act as motivators for prudent activity in Alaska. The cost analysis and conclusions presented are subjective and cannot be the sole measure towards burden and competitiveness.	SCCE Generalized Well Control	Subsea isolation device

ID	Source	Category - regulation, standard, comment	Action	Subject 1	Subject 2
145	Craig Wilson Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Public	The preamble to the proposed regulations states that capping stack, cap and flow system, and containment dome be available within short timeframes. Having immediate, or near immediate, access to source control and containment equipment is very important to minimize the size, spread, and impact of an oil discharge. However, prescribing a specific equipment suite, apparently based upon a single event (Deepwater Horizon) is ineffective and inefficient since it is based upon the false assumption that a loss of well control incident in the shallow waters of the Beaufort and Chukchi Seas would be the same as a deep-water well blowout in the Gulf of Mexico. The Norwegian safety case approach, utilizing multiple complementary barriers to release, has much to recommend it. Containment domes and capping stacks are not complementary barriers in shallow water, especially when utilized in conjunction with a bottom-founded structure. Instead of prescriptive regulations mandating specific equipment which may not be applicable to a given project, the regulations should instead be performance-based, requiring that the operator have approved source control and containment equipment in region and positioned to arrive at the location within 24 hours. Regarding BSEE's request for comments on the timeframe for arrival on-site, 7 days is too long from an emergency response viewpoint. If source control is not effectively operating within 3 days of an incident the magnitude of the spill and the resulting environmental and economic damage greatly increases.	Capping Stack/Systems	Containment Dome
146	Craig Wilson Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Public	The calculation of "expected onset of seasonal ice encroachment" needs to be sufficiently identified and explained. The proposed 30 CFR 550.220(c)(6) requires submittal of "projected end of season dates and the information used to obtain those dates" without a clear understanding of what constitutes a valid calculation of end of season and how that information will be used to determine compliance with 30 CFR 250.472(b). The calculation also does not take into account periodic ice incursions during the open water season, and how potential ice management activities, which could include rig movement, interact with this requirement. Additional clarity about what "expected onset of seasonal ice encroachment" means and how it is calculated is warranted in order for industry to determine the economics of an exploration drilling program. 30 CFR 250.472 requires a relief rig or alternative compliance (subparagraph h).	Ice and metocean data	SCCE Generalized Well Control
147	Craig Wilson Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Public	Containment Dome The safety and viability of a containment dome as a source control method for bottom-founded structures in shallow water has not been demonstrated. The safety and technical issues of installing a containment dome between the legs of a bottom-founded rig are sufficient to dismiss the use of a containment dome out of hand in most situations.	Containment Dome	

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148	Craig Wilson Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Public	Cap and Flow System Prescribing a cap and flow system for all exploration projects neglects to address the operational differences between various MODU types. With a jack-up rig, well recovery operations are significantly different than a drill ship due to the different location of the well head and associated equipment. Source Control and Containment Equipment Deployment 30 CFR 250.471(h) indicates that the Regional Supervisor has the full authority to require the deployment of the capping stack and cap and flow system, without any requirement to consult with the Regional Response Team, USCG FOSC, or any technical experts. The concept that the Regional Supervisor is in the best position to determine response options is dubious for both legal and technical reasons. Under federal law, the U.S. Coast Guard Federal On-Scene Coordinator (FOSC) is in charge of oil spill response, not BOEM/BSEE, and is the sole federal entity authorized to require actions to control a potential discharge. I suggest rewriting this to indicate that the Regional Supervisor shall consult with the FOSC (and SOSC in state waters) and appropriate stakeholders and technical experts regarding the deployment of these systems.	Capping Stack/Systems	
149	Craig Wilson Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Public	Relief Rig (30 CFR 250.472) The preamble (Section VI.B.3.i.a) states that "BOEM and BSEE anticipate that we would exercise our existing authorities to require a relief rig for any future exploratory drilling on the Arctic OCS." Given that BOEM/BSEE believe their existing regulatory authority is sufficient to require a relief rig, why is BOEM/BSEE proposing additional regulation? The proposed 45 day relief well requirement in 30 CFR 250.472(b) is an overly-prescriptive approach based upon a very specific set of criteria unique to a single drilling program. I suggest replacing it with a performance-based standard, requiring access to a relief rig, or alternative well control system equivalent to a relief rig, such that an uncontrolled well can be controlled prior to the expected onset of seasonal ice encroachment at the drill site. Comments by Craig Wilson Submitted 21 May, 2015 6	Relief Well	Risk -based and fit for purpose solutions
150	Craig Wilson Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Public	The alternative compliance option, using 30 CFR 250.141, provides no assurance that an alternative compliance measure would be reviewed in a timely manner to allow inclusion in an Arctic drilling program. More so, it appears that alternative compliance measures are predominantly approved via NTL, a lengthy process that applies to all operators in a region, not on a project-by-project basis. The NEB process for same season relief well (SSRW) equivalency is a marginally better solution. Perhaps an NTL providing a more detailed roadmap, including timelines, for alternative compliance review and approval procedures under 30 CFR 250.141 is warranted in order to provide clarity to the regulated community.	SCCE Generalized Well Control	

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151	Theresa Imm AIO Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	From AIO's perspective the primary motivation behind the Proposed Rule appears to be a desire by DOI to remedy the operational and systematic deficiencies that ultimately led to the 2010 Macondo incident in the Gulf of Mexico…AIO believes that the Proposed Rule does not fit conditions in operations on the United States' Arctic Outer Continental Shelf where most drilling occurs in shallow water from bottom-founded structures that are not impacted by sea states. We think that certain elements of the Proposed Rule, such as the requirement to employ containment domes, and the requirement to employ surface vessels with 3-phase processing capabilities, are better suited for addressing operations in ultra-deepwater conditions, such as the Gulf of Mexico. Given the diversity of physical conditions in the Arctic, as well as the variety of rig types available. AIO believes that the Proposed Rule should enable the use of the technology best suited for the particular conditions facing an operator.	Containment Dome	
152	Theresa Imm AIO Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	The proposed rule assumes a 139-day drilling season on the Arctic OCS 80 Fed. Reg. at 9950. Under current regulatory framework, this is not a realistic assumption. As the NPC study notes, "the accessible season for drilling [in the western area of the Chukchi Sea] is July 1 to November 1, a total of 124 days. " NPC study, Executive Summary at 29. However, under the Proposed Rule, the drilling season would be further shortened by the requirements of proposed section 250.472 which would mandate that an operator be able to drill a relief well "no later than 45 days after the loss of well control."...This means that an operator must build into its plan sufficient time to ensure that it could comply with the 45-day limit on drilling a relief well and means that the total drilling season lasts less than 80 days.	Relief Well	
153	Theresa Imm AIO Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	Second, a relief well does not stop the uncontrolled flow of hydrocarbons, Instead, a relief well kills a well after the out of control well has been brought under control by other means. Therefore a same season relief well is not really necessary to mitigate additional environmental harm if an operator has already regained well control through deployment of a capping stack.	Relief Well	
155	Theresa Imm AIO Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	Finally, the relief rig requirement does not provide a clear path for approval or use of well containment alternatives that are equivalent to a real-life well. With respect to oil spills, AIO and local communities want operators to be able to utilize the best technology available to quickly and effectively respond to a loss of well control Ultimately, operators must be afforded flexibility to respond to an incident as conditions warrant. The proposed rule is excessively prescriptive and does not provide operators with the opportunity to propose alternative technologies equivalent to a relief well.	Relief Well	SCCE Generalized Well Control

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156	Theresa Imm AIO Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	A range of other spill response technologies currently exist, including the Subsea Isolation Device (SID), which sits on the subsea wellhead below the blowout preventer (BOP). The SID has rams to shear and seal the out-of-control well and is operated from an independent control system. Unlike a relief well, which can take weeks to drill, a SID is instantaneous.	Subsea isolation device	
157	Theresa Imm AIO Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	Another effective well control technology is the capping stack, which sits atop of the BOP, and allows for cap and flow of full shut-in of the well. Rather than taking a month to drill, a capping stack takes days to weeks to get well under control. Alternative response technologies like the SID and capping stack are being utilized in frontier areas around the globe. For example, Exxon Mobil currently employs a SID in the Kara Sea in the Russian Arctic, while Royal Dutch Shell plans to rely on a capping stack during its summer 2015 exploratory drilling operations in the Chukchi Sea. AIO believes that it is critical for DOI to provide a mechanism to allow industry and regulators to work together to perform the analyses, investigations, and any necessary demonstrations to validate technologies for improved oils spill prevention and source control.	Capping Stack/Systems	
158	Carl Portman Resource Development Council Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	The proposed rules do not consider alternatives to floating rigs, The proposed rules limit their consideration to a particular approach to drilling based on the use of a floating rig, and the result is prescriptive rules that require particular equipment to the exclusion of other approaches that could be safely and effectively used.		Risk -based and fit for purpose solutions
159	Carl Portman Resource Development Council Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	Given the logistics associated with Arctic operations and advances in technology, it is not necessary to include a Same Season Relief Well (SSRW) requirement in the proposed Arctic regulations. The requirement should be eliminated. Since DOI began keeping comprehensive incident records in 1971, one of the more than 41,000 wells drilled over more than 40-years has depended on a relief well to control a blowout. Relief wells have been deployed to perform the final plug and abandonment wells. In the case of the Macondo incident, a capping stack was used to control the well and stop the flow. The relief well was later used to permanently plug and abandon the well.	Relief Well	Capping Stack/Systems
160	Carl Portman Resource Development Council Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	In its proposed Arctic regulations, DOI should modify the SSRW requirement by adopting a performance-based approach.	Relief Well	Risk -based and fit for purpose solutions

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161	Carl Portman Resource Development Council Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	DOI should outline a defined process for the approval of new technology and the outcome to be achieved, rather than prescribe use of specific technology.	SCCE Generalized Well Control	Risk -based and fit for purpose solutions
162	Carl Portman Resource Development Council Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	Given the advances in technology, a SSRW approach no longer constitutes the Best Available and Safest Technology in response to a loss of well control. As noted, a SSRW is not necessarily the best approach to well control, given advances in well design, mud systems, blowout preventers, and capping stacks, which itself represent more effective alternative to a SSRW. Capping stacks can be secured over a well, halt the flow, and remain in place until the well can be re-entered to perform a final plug. Moreover, blowout preventers and capping stacks are preferable to industry because they are effective and much more timely in controlling a problematic well than a SSRW, thus reducing the environmental impacts associated with a troubled well. A capping stack or subsea isolation device can be deployed to control a blown well over the winter with the operator returning during the following season to drill a relief well to permanently plug and abandon the well. As a result, such an approach would not require a SSRW during the same operating season, provided an operator uses an initial control technology that can be overwintered in place.	Relief Well	SCCE Generalized Well Control
163	Lois Epstien - Alaska Inter-tribal Council, Alaska Wilderness League, Audubon Alaska+ 12 more environmental groups. Comments on Arctic OCS Proposed Rule	Concern or Comment ENGO	A relief well is the most reliable means of controlling a well blowout. Other means, e.g., well capping and containment, can fail depending on how a blowout unfolds. As examples, it may not be possible to cap or contain a blowout if the pressurized fluids are not coming up solely through the well bore, or it may be unsafe to use capping or containment near certain blowouts (such as Walter Well blowout in the Gulf of Mexico in July 2013, which took place in shallow water)	Relief Well	Capping Stack/Systems
164	Lois Epstien - Alaska Inter-tribal Council, Alaska Wilderness League, Audubon Alaska+ 12 more environmental groups. Comments on Arctic OCS Proposed Rule BSEE - 2013-0011-0031	Concern or Comment ENGO	Following a blowout, the capping stack needs to be able to arrive at a well within 24 hours, and a cap and flow system and a containment dome must be able to arrive within 3 (rather than 7) days.	SCCE Generalized Well Control	

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165	Lois Epstien - Alaska Inter-tribal Council, Alaska Wilderness League, Audubon Alaska+ 12 more environmental groups. Comments on Arctic OCS Proposed Rule BSEE - 2013-0011-0031	Concern or Comment ENGO	Interior needs to remove the word "anticipated" in proposed 30 CFR 220 c (6) to ensure that Arctic OCS operators provide a firm date for their end of seasonal operations to avoid increase risks associated with freeze-up. This date should be based on at least ten years of historical ice and weather data, and should be reviewed and approved by Interior's and other agencies' scientists. Additionally, the final rule should allow Interior to require operations to terminate before this date if conditions during the drilling season necessitate an earlier date.	Contingency Plan	
166	Emily Buchanan, Bernie Woldford, Noble Drilling Comments on Proposed Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	BSEE seeks comments on the performance and operational issues associated with utilization of a subsea shut-in devise (SID): The use of an SID would be best considered only in the case of a jack-up MODU, specifically to be employed to allow the jack-up to be moved off location in the case of unmanageable hazardous ice encroachment. For floating MODUs the SID would not add benefit, as the subsea BOP is already deployed at the seabed. The SID would require a much deeper mud line cellar for use with a floating MODU, which raises additional risks for the mud line cellar construction and soil stability.	Subsea isolation device	
167	Theresa Fariello Exxon Mobil Corporation Comments on Arctic OCS Proposed Rule BSEE - 2013-0011-0031.	Concern or Comment Industry	The largest impediment to both risk reduction in and economic viability of arctic drilling is the same season relief well (SSRW) requirement. Records from BSEE (and its predecessor the Minerals Management Service) show that for the last 35 years and more, a relief well has never been used to regain well control in U.S. OCS waters. As such, drilling a relief well would increase risk by drilling a second well while not providing a proven method for regaining control of the first well. Further, local conditions such as water depth and drilling season length would make a SSRW non-viable in some locations.	Relief Well	
168	Theresa Fariello Exxon Mobil Corporation Comments on Arctic OCS Proposed Rule BSEE - 2013-0011-0031.	Concern or Comment Industry	...It is recommended that regulations focus on providing the framework needed to establish risk-based fit-for-purpose plans that not only enable responses to be tailored to the specific well, operating facility and environment, but also allow the continued integration of new technologies that will further prevent incidents from occurring and enhance response capabilities in the rare event an incident did occur. [Various statements on post-Macondo prevention measures]	Risk -based and fit for purpose solutions	SCCE Generalized Well Control
169	Theresa Fariello Exxon Mobil Corporation Comments on Arctic OCS Proposed Rule BSEE - 2013-0011-0031.	Concern or Comment Industry	In the highly unlikely event that all industry proven barriers fail during a drilling operation, industry has also developed new subsea shut-in device and capping stack technology that has substantially increased capability to secure a well from any uncontrolled flow of hydrocarbons.	Capping Stack/Systems	Subsea isolation device

ID	Source	Category - regulation, standard, comment	Action	Subject 1	Subject 2
170	Theresa Fariello Exxon Mobil Corporation Comments on Arctic OCS Proposed Rule BSEE - 2013-0011-0031.	Concern or Comment Industry	[MMS paper on blowout wells 1971-2006] These reports stat, "Although relief wells were initiated during several of the blowouts, all of the flowing wells were controlled by other means prior to completion of the relief wells". The same situation occurred during the Macondo incident where well control was regained at the source through installation of a capping stack, not by drilling a relief well. Reliance on the false premise that relief wells provide a primary means of regaining well control would not only add substantially to already high execution costs, it would also introduce risk by reducing the incentive or ability for an operator to use more effective alternatives appropriate to a given drilling program.	Relief Well	Capping Stack/Systems
171	Theresa Fariello Exxon Mobil Corporation Comments on Arctic OCS Proposed Rule BSEE - 2013-0011-0031.	Concern or Comment Industry	Following loss of well control, other response measures are better designed to limit the size of a spill if containment is lost. Flow-reduction measures are employed to decrease the rate of outflow by increasing the dynamic back-pressure applied by pumping through the BOP or other subsea devices. Flow-stoppage measures are employed to stop the outflow of a well to the environment through the use of shut-in devices such as a capping stack or a preinstalled shut-in device at the seafloor, whose operation is totally independent of the BOP. These tools are designed to stem any uncontrolled flow of oil as rapidly as possible to minimize damage to the environment. The final available flow-stoppage measure could theoretically be a relief well, a separate well drilled to intercept and permanently stop the flow from a blown-out well. But when you weigh the added risk of both drilling a second well and forcing multiple years to complete w well due to a shortened drilling season, with the theoretical well control value that has never been needed in the OCS, it is not a prudent risk management requirement. Again, in all cases to date, OCS subsea well control has been regained at the wellhead, not with a relief well.	Capping Stack/Systems	Subsea isolation device
172	International Law and the Arctic - Michael Byers Cambridge Studies in International and Comparative Law. 2013 University Printing House, Cambridge UK Chapter 7 Oil Spills, p. 202.	Agreement International	In 2011, the Arctic Council created a task force to negotiate a treaty on Marine Oil Pollution Preparedness and Response. ...will present a finished treaty in 2013, one that is modeled on the Arctic Search and Rescue Agreement and therefore focuses on improving communication and coordination when accidents occur. In terms of substantive obligations, the new treaty is unlikely to go beyond the 1990 OPRC to address difficult issues such as same-season relief well capability...To the degree that the treaty will fill a gap, it is likely to be in terms of promoting regional consultations, coordination, and cooperation, since there is currently no legally binding, multilateral marine oil pollution response instrument specific to the Arctic.	Contingency Plan	
172	Theresa Fariello Exxon Mobil Corporation Comments on Arctic OCS Proposed Rule BSEE - 2013-0011-0031.	Concern or Comment Industry	Included in this assessment should be consideration of existing technologies, such as pre-positioned capping tacks and BOP upgrades, which enable faster source containment and therefore reduced release size and environmental impact.	Capping Stack/Systems	BOP

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173	Theresa Fariello Exxon Mobil Corporation Comments on Arctic OCS Proposed Rule BSEE - 2013-0011-0031.	Concern or Comment Industry	Recent steps taken to improve safety include certification by a licensed professional engineer confirming there are two independently tested barriers across each flow path, verification that the casing and cementing design are appropriate, and independent third-party verification of the BOP condition and readiness. These engineering safeguards are backed up by requiring strict adherence to operations integrity management systems as part of an overall culture of safety and risk management.	BOP	
174	Theresa Fariello Exxon Mobil Corporation Comments on Arctic OCS Proposed Rule BSEE - 2013-0011-0031.	Concern or Comment Industry	The proposed regulations as written do not address the importance of prevention and its role in protecting Arctic OCS areas. As an example, there is focus placed on being able to CAP and Flow wells via either a Containment Dome or Capping stack, however no consideration of a preventative alternative is discussed.	Preventative alternative	
175	Theresa Fariello Exxon Mobil Corporation Comments on Arctic OCS Proposed Rule BSEE - 2013-0011-0031.	Concern or Comment Industry	Containment Dome equipment and the associated infrastructure may be difficult to deploy and also complicate the ability for further well intervention methods due to SIMOPS issues, especially in a shallow water Arctic environment. This could result in a greater impact to the environment. Alternatives to a Containment Dome are discussed in detail in the previously reference NPC's Arctic Potential Report. These alternatives include dispersant application, in-situ burning or a top kill, all of which could be difficult to execute under the prescribed measures defined in the proposed rules.	Containment Dome	
176	Theresa Fariello Exxon Mobil Corporation Comments on Arctic OCS Proposed Rule BSEE - 2013-0011-0031.	Concern or Comment Industry	The proposed SCCE rules state that Operators must have access to a capping stack, cap and flow system, and a containment dome that can be mobilized to location within 24 hours (capping stack) and 7 days (Cap and flow system), containment Dome, other equipment). These mobilization durations are less than those currently demonstrated in established areas... The proposed SCCE mobilization durations are such that equipment will be required to be stored in the field or staged offshore in the nearest available safe harbor. As a result, a strain will be placed on the effective storage capability of an existing marine fleet or, more likely, additional vessels will be required. The incremental vessels will further complicate SIMOPS issues and will require careful management to avoid impact on critical path operations. Furthermore, BSEE's proposal to reduce the Containment Dome and Cap and Flow equipment mobilization duration from 7 to 3 days would likely drive the need to stage equipment in less sheltered waters, increasing risk to the personnel dedicated to maintaining and operating the equipment. .. The Alaska OCS areas do not have ports with sufficient depth to service supply vessels. ...As a result, supply barges are typically stated in the relatively sheltered waters near Kotzebue over 400 nautical miles from the Chukchi operating areas. ...These logistic challenges are amplified for any operations in the more remote Beaufort OCS.	Containment Dome	Capping Stack/Systems

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177	J. Spuhler Shell Comments on the proposed Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	A SSRW is not the best available and safest technology (BAST) for well control, and is not justified from a cost-benefit perspective...In the low probability event of a loss of well control on the Arctic OCS, "relief" would not come from a second well, but rather from a source control tool that could be swiftly deployed, such as a capping stack. The regulations should address separately, and in a performance-based manner, the objective an operator must meet around source control versus a final kill of a well, If an operator uses a source control tool that can be safely overwintered, its final plug and abandon tool should not be required to be available the same season and its season should not be cut short to accommodate relief well drilling.	Relief Well	Capping Stack/Systems
178	J. Spuhler Shell Comments on the proposed Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	The BAST for source control is a capping stack, not a SSRW. A SSRW is not BAST because drilling a same season relief well takes significantly longer to control a source than does the deployment of a capping stack. Further, the risk profile executed with drilling a same season relief well is greater than that associated with a capping stack...Capping stacks and subsea isolation devices can be safely overwintered on the seafloor in an area with no known ice gouge, or in a mud line cellar in an area where ice gouge may be a concern. Under these circumstances, an operator could return during the next season to drill a relief well to permanently plug and abandon the well, Alternately, an operator may select to perform a final kill of the well be re-entering the capping stack and performing a top kill. A capping stack is superior to a SSRR also because conducting well control with a SSRW raises the risk profile of drilling undertaken by the second rig. Both of the global recent major blowouts, Montara and Macondo, were associated with wells drilled and temporarily suspended. Requiring exploratory wells to be prematurely suspended, especially after a hydrocarbon bearing zone has been entered, is not a sound operational procedure or appropriate regulatory requirement.	Capping Stack/Systems	Subsea isolation device

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179	J. Spuhler Shell Comments on the proposed Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	Quote from the National Petroleum Council's Arctic Potential: "Realizing the Promise of U.S. Arctic Oil and Gas Resources Report (2015): Additional well control devices and techniques are now available that are independent of the controls on the drilling rig. Examples of these devices are capping stacks that are deployed after an incident to stop the flow from the well and subsea isolation devices installed before the well encounters potential hydro-carbon-bearing zones in addition to standard BOP. These systems offer a dramatic reduction in worst-case discharge volumes because they are designed to stem the flow of oil in a matter of minutes, hours, or days versus weeks or months. Consequently, they can provide a superior alternative to the requirement for same season relief well and/or spill containment systems (p. 41-42)." Contrary to the agencies' assertions, the availability of these existing and superior technologies means that a second rig would (at most) perform a final plug and abandon of a well; it would not be used to "regain control" of it.	Capping Stack/Systems	Subsea isolation device
180	Richard Ranger API Institute for 21st Century Energy and NOIA Comments on Proposed Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	Just as the agencies have recognized value in allowing for some form of equivalency in the context of the SSRR requirement, there is a need for a pathway for equivalency with regard to the use of a containment dome in the Arctic OCS. Shell's arctic containment system (ACS) is a one of a kind system, built specifically for Shell's Arctic program. The system is a step forward in terms of technology, but the use of a containment dome should not be enshrined in regulation while other tools are being developed and new technology is being considered. Future and existing technologies, including subsea shut-in devices that could ultimately negate altogether the need for separate cap and flow systems and containment domes, are being pursued to provide better outcomes in the highly unlikely event of a well control incident in Arctic (and other) conditions. These prospective technologies will provide greater response capabilities and address any shortcomings of current SCCE tools. It is short-sighted to ignore near-future solutions to well control and oil spill response in favor of a prescriptive regulation that adheres to technology which may be replaced in the near future.	Containment Dome	Capping Stack/Systems

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181	Richard Ranger API Institute for 21st Century Energy and NOIA Comments on Proposed Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	The proposed rules limit their consideration to a particular approach to drilling based or use of a floating rig, and the result is prescriptive rules that require particular equipment to the exclusion of other approaches that could be safely and effectively used. In a great many areas in the Arctic OCS, the conditions at prospective drill sites allow use of alternatives to floating rigs. Nevertheless, the proposed regulations appear to be written from the perspective that the only foreseeable approach to exploration drilling projects in the region will involve floating rigs, and equipment and support systems compatible with floating rigs. This makes these Arctic-specific rules different than those that apply to other areas of the OCS and there is no Arctic-specific reason or justification for this. In fact, wells in shallow waters of Beaufort Sea have been safely drilled in the past with bottom-founded or iced-in rigs, but such rigs may not be able to accommodate a containment dome or a mudline cellar, and so this type of rig would likely be precluded by the proposed rules. Jack up rigs are safe and viable in waters up to 300-feet deep in the Chukchi Sea - but the requirements prescribed in the proposed rules may eliminate their potential use, without providing any basis for such a limitation on operators' exploration plans.	SCCE Generalized Well Control	
182	Richard Ranger API Institute for 21st Century Energy and NOIA Comments on Proposed Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	The Associations urge the Agencies to recognize that relief wells have historically not been used to regain well control, and in terms of stopping the flow and securing the well as quickly as possible, they may not represent the best solution when compared to recent technological advances such as capping stacks and seabed isolation devices. For these reasons, the Associations urge the adoption of a more flexible regulatory approach that considers fit-for-purpose response planning alternatives to respond to loss of well control in the context of a given EP [exploration plan]and the operating conditions it will be subject to.	Relief Well	Risk -based and fit for purpose solutions
183	Richard Ranger API Institute for 21st Century Energy and NOIA Comments on Proposed Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	Firstly, the proposed rules fail to describe how an operator should demonstrate equivalency to a same season relief well, nor do they address the perceived risk reduction benefit, which is critical to establishing the baseline expectation. Secondly, and more fundamentally, the proposed rules fail to establish why a same season relief well should be a blanket requirement across all Arctic OCS MODU activities despite the range of risks to be considered and the numerous other available industry technologies and methods that have previously been utilized to successfully control wells.	Relief Well	Risk -based and fit for purpose solutions

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184	Richard Ranger API Institute for 21st Century Energy and NOIA Comments on Proposed Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	The additional human and environmental risk introduced into an operation by providing for a same season relief well on stand-by argues for careful consideration of alternative measures to address loss of well control. In the low probability event of a loss of containment event, "relief" would not come from a second well, but rather from a source control tool that could be swiftly deployed, such as a capping stack.	Relief Well	Capping Stack/Systems
185	Richard Ranger API Institute for 21st Century Energy and NOIA Comments on Proposed Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	The NPC Arctic Report describes in detail industry's primary approach to loss of well control is prevention - achieved through adherence to established codes/standards and operations integrity management systems … Multiple spill prevention measures and barriers are currently designed into the wells drilled in the OCS, and these barriers are defined and specified in API/ISO standards and offshore regulations enforced by BSEE and BOEM. Drilling fluid, casing design, cement, and other well components are the primary barriers and the blowout preventers (multiple redundancies) are the secondary barrier to prevent a release to the external environment. This is the case whether a well is drilled in a temperate water or Arctic marine environment.	Preventative alternative	
186	Richard Ranger API Institute for 21st Century Energy and NOIA Comments on Proposed Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	Alternate methods such as capping stacks or subsea shut-off devices are a secondary method of spill mitigation and containment. A capping stack could be installed much more quickly than a relief rig could be deployed and put in operation (days instead of weeks), and a subsea shut-in device could be activated in minutes. Additionally, in certain situations, supplemental subsea equipment could be used to increase the range of blowout preventer (BOP) functions to further increase capability to perform well control operations.	Capping Stack/Systems	Subsea isolation device
187	API 53 BOP	Industry Standard - US	The purpose of this standard is to provide requirements on the installation and testing of blowout prevention equipment systems on land and marine drilling rigs (Barge, platform, bottom-supported, and floating. The primary functions of these systems are to confine well fluids to the wellbore, provide means to add fluid to the wellbore and allow controlled volumes to be removed from the wellbore. Diverters, shut-in devices, and rotating head systems (rotating control devices) are not addressed in this standard (See API 64 and API16RCD, respectively); their primary purpose is to safely divert or direct flow rather than to confine fluids to the wellbore..	Preventative alternative	Not applicable
188	API Spec 16 RCD (Rotating Control Device)	Industry Standard - US	This specification is developed to provide for the safe and functionally interchangeable rotating control devices (RCDs) utilized in [drilling operations for oil and gas]. Technical content provides requirements for design, performance, materials, tests and inspection, welding, marking, handling, storing, and shipping. This specification does not apply to field use or field testing of RCDs. [No information about deployment or requirements for use under prescribed circumstances].		

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189	API Recommended Practice 2N	Industry Standard - US	This standard specifies requirements and provides recommendations and guidance for the design, construction, transportation, installation, and removal of offshore structures, related to the activities of the petroleum and natural gas industries in arctic and cold regions. Reference to arctic and cold regions that are subject to similar sea ice, iceberg, and icing conditions. The objective of this standard is to ensure that offshore structures in arctic and cold regions provide an appropriate level of reliability with respect to personnel safety, environmental protection, and asset value to the owner, to the industry, and to society in general. This standard does not contain requirements for the operation, maintenance, service-life inspection, or repair of arctic and cold region offshore structures, except where the design strategy imposes specific requirements. While this standard does not apply specifically to mobile offshore drilling units, the procedures relating to ice actions and ice management contained herein are applicable to the assessment of such units. [No information about well loss or deployment]{Extensive design criteria based on arctic conditions beyond what's listed below]	Ice and metocean data	
190	API Recommended Practice 2N	Industry Standard - US	Different structural shapes, orientations, and profiles for the structure and the topsides should be considered for resisting sea ice or ice berg actions. In defining the orientation of the structure at the site, consideration should be given to the ice conditions, prevailing ice drift directions, and ice rubble buildup. The topsides should be arranged with respect to the functional and operational requirements- such as resupply, offloading, flaring, and escape, evacuation, and rescue (EER) - and with respect to wind and ice encroachment. The reliability of EER, platform supply, and offloading systems can potentially be improved through: a.) ice management to prevent ice rubble accumulation; duplication of facilities on opposite sides of the platform; and c.) large crane booms to reach over accumulated rubble.		
191	API Recommended Practice 2N	Industry Standard - US	Evaluation of minimal draft limitations shall be performed for all regions through which the structure can be transported in order to reach its final destination. Consideration shall be given to the specification of all marine spread equipment and the ability of personnel to safely perform the required transportation and installation activities during periods of low ambient temperature, low visibility, and other relevant environmental conditions. Limiting environmental conditions shall be specified for all critical offshore activities and the associated weather windows shall be included in the planning and execution of such work. Contingency planning for all critical offshore activities shall be included to ensure safe transportation and installation.		
192	API Recommended Practice 2N	Industry Standard - US	The varying amount of daylight hours in arctic regions is a consideration for initial [design] data collection and for the operations of offshore facilities. Due consideration of the effect of this parameter should be incorporated in operational planning.		

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193	API Recommended Practice 2N	Industry Standard - US	The air temperature affects ice properties and ice conditions. Air temperature changes, combined with wind and snow depth, control thermal expansion and associated actions in land fast ice, low air temperatures combined with winds, waves, and sea spray, can also lead to marine icing events.	Ice and metocean data	
194	API Recommended Practice 2N	Industry Standard - US	The combined effect of air temperature and wind shall be used to calculate wind chill. The effect of wind chill upon human capability, machinery heat loss, and topsides winterization shall be considered. The importance of PPE, heated shelters, appropriate work procedures, and other actions should be considered when workers are exposed to outdoor conditions.	Ice and metocean data	
195	API Recommended Practice 2N	Industry Standard - US	The extent to which snow can accumulate and its possible effect on the structure and machinery, shall be considered [in design] when evaluating ice properties, e.g. friction and ice strength, in determining ice actions and assessing vessel operations. As snow accumulation can affect platform operations, considerations for snow removal should be made at the design stage.	Ice and metocean data	
196	API Recommended Practice 2N	Industry Standard - US	The extent of ice accretion from sea spray, freezing rain or drizzle, freezing fog or cloud droplets shall be considered in the design and operability of the structure. Ice accretion can increase the diameter of structural components and can lead to a substantial increase of actions caused by wind and self-weight, particularly for long slender structures such as flare towers. Ice accretion also affects operations and personnel safety.	Ice and metocean data	
197	API Recommended Practice 2N	Industry Standard - US	Information on factors affecting visibility (e.g. fog, blowing snow, daylight hours) particular to the site of the offshore structure shall be obtained. Its effect upon operations and physical environmental monitoring shall be considered.	Ice and metocean data	
198	API Recommended Practice 2N	Industry Standard - US	Polar lows can affect the subarctic and arctic. Due to their small size and the lack of an extensive ground observation system in these regions, polar lows are difficult to observe and forecast. The waves and winds associated with these features are generally not in the extreme range, but can affect operations. When activities take place, the use of satellite remote sensing to seek out these features should be considered as part of the normal meteorological forecast service.	Ice and metocean data	
199	API Recommended Practice 2N	Industry Standard - US	The water depth at the site, including its variation, shall be determined. The range of water levels and its effect on ice action location shall be used to determine the most adverse effect on the foundation or structural component under consideration. For shallower water depths, ice can ground around a structure and cause changes in ice design scenarios for the structure and transportation stems, create operational problems and affect EER procedures. ...The design implications of positive and negative storm surges should be considered in the specification of actions on the structure, in the operation of the structure and for vessel operations planning.	Ice and metocean data	

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200	API Recommended Practice 2N	Industry Standard - US	Ice coverage on the sea surface affects wave growth, propagation and decay. The effect of ice cover should be considered when determining extreme and operational wave parameters, especially when numerical models are employed to determine these parameters. The effect of increased speed and elevation of ice features due to waves shall be taken into account in determining the combined wave-ice actions upon the structure.	Ice and metocean data	
201	API Recommended Practice 2N	Industry Standard - US	Consideration should be given to the effect of ice cover on tsunami wave parameters.	Ice and metocean data	
202	API Recommended Practice 2N	Industry Standard - US	The occurrence of grounded ice features, such as grounded rubble piles, and beach pile-ups shall be determined to obtain appropriate ice feature frequency, extent, size, potential gouge depth , and stability. This information shall be used in the determination of ice actions, design of flow lines and their burial depth, access to facilities, logistics and evacuation systems. Interannual and seasonal variations in ice morphology shall be considered.	Ice and metocean data	
203	API Recommended Practice 2N	Industry Standard - US	Wind, waves, current, and thermal expansion affect ice movement and pack ice pressure. Statistics, such as probability distributions, means and extremes, of movement rates for pack ice, ice floes and discrete features such as icebergs and ice islands, shall be determined on the basis of field data. Ice movement rates affect the number of ice features encountered, ice actions, and operations. Ice pressure can affect vessel traffic, ice management ,and evacuation procedures. Interannual and seasonal variations in ice presence, polynas, and physical parameters shall be considered.	Ice and metocean data	
204	API Recommended Practice 2N	Industry Standard - US	Ice conditions shall be considered as part of the physical environmental data monitoring program. Real-time information on ice conditions should be used, for example, to operate ice management systems, and EER procedures for the installations. Coupled with a management plan for shutdown and possible removal during the operational phase of the structure, ice monitoring can help to reduce the ice criteria used for structural design of both floating and bottom-founded mobile structures.	Ice and metocean data	
205	API Recommended Practice 2N	Industry Standard - US	Where seismic events are a design concern, appropriate analyses shall be carried out.		
206	API Recommended Practice 2N	Industry Standard - US	An investigation into the extent of permafrost from the shore and the presence of permafrost at platform locations shall be performed. Offshore structures founded on permafrost require special studies in order to understand the performance of the soil under time-varying actions induced by earthquakes, waves, or sea ice. The potential effects of thaw consolidation of ice-rich permafrost as a result of producing warm hydrocarbons should be considered in the design of all structure foundations.		

ID	Source	Category - regulation, standard, comment	Action	Subject 1	Subject 2
207	API Recommended Practice 2N	Industry Standard - US	Ice gouging occurs due to the interaction of ridges, icebergs, and stamukhi with the seabed…Gouge statistics shall be used in regions of seabed utilization for the design and burial of flow lines, and umbilicals, subsea facilities, and platform tie-ins. Strudel scouting shall be investigated for structures in regions near the mouths of rivers.	Ice and metocean data	
208	API Recommended Practice 2N	Industry Standard - US	The exposure level applicable to a structure or a component shall be determined by the owner prior to the design of a new structure or the assessment of an existing structure and be agreed by the regulator where applicable. Where more than one exposure level can apply to a structure or component the most stringent exposure level matching the specification is applicable. Some components or substructures can be categorized differently from each other and from the overall structure, in which case their exposure level can be different. Categorization may be revised over the design service life of the structure as a result of changes in factors affecting life-safety or consequence category [additional considerations for the suitability of an available relief well]		
209	API Recommended Practice 2N	Industry Standard - US	Operational procedures may be used to mitigate ice actions on fixed, floating, and subsea structures provided that it can be shown that, in combination with structural resistance, the intended level of reliability is achieved. Operational procedures include ice management, disconnection and removal, clearing of snow and ice accumulations, ruble and spray ice barriers, and seasonal operation. Ice management can be used to alter the ice regime through decreases in flow size and the destruction or removal of potentially hazardous ice features, and through local reduction in ice coverage. Ice action calculations for managed ice shall be performed when appropriate. Reduction in design actions shall be demonstrated through changes to the magnitude and frequency of ice actions for all applicable scenarios. The effectiveness of operational procedures shall be founded on documented experience where applicable, and the approach shall reflect the uncertainty inherent in the input data and modeling techniques.	Ice and metocean data	

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210	API RP 17A	Industry Standard - US	Well Intervention. Where a well is accessed vertically, appropriate subsea or surface BOP equipment should be employed that satisfies the required service conditions and conforms with accepted industry practices and applicable regulations. Subsea wells should be safely secured prior to commencing any well intervention involving potential exposure to live well fluids. Extreme cares should be taken when lowering and landing tools that connect to the subsea tree and/or wellhead, to minimize potential damage to installed components. If possible, the rig or surface vessel should be displaced to a position offset from the center of the well when handling and running packages, in order to reduce the risk of dropping objects or debris onto the well or adjacent components. After completion of the well intervention, downhole and tree components should be reinstalled and tested in accordance with the relevant installation procedures. The well control during a well intervention should only be possible via the workover control system. It should be possible to initiate a shutdown of associated neighboring wells form the well intervention vessel by reliable communication with the host facility. All subsea tree valves that can prevent downhole access in the event of hydraulic failure should be equipped with a mechanical override feature.	BOP	
211	API 64	Industry Standard - US	NA Information on the design, manufacture, quality control, installation ,maintenance and testing of the diverter system, and associated components. The diverter system provides a flow control system to direct controlled or uncontrolled wellbore fluids away from the immediate drilling area for the safety of personnel and equipment. Element of the BOP system, not an additional control system to be deployed.	BOP	
212	API RP 17W 6.1.2.5.3. 6.1.2.6, 6.1.2.7, 6.1.2.8, 6.1.2.9, 6.1.2.10, 6.1.2.11, 6.1.2.12	Industry Standard - US	Testing for subsea capping stacks - hydraulic chamber testing, drift tests, ram tests, valve tests, choke tests, test fluids, test pressure measurement devices. Test documentation.	Capping Stack/Systems	
213	API RP 17W 6.2	Industry Standard - US	Maintenance practices including "ensuring the subsea capping stack is ready for mobilization when required, at any time with no need for additional maintenance or repair." Maintenance schedules, cleaning, quality control, planned maintenance program, documentation,	Capping Stack/Systems	
214	API RP 17W 6.3	Industry Standard - US	Inspections - including a schedule to ensure it is maintained in a constant state of readiness.	SCCE Generalized Well Control	

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215	API RP 17W 6.4	Industry Standard - US	Preservation to ensure that the equipment is maintained in a constant state of readiness including the following criteria: security and protection of all subsea capping stack components, facility height to allow use of a crane for equipment handling, maintenance requirements, function and pressure testing requirements, long-term presentation requirements, and transportation requirements to base/quayside/airport. Protection from the environment, storage requirements, preservation of spare parts, documentation, personnel requirements. Periodic drills to ensure personnel are capable of reacting quickly and efficiently to potential situations requiring their use.	Contingency Plan	Capping Stack/Systems
216	API RP 17W Annex A	Industry Standard - US	Develop Subsea Well Capping Contingency Procedures - subsea debris and failed equipment removal including s recommended list of equipment for immediate callout, and where the equipment is retained. The debris removal plan should describe what tools the provider has available to sever the riser joints and associated riser piping to facilitate removal of debris from around the BOP stand and wellhead. Also addresses removal of the drill rig at surface, wellhead straightening, BOP removal - replacement of the BOP or attaching the capping stack to the wellhead or riser adapter.	Capping Stack/Systems	
217	API RP 17W Annex B - 1	Industry Standard - US	Example procedure for subsea capping stack assembly and testing.	Capping Stack/Systems	
218	API RP 17W Annex B - 2	Industry Standard - US	Example procedure for attaching capping stack. Develop a written procedure for attaching the capping stack to the well.	Capping Stack/Systems	
219	API RP 17W Annex B - 3	Industry Standard - US	Example procedure for operating the capping stack. Develop a written procedure for operating the capping stack.	Capping Stack/Systems	
220	API RP 17W Annex B - 3	Industry Standard - US	Example procedure for recovering the capping stack. Develop a written procedure for recovering the capping stack.	Capping Stack/Systems	
221	API RP 17W 4.1	Industry Standard - US	Recommended design considerations		
222	API RP 17W 4.2	Industry Standard - US	Subsea capping stack categories. Category 1 (Cap) capable of maintaining pressure integrity during and after shut-in of the subsea well. Category 2 (Cap and Flow) capable of connecting to a flowing well, to shut-in the well, to divert wellbore fluid, to interface to pumping equipment and to control the rate of flow through the diversion outlets with a choking device. **NA - Definition Only**	Capping Stack/Systems	

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ID	Source	Category - regulation, standard, comment	Action	Subject 1	Subject 2
223	API RP 17W 4.3	Industry Standard - US	Interface descriptions: Attachment to incident well, attachment to top of subsea capping stack, external controls and monitoring.	Capping Stack/Systems	
224	API RP 17W 4.4.1 - 4.4.8	Industry Standard - US	Systems Design and functional requirements. Pressure ratings, temperature ratings, flow capacity, solids content, operating water depth, modular designs, service life, cathodic protection, design for preservation, component design, bore size, erosion and debris tolerance, flow isolation barriers, controls, materials, designing for transportability and installation. Addressing design with consideration of offshore weather and environmental conditions to enable the largest possible deployment and operability window looking at waves, weather, water, current and seabed.		
225	API RP 17W 4.4.8.6	Industry Standard - US	Addressing design with consideration of offshore weather and environmental conditions to enable the largest possible deployment and operability window looking at waves, weather, water, current and seabed.		
226	API RP 17W 4.4.9.9.1-4.4.9.9.3	Industry Standard - US	Load Analysis and modeling. Installation and Retrieval Analysis including deployment and retrieval loads, splash zone and salt water exposure, buoyancy and weight management effects on capping stack, well blowout plume exposure, dynamic loads and load amplification during deployment, centering and uplift forces. In-place Operation analysis of operational loads during capping operations including: maximum discharge, wear resistance/exposure, CO2 exposure, diversion of flow, flow line/jumper end loads.		
227	API RP 17W 5.1	Industry Standard - US	Use of a Subsea Capping stack initial actions - ROV assessment of an incident well to assess and determine the best installation method.	Capping Stack/Systems	
228	API RP 17W 5.2	Industry Standard - US	Use of a subsea capping stack - equipment notification and callout - establish procedures, preapproval of permits for transportation, notification to owner of incident and relevant information.		
229	API RP 17W 5.3	Industry Standard - US	Well condition assessment - site assessment, attachment points,		
230	API RP 17W 5.4	Industry Standard - US	Deploying the subsea capping stack. Addressing deployment with a rig - crane capacity, deck space, sea fastenings, rig-specific material handling plan to address space and access requirements from receiving on the rig until deployment in moon pool or over the side. Deployment with a multiservice type vessel addressing vessel winch or crane load capacity at water depth. Incident owner should compile a list of available vessels capable of deploying a designated subsea capping stack(s). Pre-deployment inspections and interface tests. Utility requirements.	Capping Stack/Systems	

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231	API RP 17W 5.5	Industry Standard - US	Operating Parameters, deployment and recovery considerations including limiting motions during overloading, landing, installation and recover operations and developing an environmental operating window to establish practical limits for conducting these operations, heave compensations, recovery plans to address flushing of hydrocarbons, loose/damaged accessories, potential for dropped objects, hazardous materials, trapped pressure, marine growth, and care of equipment. Outlet positions during deployment and closure. Monitoring and in-service inspections.		
232	API RP 17W 5.6	Industry Standard - US	Operating Personnel -0 competency, skills, records.		
233	API RP 17W 5.7	Industry Standard - US	Logistics and Deployment Plans - Address details of airports and capacity to receive and service heavy-lift aircraft, customs clearance, availability of transportation resources, capacity of roads, bridges, tunnels, road permits issues and restrictions. Develop a load plan with crane capacities, trailer sites, permit loads, third party technical personnel required at site. Develop a deployment plan from receiving and handling at port of entry until the capping stack is deployed from a vessel and installed.	Contingency Plan	SCCE Generalized Well Control
234	API RP 17W 6	Industry Standard - US	Preservation, maintenance and testing to ensure that all functions are operationally ready for deployment including control systems, long-term pressure and valve torque trending for predictive maintenance purposes, and the pressure integrity of the capping stack equipment. Tests and test criteria, test methodology, test recording, function tests, pressure tests.		
235	Petroleum News 12/25/2011	Concern or Comment Industry	In its submission to the NEB's 18-month consultation with northern communities, the industry and environmentalists, Chevron said the same-season relief well requirement "would likely not be feasible as drilling moves into deeper water areas, with more complex wells and with more challenging ice conditions than were experienced in the initial phase of Canadian Beaufort exploration 20 to 35 years ago. "It said the NEB should require drillers to stop uncontrolled flows in the same season that they started, but not necessarily with a relief well. Chevron has already indicated it is developing a new-generation blowout preventer which it believes would make relief wells unnecessary.	Relief Well	BOP
236	Petroleum News 12/25/2011	Concern or Comment Industry	James Hawkins, Imperial's Arctic operations manager, said in a letter to the NEB that his company's "primary approach to well control is prevention. "While it is important to have a relief well plan that has been subject to rigorous review and approval by the NEB, a requirement for same-season relief well capability is generally neither practical nor necessary," he said.	Preventative alternative	Relief Well

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237	Government of Canada National Energy Board. Frequently Asked Questions: SSRW Technical Proceedings 2016-12-19	Regulation Canada	Through the *Review of Offshore Drilling in the Canadian Arctic* (Arctic Review), the Board re-affirmed its SSRW Policy: the applicant must demonstrate, in its Contingency Plan, the capability to drill a relief well to kill an out-of-control well during the same drilling season. This is referred to as same season relief well capability.	Relief Well	Contingency Plan
238	Government of Canada National Energy Board. Frequently Asked Questions: SSRW Technical Proceedings 2016-12-19	Regulation Canada	A relief well is one contingency measure used to respond to an out-of-control well. In addition, we will continue to require an operator to use all intervention techniques available, in addition to a relief well, so that the flow from an out-of-control well can be stopped as quickly as possible. Detailed contingency planning and commitments for relief wells remain a regulatory requirement for all offshore drilling in Canadian waters.	Relief Well	SCCE Generalized Well Control
239	Government of Canada National Energy Board. Frequently Asked Questions: SSRW Technical Proceedings 2016-12-19	Regulation Canada	The Board stated at the conclusion of the Arctic Review that it was open to evolving technology and that it would consider departures from the SSRW Policy on a case-by-case basis. Any applicant wishing to depart from the SSRW Policy must demonstrate how it would meet or exceed the intended outcome of the policy.	Relief Well	SCCE Generalized Well Control
240	National Energy Board Filing Requirements for Offshore Drilling In the Canadian Arctic National Energy Board Filing Requirements for Offshore Drilling In the Canadian Arctic Chapter 4.17 b. Capping and Containment Contingency Plan [PDF 4717 KB] September 2015 ISSN 2368-6367 (Print) ISSN 2368-6375 (Online)	Regulation Canada	Describe the capping and containment methods and system proposed to appropriately respond to the worst-case scenario. Describe the plan for mobilization, deployment, and operation of the capping and containment system, including any clearance of debris or damaged pieces of sub-sea systems. Describe the execution plan, resources, reliability, and redundancies of the capping and containment system in the unique Arctic environment. Describe the required support systems, including vessels, icebreakers, riser system, and remotely operated underwater vehicles (ROV). Describe the testing and certification process of the capping and containment system, including qualification of new technology where applicable.D243	Contingency Plan	Capping Stack/Systems

ID	Source	Category - regulation, standard, comment	Action	Subject 1	Subject 2
241	National Energy Board Filing Requirements for Offshore Drilling In the Canadian Arctic National Energy Board Filing Requirements for Offshore Drilling In the Canadian Arctic Chapter 4.17 c. Same Season Relief Well Contingency Plan [PDF 4717 KB] September 2015 ISSN 2368-6367 (Print) ISSN 2368-6375 (Online)	Regulation Canada	Policy - In the Canadian Arctic offshore, we have a policy that says the applicant must demonstrate, in its Contingency Plan, the capability to drill a relief well to kill an out-of-control well during the same drilling season. This is the Same Season Relief Well Policy. The intended outcome of this policy is to minimize harmful impacts on the environment. An applicant must demonstrate this capability. A relief well is one contingency measure employed to respond to loss of well control. An operator is also expected to continue well intervention using all available means to bring into control a well blowout while designing, mobilizing, and undertaking a relief well operation. 10. Describe the relief well plans, procedures, technology, and competencies required to kill an out-of-control well during the same drilling season, including: a. identification of the drilling unit that will be used, including mobilization details; b. identification of a minimum of two suitable locations for drilling a same season relief well, including shallow seismic interpretation of the top-hole section; c. a hazard assessment for positioning the relief well close to the out-of-control well; d. confirmation that the relief well drilling unit, support craft, and supplies are available and can drill the relief well and kill the out-of-control well in the same drilling season; and e. confirmation of the availability of well equipment and specialized equipment, personnel, services, and consumables to kill the out-of-control well during the same drilling season. 11. Describe the Contingency Plans for the relief well. 12. Provide an estimate of the time that it would take to drill the relief well and kill the out-of-control well in the same drilling season. 13. Describe how all available intervention techniques, in addition to a relief well, will be used so that the flow from an out-of-control well can be stopped as quickly as possible. 14. Describe the related strategies and preparedness to drill a relief well using a second drilling unit, including any advanced planning, preparation, and staging to reduce the time required to kill the out-of-control well.	Relief Well	Contingency Plan
242	Canada, National Energy Board, Review of offshore drilling in the Canadian Arctic December 2011 Chapter 1	Concern or Comment Public	People at the community meetings reminded us of the unique environment where they live. There are changing ice conditions, strong currents, stretches of 24-hour darkness, extreme cold and high winds.	Ice and metocean data	
243	Canada, National Energy Board, Review of offshore drilling in the Canadian Arctic December 2011 Chapter 2	Concern or Comment Government	*Instead of ruling on Imperial Oil Resources Ventures Limited's plans, we decided to conduct a review of the policy for same season relief well capability calling it "an issue of significant public concern".*	Relief Well	

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244	Canada, National Energy Board, Review of offshore drilling in the Canadian Arctic December 2011 Chapter 2	Concern or Comment Government	...after the incident in the gulf of Mexico, we initiated a review of safety and environmental requirements for Arctic offshore drilling. We called it the Arctic Offshore Drilling Review. Scope of this review included the effectiveness and reliability of available well control methods, including consideration of emerging technologies and the effectiveness and reliability of options for regaining well control, including relief wells.	SCCE Generalized Well Control	Relief Well
245	Canada, National Energy Board, Review of offshore drilling in the Canadian Arctic December 2011 Chapter 2	Concern or Comment Public	People said that the prevention of an accident is key, as well as preparedness.	Preventative alternative	
246	Canada, National Energy Board, Review of offshore drilling in the Canadian Arctic December 2011 Chapter 3	Regulation Canada	The applicant's (for offshore drilling authorization) Environmental Protection Plan should reflect the mitigation measures that have been committed to in the environmental assessment. Other elements which must be addressed in an application for offshore drilling in the Canadian Arctic include management systems, proof of financial responsibility, **same season relief well capability,** certificate of fitness and operational reporting and notification. A relief well is one contingency measure used to respond to an out-of-control well. In the Canadian Arctic offshore, we have a policy that says the applicant must demonstrate, in its contingency plan, the capability to drill a relief well to kill an out-of-control well during the same drilling season. This is referred to as same season relief well capability. The applicant must develop contingency plans that we find appropriate for the proposed project. These plans must take into account anticipated hazards and risks, and identify the appropriate equipment, procedures, and personnel for responding to anything that may go wrong.	Relief Well	General Application Information

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247	Canada, National Energy Board, Review of offshore drilling in the Canadian Arctic December 2011 Chapter 5	Regulation Canada	If the operator loses control of their well, they must have a contingency plan to regain well control. This plan could use various measures including: cap and containment methods; same-well intervention methods; and drilling a relief well. In the Canadian Arctic offshore, we have a policy that says the applicant must demonstrate, in its contingency plan, the capability to drill a relief well to kill an out-of-control well during the same drilling season. This is the Same Season Relief Well Policy. The intended outcome of this policy is to minimize harmful impacts on the environment. An applicant must demonstrate this capability. A relief well is on contingency measure employed to respond to loss of well control. An operator is also expected to continue well intervention using all available means to bring into control a well blowout while designing, mobilizing, and undertaking a relief well operation.	Relief Well	Contingency Plan
248	Canada, National Energy Board, Review of offshore drilling in the Canadian Arctic December 2011 Chapter 5 Comment by Rod Maier, Chevron Canada Resources	Concern or Comment Industry	"Over time, what we've seen from recent experience at Macondo and continued efforts from industry, that certainly a relief well is not the only option in terms of killing a blowout and, in fact, it's our…belief that there are other more superior methods available to industry in terms of killing a blowout."	SCCE Generalized Well Control	Relief Well

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249	Canada, National Energy Board, Review of offshore drilling in the Canadian Arctic December 2011 Chapter 5	Regulation Canada	We heard from other participants that while they agree with the goal of regaining control of a well as soon as possible and not relying solely on a relief well, they had concerns about not including same season relief well capability as a tool in an operator's tool box. The intended outcome of the Same Season Relief Well Policy is to kill an out-of-control well in the same season in order to minimize harmful impacts on the environment. We will continue to require that any company applying for an offshore drilling authorization provides us with specific details as to how they will meet this policy. An applicant wishing to depart from our policy would have to demonstrate how they would meet or exceed the intended outcome of our policy. It would be up to us to determine, on a case by case basis, which tools are appropriate for meeting or exceeding the intended outcome of the Same Season Relief Well Policy. In addition, we will continue to require an operator to use all intervention techniques available, in addition to a relief well, so that the flow from an out-of-control well can be stopped as quickly as possible. We acknowledge that there is a continual evolution of technology worldwide, including the technology needed to kill an out-of-control well. We are open to changing and evolving technology.	Relief Well	SCCE Generalized Well Control
250	Canada, National Energy Board, Review of offshore drilling in the Canadian Arctic December 2011 Chapter 5 Comment by Rob Powell - Director, Mackenzie River Basin, WWF, ST. Albert, Alberta	Concern or Comment Government	"An equivalent to SSRW capability would, in our view, be an Arctic proven alternative method to both control and kill a blowout before the end of the operating season. It would provide an alternative to same well intervention methods where these are either not available or not applicable...Finally, of course, it has to be capable of killing the well once it is under control. Anything less, we believe, could expose the Beaufort Sea to a blowout that could last through the winter."	Relief Well	SCCE Generalized Well Control

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251	Arctic Relief Well Drilling - An Oil & Gas Perspective MMS Arctic Technologies Workshop Anchorage, October 13 - 15th, 2009	Concern or Comment Industry	Most of the key arctic offshore nations, such as Canada, USA. Norway, and Greenland, require some form of demonstrated relief well capability either directly or via the contingency planning process. The feasibility of relief well drilling, while still possible in many areas, will become increasingly challenged in many emerging Arctic basins and plays. Chevron's AWKS (Alternative Well Kill System) is being proposed to both the local stakeholders and the regulator in Canada as an acceptable replacement for or "equivalency" to a relief well. A worst case blow-out, as defined by the regulator is assumed to occur on the last approved drilling day - October 15. Any late season relief well will take place largely in limited daylight conditions, with growing ice thicknesses. Later in the year, the extent of ridging and the type and roughness of ice cover increases and further adds to operational challenges. Relief well feasibility will thus be a function of the well depth and complexity, late season ice conditions and the ice class and capability of the drillship and its support fleet. Relief well drilling will be a particular challenge for floating platforms on the slope (+330 ft. water depth). Certain combinations of well types and ice conditions will likely preclude relief wells as an option. In the unlikely event of a loss of well control, a reactive approach, such as a relief well, may result in a significant spill. A proactive approach would represent a preventative method and as such, limit or reduce any spilled volume in the unlikely event of a loss of well control.	Relief Well	Preventative alternative

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252	Arctic Relief Well Drilling - An Oil & Gas Perspective MMS Arctic Technologies Workshop Anchorage, October 13 - 15th, 2009 Canada National Energy Board Archived project information on Chevron Canada Limited - Exploration License EL 481	Concern or Comment Industry	An "equivalency" under Canadian regulations is a procedure/tool/solution that offers the same or a lesser level of risk than that which it is proposed to replace. Chevron has chosen to develop an "equivalency to a late season relief well for offshore Arctic operations. The goal of the Chevron/Cameron relationship is to develop the next generation of shear rams, capable of simultaneous shear and seal over a broad range, grade and weight of drilling and production tubulars. The AWKS design will complete in one operation what two rams require three steps to achieve on a conventional BOP stack. A twin AWKS arrangement would be designed to provide 100% back-up/redundancy in both shearing and sealing capacity in one single operation. The AWKS is an advanced proactive well control system that is designed for and is in-keeping with the environment within which it will operate. Testing planned for 2009-2010. (Chevron decided in 2014 to put its drilling plans on hold indefinitely and so no ruling was made on the "equivalency"	BOP	Preventative alternative
253	Theresa Imm AIO Comments on Arctic OCS Rule BSEE - 2013-0011-0031	Concern or Comment Industry	First and foremost the relief rig requirement effectively shortens the drilling season prematurely because an operator must build into its plan sufficient time to ensure that it could comply with the 45-day limit on drilling a relief well.	Relief Well	
254	EN ISO 155444 (1) Petroleum and natural gas industries - offshore production installations - requirements and guidelines for emergency response 2010	Industry Standard European or Scandinavian	This international standard describes objectives, functional requirements and guidelines for emergency response (ER) measures on installations used for the development of offshore hydrocarbons resources. It is applicable to fixed offshore structures of floating production, storage and off-take systems. Requires a framework of emergency response and risk management and reduction. Includes formation of an ER strategy based on an assessment of the events that can arise and an Emergency Response Plan.. Various guidelines for competency, testing, ER equipment and maintenance, communications, escape/evacuation, medical response, handling of oil spills, drills, detection.	Contingency Plan	

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254	EN ISO 155444 (1) Amendment 1 Petroleum and natural gas industries - offshore production installations - requirements and guidelines for emergency response 2010	Industry Standard European or Scandinavian	References that equipment capable of remote control shall include at least the following as necessary for emergency response…well control.	SCCE Generalized Well Control	
255	EN ISO 19901-1 Petroleum and natural gas industries - specific requirements for offshore structures - part 1 metocean design and operating conditions. 2015	Industry Standard European or Scandinavian	Informative on types of metocean conditions to consider and data for certain regions including Canada. **No references to well loss control.**	Ice and metocean data	
256	ISO 19906(1) Petroleum and natural gas industries - Arctic offshore structures. 2010	Industry Standard - International	General risk assessment guidelines - **No references to well loss control.**	Contingency Plan	

ID	Source	Category - regulation, standard, comment	Action	Subject 1	Subject 2
257	National Petroleum Council Arctic Potential: Realizing the Promise of U.S. Arctic Oil and Gas Resources March 27, 2015 Working Document of the NPC Study **Paper #6-8 Ice Management**	Concern or Comment Industry	All marine operations taking place in an ice regime that are required to maintain their position due to the nature of the work event will require some form of an ice management system that includes ice and weather forecasting, detection, monitoring; ice alert system; support vessel(s) conducting physical ice management. There are various ice hazards. The overall ice management system and area of operation will drive season lengths for floating systems. The ice management system in an emergency should be able to provide safe ice management support much longer than the planned intended exploration period. New technology allows more sophisticated live tracking of ice floes and ice bergs such as satellite sensors and replacing long-standing helicopter ice reconnaissance with semi-autonomous UAVs that can monitor ice conditions over a greater area, while being less susceptible to weather and immune to darkness. Conclusions: 1. Physical ice management is based on risk exposure of global and local ice conditions along with knowing through experience the capability of the ice management system. 2. Knowing basic methods of physical ice management and applying the best method to the ice regime in force at the time determine how to proceed. 3. Make-up and capability of the support fleet, and type of operation drives ice management. 4. Ice drift direction needs to be accurately determined to avoid unnecessary breaking of ice. 5.Feed of actual metocean conditions to forecast providers enable better calibration of weather models for remote areas. 6.One must learn to understand the risks of ice management through prudent over reaction and the use of realistic ice management systems that fit the ice regime being worked in. Prudent over reaction	Ice and metocean data	

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258	International Regulation of the Offshore Oil Business in the Arctic the Case For and Against. Arctic Technology Conference 2012	Concern or Comment Industry	In the wake of recent offshore causalities involving oil spills, much attention has been directed to what if any international regulation exists concerning pollution caused by offshore activities. It remains the case that pollution caused by seabed activities is excluded from the ambit of the International Convention for the Prevention of Pollution from Ships (MARPOL). Although MARPOL does apply to pollution from "fixed or floating platforms", it excludes pollution resulting from "the release of harmful substances directly rising from the exploration, exploitation and associated offshore processing of seabed mineral resources". The International Convention on Oil Pollution Preparedness, Response and Cooperation 1990 (OPRC1990) does specify pollution emergency plans that vessels, offshore drilling units and production platforms must have in place. This convention also specifies the requirements of mutual assistance in international cooperation. The OPRC is considered to be: "probably the most important international legal document that regulates pollution of the marine environment resulting from offshore oil and gas activities.		
259	SPE-181393-MS Contingency Plan Society of Petroleum Engineers Ray T. Oskarsen et al 2016 SPE Annual Technical Conference and Exhibition held in Dubai UAE 26-28 September 2016.	Concern or Comment Industry	Because blowouts occur under different scenarios and have unique challenges, a well-intervention technique that worked in one case may not be the best approach on the next - it may not work at all or even be an option. The intervention technique that is determined to have the highest chance of success in the shortest amount of time will usually depend on the actual scenarios, blowout-simulation results and the assessment of the blowout task force. Blowout-kill techniques can be classified as either surface-interventions or relief-well methods. Relief wells aim to kill a blowout from the bottom by injecting fluid into the wellbore until the influx of formation fluid is stopped and the well is static when pumping stops. (Blount 1981). In many cases, a relief well sill be the safest intervention, have the highest likelihood of success, and is often considered the <u>last line of defense against a blowout.</u> Surface interventions are kill attempts aimed at controlling the discharge at the wellhead or at the fluid exit point. an example is to install a capping stack on top of the wellhead and close its openings, which can be gate valves, chokes or rams. Since the successful subsea-capping operation of the 2010 Macondo blowout in the Gulf of Mexico, there has been a lot of focus on this type of intervention. In many blowout scenarios, surface intervention will be significantly faster than a relief well, which could limit spill potential and environmental damage, In recent years many subsea capping stacks have been built and placed strategically around the world, ready to be deployed on short notice if an incident should occur.	Risk -based and fit for purpose solutions	SCCE Generalized Well Control

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260	SPE-181393-MS Contingency Plan Society of Petroleum Engineers Ray T. Oskarsen et al 2016 SPE Annual Technical Conference and Exhibition held in Dubai UAE 26-28 September 2016.	Industry Standard - International	Relief-well contingency planning has been standard practice in parts of the world for decades, and there are many available guidelines detailing a planning process. In comparison, the post--Macondo subsea-capping stacks are a relatively new technology and source control plans that cover the associated equipment and operations are a recent requirement. Industry standards and guidelines such as NORSOL D-10 and API RP17W cover a lot of general information on the equipment, connections, and interfaces needed for capping and containing a blowing subsea well. However, there is little or no information available on how to develop a well-specific capping plan that covers engineering analysis of the feasibility of deploying a capping stack from a floating vessel, the weight and stability of the capping stack to overcome the force of the blowout jet, and dynamic flow simulations of closing the capping stack outlets without loss if well integrity.	Capping Stack/Systems	Contingency Plan
261	SPE-181393-MS Contingency Plan Society of Petroleum Engineers Ray T. Oskarsen et al 2016 SPE Annual Technical Conference and Exhibition held in Dubai UAE 26-28 September 2016.	Concern or Comment Industry	The feasibility of a subsea capping operation will largely depend on the ability of vessels to work safely above or near the spill zone. For a subsea sea blowout, the plume may become trapped and all gas dissolved, or the plume could reach the surface. For capping operations, the worst-case scenario is a large gas boil with gas accumulation on the sea surface. The momentum created by the plume moving upwards could theoretically reduce stability and cause a vessel to capsize or sink. Surface accumulation of released gasses such as hydrogen sulfide, hydrocarbons, and carbon dioxide may be hazardous for personnel and introduces a risk of explosion. The likelihood of gas reaching the surface in a worst-credible blowout scenario will primarily depend on the blowout rate and the water depth. The amount of gas at surface is given by the governing physics in the water column. The density difference between the released gas and water drives the dominant force of buoyancy. Other mechanisms included are drag forces on droplets and plumes, turbulence, gas dissolution and hydrate formation.	Capping Stack/Systems	

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262	SPE-181393-MS Contingency Plan Society of Petroleum Engineers Ray T. Oskarsen et al 2016 SPE Annual Technical Conference and Exhibition held in Dubai UAE 26-28 September 2016.	Concern or Comment Industry	Due to the complexity of the mechanisms driving the gas migration and potential surfacing of hydrocarbons following a subsea blowout, advanced computational fluid dynamics (CFD) modeling is required to assess the risks of possible impacts at surface/ The knowledge and understanding learned from analyzing hundreds of studies already performed for hypothetical blowouts for subsea wells in various waters worldwide has led to development of a simple screening tool that is capable of reproducing the results from the computational fluid dynamics(CFD) modeling. The accuracy of the screening tool has been found to be within the uncertainty related to the various input parameters required by the advanced modeling tolls, like blowout rate, hydrocarbon composition, k and water currents, salinity and stratification. The tool was not developed with the intention to replace advanced CFD models; however, it serves as a fast and easy alternative tool for a first-pass iteration of assessing the potential risk for vessels involved in a subsea capping operation.	Capping Stack/Systems	
263	SPE-181393-MS Contingency Plan Society of Petroleum Engineers Ray T. Oskarsen et al 2016 SPE Annual Technical Conference and Exhibition held in Dubai UAE 26-28 September 2016.	Concern or Comment Industry	After capping a stack has been used to cap and contain or cap and flow, a well -kill technique to bring the well to static conditions must be done. For cap and contain, the choice may be to bullhead (top kill) or wait for a relief well to intersect. For cap and flow, a relief well may be the only practical kill solution as the blowout well can likely not be shut in.	Capping Stack/Systems	

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264	International Law and the Arctic - Michael Byers Cambridge Studies in International and Comparative Law. 2013 University Printing House, Cambridge UK Chapter 7 Oil Spills, p. 201.	Industry Standard - US	In response to the Deepwater Horizon blowout, the Obama administration suspended sales of offshore oil leases. In 2011, US Coast Guard Commandant Robert Papp warned Congress that the United States was unprepared to respond to a major oil spill in the Arctic. The oil companies responded that their Alaskan offshore projects take place from artificial islands or platforms anchored to the seabed in waters less than 70-meters dep. This, the companies claimed, made the Arctic drilling categorically different from deep-water drilling from floating platforms in the Gulf of Mexico. The Obama administration accepted this argument and [In 2012] Shell deployed two drill ships and twenty additional vessels to the US waters north of Alaska. Although Shell ultimately failed to complete a well that summer, due to equipment problems and drifting sea-ice, the deployment of the two drill ships was required by the US government to provide the capability of drilling a "relief well" during the same drilling season as any primary well. When a blowout occurs, drilling an adjacent intercepting well can reduce the pressure from the escaping oil, allowing the primary well to be capped.	Relief Well	
265	International Law and the Arctic - Michael Byers Cambridge Studies in International and Comparative Law. 2013 University Printing House, Cambridge UK Chapter 7 Oil Spills, page 201 (footnotes referencing WWF, "Drilling for Oil in the Arctic: Too soon, Too Risky.)	Concern or Comment ENGO	In 2010 the World Wildlife Fund responded to oil companies claim that Arctic operations were on ice islands in water [less than 70-meters deep] were categorically different than floating platforms in the Gulf of Mexico]: "The risk of a blowout is not related to depth, per se. Last year's blowout in the Timor Sea, which took 74 days to cap, occurred in 261-feet of water. The IXTOC I, the worst accidental spill in history until the Deepwater Horizon disaster, took place in only 160-feet of water. Both of these catastrophes occurred in depths and pressures comparable to those found in the Beaufort and Chukchi Seas. "	Risk -based and fit for purpose solutions	

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266	International Law and the Arctic - Michael Byers Cambridge Studies in International and Comparative Law. 2013 University Printing House, Cambridge UK Chapter 7 Oil Spills, p. 202.	Regulation Canada	Canada led the world in providing a regulatory regime for Arctic offshore drilling, including a requirement - introduced in 1976 - that oil companies have the capability to drill a same-season-relief well…As oil prices have risen, oil companies have returned to the Beaufort Sea purchasing large exploration leases from the Canadian government. Some of these leases have been for deep-water areas where drilling a well, whether an initial well or a relief well, would necessarily be a multi-year exercise. For this reason, some of those leaseholders began lobbying Canada's National Energy Board (NEB)...for a relaxation of the same-season relief well requirement. After the Deepwater Horizon blowout, the companies themselves called for a pause. In 2011, the NEB issued a report into Arctic offshore drilling in which it retained the same-season relief well requirement, while adding an important potential loophole. "The intended outcome of the Same Season Relief Well Policy is to kill an out-of-control well in the same season in order to minimize harmful impacts on the environment. We will continue to require that any company applying for an offshore drilling authorization provides us with specific details as to how they will meet this policy. An applicant wishing to depart from our policy would have to demonstrate how they would meet or exceed the intended outcome of our policy... We acknowledge that there is a continual evolution of technology worldwide, including the technology needed to kill an out-of-control well. We are open to changing and evolving technology. Also imposed requirements to explain how environmental factors in the Arctic, including extreme temperatures, darkness, polynyas, ice cover, ice movement, sea state, currents, shoreline features and seafloor features, could potentially affect the project. Also required to describe the worst-case scenario, including the estimated flow rate, total volumes of fluids, oil properties, and maximum duration of a potential blowout and the measures available to regain well control through same-well intervention and by drilling a relief well.	Relief Well	Ice and metocean data
267	International Law and the Arctic - Michael Byers Cambridge Studies in International and Comparative Law. 2013 University Printing House, Cambridge UK Chapter 7 Oil Spills, p. 202.	Regulation Norway	Norway has some of the highest safety standards for offshore drilling of any country in the world, including a long-standing requirement for the capability to initiate a relief well within twelve days of a blowout.	Relief Well	

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268	International Law and the Arctic - Michael Byers Cambridge Studies in International and Comparative Law. 2013 University Printing House, Cambridge UK Chapter 7 Oil Spills, p. 202.	Regulation Greenland	Greenland has adopted Norway's high standards for offshore drilling. When Cairn Energy, a Scottish oil company, drilled a number of wells in Davis Strait in 2010 and 2011, two drill ships were required to be in the area at all times, leaving one available to drill a relief well if a blowout occurred. Several ice-management vessels were also kept on standby to tow threatening icebergs away.	Relief Well	
269	International Law and the Arctic - Michael Byers Cambridge Studies in International and Comparative Law. 2013 University Printing House, Cambridge UK Chapter 7 Oil Spills, p. 208.	Regulation Russia	Russia's environmental protection record leaves much to be desired. In 2011, Oleg Kuznetsov, an official from the Russian Emergencies Ministry, revealed the existence of almost 25,000 objects containing solid radioactive waste in Russian waters…As for oil spills, Russia loses at least 1 percent of its annual oil production through leaks and spills. Approximately 10 percent of that production escapes into rivers that flow into the Arctic Ocean...more than half of the amount spilled by the Deepwater horizon disaster. Russia has treaties with its neighbors concerning cooperation in the event of an oil spill. In 1989, the Soviet Union and the US concluded an agreement concerning Cooperation in Combatting Pollution in the Bering and chichi Seas in Emergency Situations. Under the agreement, the two countries undertake to render assistance to each other in combatting pollution incidents...regardless of where such incidents may occur, to develop a Joint Contingency Plan and periodically conduct joint pollution response exercise. In 1994, Russia and Norway signed an agreement on oil spill response in the Barents Sea. The agreement requires the two countries also to develop a joint contingency plan and to notify each	Contingency Plan	

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270	International Law and the Arctic - Michael Byers Cambridge Studies in International and Comparative Law. 2013 University Printing House, Cambridge UK Chapter 7 Oil Spills, p. 202.	Agreement European	All eight Arctic Council states have ratified the 1990 Convention on Oil Pollution Prevention Response and Cooperation (OPRC), a treaty negotiated within the framework of the International Maritime Organization. Parties to OPRC are required to establish measures for dealing with pollution incidents; these include the stockpiling of oil spill equipment, the development of clean-up plans and the holding of exercises....In 1997 the Arctic Council adopted a set of "Arctic offshore oil and gas guidelines" which it updated in 2002 and again in 2009. Although the guidelines included both general principles as well as some more detailed recommendations, they fell short in two respects. First, they were non-binding, with all the compliance problems this can entail. Second they avoided some of the more difficult and important issues, such as whether oil companies should be required to maintain a same season relief well capability.	Contingency Plan	
271	Pew Charitable Trust Notes for Office of Information and Regulatory Affairs(OIRA), OMB, DOI 2014 - Review of Proposed Department of Interior OCS Regulation Revision for Arctic	Concern or Comment ENGO	The Department of Interior's regulations do not currently include Arctic relief well rig performance standards and do not require Oil Spill Response Plans to include a complete description of its relief well rig capability to control and contain a well blowout... Oil Spill Response Plan holders should be required to own, have on contract, or have available under a mutual aide agreement a Polar Class (or equivalent) drilling rig capable of drilling a relief well at the proposed location and for the period required to complete the relief well.	Contingency Plan	Relief Well
273	Pew Charitable Trust Notes for Office of Information and Regulatory Affairs(OIRA), OMB, DOI 2014 - Review of Proposed Department of Interior OCS Regulation Revision for Arctic	Concern or Comment ENGO	A relief well is the most reliable means of controlling a well blowout and is typically the last resort for well control when surface intervention methods fail. If a well cannot be controlled using surface intervention methods (e.g., well capping and containment) or when surface kill operations may exacerbate the blowout, a relief well must be drilled...While there is a general agreement that surface intervention options should commence immediately (if technically feasible and safe) in response to a blowout, relief wells are typically started in parallel to ensure more than one well control method is in progress, and to ensure the most reliable method (relief well) is in progress in case surface intervention is unsuccessful. Relief well drilling operations (subsurface intervention) can be stopped if surface intervention methods are successful before the relief well operations are complete...While it is true that well blowouts are often controlled using surface intervention before a relief well is drilled, this does not diminish the need for and role of a relief well, especially in the Arctic where the time to control the well is limited by the weather.	Relief Well	

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274	Pew Charitable Trust Notes for Office of Information and Regulatory Affairs(OIRA), OMB, DOI 2014 - Review of Proposed Department of Interior OCS Regulation Revision for Arctic	Concern or Comment ENGO	Industry has requested the federal government to consider a well capping stack to replace a Same-Season Relief Well requirement. Well capping stacks are not equivalent to a Same-Season Relief Well…a well capping stack is a viable and necessary surface control intervention method that should be immediately implemented. However, well capping stacks are not successful 100% of the time. History shows that 5-10% of the time surface intervention is not possible and a relief well is the only resort.	Capping Stack/Systems	
275	Arctic Council Arctic Offshore Oil and Gas Guidelines 2009	Agreement International	Arctic States that are party to the International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC 1990) and/or the International Convention for the Prevention of Pollution from Ships (MARPOL 1973/1978, Annex I…) are required to ensure that operators have oil pollution emergency plans and that these plans are carried on board installations.	Contingency Plan	
276	Arctic Council Arctic Offshore Oil and Gas Guidelines 2009	Agreement International	PREPAREDNESS Operators should establish and maintain emergency preparedness so that the mitigation of an incident will be carried out without delay in a controlled, organized, and safe manner. Risk Analysis should be carried out in order to identify the accidental events that may occur and the consequences of such accidental events. ...An analysis should be carried out to design the emergency preparedness requirements so as to meet the specific circumstances of the operation... Preparedness relating to oil pollution should ensure that the source of any oil pollution is first secured, and any release is effectively contained and collected near the source of the discharge as quickly as possible. Particular attention should be paid to response contingencies in ice conditions, where oil spill response, including containment, may require a range of techniques depending on the condition of the ice....	Contingency Plan	

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277	Arctic Council Arctic Offshore Oil and Gas Guidelines 2009	Agreement International	RESPONSE The contingency planning process is one of the key best management practices for evaluating the environmental effects of the response operation. Through the planning process, response options …can be fully evaluated under varying weather and ice conditions to decide ahead of time which options may be most successful in minimizing the effects of a spill and subsequent clean-up operations... EMERGENCY RESPONSE PLANS Emergency response plans should address abnormal conditions and emergencies that can be anticipated during the oil and gas operation being carried out including...loss of well control... CONTENTS OF EMERGENCY RESPONSE PLAN An emergency response plan should contain at least the following elements... Relief Well Arrangements: the operator should outline his immediate response to a well control incident or blowout. Also, the operator should demonstrate the availability of the necessary equipment, and support systems to be utilized.	Contingency Plan	
278	ADEC Prevention, Preparedness, and Response Program Oil Discharge Prevention and Contingency Plan Application Package and Review Guidance Document Rev 1 2016 Chapter 3 Section 1.9.1 Well Blowout Control	Regulation Alaska State or Local	For exploration or production facilities, the primary method of well control utilizes drilling fluids to overbalance formation pressure. Secondary methods typically include blowout preventers (BOPs). Once a blowout has occurred, measures taken to regain well control may include surface control measures, BOP activation, or drilling a relief well. The scenario for an exploration or production facility illustrates the methods, equipment, logistics, and associated timeframes for mobilization and deployment employed to control a well blowout. ... Exploration or production facilities must maintain a separate blowout contingency plan. The blowout contingency plan is not part of the plan application package required under 18 AAC 75.408, but must be made available to the department prior to plan approval and for inspection upon request under 18 AAC 75.480...The department may consult with AOGCC or other agencies to determine the adequacy of the planned methods, equipment, logistics, and timeframes for the control of a well blowout.	Contingency Plan	

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279	National Energy Board - Filing Requirements for Offshore Drilling in the Canadian Arctic - 2015 Section 2.2.1 #4	Regulation Canada	Describe how environmental factors in the Arctic, including extreme temperatures, darkness, polynas, ice cover, ice movement, sea state, currents, shoreline features, and seafloor features, could potentially affect the project. Address the following: a.) design or selection of the drilling unit, drilling rig, equipment, and working conditions; b.) well design and drilling operations, including emergency disconnect; and c.) well completions, suspension, and abandonment.	Contingency Plan	Ice and metocean data
280	National Energy Board - Filing Requirements for Offshore Drilling in the Canadian Arctic - 2015 Section 4.12 Ice Management	Regulation Canada	Goal: The application describes the ice management program with enough detail to demonstrate: the adequacy and effectiveness of the program in support of the proposed drilling activity; that the drilling system (the drilling platform and any supporting vessels) is able to stay at the drilling location so that drilling and related operations can be carried out safely; and that there is sufficient time to secure and suspend or abandon well operations properly in the event that the drilling system or personnel have to move away from the drilling location. Filing Requirements: 1.) Describe the design and operating limits of the drilling system in the anticipated ice-ocean-atmosphere conditions in the operating area and at the drilling location. Information on how the limits were established and validated should be included. 2.) Describe the conditions and ice features that would constitute hazards to the drilling system and its ability to stay at location. Provide information on the threshold used to identify conditions and ice features that could be a hazard, and a description of the conditions and ice features that would be at or above this threshold for the drilling system. 3.) Describe how hazards will be identified and located. Provide information on ice detection systems and capabilities and their effective range. 4.) Describe how ice hazards will be predicted and tracked. Provide specifications of the forecasting and tracking systems that would be used. Provide information on system capabilities, reliability, and frequency of forecasting and tracking updates. 5.) Describe how ice hazards will be managed. Provide information on ice management system capabilities, reliability, and contingencies. 6.) Describe how the drilling unit and well operations would be managed when ice hazards are predicted to exceed the ice management capability.	Contingency Plan	Ice and metocean data

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281	National Energy Board - Filing Requirements for Offshore Drilling in the Canadian Arctic - 2015 Section 4.17 Contingency Plan for an Uncontrolled Release of Reservoir Fluids - Goal and General Filing Requirements	Regulation Canada	Goal: The application describes the Contingency Plan for an uncontrolled release of reservoir fluids or a blowout event with enough derail to demonstrate the adequacy of the surface, sea floor, and sub-surface response capability to stop the flow from an uncontrolled well. Filing Requirements a) General 1.) Describe the worst-case scenario, including the estimated flow rate, total volumes of fluids, oil properties, and maximum duration of a potential blowout. 2.) Describe criteria that would be used to select the appropriate contingency measure to regain well control during Arctic offshore well operations, minimizing spill duration and environmental effects. This is notwithstanding the requirement to demonstrate same-season relief well capability. 3.) Describe the measures available to regain well control through same-well intervention, and by drilling a relief well. For each measure, provide details on: the sequence on which these measures would be implemented; the time it would take to imp[implement each of these measures; any constraints or limitations, including prevailing environmental conditions (e.g. ice encroachment, adverse weather); and the availability of competent people, equipment, drilling unit and consumables. 4.) Describe how lessons learned from previous major hazard incidents and near-misses have been incorporated into the proposed Contingency Plan.	Contingency Plan	
282	National Energy Board - Filing Requirements for Offshore Drilling in the Canadian Arctic - 2015 Section 4.17 Contingency Plan for an Uncontrolled Release of Reservoir Fluids - Capping and Containment Filing Requirements	Regulation Canada	b) Capping and containment: (starts at #5 continuing number section from the General Requirements) 5.) Describe the capping and containment methods and system proposed to appropriately respond to the worst-case scenario. 6.) Describe the plan for mobilization, deployment, and operation of the capping and containment system, including any clearance of debris or damaged pieces of sub-sea systems. 7.) Describe the execution plan, resources, reliability, and redundancies of the capping and containment system in the unique Arctic environment. 8.) Describe the required support systems, including vessels, icebreakers, riser system, and remotely operated underwater vehicles (ROV). 9.) Describe the testing and certification process of the capping and containment system, including qualification of new technology where applicable.	Contingency Plan	Capping Stack/Systems

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283	National Energy Board - Filing Requirements for Offshore Drilling in the Canadian Arctic - 2015 Section 4.17 Contingency Plan for an Uncontrolled Release of Reservoir Fluids - Same Season Relief Well Policy	Regulation Canada	Policy: In the Canadian Arctic offshore, we have a policy that says the applicant must demonstrate, in its Contingency Plan, the capability to drill a relief well to kill an out-of-control well during the same drilling season. This is the Same Season Relief Well Policy. The intended outcome of this policy is to minimize harmful impacts on the environment. An applicant must demonstrate this capability. A relief well is one contingency measure employed to respond to loss of well control. An operator is also expected to continue well intervention using all available means to bring into control a well blowout while designing, mobilizing, and undertaking a relief well operation.	Contingency Plan	Relief Well
284	National Energy Board - Filing Requirements for Offshore Drilling in the Canadian Arctic - 2015 Section 4.17 Contingency Plan for an Uncontrolled Release of Reservoir Fluids - Same Season Relief Well Capability Filling Requirements	Regulation Canada	c.) Same season relief well capability (starts at #10 continuing number section from the Capping and Containment General Requirements) 10.) Describe the relief well plans, procedures, technology, and competencies required to kill an out-of-control well during the same drilling season, including: a.) identification of the drilling unit that will be used, including mobilization details; b.)identification of a minimum of two suitable locations for drilling a same season relief well, including shallow seismic interpretation of the top-hole section; c.) a hazard assessment for positioning the relief well close to the out-of-control well; d.) confirmation that the relief well drilling unit, support craft, and supplies are available and can drill the relief well and kill the out-of-control well in the same drilling season; and e.) confirmation of the availability of well equipment and specialized equipment, personnel services, and consumables to kill the out-of -control well during the same drilling season. 11.) Describe the Contingency Plans for the relief well. 12.)Provide an estimate of the time that it would take to drill the relief well and kill the out-of-control well in the same drilling season. 13.) Describe how all available intervention techniques, in addition to a relief well, will be used so that the flow from an out-of-control well can be stopped as quickly as possible. 14.) Describe the related strategies and preparedness to drill a relief well using a second drilling unit including any advanced planning, preparation, and staging to reduce the time required to kill the out-of-control well.	Contingency Plan	Relief Well

ID	Source	Category - regulation, standard, comment	Action	Subject 1	Subject 2
285	National Energy Board - Filing Requirements for Offshore Drilling in the Canadian Arctic - 2015 Section 4.18 Spill Contingency Plan Context and Goal	Regulation Canada	Context: Spill Contingency Plans provide emergency response procedures to mitigate environmental and safety impacts from unplanned or accidental discharges to the environment. Pollution, which includes spills, also refers to situations where discharges from authorized operations or activities exceed the authorized discharge limits. Goal: The Contingency Plans for spill response will provide enough detail to demonstrate that effective systems, processes, procedures, and capabilities will be in place to: minimize the impacts to the marine, terrestrial, and atmospheric environments from unauthorized or accidental discharges; and protect workers and public. Filing Requirements - several general spill clean up and prevention requirements listed including: potential sources and substances, descriptions of scenarios, environmental sensitive areas, modeling, training, tracking, waste management, reporting, organization charts, specific countermeasures, support vessels and equipment, infrastructure, drills, monitoring, aerial observation.	Contingency Plan	
286	National Energy Board - Filing Requirements for Offshore Drilling in the Canadian Arctic - 2015 Section 4.19 Emergency Response Procedures Goal	Regulation Canada	Goal - The application describes the emergency response procedures with enough detail to demonstrate that any incident will be managed by integrating a combination of facilities, equipment, personnel and communications within a common organizational structure. The NEB expects that the application would describe an incident management system that is both consistent and compatible with the Incident Command System (ICS), thereby: minimizing the impacts to the marine, terrestrial and atmospheric environments from unauthorized or accidental discharges; protecting workers and the public; and permitting coordinated emergency response activities when multiple jurisdictions or response agencies are involved. Filing Requirements require information on command structure and protocol with target timelines for a worse case spill under weather and sea conditions that will allow appropriate response strategies.	Contingency Plan	
287					
288	Capt. D.O. (Don) Connelly DC Marine Offshore Services Inc.	Concern or Comment Industry	If I recall correctly, it was Devon's plan to submit the AWK system to the NEB as an equivalency to the same season relief well requirement. However the R&D on the system was behind schedule and could not get approved by the NEB in time for the project start and still get shipped in time to be barged out to the rig before freeze up. Once on board the SDC it was installed and field-tested at the conclusion of the 2005 / 2006 program. Devon's well program timeline was designed around being completed prior to the need to construct an ice island for a relief well event. Chevron took over ownership on the AWK from Devon and continued the R&D process.	Subsea isolation device	

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289	Capt. D.O. (Don) Connelly DC Marine Offshore Services Inc.	Concern or Comment Industry	An ice management system is site specific and designed to meet physical ice management needs, if any and operational time requirements on the MODU. The ice management system will drive, among many things, the number and capability of support vessels.	Ice and metocean data	
290	Capt. D.O. (Don) Connelly DC Marine Offshore Services Inc.	Concern or Comment Industry	Upcoming technology such as all-weather satellite clusters providing high definition near real-time data will likely make helicopter, fix-wing and UAV/UAS drones redundant for the above task. But what none of them can do is actually go to a ice feature of concern and conduct a taste-test with an ice management vessel to determine it's manageability and management timeline to determine the alert level and impact on a T-Time (time to secure the well). What I was trying to say is that planes, helicopter and drone reconnaissance will become less and less needed for recon as the satellite technology gets better and better. But for an ice management system that requires physical ice management you will still need occasionally to send out one of the ice management vessels to an ice feature that satellite technology, (or aircraft), has labeled as potential hazardous to confirm its manageability. In other words, looking at a sat image or aircraft generated ice map cannot always inform you that the ice management vessels on site can handle breaking it down to a non-hazardous condition in time before it comes onto site and impacts the MODU. To take it one step further for overall clarity, all this information from satellite, aircraft and ice management vessels feeds into the alert system which in turn drives the alert level which drives what is happening, going to happen or not happening on the well side whether its normal drilling operations or conduction a relief well.	Ice and metocean data	
291	Capt. D.O. (Don) Connelly DC Marine Offshore Services Inc.	Concern or Comment Industry	Regarding 30 CFR 250.472 (b) which requires drilling operations in the Arctic OCS to have access to a relief rig, different from your primary drilling rig, staged in a location such that it can arrive on site, drill a relief well, kill and abandon the original well, and abandon the relief well prior to expected seasonal ice encroachment at the drill site, but no later than 45 days after the loss of well control. Also Regarding ADNR Best Interest Finding for /beau fort Sea Areawide Lease Sale (2016) that estimates "Arranging for and drilling a relief well could take from 10-15 weeks depending on various factors" Comment: It is unreasonable to expect that a relief well can be drilled faster than an original well.	Relief Well	

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292	US 30 CFR 250.418	Regulation US	You must include the following with the APD: (a) Rated capacities of the drilling rig and major drilling equipment, if not already on file with the appropriate District office; (b) A drilling fluids program that includes the minimum quantities of drilling fluids and drilling fluid materials, including weight materials, to be kept at the site; (c) A proposed directional plot if the well is to be directionally drilled; (d) A Hydrogen Sulfide Contingency Plan (see §250.490), if applicable, and not previously submitted; (e) A welding plan (see §§250.109 to 250.113) if not previously submitted; (f) In areas subject to subfreezing conditions, evidence that the drilling equipment, BOP systems and components, diverter systems, and other associated equipment and materials are suitable for operating under such conditions; (g) A request for approval, if you plan to wash out or displace cement to facilitate casing removal upon well abandonment. Your request must include a description of how far below the mudline you propose to displace cement and how you will visually monitor returns; (h) Certification of your casing and cementing program as required in §250.420(a)(7); and (i) Such other information as the District Manager may require. (j) For Arctic OCS exploratory drilling operations, you must provide the information required by §250.470.	General Application Information	
293	Capt. D.O. (Don) Connelly DC Marine Offshore Services Inc.	Concern or Comment Industry	The ice management system for each operation will need to be designed to meet site-specific physical ice management needs, if any and operational time requirements on the MODU. The site-specific design should include an understanding of typical ice and metocean conditions for planning purposes, systems for real-time ice and weather forecasting, detection, and monitoring; an ice alert system; and support vessel(s) for conducting physical ice management. The conditions at the site will drive, among many things, the number and capability of support vessels .	Ice and metocean data	
294	Capt. D.O. (Don) Connelly DC Marine Offshore Services Inc.	Concern or Comment Industry	Information collected from satellite, aircraft and ice management marine vessels feed into an alert system which in turn drives the alert level which drives operational decisions on the well site ranging from normal drilling operations to initiating and drilling relief well. Marine vessels are also used for ice reconnaissance to inform an operation if their available ice-management vessels can are capable of breaking the ice features down to a non-hazardous condition in time to prevent impacts to the MODU.	Ice and metocean data	
295	Capt. D.O. (Don) Connelly DC Marine Offshore Services Inc.	Concern or Comment Industry	Marine reconnaissance vessels will likely continue to be necessary to physically go to an ice feature that satellite technology (or aircraft) has labeled as potentially hazardous to conduct a “taste-test”. This test is used to determine the manageability of the ice feature and to set a management timeline used to determine the alert level and impact on a T-Time (time to secure the well).	Ice and metocean data	

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296	Capt. D.O. (Don) Connelly DC Marine Offshore Services Inc.	Concern or Comment Industry	Devon designed a promising super shear and seal system referred to as the Alternative Well kill (AWK) system which was installed and field-tested on the SDC at the conclusion of the 2005 / 2006 program. Devon proposed that the National Energy Board of Canada consider the use of AWKS as an alternative technology to the Canadian same-season relief well requirement. However, R&D delays prevented the system from being completed in time to both meet the approval process timelines and meet shipping deadlines required for timely implementation of the unit at site (it needed to be onsite prior to the minimum construction schedule required for building an ice island to support a relief well event). Between the project delays and due to new concerns raised by the Macondo event, the AWKS proposal was suspended. Chevron has since taken over ownership of the AWKS from Devon and has continued the R&D process. Industry commented that this is another technology system that should be considered when regulating SCCE.	Subsea isolation device	
297	Capt. D.O. (Don) Connelly DC Marine Offshore Services Inc.	Concern or Comment Industry	The Chevron Arctic Centre during their Canadian Arctic review that took place over a number of years came to the conclusion that a same-season relief well was simply not safe in late season environmental conditions. Even if the relief well vessel was maintained on site during a late season well event the down time could be significant due to a physical ice management and alert system process reducing the actual response capability on the relief well efforts. Not to mention one's marine support vessel and drilling unit would have to be capable of minimally working in a first year pack ice regime under ice pressure. The Chevron team felt proactive SCCE technology such as the AWKS, containment technology, oil spill response techniques and having the right marine support system needed to be part of an overall plan to secure the well safely and quickly reduce the hydrocarbon discharge. The relief well operation would take place at a time when it was safe to do so, which might not be same season but the following season .	Relief Well	Subsea isolation device
298					
299	Equivalency: Regulatory Flexibility in a Changing World, Bill Scott, GM Chevron Arctic Center et al. 2015	Concern or Comment Industry	Technology, by its very nature, is always evolving. As such, the requirement for flexible regulatory systems is essential to facilitate the levels of economic viability and environmental stewardship/sustainability that are desired by all stakeholders.	SCCE Generalized Well Control	Approval process

Attachment A: BSEE SCCE Review Gap Analysis Matrix of Regulations, Standards and Guidance

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ID	Source	Category - regulation, standard, comment	Action	Subject 1	Subject 2
230	Equivalency: Regulatory Flexibility in a Changing World, Bill Scott, GM Chevron Arctic Center et al. 2015	Concern or Comment Industry	The offshore drilling season length in the Arctic is largely determined by the regulatory requirement to use a relief well. Recent technological advances in well-secure techniques such as well capping and the use of Seabed Isolation Devices have demonstrated the ability to secure a well more efficiently than is possible through the use of a relief well. The use of these advances in well-secure technology can: 1.) Significantly reduce the amount of spilled hydrocarbons and associated environmental impact due to the relatively short duration associated with these well-secure techniques as compared to a relief well. 2.) Lengthen the drilling season in a safe and efficient manner, resulting in: (i) the potential for lower exploration drilling costs - often a barrier to basin entry; (ii) a greater likelihood of completing the necessary exploration and appraisal drilling program within the lease term; (iii) the ability to generate acceptable development drilling costs and project economics; and (iv) increased competitiveness of Arctic resources in the global marketplace.	Relief Well	SCCE Generalized Well Control
231	Equivalency: Regulatory Flexibility in a Changing World, Bill Scott, GM Chevron Arctic Center et al. 2015	Concern or Comment Industry	To determine the drilling season length in a generic offshore Arctic setting, there are a number of factors to consider, namely:, Drilling Season Start Date - determined by when the drilling system can be safely mobilized to site, Drilling Season End Date determined by the time required to allow the chosen well control technique to be implemented safely, Risk and Non-Risk Drilling - specific terms to describe what agreed types of drilling activity can occur, Drilling System Capability - the capability of the entire marine and support systems to safely drill the well in the physical environment including the drilling unit, marine support vessels, oil spill response, and emergency escape and rescue systems, Well Secure Duration - the time required to safely implement the chosen well control technique (e.g. relief well or alternative well-secure technique).	Relief Well	SCCE Generalized Well Control

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232	Equivalency: Regulatory Flexibility in a Changing World, Bill Scott, GM Chevron Arctic Center et al. 2015	Concern or Comment Industry	Currently the Drilling Season Start Date is approximately July 7. This estimate is based on accessing the Chukchi Sea from the Bering Strait on July 1, plus the time to mobilize to site and prepare to drill (approximately 7 days in total). The Drilling Season End Date is currently based on the number of days required to drill a relief well prior to the assumed freeze-up date. This calculation of dates is applied uniformly when the Drilling System Capability is not taken into account and the well-secure technique is a relief well. There are a number of shortcomings with the current system. The net impact of the following factors makes operations in this area less competitive on a global basis: 1.) Drilling a relief well takes significantly longer than other well-secure technologies and is more likely to result in a greater volume of spilled oil when compared to alternative technologies. 2.) During the shoulder season (Nov - Dec 15) the ice is relatively light and, under the current regulatory guidelines, is not available for operational utilization. This can substantially increase the drilling costs. 3.) A Drilling Season Length of 79 days is barely sufficient to complete and evaluate a single well. Options to use the shoulder season with well capping followed by a relief well increases the Drilling Season Length 40% to 109 days. Options to use the shoulder season, cap the well (on a well designed to ensure that the well kill could be safely completed during the following operation season), and return the next season to carry out remaining well intervention activities could increase the drilling season by 85% to 146 days.	Relief Well	SCCE Generalized Well Control
233	Equivalency: Regulatory Flexibility in a Changing World, Bill Scott, GM Chevron Arctic Center et al. 2015	Concern or Comment Industry	This case assumes that a well capping system is accepted as a primary means of stopping the flow and securing the well. It further assumes that the well was designed to ensure that the well kill operation could be safely completed during the following operating season. A two stage approach similar to this is being utilized in the Kara Sea with a Seabed Isolation Device and is being considered for use in Canada. The two stage approach comprises of: 1.) Stopping the flow and securing the well as quickly as possible in season 1; and 2.) Carrying out well intervention activities in season 2 which may, or may not, require a relief well.	SCCE Generalized Well Control	Relief Well

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234	Equivalency: Regulatory Flexibility in a Changing World, Bill Scott, GM Chevron Arctic Center et al. 2015	Concern or Comment Industry	The filing requirements for offshore regulatory approvals are extensive and involve detailed information on several topics such as: Technical well requirements; Drilling schedules and timelines; Declarations and certificates of equipment fitness; Safety and emergency response plans, including contingency measures; Financial responsibility requirements; Environmental effects of the drilling operation; Socio-economic effects and benefits of the drilling operation; and consultation with stakeholders and community members.	General Application Information	Approval process
235	Equivalency: Regulatory Flexibility in a Changing World, Bill Scott, GM Chevron Arctic Center et al. 2015	Concern or Comment Industry	A company requires a variety of regulatory approvals to drill an exploration well in the Canadian offshore. This includes authorizations from the National Energy Board (NEB) under the Canada Oil and Gas Operations Act and the Canadian Environmental Assessment Act, 2012. In the Beaufort Sea, environmental assessment approvals are also required from the Inuvialuit Environmental Impact Review Board.	Approval process	
236	Equivalency: Regulatory Flexibility in a Changing World, Bill Scott, GM Chevron Arctic Center et al. 2015	Concern or Comment Industry	NEB introduced its SSRW Policy in 1976 when floating drilling was first proposed in the Beaufort Sea.	Relief Well	
237	Equivalency: Regulatory Flexibility in a Changing World, Bill Scott, GM Chevron Arctic Center et al. 2015	Concern or Comment Industry	In recent years, three companies have taken steps to advance their Arctic exploration plans in Canada. Each has indicated that it wishes to depart from the SSRW Policy and use an alternative well-secure system, requiring the NEB to rule on equivalency. The NEB acknowledged the complicated logistics involved in planning an Arctic drilling program. To drill an exploration well using an alternative well-secure system, companies need to secure highly specialized equipment such as an Arctic capable drillship and multiple high ice class icebreaking/multi-functional vessels. In order to do so, they must enter into long-term contracts to lease existing vessels or construct new equipment. Both options require material upfront capital commitments by the proponent before the NEB confirmed that the proposed well-secure system is consistent with the SSRW policy. Acceptance or rejection by the NEB of the alternative method is critical to any of the investment decisions involved in securing drilling and marine support equipment. The risk of a rejection creates a considerable economic disincentive for companies and influence ultimate investment decisions.	Approval process	Relief Well

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238	Equivalency: Regulatory Flexibility in a Changing World, Bill Scott, GM Chevron Arctic Center et al. 2015	Concern or Comment Industry	The NEB's response to this request [for equivalency of SCCE] was endorsing the approach of a two-phase process, again, applied on a case-by-case basis. In Phase I, the NEB would address the equivalency determination and rule on whether an alternative well-secure system is the same as, or better than, the SSRW Policy. If the NEB determined that a proposal satisfied the intended outcome of the SSRW Policy, the company would then be in a position to prepare its detailed application for all required drilling authorizations based on the alternative well-secure system. In Phase II, the detailed application would be submitted to regulatory authorities and subject to a full technical, economic, environmental and socio-economic assessment to determine whether approval of the whole drilling program is in the public interest. Each phase would be treated as a separate application and would follow the standard NEB review process. The NEB determined that issuing advanced rulings on equivalency was in the public interest in situation where it is appropriate to do so. A staged process leads to efficiencies in the overall regulatory process and can provide a solution that is acceptable to all parties involved; parties do not have to spend significant resources preparing and reviewing studies on the details of a drilling program that has the potential to be rejected, the company is given n opportunity to obtain the certainty it needs to make the capital commitments for a drilling program, and the adjusted process supported the NEB's goal of "smart regulation".	Approval process	Relief Well

ID	Source	Category - regulation, standard, comment	Action	Subject 1	Subject 2
239	Equivalency: Regulatory Flexibility in a Changing World, Bill Scott, GM Chevron Arctic Center et al. 2015	Concern or Comment Industry	The adoption of emerging technology has the potential to significantly reshape both the economic and environmental stewardship/sustainability obstacles associated with global Arctic exploration and development activities in a positive manner. Regulatory equivalency goes a step further to serve the public interest beyond the basic economic viability and environment stewardship/sustainability considerations. A logical phased approach not only avoids the possibility of "consultation fatigue" but also sets out a process where stakeholders, industry, and other interested parties can participate in considering the adoption of new and emerging technologies to the benefit of everyone. This is particularly aligned with the desires of the Inuvialuit who have a vested interest in ensuring the responsible development of the Arctic. When phased processes are properly managed by a regulator, they promote innovation and are critical in building the confidence that is necessary to ensure fair, efficient and timely approvals of technology proposals	Approval process	Relief Well
240	Government of Canada Justice Law Website, Canada Oil and Gas Drilling and Production Regulations: SOR/2009-315 Part 11, #78 http://laws-lois.justice.gc.ca/eng/regulations/SOR-2009-315/index.html	Regulation Canada	Meteorological Observations The operator of an offshore installation shall ensure (a) that the installation is equipped with facilities and equipment for observing, measuring and recording physical environmental conditions and that a comprehensive record of observations of physical environmental conditions is maintained onboard the installation; and (b) that forecasts of meteorological conditions, sea states and ice movements are obtained and recorded each day and each time during the day that they change substantially from those forecasted.	Ice and metocean data	

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241	Government of Canada, National Energy Board, ARCHIVED: NEB to Review Proposals Related to Same Season Relief Well Policy July 11, 2014 https://www.neb-one.gc.ca/bts/nws/nr/archive/2014/nr24-eng.html	Regulation Canada	The National Energy Board (NEB or the Board) has decided to review separate proposals from Imperial Oil Resources Ventures Limited (IORVL) and Chevron Canada Limited (Chevron) to determine if the proposals will meet the intended outcome of the NEB's Same Season Relief Well (SSRW) Policy. The Board's SSRW Policy is that an applicant must demonstrate, in its Contingency Plan, the capability to drill a relief well to kill an out-of-control well during the same drilling season. The intended outcome of the SSRW Policy is to minimize harmful impacts on the environment. An applicant wishing to depart from the NEB's SSRW Policy must demonstrate how they would meet or exceed the intended outcome of the policy. On April 24, 2014 IORVL requested that the NEB consider and provide a ruling on the approach IORVL will propose to meet the intended outcome of the NEB's SSRW Policy in the context of its Beaufort Sea Exploration Joint Venture Drilling Program. IORVL has indicated that the proposed approach would not include plans for a SSRW. On May 8, 2014 Chevron requested that the NEB consider its drilling application for exploration license EL 481 in two stages. Phase 1 would provide a ruling on whether Chevron's well control system would meet the intent of the SSRW Policy. Phase 2 involves the detailed applications for drilling authorizations under the Canada Oil and Gas Operations Act (COGOA). After carefully considering the information submitted, the Board has decided to grant the two requests for review. The Board determined it would be beneficial, early in the regulatory review process, to establish whether the proposals would meet the intended outcome of the SSRW Policy, as it is a major element of both projects. There will be an opportunity for public participation in the review process. An environmental assessment would be undertaken later, at the project application stage, under the COGOA	Approval process	Relief Well

ID	Source	Category - regulation, standard, comment	Action	Subject 1	Subject 2
242	Government of Canada, National Energy Board, ARCHIVED: Imperial Oil Resources Ventures Limited - Same Season Relief Well Technical Proceeding. http://www.neb-one.gc.ca/pplctnflng/mjrpp/archive/mprlssrw/index-eng.html	Regulation Canada	Project Description: The NEB's Same Season Relief Well (SSRW) Policy is that the applicant must demonstrate the capability to kill an out-of-control well during the same drilling season. The intended outcome of the Policy is to minimize harmful impacts on the environment. As stated in the Board's Review of Offshore Drilling the Canadian Arctic, an applicant wishing to depart from the SSRW Policy would have to demonstrate how they would meet or exceed the intended outcome of the Policy. Imperial Oil Resources Ventures Limited (IORVL) is proposing the Beaufort Sea Exploration Joint Venture Drilling Program (the Project). In the fall of 2013, IORVL provided the NEB with a copy of its Project Description [PDF 19620 KB]. The Project would take place within the waters of the Inuvialuit Settlement Region. It would involve drilling one or more exploration wells on in the Canadian Beaufort Sea, approximately 175 km north-northwest of Tuktoyaktuk in the Northwest Territories. If approved, drilling would occur in Exploration Licenses (EL) 476 or EL 477, where water depths range from 60 to 1500 m. On April 24 the NEB received a letter from IORVL requesting the Board to consider and provide a ruling on its proposed approach to meeting the intended outcome of the NEB's SSRW Policy. On May 8, the NEB received a similar request from Chevron Canada Limited (Chevron). On July 11, the Board granted IORVL's request to provide a ruling on its proposed approach to meeting the intended outcome of the NEB's SSRW Policy.	Approval process	Relief Well
243	Government of Canada, National Energy Board, ARCHIVED: Imperial Oil Resources Ventures Limited - Same Season Relief Well Technical Proceeding. http://www.neb-one.gc.ca/pplctnflng/mjrpp/archive/mprlssrw/index-eng.html	Regulation Canada	Regulatory Process: The Board determined it would be beneficial, early in the regulatory review process, to establish whether IORVL's proposal would meet the intended outcome of the SSRW Policy, as it is a major element of the Project. Any ruling at the conclusion of the SSRW technical proceeding will only address whether the intent of the SSRW Policy has been met or exceeded, not whether the Project would be authorized to proceed. IORVL would still need to file an application for an Operations Authorization (OA). An OA can only be issued by the Board after considering a full Project application, and after: reaching a decision about the likelihood of significant adverse environmental effects under the Canadian Environmental Assessment Act, 2012; and considering the recommendations of the Environmental Impact Review Board established under the Inuvialuit Final Agreement.	Approval process	Relief Well

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244	Government of Canada, National Energy Board, ARCHIVED: Imperial Oil Resources Ventures Limited - Same Season Relief Well Technical Proceeding. http://www.neb-one.gc.ca/pplctnflng/mjrpp/archive/mprlssrw/index-eng.html	Regulation Canada	List of Issues: The List of Issues reflects the Board's views of what topics will be important to examine in detail during the technical proceedings. The List of Issues and the decision explaining how comments were considered can also be found in Filing A62631. This decision is in no way a predetermination of the merits of IORVL's Project application. 1.What criteria and risks should be considered in determining whether the intent of the SSRW Policy has been satisfied by the tools and techniques proposed to respond to an out-of-control well. 2.How the tools and techniques proposed would meet the criteria and address risks in the circumstances of a worst case scenario. 3.How the tools and techniques proposed would address the challenges of the unique Arctic environment. 4.The terms and conditions, if any, that should be considered at the Project application stage if the departure from the SSRW Policy is granted. 5.Implications of the Board accepting a departure from the SSRW Policy. The Board does not intend to conduct an environmental assessment as part of this proceeding. An environmental assessment would be undertaken at the Project application stage. The Board has not made any decisions on what the SSRW technical proceedings will look like at this stage. There will be an opportunity for public participation and details will be posted on this page as they become available	Approval process	Relief Well

APPENDIX E

Bibliography

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