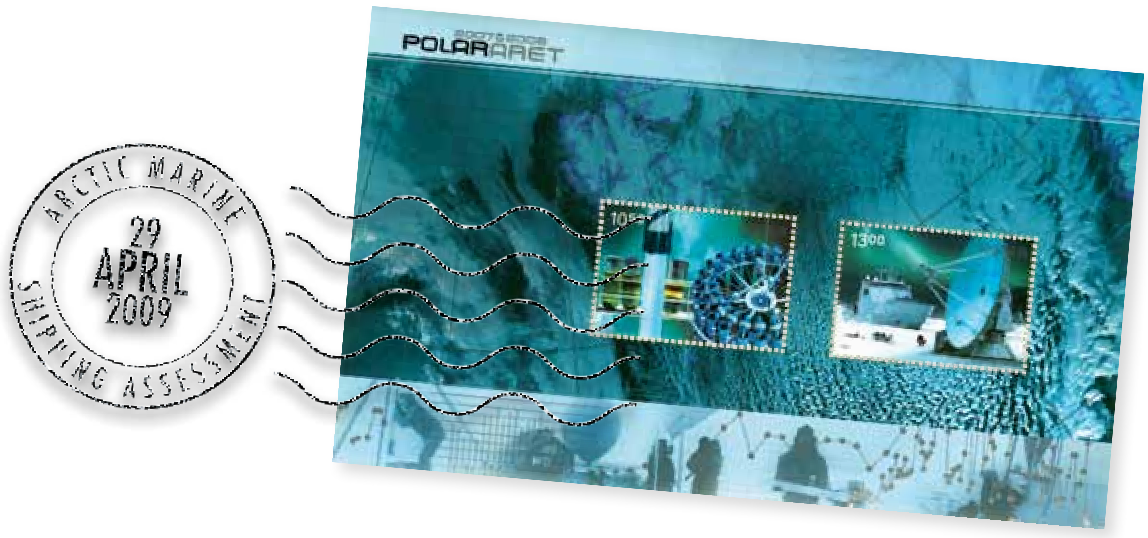

Arctic Marine Infrastructure

When compared with marine infrastructure in the world's other oceans, the Arctic is significantly lacking throughout most of the circumpolar north. The current increase in human activity in the Arctic is placing new demands on Arctic infrastructure needed to support safe marine shipping, protect the environment and respond to emergencies. Anticipated increases in Arctic marine shipping during the coming decades will place additional demands on infrastructure and require innovative, cooperative solutions that best use the limited resources available in this remote region.

The findings contained in this section are the result of extensive input received across a wide spectrum of interests from those experienced in Arctic marine operations, including representatives from the Arctic states. The analysis of current Arctic infrastructure included surveys based on information from the Arctic states regarding Arctic ports, capabilities for handling larger vessels, search and rescue assets and icebreaker capacity. In addition, an international workshop was held at the University of New Hampshire in March 2008 to consider infrastructure needs and gaps associated with emergency response to Arctic incidents. Workshop participants represented a broad spectrum of expertise including governmental agencies, industry, non-governmental organizations and indigenous people from the Arctic nations. The workshop, "Opening the Arctic Seas: Envisioning Disasters and Framing Solutions," considered five realistic emergency scenarios in diverse locations throughout the Arctic. Incidents envisioned involved vessels caught in ice or in a collision, oil spills, search and rescue, environmental damage and disruption of indigenous communities. The workshop report provides a qualitative analysis of risk factors for Arctic marine incidents likely to happen as shipping, tourism, exploration and development of natural resources such as oil, gas and minerals increase with the retreating ice cover (See page 176).

Major Arctic infrastructure themes emerged and are reflected throughout this section and its findings. Currently, vast areas of the Arctic have insufficient infrastructure to support safe marine shipping and respond to marine incidents in the Arctic. This includes such critical infrastructure components as the accuracy and availability of timely information needed for safe navigation; availability of search and rescue assets, pollution response assets and supporting shoreside infrastructure to respond appropriately to marine incidents; port reception facilities for ship-generated waste; and availability of deepwater ports, places of refuge and salvage resources for vessels in distress. While there are notable exceptions, where infrastructure is more developed, they are the exception rather than the rule. To assist with ship navigation, locating refuges, pollution response and other activities, adequate weather forecasting and warning capabilities are essential and necessitate adequate observations, models and forecasts.

Emergency response is particularly challenging in the Arctic for a variety of reasons, including the remoteness and great distances that are often involved in responding; the impacts of cold, ice and a harsh operating environment on response personnel and equipment; and the lack of shoreside infrastructure and communications to support and sustain a response of any significant magnitude. Prevention of marine accidents, and actions designed to strengthen the effectiveness of preventive measures, are especially critical for Arctic marine shipping given the difficulties of responding once an incident has occurred. Preventive measures include ensuring that vessels operating in the Arctic meet appropriate design, construction and equipment standards; that vessel personnel have the specialized skills needed for operating in Arctic conditions, including operations in ice-infested waters where applicable; and that information needed for safe navigation is available, from accurate charts to timely information on meteorological and ice conditions and on other vessel traffic and activities in the area.

While there are many challenges associated with strengthening Arctic marine shipping infrastructure, there are also opportunities to develop measures to improve safe marine shipping operations and protect the Arctic environment in anticipation of the continuing increase in Arctic marine activity, rather than responding after an incident has occurred. Considering the long lead time to put marine infrastructure in place, this should be considered early in the prioritization process.

Systems Related to Safe Navigation

To the mariner, there are several environmental factors that make the Arctic uniquely difficult to navigate compared to temperate waters. These include: presence and movement of sea ice, icebergs, cold air and water temperatures, variable and often unpredictable severe weather, magnetic variation, solar flare activity and extended daylight or nighttime conditions. These environmental conditions, combined with the remoteness of the region from commercial shipping centers and shipping lanes, highlight the need for improved systems to support safe navigation in the Arctic region.

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Ship Name	Country of Ownership	Year Entered Service	Propulsion Plant*	Operations
ARKTIKA	Russian Federation	1975	N:75,000	NSR
ROSSIYA	Russian Federation	1985	N:75,000	NSR
SOVETSKIY SOYUZ	Russian Federation	1990	N:75,000	NSR; Arctic tourism
YAMAL	Russian Federation	1993	N:75,000	NSR; Arctic tourism
50 LET POBEDY	Russian Federation	2006	N:75,000	NSR
POLAR STAR	United States	1976	GT:60,000 DE:18,000	Arctic and Antarctic research and logistics
POLAR SEA	United States	1977	GT:60,000 DE:18,000	Arctic and Antarctic research and logistics
TAYMYR	Russian Federation	1989	N:47,600	NSR
VAYGACH	Russian Federation	1990	N:47,600	NSR
KRASIN	Russian Federation	1976	DE:36,000	NSR; Antarctic

Table 9.1 Ten most powerful icebreakers in the world. *Note: DE = Diesel-Electric; GT= Gas Turbine; N= Nuclear; NSR = Northern Sea Route.* Source: AMSA
** shaft horse power*

Arctic Charting

Hydrography is the oldest science of the sea. The earliest explorers were often hydrographers and cartographers who recorded their discoveries on marine charts, sometimes to claim new territory, and always to ensure safe passage.

Modern marine charts are compiled from accurate hydrographic surveys conducted onboard specialized vessels equipped with echo sounders that measure water depths and satellite navigation systems, such as the Global Positioning System (GPS), that determine the geographic positions of these soundings. Numerous other sources of information are used in the creation of charts, such as shoreline location, details of navigational aids, place names, conspicuous land-based features, overhead cables and underwater pipelines. Data on navigational charts are also corrected for the movement of tides, such that the depth portrayed is normally the minimum the mariner will find under the keel. Expert information specialists combine all these various sources of data into navigational charts, taking extreme care to ensure the information is clear and accurate for use by mariners. The collection of the hydrographic data required and the process to produce a new navigational chart can often take years.

In light of the limited amount of marine traffic, the historical survey methods (ship-based and ice-based) and the significant costs and the volatility of the weather conditions, hydrographic surveys in the Arctic have not achieved the same level of coverage and quality as surveys in southern latitudes. As a result, Arctic charting base hydrographic data is not adequate in most areas to support current and future marine activities. This situation could improve if collection methods and platforms were developed that would be minimally affected by the Arctic conditions of weather, ice and isolation.

For hundreds of years, navigation at sea has relied upon the manual plotting of vessel location on traditional paper charts. Modern Electronic Chart Display and Information Systems (ECDIS), combined with satellite-based positioning, bring hydrographic data into onboard computers, greatly improving the navigation information available to the mariner and potentially reducing the reliance on traditional aids, such as floating buoys and fixed lights. Advances are also being made in consolidating information such as weather and ice conditions into electronic charting systems, further assisting mariners.

Recognizing the benefits of electronic charts, the International Maritime Organization (IMO) has proposed compulsory carriage of ECDIS and Electronic Navigational Charts (ENCs) on high speed craft from July 1, 2008 onward for all new craft and from July 1, 2010 onward for existing craft. In addition, IMO's Safety of Navigation Subcommittee has reached consensus to implement the mandatory carriage of ECDIS on new passenger ships above 500 gross tonnage by 2012, with a broadening of this requirement in subsequent years.

Arctic nations report various levels of ENC coverage for their northern waters (Maps 9.1, 9.2, 9.3). The presence of an ENC does not guarantee adequate information for safe navigation, however, as they are normally created using the same information available on traditional charts. As previously mentioned, the hydrographic data in many Arctic locations is either non-existent or in serious need of improvement.

10%

The portion of the Canadian Arctic that the Canadian Hydrographic Service says has been surveyed to modern standards.

Arctic Marine Infrastructure Terminology

For the purpose of this assessment, "infrastructure" is defined broadly to address all major aspects of marine shipping, including vessels and crews, the systems needed to gather and supply accurate and timely information for safe navigation and operations, the personnel and resources needed to respond to a variety of potential emergencies, port reception facilities for ship-generated waste and the shoreside facilities needed to provide supplies and logistics in support of marine shipping and emergency response. "Vessels" include tankers, passenger vessels (ferries, large and small cruise ships) and pleasure craft, bulk carriers, container ships, fishing vessels, tug and barge combinations, offshore supply vessels, research ships, icebreakers and other watercraft. "Officers and crew" includes vessel personnel with special expertise for operations in cold and ice-infested waters, such as ice navigators or ice pilots, and considers the training, experience and expertise required for all vessel personnel when confronting the unique challenges of Arctic marine operations. "Emergency response resources" include response assets such as aircraft, vessels and specialized equipment; the logistics and supply chains needed to support these operations both at sea and ashore; and the availability of related shoreside facilities and resources such as port, medical, refueling facilities and living quarters to accommodate emergency responders. "Shoreside facilities" include ports and port facilities, particularly ports with adequate depth to accommodate larger vessels, potential places of refuge, airports and shoreside transportation systems.

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Increased Arctic activity, coupled with the difficulties in deploying and maintaining navigational aids in the region, presents an opportunity to implement ECDIS to improve navigation safety and save costs. The benefits of ECDIS, however, are wholly dependent on the underlying hydrographic navigational charts and consequently the hydrographic data on which they are based. Coverage of GPS, or other means of positioning, is also crucial to take full advantage of the system.

Canada, the United States, the Russian Federation and Denmark are carrying out charting activities that include portions of the Northern Sea Route and the Northwest Passage. These countries, as well as Iceland and Norway, are all member states of the International Hydrographic Organization (IHO) whose mission "is to facilitate the provision of adequate and timely hydrographic information for worldwide marine navigation."

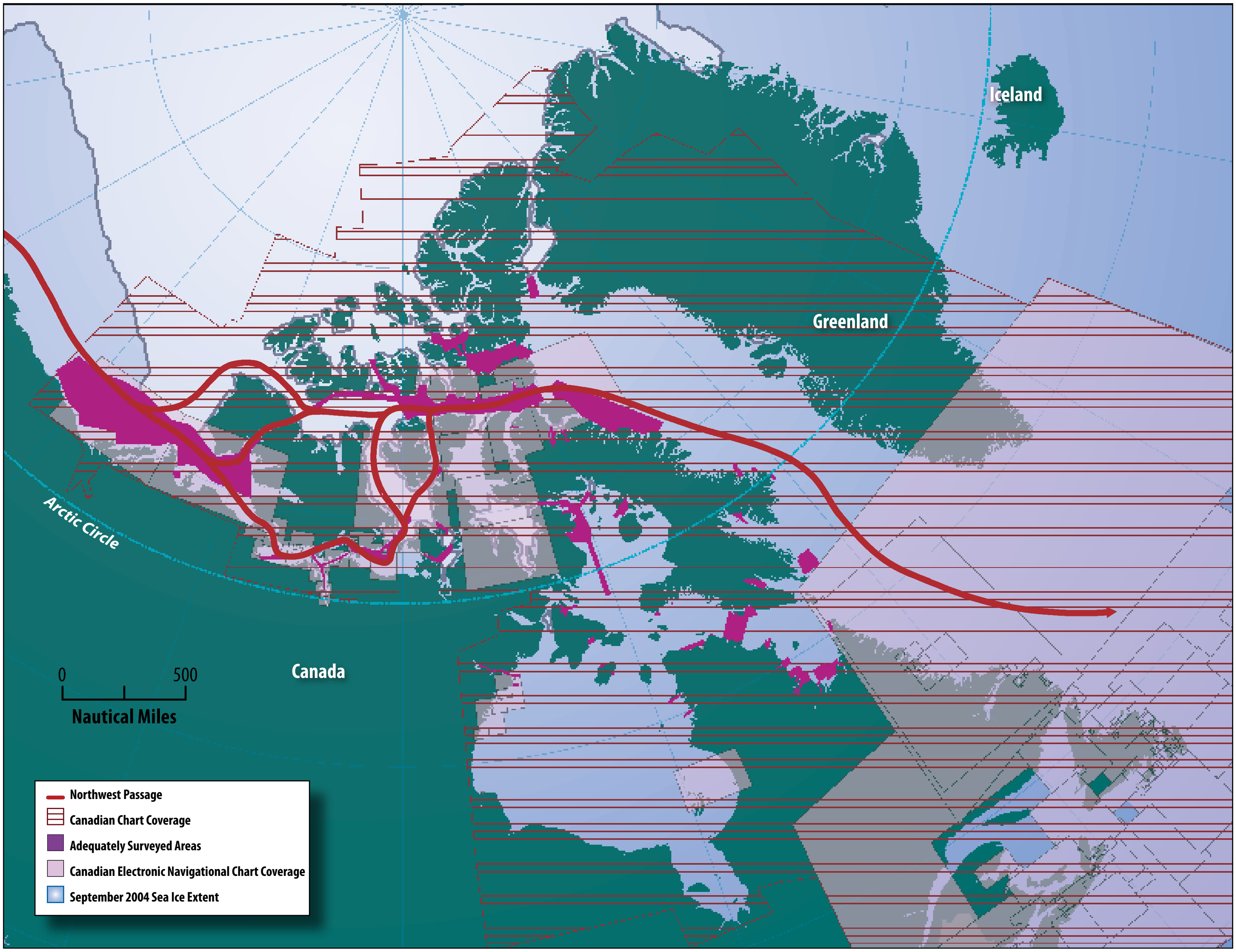
While there are published charts whose physical limits cover both the Canadian Northwest Passage and the Russian Northern Sea Route, the quality of the underlying data varies widely from modern, high resolution hydrographic surveys to no sounding information in some areas.

The quality and accuracy of navigational charts is entirely dependent on the hydrographic data used to compile them. Hydrographic surveys in the Arctic are logistically very complicated, expensive to undertake and highly dependent on weather and ice conditions. In addition, hydrographic offices normally prioritize their efforts based on a risk classification approach. Because the Arctic has traditionally seen smaller volumes of marine traffic, these risks have been perceived as low compared to other regions and progress in improving hydrographic coverage in the Arctic has been painstakingly slow.

IHO provides the current state of hydrographic surveys for member countries throughout the world. In Greenland, the limit for navigable waters has been set to 75 degrees northern latitude due to the permanent ice cover and the sparse population of its east coast. Within Canada, a high proportion of Arctic waters are inadequately surveyed or covered by frontier surveys only. A similar situation exists in the Russian Federation where ice conditions have precluded the systematic survey of the central parts of the Laptev and East Siberian seas. Only passage sounding

1933

The year the Russian Federal State Unitary "Hydrographic Enterprise" began conducting surveys.



Map 9.1 Canadian charting and survey status. *Source: AMSA*

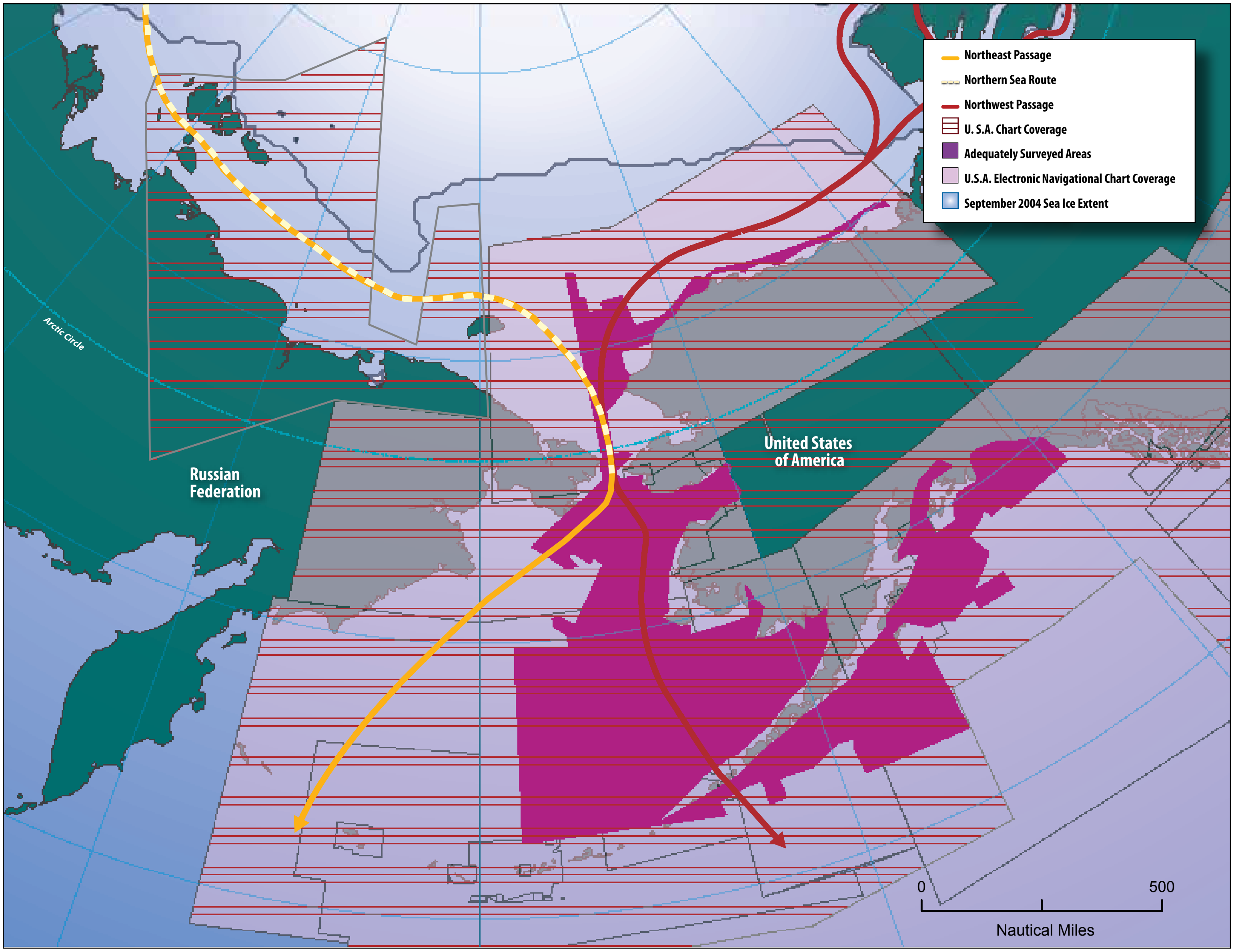
data is available for the deep water areas of the Sea of Okhotsk and the Bering Sea. The following figures illustrate the status of individual countries.

The Canadian Hydrographic Service reports that 10 percent of the Canadian Arctic has been surveyed to modern standards (Map 9.1). Coverage is often minimal and collected using rudimentary equipment and methods.

Surveys of the U.S. Arctic have been predominately along the northern coast of Alaska (Map 9.2).

The Russian Federal State Unitary "Hydrographic Enterprise" (SHD), formerly known as the Hydrographic Department, has conducted surveys since 1933. For the main areas of the Arctic shelf that cover 90 percent of the traditional navigation routes, detailed underwater topography is available (Map 9.3). Coastal surveys are completed for the Chukchi Sea, the East Siberian Sea, the Kara Sea, the navigable part of the Gulf of Ob', the shipping channel of the Yenisei River up to the port of Igarka, the shipping channel of the Khatanga and Kolyma rivers and the entrance of the Bykovsky waterway from the sea to the delta of the Lena River.

The SHD has set modern standards for Russian hydrographic surveys that recommend survey methods to ensure the detection of all



Map 9.2 U.S. charting and status of surveys in the Arctic. *Source: AMSA*

underwater obstacles on routes of intense navigation. To meet these modern standards, charts will need to be updated and, in the near future, an appreciable amount of work will have to be done. This includes detailed surveys of recommended shipping routes, harborages and anchorages for cargo operations using an instrumental area survey by special hydrographic equipment; regular measurement in areas not yet surveyed or surveyed with poor accuracy and details; and regular measurements in regions that are difficult to access because of ice conditions.

As mariners traverse the waters of nations around the world, they must be able to reliably interpret hydrographic products, independent of the country of origin. By becoming members of the International Hydrographic Organization, hydrographic offices agree to achieve uniformity in data quality and presentation standards. The emergence of digital products, most importantly electronic charts, has introduced a new aspect to the dissemination of hydrographic data. While a convergence of data sharing approaches is underway, significant inconsistencies remain. The Arctic provides an excellent opportunity to demonstrate the benefits of an open approach to data sharing in the international hydrographic community.

Sea ice is what sets the Arctic apart - what makes navigation in the Arctic especially unique and hazardous.

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Ice Information in the Arctic

Without sea ice, the needs for environmental information in the Arctic would be little different from the world's other oceans - wind and weather, waves, tides, currents, etc. Sea ice is what sets the Arctic apart - what makes navigation in the Arctic especially unique and hazardous.

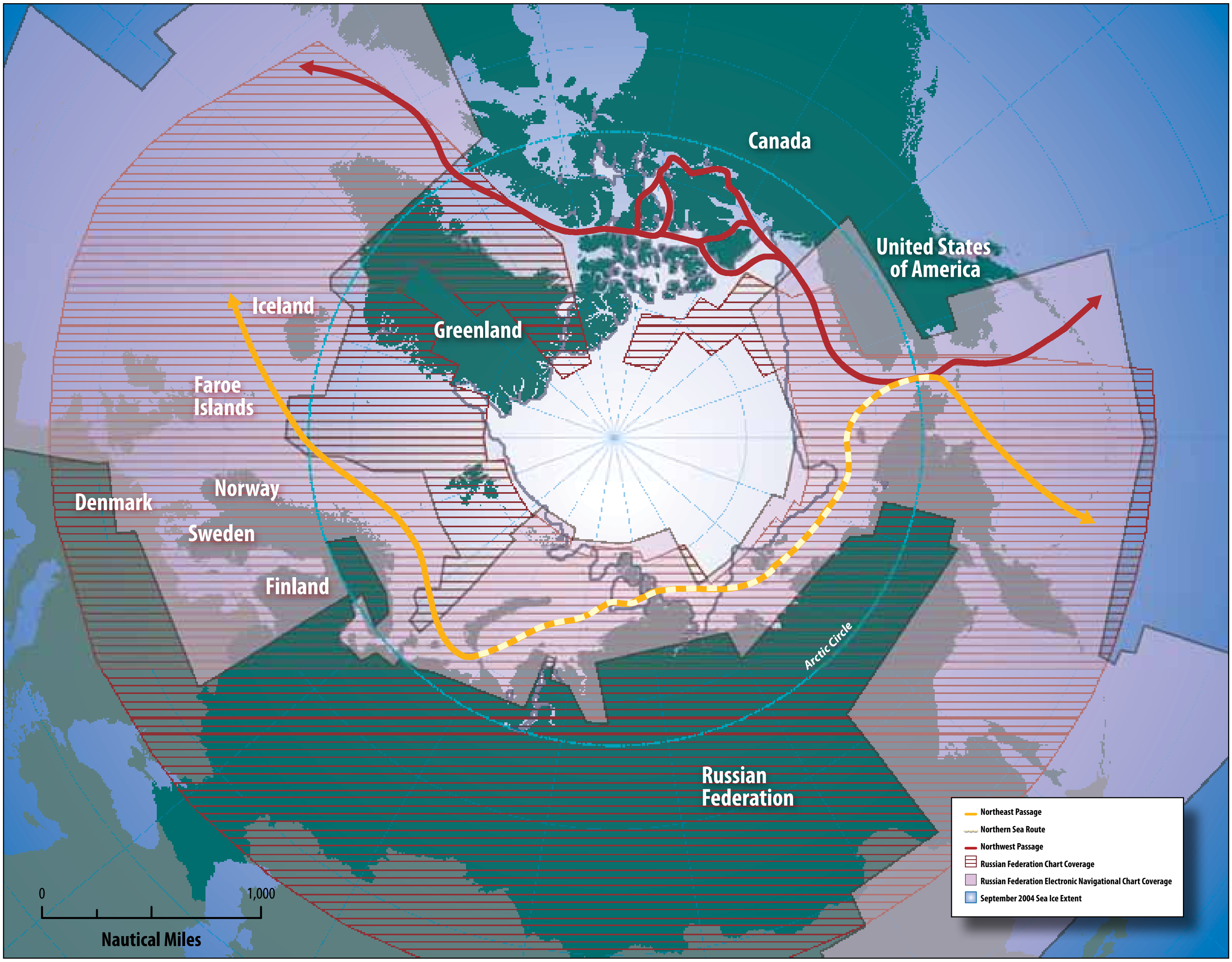
Sea ice in the Arctic has an annual cycle of freeze and melting that will not change in the future. When the sun goes down in the autumn and the extreme cold arrives, the ocean freezes. March is the month of maximum ice coverage. Through the summer months, the ice melts and retreats to a minimum extent in September.

It is generally agreed that the reduction in the thickness and extent of Arctic sea ice will continue into the future until, eventually, the Arctic will become free of sea ice in summer - much like the Baltic Sea, Sea of Okhotsk or the waters off the east coast of Canada. However, this will not eliminate the hazard that ice presents to Arctic shipping. There will still be a winter ice cover and significant inter-annual variability means that not all of the ice will melt every year, so scattered old ice floes will hide in the pack ice along with icebergs and ice island fragments. Moving ice driven by winds and currents will create a dynamic and hazardous operating environment. Variability in the onset of autumn freeze-up will present the risk of getting trapped in the Arctic over winter. Spring break-up to mark the start of summer navigation will vary and, as happens now in more southerly seas, shippers eager to start work will test the limits of their vessels in ice.

As more ships venture into the Arctic, the demand for ice information, as well as other ocean data, products and services, will continue to increase and the resources available to meet this increased demand will be stretched. The ice parameters needed in the future will not change significantly but will be required over larger geographic areas and longer periods of the year. Operators will still need to know where the ice is and isn't; where it's going to be, how closely packed it is and how thick and strong it is; generally, how difficult it will be to go around or, when necessary, go through. These parameters will be needed on a variety of space and time scales - from the hemispheric to the local, from months and weeks to daily or even hourly - to support tactical and strategic route planning for ships, scientific study and the development of policy and regulations to ensure safe marine practices.

The needs of mariners for ice information are currently met by a number of organizations, including national ice services that produce information for the Arctic that is generally freely available as a public service funded by tax-payers; academic institutions that provide ice information as part of an ongoing research program or to support field research campaigns; and commercial ice information services that provide services that are specific to individual clients with particular needs. As more ships venture into the Arctic and the demand for ice information and related services increases, there will be increasing pressure on the resources of ice information providers.

The national ice services collaborate in the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology Expert Team on Sea Ice, the body that establishes and maintains the standards for ice information internationally; and in the International Ice Charting Working Group (IICWG), an ad hoc group



Map 9.3 Russian Federation chart and ENC coverage of the Northern Sea Route. *Source: AMSA*

that coordinates ice information services internationally and advises the Expert Team on Sea Ice. As a result of this collaboration, there is an internationally accepted nomenclature for ice in the ocean, common charting and coding practices and cooperative information sharing among the ice services.

Ice information products include ice charts depicting the distribution and characteristics of the sea ice in an area; satellite images of ice-infested waters, often with interpretative text added; and text messages describing ice conditions. There is a wide range of scales for these products - from hemispheric charts that are useful for long-range planning to the navigation scale to support tactical vessel movements.

It is certain that the needs for ice information will evolve as more Arctic shipping develops. It is impossible to predict exactly how that evolution will occur because it depends on many factors - how the ice distribution itself changes, where resources are found, what markets are developed, advances in ship design and improving technology to observe, produce and disseminate ice information. The following examples are intended to provide illustrations of the particular ice information needs for some probable scenarios.

Potential shipping routes for extracting resources - principally oil, gas and minerals - will primarily be along shortest distance lines from the production sites to markets. It is likely the vessels used in this trade will be purpose-built for the trade in question and will operate year-round. They will be ice-strengthened and powered sufficiently to handle the most severe ice conditions encountered along the route. Ice information of most importance to these vessels will be that which can help them reduce time and fuel consumption en route as well as minimize the risks and delays that can be caused by difficult ice conditions around loading docks and piers.

Arctic transit shipping, using the Arctic Ocean as a short cut between Atlantic and Pacific, is not expected to become common because of the seasonal nature of the ice cover. Vessels designed to reliably pass through the winter Arctic ice cover will be greatly disadvantaged economically during the ice-free season. If transit shipping does occur in the Arctic, it will likely be limited to the summer season. These vessels will have some ice-strengthening to handle summer Arctic ice encounters but will not be able to deal with winter conditions. The most important ice information for this trade will be medium- and long-range forecasts of break-up and freeze-up to help companies decide when to head for the Arctic and when to get out in order to avoid being trapped over a winter. Close in the order of importance will be analyses and short-range forecasts of ice concentration, strength and motion to allow masters en route to set courses that avoid ice as much as possible.

Marine Weather Information for the Arctic

Modern weather information, including information for shipping, is based on numerical models. Numerical weather prediction analyses and forecasts are available for the Arctic from all of the major meteorological centers that run global models. States having the need for more detailed information for the Arctic areas have implemented high resolution models covering the Arctic region according to their needs.

In addition, Arctic coastal states provide marine weather information for their coastal waters. In most cases information for shipping is issued for large areas extending well offshore. Within the coverage of INMARSAT Global Maritime Distress Safety System transmissions, marine safety information in the form of gale and storm warnings is in place consistent with all other high sea areas in the world. However, no responsibility has yet been assigned for the high seas regions of the Arctic outside the coverage of INMARSAT, although an initiative is underway to do so by the World Meteorological Organization. Several states have offered to issue and/or prepare weather information for the Arctic. Progress in this initiative is expected and routine weather bulletins for the high Arctic areas may be in place in a few years. Prediction of the development and paths of lows giving rise to high winds is of particular concern for Arctic shipping. Accurate

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forecasts of sea ice, wave height, wind direction and speed, visibility, temperature and superstructure icing are the most important routine forecast parameters for shipping - with at least the same accuracy and timeliness requirements as on the other oceans.

Although weather forecasts for the Arctic are based on the same tools using the same techniques as in other areas of the world, the scarcity of observations in the Arctic makes the monitoring of the weather more difficult than in areas with more observations. Meteorological observations in the Arctic rely on drifting buoys placed on top of the sea ice. A new generation of buoys that will withstand multiple freeze-thaw cycles is currently under development and is urgently needed to provide surface observations in the Arctic Ocean. The ability to measure the conditions of the atmosphere and ocean from satellites is, however, developing rapidly and, with adequate surface validation, the quality of weather forecasts will approach the quality used in other areas.

The future increase in human activity in the Arctic, including Arctic marine shipping and the continued overflight of the Arctic region by commercial aircraft, will place increasing demands on the SAR infrastructure.

Wave Information for the Arctic

Because of the ubiquitous presence of sea ice, waves have not been a major navigational hazard in the Arctic. However, with less sea ice to dampen the waves, this will no longer be the case in the future. Wave information is typically packaged along with marine weather information in sea ice-free areas. New operational modeling capability will be needed to deal with a partial ice cover and its effect on wave generation and transmission. Buoys that measure the wave heights and directions are essential for model validation but none of these exist in the Arctic for operational reporting. Because of the necessity to deal with winter ice, a new generation of buoys will have to be developed.

Marine Aids to Navigation

The safe and effective use of northern waters by maritime shipping relies heavily on such safety systems as fixed and floating aids to navigation, long-range aids to navigation (shore-based electronic or satellite-based), as well as safety and navigation information broadcasts. While southern waters and well-used maritime routes are well served by established systems, northern waters are served by a patchwork of these systems. Ships navigating in the Arctic encounter unique situations. Ships usually use a combination of satellite positioning and traditional navigation techniques.

Of the eight circumpolar countries, six have coastlines. Of these, Canada, Denmark, Norway, Iceland and the Russian Federation maintain active aids to navigation (ATON) networks. More specifically: The Canadian Coast Guard maintains a number of seasonal fixed and floating aids throughout the Canadian Arctic. These are placed around the last week in June by icebreakers in Ungava Bay, Hudson Strait, Frobisher Bay and in the western Arctic by the third week in July. There is an active aids program along the Mackenzie River, serviced by two CCG shallow draft tenders. These aids are then picked up and the fixed aids deactivated as the icebreakers leave the Arctic, generally by the last week in October.

Norway maintains aids to navigation along its entire coast and at Svalbard along the coast and in fjords. Of note are a number of fixed and floating aids to navigation in Svalbard internal waters. It is expected that the requirement for aids to navigation in the Svalbard area will increase based on analyses of both the changing traffic patterns and the utilization of better risk analysis methodology.

Denmark has a permanent system of radio communication and radar beacons (RACON) along the west coast of Greenland from Uummannarsuaq/Kap Farvel to Qeqertarsuup Tunual/Diskobugten, as well as a system of coastal fixed aids, such as daymarks, from Uummannarsuaq/Kap Farvel to Upernavik.

Iceland maintains a number of fixed and floating aids to navigation in its internal waters including a Digital Global Positioning System and RACON beacons and has a permanent system of radio communication for radio monitoring of its fishing fleet.

The Russian Federation has an extensive system of fixed and floating aids to navigation mainly in the harbors of the NSR, which also includes some lighted and unlighted beacons and daymarks along the coast between ports.

The United States has no aids to navigation along the north coast of Alaska. The current U.S. short-range ATON footprint in the


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The service is designed to monitor and guide vessels, to promote safe and efficient navigation, and to protect the marine environment against undesired events in the Barents Sea and along the Norwegian coast. The area of operation for Vardø VTS Center is the Norwegian Economic Zone (NEZ) outside the baseline, the area around Svalbard and the area outside Tromsø and Finnmark in northern Norway. The VTS Center interacts with vessels, other government agencies, the NCA duty team that is responsible for national response and with the Norwegian SAR for search and rescue services. The administration also coordinates, on a daily basis, the tugboat preparedness in North Norway in conjunction with Regional Headquarters North-Norway (Norwegian Armed Forces) and the NCA duty team.

Arctic extends a short distance north of the Bering Strait where the largest zinc mine in the world (Cominco's Red Dog mine) near Kivalina receives ore carriers. North of the Aleutians along the coast of the Bering Sea, the U.S. has some floating and fixed ATON near the Pribilof Islands and Bristol Bay for tug, barge and fishing vessel traffic. In the Aleutian chain, there are several areas where navigational aids are maintained for local traffic, as well as for the trans-Pacific shipping transiting this region.

Marine Communications, Traffic Monitoring and Control

The historical standard for communicating weather, wave and ice information to ships at sea is the radio facsimile broadcast. While its use is being eclipsed world-wide by digital communications, the analogue radio broadcast remains an important source of information in the Arctic. Radio stations in the United States, Canada, the United Kingdom, Denmark, Germany and the Russian Federation broadcast analysis and forecast charts for sea ice, icebergs, sea state and weather, as well as providing vessel traffic services and general marine communications.

Norway has established a very advanced system composed of Automatic Identification System (AIS) and Maritime Communications and Traffic Services along the Arctic coast. In January 2007, a Vessel Traffic Service (VTS) for the coast of northern Norway was established in Vardø, operated by the Norwegian Coastal Administration (NCA).

The United States marine communications infrastructure in Alaska is concentrated where vessels operate the most. There is excellent very high frequency (VHF) coverage throughout southeast Alaska and into portions of the Bering Sea north to St. Paul and the Bristol Bay area. North of this region there is local VHF coverage at Nome, Kotzebue and Barrow. Barrow and Kotzebue, both north of the Bering Strait, also have high frequency (HF) NOAA radios. Mariners in these areas can speak directly to a weather expert via HF radio. Outside of VHF marine coverage, the U.S. Coast Guard relies on high frequency or satellite communications. Canada operates a seasonal system, while the Russian Federation is planning to augment their existing service during the next two years with further investment up to the 2020 timeframe. The Danish Navy operates a year-round high frequency radio station on the southwest coast of Greenland and maintains the IMO mandatory ship reporting system, GREENPOS, for all ships on voyage to or from Greenland ports and places of call. Furthermore, Denmark maintains a number of stations with limited communications capabilities in the south/southeast and lower western half of Greenland. Iceland has an advanced system of AIS along its coast with 23 base stations and repeaters with total coverage of the coastline. The maritime radio system has recently been renewed in VHF, MF (medium frequency) and HF bands and two new NAVTEX stations have been established. The traffic monitoring is carried out by the Maritime Traffic Service in Reykjavik operated by the Icelandic Coast Guard.

Communications using VHF, MF and HF as well as satellite are generally sufficient for the lower Arctic areas (Hudson Bay, Foxe Basin, southern Greenland waters and waters of the Northern Sea Route); however, once the high Arctic is reached, voice and data transmission become problematic.

Most modern ships are equipped with satellite digital communications equipment - not only for safety reasons but for the management and navigation of the ship. This equipment relies on geostationary INMARSAT satellites that do not provide service northward of about 80º N latitude. Other systems, such as the IRIDIUM constellation of 66 polar orbiting satellites, provide worldwide coverage including the Arctic. IRIDIUM is capable of providing a Ship Safety and Alerting System that meets IMO requirements but its data transfer rates are very low (less than 9.6 kb/s). The feasibility of communicating ice charts and satellite images to ships in the Arctic via the IRIDIUM system has been demonstrated but communications are limited and often interrupted. Other regional systems such as the Mobile Satellite System (MSAT) offer limited voice and data transfer capability only in North America including the Canadian Arctic Archipelago.

Improvements in capacity and reductions in cost are necessary for IRIDIUM and other regional systems to become a practical, widespread solution for the Arctic not only for voice, but more importantly for data transmission. The Russian Federation has been using communication satellites in highly elliptical orbits that provide long residence time over the Arctic ("Molniya" orbits) for television and other communications needs for several decades and, in 2007, pledged to improve radio and telecommunications in the Arctic.

It should be noted that the Canadian government has initiated a "Polar Communications and Weather space mission for Canada's North," (PCW) which is planning to provide robust 24/7 two-way satellite communications capability to all of the Canadian north for rapid high rate data transmission and information products, as well as low-data rate communications capability and also near-real time meteorological information products about the north to users throughout Canada.

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Various maritime training institutions are developing, or have developed, ice navigation courses, employing full mission bridge simulators and associated software products.

Norway is in dialogue with the United Kingdom, Denmark (Greenland), Faroe Islands and Iceland with regard to establishing a regional North Atlantic AIS/VTMIS (Vessel and Traffic Monitoring and Information System). The system is planned to be in force in 2009, and will facilitate the implementation of Article 9 of the Directive 2002/59 and the establishment of the SafeSeaNet Tracking Identification Relay and Exchange System (STIRES) as presented in the STIRES study (Saab AB, PM PM 374185).

Satellites and aerial surveillance systems can improve monitoring capability and serve to improve compliance with state regulations such as those intended for pollution prevention, or traffic reporting schemes that consequently can help in protecting the environment. As shipping increases in the Arctic regions, the requirement for improved voice and data transmission coverage becomes paramount.

Personnel and Maritime Training

Considering the Arctic operational environment and the lack of infrastructure, safe navigation in the Arctic is often dependent on the skills of a limited number of seasoned northern mariners. The Arctic offers significant navigational challenges, especially to the uninitiated. For decades, safe navigation has rested in the hands of a small number of experienced officers in a few countries. Their training has mostly been on-the-job with relatively little in the way of formal ice navigation education except within the limited regular navigation curriculum. With increased shipping in the Arctic, the need for skilled mariners will increase. Earlier melt periods and later freeze-ups will allow a greater amount of multi-year ice and ice of land origin (iceberg fragments such as growlers and smaller pieces called bergy bits) into the shipping lanes of the Northern Sea Route and the Northwest Passage, as well as in Greenland waters. It should be noted that less ice does not mean less danger. Understanding of the special conditions influencing navigation in the Arctic is crucial to the maintenance of a safe shipping regime.

The IMO's *Guidelines for Ships Operating in Arctic Ice-covered Waters* and the *International Convention on Standards of Training, Certification and Watchkeeping of Seafarers* (STCW '95) call for specialized training for mariners in Arctic waters. The guidelines define an ice navigator as "any individual who, in addition to being qualified under the STCW Convention, is especially trained and otherwise qualified to direct the movement of a ship in ice-covered waters. It also states: "The Ice Navigator should have documentary evidence of having satisfactorily completed an approved training program in ice navigation. Such a training program should provide [the] knowledge, [the] understanding and proficiency required for operating a ship in Arctic ice-covered waters, including recognition of ice formation and characteristics; ice indications; ice maneuvering; use of ice forecasts, atlases and codes; hull stress caused by ice; ice escort operations; ice-breaking operations and effect of ice accretion on vessel stability." It also provides guidelines for companies operating in Arctic ice-covered waters to develop a training manual, including the development and inclusion of drills and emergency instructions, emphasizing changes to standard procedures made necessary by operations in Arctic ice-covered waters. These drills and emergency instructions would be incorporated into the routine vessel operational training.

The STCW includes mandatory training requirements for passage planning and ice navigation in ice-covered waters. This section also authorizes the use of approved training simulators to achieve the stated training requirements. The concept of an officer experienced in navigation in ice, as well as the qualifications required, forms part of various national legislation and rules among northern countries such as the Canadian *Arctic Waters Pollution Prevention Act* and its associated regulations: the *Joint Industry Coast Guard Guidelines* for the control and operation of oil tankers and bulk chemical carriers in ice control zones of Eastern Canada.

The Russian Federation has a modern Arctic maritime training regime concentrated in the following marine educational centers: the Admiral Makarov State Maritime Academy in St. Petersburg; the Admiral Nevelskoy Far East State Maritime Academy in Vladivostok; the regional center of continuing professional education at the Captain Voronin Maritime College in Arkhangelsk; the "MARSTAR" Academy in St. Petersburg; and the Primorsk Shipping Corporation training Center in Nakhodka.

These centers train prospective Arctic navigators using the "Preparation for Navigation in Ice Conditions" course developed by the Makharov Training Center. These courses are designed around three subdivisions: theoretical training, simulator training and practical training onboard a vessel. The courses follow the requirements

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As more ships venture into the Arctic, the demand for ice information, as well as other ocean data, products and services, will continue to increase and the resources available to meet this increased demand will be stretched.

expressed in the IMO STCW 78/95 Requirements; the IMO's *Guidelines for Ships Operating in Arctic Ice-covered Waters* and finally those specified by the Russian *Rules of Navigation on the Seaways of the Northern Sea Route*.

The course trains officers in all aspects of operations in ice-covered waters, through theoretical and simulator-based training including: the preparation and planning for voyages in ice-covered waters; operating, navigating, maneuvering and escorting ships in Arctic ice-covered waters, including recognition of ice formation and its characteristics; features of maneuvering in ice of different density and thickness; communication between cargo vessels and icebreakers; and familiarization with emergency and search and rescue operations.

The prospective navigator must follow a practical regime composed of two phases that reinforces the theoretical and simulated aspects of the training already received, as well as knowledge passed on from more experienced operational personnel. These include practical navigation training where the student is taken onboard as a bridge officer trainee and is supervised by the navigating officers; and practical deck training where the student is taken onboard as a regular member of the ship's crew and studies features of ice operations from their point of view.

Certification of Ships' Officers and Crew

Maritime administrations around the globe are tasked with the certification process, which is linked to the maritime licensing programs for most countries. Several areas, such as vessel security officers, radar navigation and pilotage, have been fully addressed with special endorsements on individual licenses. Certification for tanker operations, vessel classification, vessel design and equipment for vessels operating in ice-covered waters has been established. Several regulations address oil spill response and environmental issues.

Various maritime training institutions are developing, or have developed, ice navigation courses, employing full mission bridge simulators and associated software products. The IMO has created a program of model training to assist institutions developing ice navigation courses with an emphasis on meeting STCW requirements. Several countries have instituted courses, including Finland and the Russian Federation, for the Baltic region, as well as Norway and Argentina. Canada has developed a model course using a simulator at the Marine Institute in St. John's, Newfoundland. While these classes begin to address the deficit in standardized ice navigation training, international harmonization is still necessary in order to provide the next generation of qualified northern navigators.

Incident Response and Capacity

As marine activity continues to expand in the Arctic, statistical trends indicate that the potential risk of vessel mishaps and marine pollution incidents also increases. The inherent navigational and environmental hazards and limited number of experienced personnel, combined with Arctic ecosystem sensitivity, heightens the need for greater incident response capacity and preparedness. It is important to learn, as soon as possible, what has been spilled, where and when in order to address it in an appropriate manner.

Protection of the Environment: Oil and Other Hazardous Spills Response

Marine incident prevention is based upon addressing four conditions that may result in pollution incidents:

- human error or failure caused by fatigue, malfeasance, unfamiliarity or other conditions either exclusively or in conjunction with each other;
- lack of operational readiness and preparedness caused by marginal or unprepared ship or crews;
- older vessel or vessel operating outside of operation parameters; and
- Arctic climate and situational unknowns caused by less predictable or rapidly changing weather, ice conditions, iceberg awareness or failure of mechanical systems unprepared for the rigors of Arctic operations.

Alone, or in combination, these conditions contribute to a myriad of scenarios for pollution and are the focus of the vast majority of preventive measures.

In addition, the variety of pollutant types and sub-types threaten the environment in different ways depending upon their chemical nature and how they behave when released. This may include circumstances such as waterway type, time of year, weather (wind, temperature) and local geography. Further adding to these circumstances are the variables associated with the potential impacts or sensitivities related to shoreline ecosystems, marine ecosystems, socio-economic systems or, in general terms, the overall exposed environments that would be lost or degraded.

Given the recognition that prevention may greatly diminish but not necessarily eliminate pollution threats, all maritime nations support preparedness and response activities. The challenge lies in the creation and sustainability of a preparedness and response regime that deals with the innumerable combinations and permutations possible.

While there are exceptions, there are few Arctic-based resources to address oil spills, especially the ability to recover trapped oil in hulls and compartments in both shallow and deep water.

Internationally, the Arctic countries are all signatories to MARPOL 73/78 (Annex I and II), COLREG Convention 72, STCW Convention 78 and Load Lines Convention 1966 and Protocol 1988, all of which fundamentally support the domestic legal frameworks for limiting vessel casualty situations. While these conventions apply internationally, the unique Arctic conditions relating to ice cover, weather fluctuation, limited basic infrastructure due to remoteness and particular biological susceptibilities increase the reliance on clear and robust prevention and preparedness regimes.

The Emergency Prevention, Preparedness and Response working group of the Arctic Council has created several products for dealing with oil spills in the Arctic. These products are available to the general public through http://eppr.arctic-council.org and include:

- an Arctic Guide referencing emergency systems and governmental contacts for all circumpolar nations that is updated annually;
- a Shoreline Cleanup and Assessment Manual (2004) for use in determining the most appropriate techniques for enhancing shoreline recovery;
- a series of Circumpolar Maps of Resources at Risk from Oil Spills in the Arctic (2002);
- a Field Guide (1998) for oil spills response referencing all manner of protection and recovery techniques; and
- an Environmental Risk Analysis (1998) of Arctic activities that indicates current potential spill sources.

Of particular note, the series of circumpolar maps, http://eppr.akvaplan.com, provides a first order overview of information for stakeholders to easily identify potential sources of spills and internationally important biological resources that could be at risk. The map catalogue includes thematic, regional and seasonal views including fish, bird, mammal, human population and protected areas.

A review of each Arctic state's response profile reveals a relatively consistent allocation of marine pollution interests from federal to local levels. In addition, there exists a number of longstanding bilateral agreements between adjacent countries that encourage cooperative efforts and transfer of best practices. For example, Norway and the Russian Federation have a bilateral oil spill response agreement for the Barents Sea that is exercised annually. There is no multilateral oil spill response agreement for the Arctic, but it may warrant an umbrella or multilateral agreement and/or a contingency planning process. Because of the diverse nature of the areas and interest, there is no particular advantage or disadvantage to any one model provided that entities share their objectives and communicate effectively.

In terms of current and future marine traffic, the Arctic is an immense, seasonally variable waterway with very little development along its shores. Despite the current disposition of resources and regimes, a more consistent country by country approach is required to address the pollution risk more effectively. Issues related to identifying risk areas, establishing timelines for response and ultimately designing a consistent response capacity remains a challenge.

Logistics - the procurement, maintenance and transportation of materials, facilities and personnel - are dependent upon existing Arctic infrastructure. This is a critical component of all Arctic operations. Sea-state and environmental exposure will place larger burdens on logistics supply lines. In the absence of shore-based infrastructure, longer range planning for refueling and replenishment are required. Distances between ports, coupled with the unpredictability of weather, may complicate access and supply, as well as removal of recovered product and waste. With public expectation of four season response capability for large or environmentally disastrous spills, the logistics infrastructure may need to be modified.

The issue of logistics is not surprisingly a significant and mostly limiting factor in facilitating an effective response. In remote areas, two distinct situations exist in relation to the provision of logistics: incidents within reasonable distances from established communities and those in more remote settings. Pre-existing infrastructure or pre-placement of response assets typically support this first scenario, while remote incident sites require the creation of infrastructure from the ground up. A mobile and relatively self-sustaining infrastructure is called for currently and likely into the foreseeable future. Selecting a site for this type of infrastructure becomes the key logistical issue facing a response and obtaining local knowledge of the areas is considered vital.

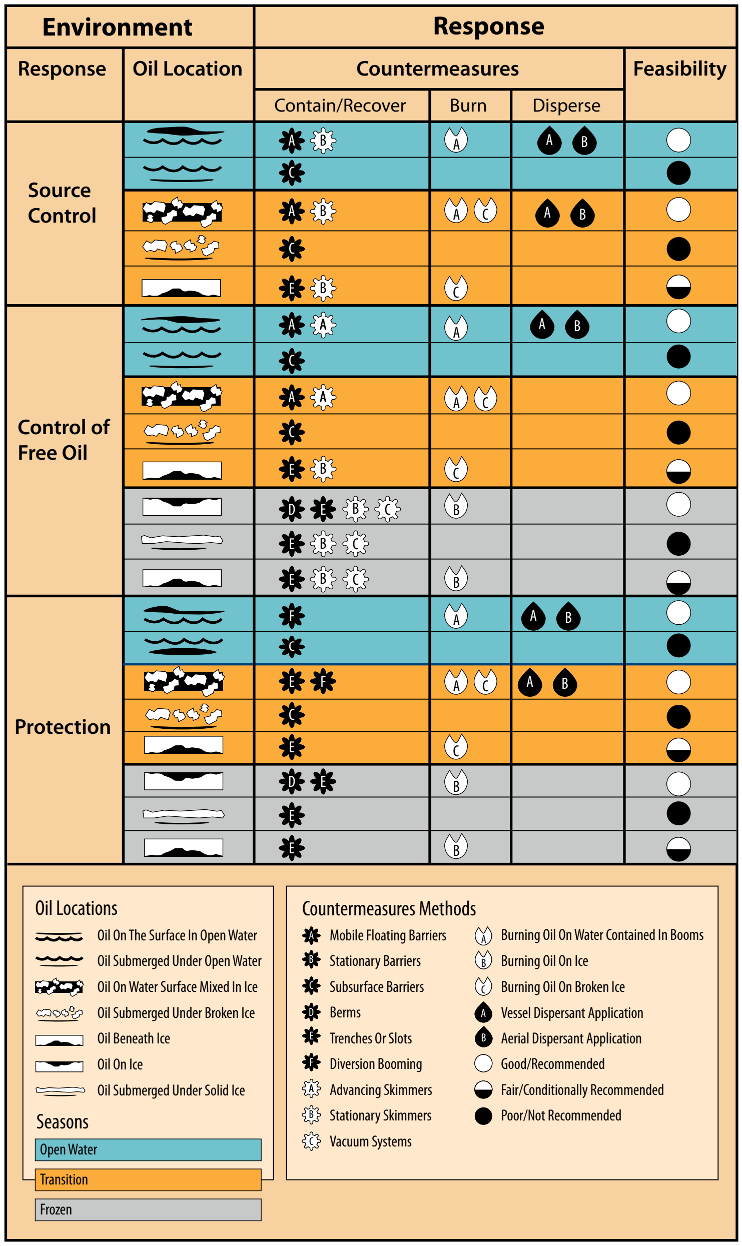

Table 9.2 Summary of typical response countermeasures in various seasons and seas. *Source: First Responder's Guide for Arctic Oil Spills, EPPR*

It is important to learn, as soon as possible, what has been spilled, where and when in order to address it in an appropriate manner.


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Oil spills in ice are more complicated to address than oil spills in open waters and there are several challenges connected with oil spill response in ice and snow and cold water. Apart from the normally long distances from existing infrastructure, the oil is less accessible in ice-covered waters. The oil can be spilled on ice or snow, in open pools between ice floes, in open channels behind vessels or even under the ice from pipelines or other sources.

There are some advantages in addressing oil spills in ice compared to open water. The weathering rate is normally much slower for an oil spill in ice as the emulsification rate is slower, resulting in an increased window of opportunity for use of most response techniques. The spreading of oil will be normally slower also, resulting in a large oil film thickness that may be favorable for oil spill response. The reduced weathering of oil in these conditions does, however, maintain the levels of its more toxic components for greater periods of time, thereby increasing the availability or risk of uptake by organisms.

Arctic Oil Spill Recovery Operations: Technology and Tactics

Effective Arctic oil spill recovery operations require advanced planning and international cooperation. All available methods must be available and considered for each situation although some methods have proven more effective in ice-covered waters. Along with planning and cooperation, training, incident communications and risk management are key elements to any oil recovery operation.

Mechanical recovery techniques combined with oil detection and tracking methods, currently dominate the in-field capabilities of most nations. However, tracking, detecting, as well as modeling oil in ice-covered waters has inherent environmental limitations. The mechanical methods are often considered the most environmentally friendly recovery methods. The concept is to create barriers via floating or alternative booms, recover the oil out of the sea with a mechanical skimmer and then do the post-treatment for the recovered oil in a controlled manner in environmentally safe conditions. However, the mechanical methods are laborious and time consuming and their efficiency is low. Further, mechanical methods often require complicated logistical support in the form of equipment and personnel transportation, which in remote or harsh conditions cannot easily be provided. Mechanical recovery in ice and snow conditions must meet challenges in terms of booming, skimming, recovery and pumping capabilities. Each of these areas has specific challenges to optimum recovery efforts.

Chemical dispersion can be utilized to promote the formation of oil droplets in order to accelerate the natural dispersion and biodegradation of spilled oil. Dispersants (surfactants) can be applied to control offshore slicks or oil that accumulates in coastal areas that have significant tidal or flushing action. In order for dispersion to be effective there needs to be limited weathering of the spilled oil, a cohesive slick, an oil within the viscosity ranges of dispersibility, an appropriate dispersant to oil ratio and turbulent mixing. Only a few research studies have been performed in the past 20 years regarding the use of dispersants on oil spills in ice-infested waters, either from an effectiveness or environmental-impact perspective, and these are of limited value in assessing the situation in realistic terms. Logistical support and effectiveness may also be a challenge when using dispersants. Limited studies such as the Joint Industry Program (JIP) on Oil in Ice, have followed the long-term fate of dispersed oil, but most impacts have been derived from laboratory studies.

In-situ burning, or ISB, is a treatment method that can be used for oil on open water, on ice and in broken ice, if adequate oil thickness can be achieved to sustain burning. This may require the use of booms or herding agents. While continued studies are needed to best determine the ISB effectiveness window of opportunity, for in-situ burning to be a viable option, planning, special equipment and training specific to ISB must be in place before the limited window of opportunity presents itself during a spill. Burnability is a function of oil type (chemical/physical factors), oil thickness on the interface and its state of weathering/degradation. While colder Arctic temperatures are a force to overcome for ISB in ice-covered waters, other natural degradation processes such as slower rates of spreading, evaporation and emulsification have supported burning.

450

The approximate number of lives saved in 2007 because of the Automated Mutual-Assistance Vessel Rescue System.

From the recovery rate point of view, in-situ burning seems to be the most effective method for clean-up of oil spills in ice and snow conditions. Furthermore, removal efficiency exceeding 90 percent can be achieved in ideal conditions (open water, fire booms and quiet conditions), but a burning rate of 60 to 70 percent can be considered as representative for burning on ice-free water. The burning rate can also be zero percent if the oil is not ignitable. ISB may be more limited due to weathering of the oil than the use of dispersants. This is significantly more effective than rates of 10 to 20 percent for mechanical recovery. Alternatively, in-situ burning will generate smoke and soot, thus moving part of the pollution from the sea to the air, and will leave a burn residue that must be recovered. Monitoring and assessment of these results is always necessary.

Oil may be removed by biological degradation. Oil-degrading bacteria naturally exist in the seas with oil, including the cold and icy waters. By adding oxygen and/or nutrients and/or bacteria a possible acceleration of this fundamentally natural process can occur. While bioremediation is an effective countermeasure for small spills with high surface areas (e.g., very thin staining or coating on shorelines), it is a relatively slow process, possibly requiring months if not years to fully accomplish and is best suited for post-spill response final treatment.

Protection of People and Property

The current search and rescue, or SAR, infrastructure in the Arctic, while varying between regions, is limited. For example, while there is a robust set of assets off the coast of Norway to respond in an emergency, there is little to no infrastructure along the coast of Greenland to respond to a passenger ship in distress. A survey of search and rescue resources among Arctic states indicates limited availability of fixed wing aircraft and helicopters in most of the region. Some survey responses included icebreakers and seasonal patrol vessels that can be used for SAR when near enough to an incident. However, in general, there are shortages of critical SAR response assets, such as long-distance, heavy-lift capacity helicopters. The usefulness of these assets is often limited by weather and other operating conditions. Emergency response efforts are further hampered in many regions by an insufficient shoreside infrastructure needed to provide basic logistics and support functions for SAR missions. The location and availability of SAR assets are often problematic given the vast distances and frequent harsh operating conditions typical in this region. In some instances, such as in connection with oil and gas activities, private industry addresses these gaps and shortfalls by providing its own supplemental SAR capacity

as part of its ongoing Arctic operations, but this remains the exception rather than the rule.

Arctic states have attempted to maximize the effectiveness of existing SAR resources by entering into bilateral and sub-regional SAR agreements with neighboring nations that have improved coordination of SAR responses in specific areas of the Arctic. For example, the Russian Federation, Canada and the United States have a search and rescue agreement. Norway and the Russian Federation have a bilateral search and rescue agreement for the Barents Sea that is exercised annually. There are also informal search and rescue arrangements with local governmental and private entities. There is no multilateral search and rescue agreement covering the entire Arctic region.

The future increase in human activity in the Arctic, including Arctic marine shipping and the continued overflight of the Arctic region by commercial aircraft, will place increasing demands on the SAR infrastructure. Many of the infrastructure deficiencies discussed in this report, such as the insufficient number of accurate charts or the need for better real-time information concerning the operational environment and communications difficulties, will also impact search and rescue efforts.

The need to strengthen search and rescue capabilities was specifically recognized by the representatives from the Russian Federation, Canada, the U.S., Denmark and Norway who met in Ilulissat, Greenland, in May 2008. "The increased use of Arctic waters for tourism, shipping, research and resource development also increases the risk of accidents and, therefore, the need to further strengthen search and rescue capabilities and capacity around the Arctic Ocean to ensure an appropriate response from states to any accident," states the Ilulissat Declaration. "Cooperation, including on the sharing of information, is a prerequisite for addressing these challenges. We will work to promote safety of life at sea in the Arctic Ocean, including through bilateral and multilateral arrangements between or among relevant states."

Passenger Vessel Safety in the Arctic

The most significant emerging challenge to the existing search and rescue infrastructure arises from the increase in marine tourism and passenger vessels operating in Arctic waters. As large passenger vessels continue to operate more frequently and farther north in the Arctic, the prospect of having to conduct mass rescue operations with limited SAR resources increases. Recent growth in Arctic marine tourism is outpacing infrastructure investment, development and support throughout the region. There are several potential problems associated with responding to an incident aboard a cruise ship. The potential number of people that would have to be rescued from a cruise ship far exceeds the capacity of most SAR response vessels and aircraft available in the Arctic. Cruise ships have a minimal capacity for self-rescue. Compliance with IMO guidelines for passenger

Emergency response is particularly challenging in the Arctic for a variety of reasons, including the remoteness and great distances that are often involved in responding; the impacts of cold, ice and a harsh operating environment on response personnel and equipment; and the lack of shoreside infrastructure and communications to support and sustain a response of any significant magnitude.

vessels operating in remote areas is voluntary and, as a result, the planning and capability for self-rescue varies. Passengers are likely to be ill-prepared for the weather, which decreases their likelihood of survival if they are not rescued quickly. There are also a host of logistical challenges associated with the lack of shoreside infrastructure in most of the Arctic needed to accommodate and care for those that are rescued, including the lack of sufficient food, lodging and medical facilities. In many cases, the only available platform with capacity to feed and house rescued passengers would be another cruise ship.

A number of potential actions are available to address the challenges presented by emergency response to passenger vessel incidents in Arctic waters. First, ships intending to conduct passenger vessel transits in the Arctic would greatly improve the prospects for a successful rescue and survival of passengers and crew if they coordinated their transits with other passenger ships in the vicinity. In two incidents in the Antarctic, passengers and crew from stricken vessels were successfully transferred to other nearby passenger vessels. One of the stricken passenger vessels, the *M/V Explorer,* sank shortly after the transfer. Second, provisions in the *Enhanced Contingency Planning Guidance for Passenger Ships Operating in Areas Remote from SAR Facilities* (IMO 2006) provide valuable guidance for passenger vessels operating in remote areas such as the Arctic. The voluntary guidelines provide detailed information on emergency drills and inspections, and contain additional requirements for lifeboats, liferafts and survival kits that would allow passengers and crew to better survive the harsh Arctic environment until SAR response arrived on scene. The value of these guidelines is dependent in large part on the degree to which they are adopted and implemented. Third, search and rescue operations could be improved and limited resources used to best advantage by sharing information, lessons learned and best practices arising from incidents that have already occurred in polar regions, including the two latest Antarctic incidents.

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The advantages of mutual assistance between vessels operating in the Arctic, although particularly significant for passenger vessels, extend to all vessels. Voluntary systems have been established that allow search and rescue authorities to identify and request assistance from other vessels in the vicinity of a vessel in distress. The Automated Mutual-Assistance Vessel Rescue System (AMVER) is one such established system that can be accessed by Arctic SAR authorities to identify a possible source for assistance in any distress case in the Arctic region. There are more than 17,000 vessels enrolled in the AMVER network, representing 155 countries. On any given day, more than 3,500 vessels are available to divert and assist in a distress situation at sea. Approximately 450 lives were saved in 2007 because of AMVER. Participation is voluntary unless mandated by a vessel's flag state, shipping company or other authority.

€4.4B

The amount of money invested since 2004 to improve Murmansk's deepwater port facilities to include new oil, coal and container terminals as well as expanded rail lines.

Participating vessels provide regularly updated information on their SAR capabilities and intended track to rescue coordination centers. AMVER information is released only to recognized SAR agencies for safety-of-life-at-sea purposes, and provides rescue coordination centers with data on vessels in the vicinity of a SAR case that may be available to divert and assist.

Another example is the Russian Vessel Monitoring System, referred to as *VMS Victoria*. The system is intended for near real-time automated monitoring of vessels positions provided vessels are fitted with the ship satellite communication systems: INMARSAT-C or INMARSAT-D+, and for delivering the collected position reports data via Internet to remote users. *VMS Victoria* caters to the shipowners, operators and organizations responsible for control and surveillance of maritime vessels, as well as for search and rescue at sea. There are more than 1,200 vessels enrolled in the system, among them more than 600 foreign flag-state vessels. *VMS Victoria* operates constantly and allows its users: to track the movements of their fleets by receiving regular automated position reports from the vessels; to request an immediate position report from any vessel on demand if required; and to send short text messages and FleetNet broadcasts to a vessel/vessels. *VMS Victoria* processes messages in real time and then transmits them to INMARSAT. It is anticipated that the establishment of the LRIT-system will be an important system to identify ships in the vicinity of a distressed vessel, thereby requesting them to provide assistance.

Promoting the use of mutual vessel assistance systems such as AMVER or *VMS Victoria* would serve to supplement the extremely limited search and rescue resources and improve SAR capacity in the Arctic.

Although Arctic states often have existing agreements in place to coordinate SAR operations with neighboring nations, there are several advantages to creating a multilateral Arctic SAR agreement that would cover the entire northern region for both aeronautical and maritime SAR. A multilateral SAR agreement for the entire Arctic region would facilitate the most effective use of limited SAR resources throughout the Arctic and would ensure that available Arctic SAR facilities closest to a vessel or aircraft in distress are identified and respond first, regardless of nationality, in order to reduce response time and potentially save the most lives. A region-wide agreement would also improve SAR response by serving as the framework within which to conduct joint exercises and training; share information, lessons learned and best practices; and identify and improve mechanisms for mutual cooperation, coordination and support in search and rescue and emergency response.

The creation of a more comprehensive multilateral SAR agreement would build on existing proposals for an aeronautical Arctic SAR Memorandum of Agreement to include both aeronautical and maritime SAR, as encouraged by the *International Convention on Maritime Search and Rescue,* 1979, as amended; the *Convention on International Civil Aviation*, 1944 (Annex 12), as amended; and the *International Aeronautical and Maritime Search and Rescue Manual* (IAMSAR Manual). The proposed Arctic Region SAR agreement would identify aeronautical and maritime SAR region lines of delimitation; as affirmed in both conventions, such delimitation of SAR regions is not related to and would not prejudice the delimitation of any boundary between nations.

A multilateral SAR agreement would serve as the centerpiece of cooperation and coordination in support of Arctic emergency response operations while providing an important example of a mutually beneficial regional approach among Arctic nations to address important shared issues of concern.

Since Arctic and Antarctic emergency responses are similar in many ways, Arctic and Antarctic nations engaged in polar SAR could benefit from consultation and cooperation on issues of mutual concern and applicability. The five nations responsible for SAR in the Southern Ocean (New Zealand, Australia, Argentina, Chile and South Africa) currently meet to address many of the same challenges that face the eight Arctic Council nations concerning distance, harsh environment and limited SAR resources. In August 2008, New Zealand, Australia, Argentina, Chile, South Africa, United States, France, United Kingdom and the Council of Managers of National Antarctic Programs (COMNAP), met in Valparaiso, Chile, to discuss improving Antarctic SAR coordination and cooperation. One means of enhancing cooperation would be through mutual efforts of the Arctic Council and Antarctic Treaty Consultative Meetings. Future proposals and recommendations on polar SAR could be coordinated between both international fora to ensure continuity and standardization where appropriate.

Gaps in Preparedness and Response Operations

Remote surveillance and detection technologies (i.e., satellite communications, GPS availability, weather stations) are critical for establishing situational awareness for both preventive and response issues. This overall capability is limited in the Arctic due to a lack of coverage and the availability of real-time weather information.

Lightering in emergency situations and salvage typically represent two distinct marine activities that may be used in whole or in part to prevent and/or recover pollutants, and are considered in many cases synonymous with mechanical response capacities.

While all Arctic states individually support the overall strategic goal of limiting negative environmental impact and establishing sustainable development, the potential for increased shipping has led to increased concern for threats, risk and evaluation of potential consequences worldwide. This leads to a high expectation by public and environmental groups for adoption of stringent preventive measures, as well as thorough mitigation and restoration measures in the event of an incident. This has also contributed to an increasing gap in maintaining realistic response expectations. To address this pressure many recent workshops and panel discussions have indicated a need for more harmonious pan-Arctic shipping rules. Cooperation at this level requires nations to develop common goals and objectives based upon mutually acceptable and scientific criteria. Ultimately the communication of these objectives is vital in maintaining realistic expectations.

While there are exceptions, there are few Arctic-based resources to address oil spills, especially the ability to recover trapped oil in hulls and compartments in both shallow and deep water. A multilateral oil spill contingency plan or an oil spill agreement may be options to address this issue.

Ports

In temperate maritime areas, deepwater ports and the services they provide are typically relatively close to global maritime shipping and often taken for granted. The situation in the Arctic is quite different. Deepwater ports, places of refuge, marine salvage, adequate port reception facilities for ship-generated waste and towing services are rarely available. The availability of port infrastructure and support directly influences the level of risk associated with transiting a particular waterway and corresponds to the levels of marine insurance rates.

Ports and Intermodal Transport Links

There are few deepwater ports in U.S. or Russian waters near the Bering Strait. The closest U.S. harbor with deep water is Dutch Harbor in the southern Bering Sea. On the Russian Federation side, the nearest deepwater port is Provideniya. Other Russian ports near the Bering Strait that are closed to foreign ships are Egvekinot, Anadyr and Beringovsky.

Arctic Marine Incidents Workshop

A key AMSA workshop, Opening the Arctic Seas: Envisioning Disasters and Framing Solutions, was held in March 2008 at the Coastal Response Research Center of the University of New Hampshire. The center, a partnership between the U.S. National Oceanic and Atmospheric Administration and UNH, develops new approaches to spill response and restoration through research and synthesis of information.

In cooperation with the U.S. Coast Guard and U.S. Arctic Research Commission, the center hosted the workshop to identify key strategies, action items and resource needs for preparedness and response to potential Arctic marine incidents. The 50 workshop participants represented a spectrum of constituencies and expertise including government agencies, the marine industry, Arctic indigenous groups, academia and non-governmental organizations. Experts from the U.S., Denmark, Canada, Russian Federation, Norway and Finland and one non-Arctic state, South Africa, participated.

The workshop focused on the qualitative risk factors for five plausible Arctic marine incidents developed by the organizing committee and bear some similarities with incidents that have already occurred in polar waters. The incidents were designed to explore: spill response; search and rescue; firefighting and salvage; communications; governance and jurisdiction; and legal issues. The five incidents were:

- **Cruise ship grounding in the west coast of Greenland**
  Mid-September grounding in a fjord of a cruise ship with 1,400 passengers. Progressive flooding makes the ship unstable and all passengers and crew must abandon ship.

- **Bulk carrier trapped in ice in the central Arctic Ocean**
  September/late season crossing of the Arctic Ocean en route to the Bering Strait and the Pacific Ocean. Ice damages the ships' rudder and propeller. The ship's non-ice strengthened hull makes wintering impossible. Rescue operations are challenging due to the remote location and changing sea ice cover.

- **Fire and collision in offshore operations in the Beaufort Sea**
  In late winter, a drill ship, two oil spill response vessels and one ice management icebreaker are conducting exploratory drilling operations in 50 meters of water 20 nautical miles offshore within the disputed U.S.-Canada border area in the Beaufort Sea. An engine room fire on the icebreaker causes it to lose control and collide with the drill ship, rupturing a ballast tank. The drill ship empties 700 barrels of Arctic grade diesel fuel to maintain stability; 300 barrels of diesel fuel are also spilled because of the fire on the ice management ship. Crew members on both vessels suffer injuries.

- **Oil tanker and fishing vessel collision in the Barents Sea**
  The collision occurs in near-zero visibility within the disputed Russia-Norway border in the Barents Sea. The tanker releases 25,000 barrels of crude oil in the water and must be towed to a place of refuge to avoid potentially spilling its remaining cargo. The fishing vessel sinks making salvage impractical.

- **Tug and barge grounding on St. Lawrence Island in the Bering Sea** In May in broken ice conditions, a tug loses power while towing a barge laden with mining explosives and other containerized cargo for several Arctic communities. Pushed by a storm surge, the tug and barge are grounded in an area that was a critical habitat for threatened and endangered species and a haul-out location for Pacific walrus. The tug and barge are separated by several miles, the tug ruptures a fuel tank, containers are in the water and some wash onshore.

Workshop participants were divided into five groups each working on a single, plausible incident. Four questions were addressed by each group: If this incident happened today in the Arctic, how would we respond? How would we prefer to respond? What are the gaps and needs that exist today that prevent us from responding in the preferred manner? What do we need to do to address those needs and fill the gaps?

The exercise yielded the following themes:

(A) Ports and Waterways Management
- Designate potential places of refuge in the Arctic and develop guidelines for their use; an international effort should also rank them by seasonal environmental conditions.
- Establish policies and systems to control ship movements such as route planning; use of Automatic Identification Systems on all Arctic ships; vessel tracking systems and designation as Particularly Sensitive Sea Areas from IMO.

(B) Vessels and Crew Safety
- Institute mandatory safety regulations for Arctic operations; the current IMO Guidelines for Ships Operating in Arctic Ice-Covered Waters address specific construction, fire safety, lifesaving, navigational, operational and crew training issues, but they are voluntary; mandatory training for ice navigation and emergency response in polar environments is necessary; a non-binding regulatory framework seems inconsistent with the hazards of Arctic navigation and the potential for environmental damage in the Arctic Ocean.

(C) Response Agreements and Plans
- Existing search and rescue and pollution contingency plans do not provide enough detailed information to facilitate an effective response; there is a need for Arctic-wide agreements for SAR and pollution response; agreements and response plans should

designate which nations respond in specific areas and clarify operations in disputed regions; agreements and response plans should also ensure foreign responders can participate in operations unimpeded by customs and immigration issues; Arctic states could establish an integrated response management center to manage the execution of agreements and facilitate the decision-making process.

(D) Strategies to Improve Prevention and Preparedness

- Conduct comprehensive environmental risk assessments and impact assessments to assist in decision-making, route planning, emergency response, etc.
- Increase emergency response assets, equipment and supplies in the Arctic, placing emphasis on regions of active development; self-sustaining, forward-operating response bases should be established.
- Improve knowledge for Arctic incident response through training and engagement of the local community, responders and the maritime industry; Arctic indigenous people should be trained in response and local communities must participate in response operations.

(E) Strategies to Improve Response

- Consider alternative countermeasures for oil spill cleanup; mechanical measures in ice-covered waters may be impractical and alternative response options should be considered (dispersants, chemical herders, sinking agents, in-situ burning, etc.).
- Expand communications capabilities throughout the Arctic; expanded shore based (VHF and HF) and satellite systems are required.
- Improve logistical support capabilities for responders; support for response personnel in remote Arctic regions must be brought to the region of operations.

(F) Strategies to Foster Community Involvement

- Involve indigenous people and local communities in planning, response, recovery and restoration decisions and operations.
- Conduct outreach to local communities and keep all stakeholders well informed.

(G) Strategies to Ensure Availability of Funds for Response

- Establish an international Arctic response fund to offset the costs of SAR and pollution response.
- Increase penalties and insurance requirements for ships operating in the Arctic to ensure response funding and act as a deterrent.

The workshop identified three key areas of data and research needs: (1) the updating of weather data due to a lack of overall information, and investment to update navigational charts for Arctic regional seas, ports and waterways; (2) studies on the behavior of oil in cold water and technologies for spill response (including the detection of oil under ice as well as cleanup measures for oil in ice); and (3) improving the baseline information for Arctic resources (biological/ecological resources and areas important for human use and cultural significance) that could be affected by potential marine incidents.

Two themes resonated throughout the workshop: The Arctic states need to foster and enhance their cooperation to improve joint contingency plans and multinational agreements, as well as to agree to develop mandatory safety regulations for Arctic marine operations. The proper management of risk using appropriate policies and strategies, supported by scientific research, can lead to reduced risk for loss of life and environmental damage.

Map 9.4 Plausible Arctic marine incident locations. *Source: AMSA*

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This situation differs with the region between the Atlantic and Arctic oceans, where there are many Norwegian, Icelandic and Russian deepwater ports. There are a number of deepwater ports along the west coast of Greenland. In the Arctic, there are essentially no deepwater ports along the North Slope of Alaska or throughout the Canadian Archipelago, except for that of Tuktoyaktuk, which, while having a relatively deepwater port, suffers from a shallow approach channel and a high degree of in-fill silting, situated as it is in the delta of the Mackenzie River. Mention should also be made of the limited port facilities at Resolute Bay, in the middle of the archipelago, which acts as a center of transportation, communications and administration for the high Arctic but which can only handle ships of 5m draft alongside a sunken barge used as a dock. Ships of deeper draft must anchor in an open roadstead.

In Hudson Bay, the Port of Churchill is Canada's only northern deepwater seaport with well sheltered, along-side berthing facilities. It provides access, via rail, to the interior of Canada and North America in general. The growing Port of Churchill offers four berths for the loading and unloading of grain, general cargo and tanker vessels. The Port can efficiently load Panamax size vessels. The link between Murmansk and Churchill has become known as the "Arctic Bridge" since it requires sea and rail systems to complete the transport of goods to North American destinations. The use of the Port of Churchill eliminates time-consuming navigation, additional handling and high-cost transportation through the Great Lakes and St. Lawrence Seaway. The current shipping season runs from mid-July to the beginning of November. The use of icebreakers could significantly lengthen the shipping season. Another significant port in the Eastern Canadian Arctic is Iqaluit, which requires that ships anchor and use barges to land their cargo and features some of the highest tides on the planet as well as one of the largest tidal ranges in existence.

The Canadian government has recently proposed an upgrade to the rail link to Churchill, as well as the development of a deepwater port at the old mining town of Nanisivik in Nunavut on Baffin Island, to be used primarily by the Department of National Defence. It is unclear what facilities this port will have since it is not situated near a major population center, major shipping route or railroad. In addition to the proposed port at Nanisivik, future planned development on Baffin Island also includes the iron-ore mine at Mary River under construction by Baffinland Iron Mines Corporation that will include a railroad to the planned port at Steensby Inlet.

In contrast, the northern coast of the Russian Federation has several deepwater ports that have been supported by the Northern Sea Route Authority and fleet of icebreakers for several decades. Murmansk is well known for being the largest deepwater port north of the Arctic Circle that is ice-free throughout the year. Murmansk also provides intermodal access to northern European and Asian industrial centers. In recent years, Russian Arctic ports in the Barents Sea, including Murmansk, have expanded significantly as offshore oil and ore production have increased in the region. Since 2004, more than €4.4 billion have been invested in improving Murmansk's deepwater port facilities to include new oil, coal and container terminals as well as expanded rail lines. Murmansk port capacities are projected to increase to an annual 28.5 million tonnes by 2010 and 52 million tonnes by 2020. Other Russian Arctic ports along the Northern Sea Route include Pevek, Tiksi, Igarka, Dudinka, Dikson, Vitino, Arkhangelsk and Novy. These ports are well-established and supported by the Russian icebreaker fleet, although many require long river transits to access.

Unique to the region is the Port of Varandey on the Pechora Sea coast. As oil production expands in the Russian Arctic, LUKOIL, in cooperation with ConocoPhillips, has developed Varandey into a deepwater oil export terminal. The Varandey facility consists of an onshore tank farm with a total rated capacity of 325,000 cubic meters (2,000,000 barrels); and an innovative fixed ice-resistant oil terminal 14 miles offshore, with a height of more than 160 feet. The terminal includes living quarters and a mooring cargo handling system with a jib and a helicopter platform; two underwater pipelines, connecting the onshore tank battery and the offshore oil terminal; and an oil metering station, auxiliary tanks, pumping station and power supply facilities. Sovkomflot has one new 70,000 DWT ice-strengthened oil tanker in operation and two being built in South Korean shipyards, to shuttle oil to Murmansk, as well as other locations in Europe and North America.

There are likely to be significant practical difficulties to be encountered in finding and supporting suitable places of refuge for ships in need of assistance in the Arctic and in providing such ships with adequate support.

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Places of Refuge

The Ilulissat Declaration outlined the need to cooperate to improve search and rescue and disaster response capability in the Arctic as marine activity increases. Central to this objective is the need for deepwater places of refuge and marine salvage/support capability.

According to IMO's *Guidelines on Places of Refuge for Ships in Need of Assistance*, a place of refuge means a location where a ship in need of assistance can take action to enable it to stabilize its condition and reduce the hazards to navigation, and to protect human life and the environment. A ship in need of assistance means a ship in a situation, apart from one requiring rescue of persons on board, which could give rise to the loss of the vessel or an environmental or navigational hazard.

With an increase in international Arctic shipping, it is likely that ships in need of assistance may need to request refuge in sheltered waters of the Arctic states. There are likely to be significant practical difficulties to be encountered in finding and supporting suitable places of refuge for ships in need of assistance in the Arctic and in providing such ships with adequate support. In the Arctic, harsh environmental conditions and increasing marine traffic densities make this course of action even more critical. Potential place of refuge guidelines detail the process by which port authorities decide where to allow a damaged ship to berth. In an attempt to balance shipping interests with the protection of natural and cultural resources, selection of such places should incorporate input from potentially affected governments, communities, the shipping industry and other stakeholders. Authorities should also rank places based on seasonal environmental conditions.

The European Union Places of Refuge Framework provides a model for the development of potential place of refuge guidelines by Arctic nations. Western Norway has an established system for places

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of refuge based on IMO guidelines and the EU framework, including predefined places if applicable. The system will be expanded to include the entire Norwegian coast, including Svalbard, by late 2009 or early 2010. The places of refuge are evaluated based on the EU Safety at Sea project.

Other Infrastructure Components

Arctic marine infrastructure includes components not required or taken for granted in temperate waters. Polar icebreakers and marine salvage capability are risk mitigators from the perspective of marine insurance companies. If a vessel navigating in the Arctic has readily available polar icebreaker and/or marine salvage support, the risk to the vessel and corresponding financial risk to owners and insurers is substantially reduced.

Icebreakers

Government and private icebreakers are a key resource in the development of the Arctic. Generally, icebreakers are able to carry out the following roles: maintenance of shipping tracks in ice-covered waters, close escort of shipping in ice, provision of ice information, sovereignty support/representation, search and rescue, environmental response, command platform for emergency response, medical evacuation in remote areas, harbor breakout, electrical power supply, science platform, constabulary function (maritime security), transporting cargo (northern re-supply and logistic support) and fisheries conservation and protection.

There are some 50 icebreakers in the world fleet. The Russian fleet is by far the largest and most powerful, counting icebreakers powered by nuclear power plants, with five of 75,000 shaft horsepower (shp). The Russian Federation recently announced the allocation of some 15 billion rubles to build another 75,000 shp icebreaker. The next largest

The world’s icebreaker fleets are aging and will require significant investment during the coming years to maintain their effectiveness and capability.

fleet of Arctic-class icebreakers is that of the Canadian Coast Guard. The Canadian Government recently announced an investment of $C720 million to provide an Arctic-class replacement for the *CCGS Louis S. St-Laurent*. Most other countries that operate icebreakers own one or two, other countries such as Denmark and Norway have small fleets of ice-strengthened vessels generally intended for fisheries patrol and interdiction. The world's icebreaker fleets are aging and will require significant investment during the coming years to maintain their effectiveness and capability. For instance, Canadian icebreakers are on the average 30-plus years old, while those of the U.S. are 30 years old, with the exception of the *USCGC Healy*, which was built in 2000. Of note is the recently issued report, *Polar Icebreakers in a Changing World*, which is a needs analysis of U.S. icebreaking requirements in the coming years. In addition, it is also known that a number of other countries are either building or planning construction of new icebreakers primarily intended for science research, namely the European Union and South Korea.

Icebreaker construction is very specialized and very expensive. Steel is thicker and stronger than that required for normal cargo ship construction. In addition, there are other necessary specific features, such as horizontal and vertical construction members that are deeper and stronger, reinforced icebelts and redundant features. These details are specified in a number of national regulations governing construction of ice-class ships, namely those of the Russian Federation, Canada, Finland and Sweden; as well as classification societies such as the American Bureau of Shipping, Det Norske Veritas, Germanischer Lloyd and Lloyd's Register. Recently, the International Association of Classification Societies approved their *Polar Class* construction standard as one of a number of "Unified Requirements." Classification societies have one year to enter the new requirement in their respective rules. Classification societies have the new requirements in their respective rules, and some are expected to keep their existing rules.

Marine Salvage Support

In the Arctic Ocean, with the exception of Norway, Iceland and ports along the Northern Sea Route, there are few places of refuge or government/commercial salvage response to support commercial shipping. Generally, there are limited ship repair and/or salvage infrastructure and pollution countermeasures capabilities based around the Arctic basin. This lack of an Arctic salvage capability is a concern to the marine insurance industry.

There is inadequate port, salvage, towing and other necessary marine infrastructure support for the growing amount of commercial traffic transiting the Great Circle Route through the Aleutian Islands. This was highlighted by the 2004 *M/V Selendang Ayu* engine failure and subsequent grounding with a spill of more than 1 million liters of fuel oil along the northern side of Unalaska Island (See page 88). This incident could have been prevented if large tugs and adequate salvage support were nearby; instead, the nearest tugs capable of handling this type of emergency were in Seattle, Washington. After the 738 ft *M/V Selendang Ayu's* engine broke down in gale-force Bering Sea winter weather, several efforts to tow it by small tugs based out of Dutch Harbor failed.

Baltic Sea Case Study

Introduction

As the Arctic Ocean becomes seasonally ice-covered, coupled with the likelihood of increased marine shipping activity, an evaluation of the Baltic Sea marine shipping regime could be considered as a model for ship operations, information systems, incident response and harmonization of regulations.

The countries of the Baltic Sea Area work to protect the marine environment of the Baltic Sea from all sources of pollution through intergovernmental cooperation under the Convention on the Protection of the Marine Environment of the Baltic Sea Area and its governing body, the Baltic Marine Environment Protection Commission (HELCOM). All detailed information of the HELCOM activities is placed on website www.helcom.fi.

The Baltic Sea area is a sensitive marine ecosystem that needs comprehensive nature conservation and protection measures. The Baltic Sea states within the framework of HELCOM designated 89 areas as Baltic Sea Protected Areas (BSPAs) on the basis of their significance for marine nature conservation and protection of habitat and species. Work is still ongoing to designate other offshore areas as BSPAs. In order to harmonize the approaches and implementation process for marine protected areas (MPAs) in the Northeast

Atlantic and the Baltic Sea, HELCOM and the OSPAR Commission, the governing body of the Convention for the Protection of the Marine Environment of the North-East Atlantic, have developed a detailed work program on marine protected areas closely linked to the European Union network for the protection of European fauna and flora, the so-called NATURA 2000 network.

The Baltic Sea States are dependent upon safe, secure and sustainable sea transports. The maritime traffic in the Baltic Sea area is dense and has increased notably since the beginning of the 1990s. The annual turnover for oil and oil products in the Baltic Sea is calculated to be approximately 160 million tonnes. On top of that, 500 million tonnes of other goods are annually transported by ships within the Baltic Sea area. Therefore an extensive regime of protective measures consisting of both international and national regulations is in place inside and adjacent to this semi-enclosed sea; examples of relevant measures are compulsory reporting and traffic surveillance, routing systems, compulsory pilotage and the designation of the area as a Special Area under Annexes I and V; and as a SOx Emission Control Area under Annex VI of the MARPOL 73/78 Convention.

Navigation Systems and Ship Operations

The Baltic Sea has some of the densest maritime traffic in the world. More than 2,000 ships are en route in the Baltic on an average day, not including ferries, smaller fishing boats or pleasure craft. Among those 2,000 ships, some 200 are oil tankers with a cargo up to 150,000 tonnes.

Several ferry lines connect the states in the Baltic proper. Some of the world's biggest ferries are transporting goods and people

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between Sweden and Finland and there are several other ferry lines; i.e., between Sweden and Germany, Denmark and Germany, and between Denmark and Sweden. Most of the year intensive fishing for herring, cod and salmon takes place, sometimes in close vicinity to the major shipping lanes. Incidents are not rare considering that up to 2,000 fishing boats could be at sea on an average day. In summer, large numbers of cruise ships from all over the world enter the Baltic Sea area to visit the many coastal cities of cultural interest, such as Helsinki, St. Petersburg, Tallinn, Riga, Gdansk, Rostock, Lübeck, Copenhagen, Visby and Stockholm. Also numerous pleasure craft are sailing between the more than 500 ports or between different archipelago areas in the Baltic Sea. Oil and gas activities are for the time being few, but are expected to grow in the southern section of the area.

Compulsory Reporting and Traffic Surveillance

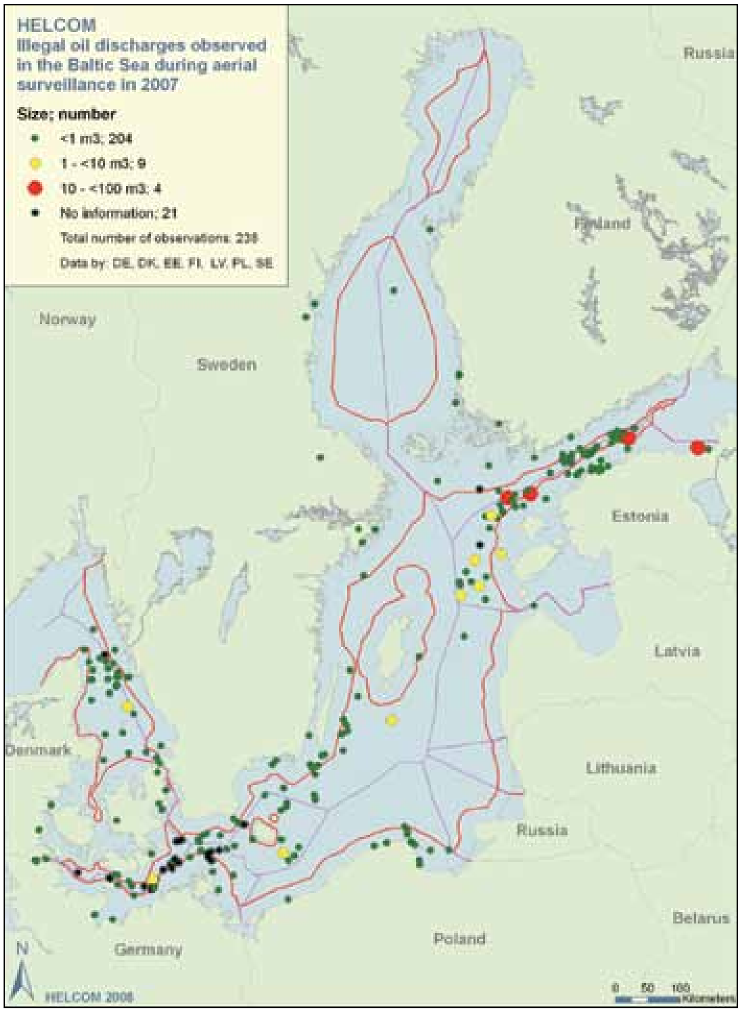
When ships enter the Baltic Sea they have to go through the Kattegat and the Great Belt or the Sound. There is intense traffic in the northern part of the area, where an extensive part of the traffic goes to and from Denmark as well as to and from the Baltic Sea. Large vessels follow the traffic lane Route T.

It is recommended that all ships of 20,000 gross tonnage and above navigating Route T should participate in the radio reporting service SHIPPOS together with all ships with a draft of 11 meters and more; loaded oil-, gas- and chemical tankers of 1,600 gross tonnage and above; and all ships carrying radioactive cargoes.

The system provides beneficial information to ships about other ship movements in the area. IMO has adopted a mandatory ship reporting system in the Great Belt Traffic Area. Ships with a gross tonnage equal to or exceeding 50 and all ships with a draft of 15 meters or more are required to submit a ship report to the VTS Centre.

Mandatory ship reporting systems have been established nationally by the Baltic Sea states in approaches to oil terminals and other ports. Article 4 of the EU directive 2002/59/EC of June 27, 2002, establishing a community vessel traffic monitoring and information system, states the operator, agent or master of a ship bound to a port of a member state shall report information to the port authority at least 24 hours in advance or in certain cases earlier. The information includes ship identification, port of destination, estimated time of arrival, etc.

A new mandatory reporting system has been introduced in the Gulf of Finland using the Gulf of Finland Mandatory Reporting System, GOFREP. In accordance with the IMO resolution, Finland, Estonia and the Russian Federation require that all vessels exceeding



Map 9.5 Location of oil spills observed in the Baltic Sea area in 2007. *Source: HELCOM*

300 gross tonnage are required to participate in the GOFREP system when sailing in the international waters in the Gulf of Finland. This reporting system will allow automatic reporting with AIS and automatic response from the GOFREP.

IMO resolution MSC.138(76) recommends masters use new and improved navigation equipment including Electronic Chart Display and Information System (ECDIS) onboard ships navigating Route T with a draft of 11 meters or more; oil tankers navigating the Sound with a draft of seven meters or more; chemical tankers; gas carriers; and ships carrying a shipment of irradiated nuclear fuel, plutonium and high level radioactive wastes (INF cargoes) irrespective of size. ECDIS supports plotting and automatically monitoring ships' positions throughout their voyage. The risk of collisions and groundings will be reduced by superimposing AIS and radar information on the electronic chart display.

Research Opportunities

- Research to advance the convergence of critical navigational information including hydrography (ENCs), weather, ice conditions and other data into integrated shipboard navigation systems.
- Research into technologies for hydrographic data collection, especially for adaptation to the Arctic environment. This should include the use of unmanned, underwater (under-ice) vehicles, multibeam technology, through-the-ice data collection, and airborne systems for the collection of nearshore depths and for shoreline identification.
- Research on satellite remote sensing and surface validation to develop means of monitoring ice thickness across the Arctic Ocean.
- Simulated conditions or field testing of oil spills and other pollutants to determine behavior including fate and effects. This should include improvements in remote surveillance and detection technologies; improved oil-in-ice modeling capabilities and long-term fate and effects of lingering oil.
- Focus on further development and improvement of ice service products and services on ice thickness, iceberg detection, forecasting of ice drift and drift of icebergs.
- Research on behavior of oil in cold, ice infested areas including establishing forecasting models to compute the drift of oil in such waters.
- Further development of satellite based oil detection algorithms for ice-covered areas.
- Research on effective response techniques and technology for oil spill recovery on ice, broken ice and cold water.

Routing Systems

A transit route (Route T) through the Kattegat, the Great Belt and the Western Baltic has been established for deep draft ships. Routing systems have been established for ships navigating the Sound. A deepwater route (DW) from Bornholm, south of the Hoburgen bank and up to the border with the Estonian Economic Zone fulfilling the IHO S44 standard for hydrographic surveying has been established. With a clearance of 10 nautical miles to the banks, this will allow a ship with, for example, an engine failure, ample time for speed reduction to be able to drop anchor.

Fifteen traffic separation schemes are established and adopted by IMO in eight parts of the Baltic Sea Area. Two schemes are established in Samsø Belt/Great Belt, two in the Sound, one off Kiel lighthouse, one south of Gedser, one south of Öland Island, one south of Gotland Island, two in the entrance to the Gulf of Finland and five in the Gulf of Finland.

Pilotage

Pilotage services are established locally by the port states and are normally compulsory for ships over certain sizes.

Due to the *Copenhagen Treaty 1857*, ships sailing to or from the North Sea to the Baltic Sea are not required to use pilots. The IMO recommends that when navigating the entrances to the Baltic Sea, local pilotage services should be used by ships as identified in Resolution MSC.138 (76). Certified pilots for the entrances to the Baltic Sea are available in Denmark and, for ships passing through the Sound, in Sweden. Certified Baltic Sea deep-sea pilots are available in all Baltic Sea States.

Weather and Wave Information Systems

Weather and wave monitoring and information systems have been established by the Baltic Sea States in the Baltic Sea area. Weather and wave information is available for seafarers at all times.

Ice Information Systems

Baltic Icebreaking Management (BIM) is an organization with members from all the Baltic Sea states: Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Norway, Poland, the Russian Federation and Sweden. The overall objective of BIM is to ensure a well functioning, year-round maritime transport system in the Baltic Sea through the enhancement of strategic and operational cooperation between the Baltic Sea countries in the area of winter navigation assistance.

The Internet site, www.Baltice.org, is a single access point to reliable and up-to-date information related to winter navigation in the Baltic Sea area.

Protection of People and Property: Incident Response and Overall Coordination

Search and rescue at sea means saving and protecting lives of persons in distress in the sea area. This includes many different duties like assisting vessels and boats in distress at sea, preventing disasters, searching for missing people and performing medical transport in the archipelago and sea area. The basis for carrying out these duties is enacted in international treaties and decrees. All authorities operating in the Baltic Sea area carry out SAR at sea. Also participating are merchant shipping and voluntary organizations. For example, in Finland, the Border Guard is responsible for SAR service at sea and the Maritime Rescue Coordination Centre and maritime rescue sub-centers lead SAR operations. When the persons or environment are no longer in danger, commercial companies carry out the salvage of vessels and cargo.

Protection of the Environment: Oil and Other Hazardous Spills Response

The cooperation in combating spillages of oil and other harmful substances in the Baltic Sea area is based on the Helsinki Convention and HELCOM Recommendations on combating matters, adopted by the Helsinki Commission.

In accordance with the Helsinki Convention the Contracting Parties shall maintain the ability to respond to spillages of oil and other harmful substances into the sea threatening the marine environment of the Baltic Sea area. This ability shall include adequate equipment, ships and manpower prepared for operations in coastal waters as well as on the high seas.

According to the Helsinki Convention, the Contracting Parties shall agree bilaterally or multilaterally on those regions of the Baltic Sea Area in which they should conduct aerial surveillance and take action for combating or salvage activities whenever a significant spillage of oil or other harmful substance or any incident causing or likely to cause pollution within the Baltic Sea area has occurred or is likely to occur.

In cases where a Contracting Party is not able to cope with a spillage by the sole use of its personnel and equipment, the Contracting Party in question can request combating assistance from other Contracting Parties, starting with those who seem likely also to be affected by the spillage.

Monitoring / Enforcing Compliance with Marine Regulation

Port State Control

Port State Control systems have been established by the Baltic Sea States in all Baltic Sea ports in accordance with the Paris Memorandum of Understanding.

Aerial Surveillance

By international law, any release of oily wastes or oily water from ships is prohibited in the Baltic Sea, where oil pollution can affect sensitive ecosystems for long periods. But ships persist in making illegal discharges, despite improvements in port reception facilities and a harbor fee system, which means there is no financial gain to be had from polluting the sea. Every year national surveillance aircraft detect several hundred illegal oil discharges in the Baltic Sea. The actual number of illegal discharges is probably much higher than this. In fact, during most years more oil is released on purpose around the Baltic Sea than is spilled accidentally.

Internationally Coordinated Surveillance Flights

The HELCOM states endeavor to fly, at a minimum, twice per week over regular traffic zones including approaches to major sea ports, as well as in regions with regular offshore activities; and once per week over the regions with sporadic traffic and fishing activities. Twice a year, several Baltic Sea states jointly organize surveillance flights (24 to 36 hours): one covering the southern part of the Baltic Sea and another flight over waters further north.

Arctic Maritime Training

Maritime training in ice conditions is available by private companies in the Baltic Sea area.

The content of the courses includes ice characteristics and ice classifications, ice charts, ice classes, winterization, ship operations in ice, independent navigation in ice, icebreaker operations and ice navigation in convoy. Training of ship maneuvering in ice is done in a full-mission simulator.

Findings

1] Considering the Arctic operational environment and the lack of infrastructure, safe navigation in the Arctic is often dependent on the skills of a limited number of seasoned northern mariners. The demand for skilled mariners is increasing, the number of experienced Arctic mariners is decreasing and there are no universal or mandatory formal education, training and certification requirements in place for ice navigators or crew to prepare them for Arctic marine operations.

2] Based on the information provided, significant portions of the primary Arctic shipping routes do not have adequate hydrographic data, and therefore charts, to support safe navigation. This appears most critical in the Canadian Archipelago and the Beaufort Sea and possibly other areas in the Arctic; at the same time the Russian Federation has broadly identified a requirement for updated hydrography in its Arctic waters. In addition, expansion of the current routes is required to allow alternative courses when hazardous ice conditions are encountered, for entry to points of refuge when necessary, and to support access to natural resources.

3] Electronic Chart Display and Information Systems (ECDIS), especially when coupled with Digital Global Positioning System, improves navigational safety by providing precise, real-time positioning along with holistic display of navigation and environmental information critical for safe navigation in the Arctic. ECDIS may also reduce the requirements and costs associated with deploying and maintaining traditional aids to navigation systems. This creates a high expectation that hydrographic offices will have electronic charts ready for use in the primary navigation routes in the Arctic by 2012. However, the use of ECDIS is wholly dependent on the availability of accurate navigational charts, which rely on comprehensive hydrographic surveys and data.

4] Arctic Maritime Traffic Awareness - There are few systems to monitor and control the movement of ships in ice-covered Arctic waters as an effective way to reduce the risk of incidents, particularly in areas deemed sensitive for environmental or cultural reasons.

5] There are serious limitations to radio and satellite communications for voice or data transmission in the Arctic because there is not complete satellite coverage of the region.

6] There is no binding requirement to implement the recently developed and adopted International Association of Classification Societies (IACS) Unified Requirements concerning *Polar Class* and the December 2002 IMO *Guidelines for Ships Operating in Arctic Ice-covered Waters;* consequently polar vessel construction standards are unevenly applied.

7] For safe operations, ships navigating in the Arctic need the same suite of meteorological and oceanographic data, products and services as in the other oceans plus a comprehensive suite of data, products and services related to sea ice and icebergs. As the shipping season becomes extended, significant increases in resources will be needed to expand the information services accordingly.

8] Emergency response capacity for saving lives and pollution mitigation is highly dependent upon a nation's ability to project human and physical resources over vast geographic distances in various seasonal and climatic circumstances. The current lack of infrastructure in all but a limited number of areas, coupled with the vastness and harsh environment, makes carrying out a response significantly more difficult in the Arctic. Without further investment and development in infrastructure, only a targeted fraction of the potential risk scenarios can be addressed.

9] The operational network of meteorological and oceanographic observations in the Arctic, essential for accurate weather and wave forecasting for safe navigation, is extremely sparse.