PART III

POTENTIAL ARCTIC FISHERIES

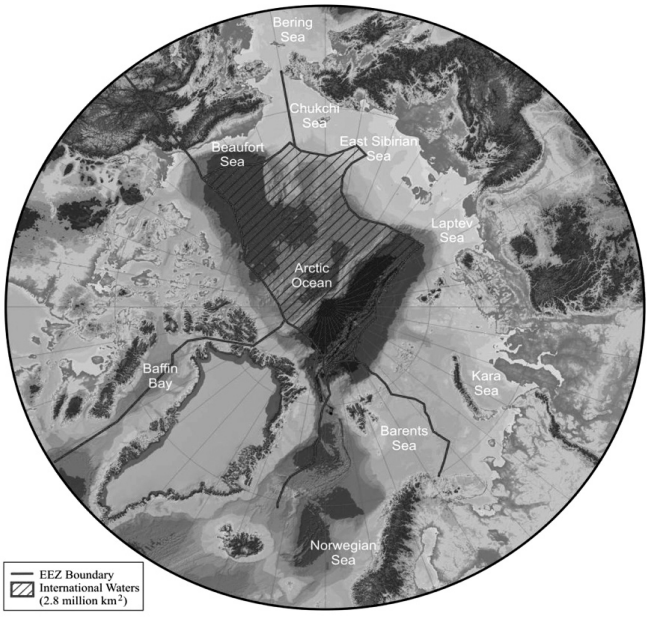
Natural science perspective

Herald Loeng

INTRODUCTION

A high proportion of shallow continental shelves (Figure III-1), dramatic seasonal changes, low temperatures, extensive ice cover, and a large supply of freshwater from rivers and melting ice: this combination of extreme conditions makes the Arctic a unique marine ecosystem. This ecosystem hosts a large number of specialist species not found elsewhere. While these organisms have adapted to the Arctic environment over time, they continue to be challenged by extreme interannual variations.

Climate variability affects ecological processes in a multitude of well-documented ways, varying across a broad range of temporal and spatial scales. Empirical evidence shows the effects of climate variability on the dynamics of marine ecosystems; these effects carry with them potentially



Note: The red lines indicate EEZ boundaries; the hashed area in the middle is international water.

Figure III-1 Arctic Ocean and surrounding shelf seas

important implications for commercial fisheries.

The abundance and distribution of fish and shellfish stocks associated with long-term temperature changes provide one example. Fish can be affected directly through physiology, including metabolic and reproductive processes, and indirectly as their biological (predators, prey, species interactions) and abiotic environments (habitat type and structure) change. Added to these processes are ecological responses to climatic variation, which may be immediate or lagged, linear or nonlinear, and result from interactions between climate and other sources of variability (such as the amplification of climate effects due to fishing).

Significant progress has been made in identifying mechanisms by which climate change can affect fish population dynamics through efforts to understand how climate change will impact shifts in the distribution of fish species and through the development of climate models to predict the future effects of climate change on species distribution. Several cases show how increased temperatures can cause fish to migrate northward in the North, Norwegian, Barents and Bering Seas. The recent migration of mackerel into Icelandic waters may be a consequence of increasing ocean temperature.

Predicting the responses of commercial species to further climate change is of great interest to scientists, governments, and fishers. While acknowledging the present limitations in understanding, several scientists have synthesized existing information to develop conceptual models of how climate change will impact marine ecosystems. One question that weighs heavily in such efforts is whether it is possible to evaluate the potential for commercially important fish stocks to migrate from subarctic areas into the central Arctic Ocean or Arctic continental shelf seas.

Species such as Arcto-Norwegian cod and capelin that already live close to the Arctic Ocean are more likely to expand or move into the high Arctic than other species. Considerable uncertainty remains as to whether or not these species will be able to colonize the Arctic successfully. Despite the fact that many species have evolved temporal patterns of feeding and reproductive behavior that maximize survival, climate change that shifts the temporal match with key aspects of life history may affect survival. Several species exhibit seasonal spawning or feeding migrations. If the quality or quantity of habitat changes, these migrations may fail. Qualitative assessments have identified several factors that will govern the potential expansion and movement of commercial fish and shellfish species into the

Arctic. The important environmental factors include the spatial distribution of suitable thermal conditions, the availability of prey, and the depth of migration corridors into or out of the Arctic Ocean. Key life history and behavioral characteristics include growth potential, fidelity to spawning sites, foraging plasticity, thermal tolerances, habitat depth, and projected spawning stock size.

The potential consequences of climate change for marine fish stocks may include large-scale geographical redistribution as well as alterations to the trophic flows and food webs. It is therefore important to understand the processes that influence the spatial distribution of fish stocks.

Our current understanding of the effects of these interactive forces is summarized in Hollowed, Planque and Loeng (2013). At this time, we can identify a number of issues that require further investigation in this context.

MAXIMUM SUSTAINABLE YIELD

There are few fishable resources in the Arctic Ocean today; immigration of species from further south in the near future is not likely. Several factors account for this situation. First, the Arctic Ocean has hitherto low primary production due to the almost permanent ice cover. Where there is no primary production, there will be no basis for a food web. Second, the Arctic Ocean is a deep ocean, preventing bottom-dwelling fish from entering, so the large stocks of demersal fish found in the surrounding shelf areas will not enter the Arctic Ocean, even if production should increase following the thawing of ice. Should plankton production increase in the future, some stocks of pelagic fish might enter the Arctic Ocean during a feeding migration in the ice-free season. Candidates on the Atlantic side include the big pelagic stocks in the Norwegian Sea; the Atlantic herring (*Clupea harengus*), the blue whiting (*Micromestitius poutassou*), and the stock of capelin (*Mallotus villosus*) in the Barents Sea. Other possible candidates among fishable resources for entry into the Arctic Ocean during feeding migrations are the beaked redfish (*Sebastes mentella*) and the Greenland halibut (*Reinhardtius hippoglossoides*), both deep-water species that live partly near the sea floor and partly lead a deep pelagic life. But even if these or other stocks were to enter the Arctic Ocean during the feeding season, the chances that a fishery based on those stocks would develop are low. Since these species would be accessible in greater

concentrations further south during their spawning season or during migration to and from the spawning areas, which would be much nearer to the home ports of fishers, it would probably not be economically viable to fish for those stocks in the Arctic Ocean, even though it would be possible to do so.

In a situation where future temperatures in the sub-Arctic areas rise to a level at which the stocks living there today would have to move northward to survive, a scenario featuring fishing for pelagic species in the Arctic Ocean is conceivable. But for the stocks to survive in such a situation, their whole lifecycle would have to change, giving rise to a new lifecycle with new spawning areas, nursery areas, wintering areas, feeding areas and migration routes of adult fish as well as passive transport routes for eggs and larvae. This process would probably take many decades or even centuries. Most likely, stocks would barely survive such a period, and we would be unable to maintain any fishing while they gradually establish their lifecycle in a new environment.

MANAGEMENT AND CONTROL

In a situation where resources have moved into the Arctic Ocean, either during part of the year or permanently, fishing there could be profitable. In such a situation, the management regime in force today would have to be amended to include these areas. The first parts of the Arctic Ocean to become ice-free and support harvestable stocks of fish or crustaceans would likely be the peripheral areas adjacent to the shelf seas to the south. These areas are found within the exclusive economic zones of Russia, Norway, Denmark, Canada and the United States. Fishing within these zones would not require any change from the present management and control regime. If fishing developed in the high seas beyond the jurisdiction of coastal states, management would have to be carried out by an organization such as the North East Atlantic Fisheries Commission (NEAFC), which could undertake management beyond the exclusive economic zones in the Norwegian and Barents seas, or by a new management regime established by the countries surrounding the Arctic Ocean.

SOME POINTS FOR FUTURE RESEARCH AND DISCUSSION

1. How will the Arctic marine climate change? Will the Atlantic inflow increase or decrease, and how will warming from the atmosphere impact the temperature of the shallow shelf seas and the deep Arctic Ocean? Changes in the physical environment are highly uncertain, but critical for the kind of marine ecosystem that will develop in the Arctic. Improved modeling of the ocean and sea ice in global circulation models is necessary. For example, how will the thermohaline circulation change? What will be the consequences of changes in the thermohaline circulation for the position and strength of ocean fronts, ocean current patterns, and vertical stratification? The development of reliable regional models for the Arctic is essential in determining impacts on the physics and biology of Arctic marine ecosystems. Increased emphasis on coupling biological models with physical models is needed to improve predictive capabilities.
2. How will the productivity of Arctic ecosystems change? It is anticipated that climate change will result in higher phytoplankton production in the Arctic due to the loss of seasonal sea ice (http://www.cbc.ca/news/technology/ story/2012/06/07/ sci-phytoplankton-blooms-arctic.html). It is clear that we will have a longer production season in ice-covered areas, as described by Wassman (2011). But will the total primary production increase? Stronger stratification will reduce the vertical mixing and transport of nutrients from deeper layers to the surface layer where the primary production takes place.
3. What species are most likely to migrate successfully into the Arctic, establishing self-sustaining populations? Bottom topography will limit fish migration to the Arctic Ocean to pelagic species. Dermersal stocks such as northeast Arctic cod and haddock will be unable migrate to the deep Arctic Ocean. Climatic conditions and sea ice distribution are factors that also will influence future fish migrations. Other factors are food conditions and distance to spawning grounds. The timing of reproduction for many species is related to that of the behavior of their prey. How the timing and location of the production or spawning of most species may change in response to climate change is unclear. So is the potential match or mismatch

between predators and their prey. This factor could impact the whole Arctic ecosystem.

4. How are successful migrations likely to alter Arctic marine ecosystems? The biota is affected indirectly by atmospheric climate change through effects on the surrounding environment and on the food web. While the response of a species to change in one particular variable often can be surmised (but generally not quantified), its response to a collection of direct and indirect effects occurring simultaneously is considerably more difficult to anticipate. The nonlinearity of many relevant processes adds further complications. We cannot predict the competition that may occur if and when new species are introduced into the ecosystem. Many Arctic specialists have a relatively narrow habitat and other niche requirements. Their responses to possible increases in competition from more opportunistic/generalist species in a warmer Arctic are unclear. The abundance and variability of gelatinous zooplankton such as jellyfish have not been determined for most Arctic regions. Gelatinous zooplankton are known to be important as both predators and prey, and they can represent a significant component of the biomass at times. But their actual role within the ecosystem is unclear.

References

Hollowed, A. B., B. Planque, and H. Loeng. 2013. "Potential Movement of Fish and Shellfish Stocks from the Sub-Arctic to the Arctic, Ocean." *Fisheries Oceanography* 22: 355-370.

Wassman, P. 2011. "Arctic Marine Ecosystems in an Era of Rapid Climate Change." *Progress in Oceanography* 90: 1-17.

Social science perspective: the future of Arctic fisheries governance – a restless sea

David L. VanderZwaag*

INTRODUCTION

Harald Loeng's perspective is especially useful as a "myth buster." A considerable number of nongovernmental organizations (NGOs) and academics have jumped quickly to the conclusion that sub-Arctic fish stocks are swarming to the higher Arctic and that immediate establishment of a regional fisheries management organization (RFMO) is necessary to ward off the hordes of commercial fishers waiting in the wings. While recognizing the numerous uncertainties surrounding the prediction of future fish stock distributions in light of climate change impacts on the Arctic marine environment, Loeng's perspective offers a counter dose of scientific realism. Loeng highlights the various factors hindering the substantial movement of sub-Arctic fish stocks into the Arctic Ocean in the near future. Those factors include the cold water pool in the Bering and Chukchi Seas, the general low primary production of Arctic waters, and the prevalence of areas of deep ocean.

He notes the possibility that some pelagic fish stocks will enter the Arctic Ocean during feeding migrations in the ice-free season. Those stocks include Atlantic herring, blue whiting, capelin and two deep-water species, beaked redfish and Greenland halibut. However, he does not foresee a high probability of commercial fishing due to far greater accessibility to such stocks in more southerly waters.

Given his overall scepticism regarding future commercial fisheries in the Arctic Ocean, Loeng devotes minimal attention to future management scenarios. He suggests the areas of the Arctic Ocean will most likely experience commercially harvestable fish or crustaceans within the 200 nautical mile zones of the five coastal states where national governance regimes would apply. If commercial fishing in the Arctic Ocean beyond

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national jurisdiction were to develop in the future, he notes that the existing North East Atlantic Fisheries Commission (NEAFC) already covers a significant portion of the area, and concludes that a new agreement might have to be forged and an equivalent commission formed to cover the broader ocean area.

Launching from Loeng's limited-governance discussion, my comments provide additional detail on the future governance of Arctic fisheries with a focus on the North Pacific Arctic and Central Arctic Ocean (CAO). A nautical image largely capturing the fishery governance seascape is that of a "restless sea."

RESTLESS SEA

Five unsettled governance dimensions stand out: the multiplicity of governance options offered by academics, NGOs and others; limited attention to CAO issues on the part of the Arctic Council; limited setting of governance coordinates by the five Arctic coastal states; the churning waters of Arctic marine scientific research, and ongoing debates within the United Nations over future governance of marine biodiversity beyond national jurisdiction.

Multiplicity of Governance Options

A broad array of future governance options for the CAO has surged from academics, NGOs and others without producing any obvious consensus. Suggestions include: establishment of a regional fisheries management organization; possible expansion of the fisheries jurisdiction of NEAFC; creation of a regional ocean management organization; adoption of an Arctic Ocean framework convention applicable to the Arctic marine environment both within and beyond national jurisdiction; a regional *sui generis* approach whereby the five Arctic Coastal States (Arctic 5) would divide the "CAO pie" into national sections, and a declaration of governance principles, including a precautionary approach to new resource developments.

Limited Addressing of CAO Issues by the Arctic Council

The Arctic Council has not paid much attention to issues of fisheries management issues. Only recently has the Council paid attention to looming CAO living marine resource governance concerns. The Arctic Ocean Review (AOR) report, prepared by the Protection of the Arctic Marine Environment (PAME) Working Group and submitted to the May 2013 ministerial meeting in Kiruna, Sweden, included a chapter on living marine resources that suggested various possible future management options. These options include: expanding the existing United States' precautionary moratorium on commercial fisheries located in its Arctic exclusive economic zone (EEZ) to the broader CAO; establishing a treaty-based fisheries research council, and forging a less formal scientific committee.

The AOR-negotiated recommendation on fisheries resources beyond national jurisdiction is very general and noncommittal. Recommendation 10 simply calls for such fisheries resources to be "managed based on cooperation in accordance with international law to ensure long-term sustainability of fish stocks and ecosystems" (AOR, p. 94). The lack of greater clarity and specificity in the text apparently stems from concerns by Norway regarding the appropriateness of the Arctic Council versus the Arctic 5 as the proper forum for addressing fisheries issues in the Arctic Ocean.

Limited Setting of Governance Coordinates by the Arctic 5

The representatives of the five Arctic coastal states did address CAO governance tangentially at their meeting in Ilulissat, Greenland in May 2008. Through the Ilulissat Declaration, they indicated that the law of the sea provides a solid foundation for responsible management by the Arctic 5 and other users of the Arctic Ocean, and they opined that there is no need to develop a new comprehensive international legal regime to govern the Arctic Ocean. Under a law of the sea approach, all states enjoy various freedoms, including those of fishing and navigation, but various responsibilities would also apply, including duties to cooperate in conserving and managing fish stocks on the high seas.

Building on meetings of the Arctic 5 officials in Oslo in 2010 and a meeting of fisheries science experts in Anchorage in 2011, officials from Canada, Denmark, Norway, the Russian Federation and the United States met again from April 29 to May 1, 2013, in Washington, D.C. to discuss

possible future fisheries in the CAO. The Chairman's Statement from the meeting, while expressing the general understanding that commercial fishing in the high seas area of the CAO is unlikely to occur in the near future. It also noted a recognition of the desirability of addressing the possibility of future commercial fishing in the area. Key points relating to management that emerged from the discussions included: the present lack of need to establish any additional RFMO(s) for the area; the desirability of developing interim measures whereby commercial fishing in the high seas area should only take place pursuant to one or more regional or sub-regional fisheries management organizations or arrangements that are or may be established; the need to improve scientific understanding, and the appropriateness of the Arctic 5 taking the initiative on this matter.

The Washington meeting certainly leaves a "restless sea" in its wake. The Chairman's Statement recognized the need to engage with Arctic residents, particularly indigenous peoples, and acknowledged the advisability of including non-Arctic states in talks at some point in the future. Norway offered to host a further scientific workshop in October 2013 and Denmark offered to convene the next meeting of the Arctic 5 officials to continue policy discussions before the end of 2013. How interim measures might best be facilitated has not been sorted out, with various avenues possible, such as through a UN sustainable fisheries resolution, a declaration by the Arctic 5, or a multilateral agreement.

Churning Waters of Arctic Marine Scientific Research

Scientific research into changing Arctic fisheries appears to be quite fragmented and is evolving continually. For the North Pacific, scientific research efforts are spread across a number of entities including the North Pacific Marine Science Organization (PICES), the Scientific and Technical Committee on the Conservation and Management of Pollock Resources in the Central Bering Sea, and the North Pacific Anadromous Fish Commission. A new Convention on the Conservation and Management of High Seas Fisheries Resources in the North Pacific Ocean opened for signature in April 2012 and includes a commitment by parties to cooperate in enhancing scientific research on fisheries and associated ecosystems, although the scientific committee is not to duplicate the activities of other scientific organizations and arrangements that cover the new agreement's conservation area.

The role of the Arctic Council in facilitating and coordinating scientific research across the circumpolar Arctic might be described as a work in progress. Ministers of the Arctic Council at their May 2013 meeting in Kiruna agreed upon the great importance of cooperation in scientific research and decided to establish a task force to work towards an arrangement on improved scientific research cooperation among the eight Arctic states.

The initiative of the Arctic 5 to address possible future fisheries in the CAO is a further churning aspect. While consensus on the need to improve scientific understanding of the Arctic high seas areas was reached at the Washington, D.C. meeting of officials in 2013, precisely how to advance stronger scientific cooperation has yet to be determined.

Ongoing Debates within the UN

Debates within the UN over future directions for governance of marine biodiversity in areas beyond national jurisdiction have been ongoing for almost a decade. The two main bones of contention are whether marine genetic resources located beyond areas of national jurisdiction are subject to the freedom of the high seas regime under the law of the sea, and whether there should be a new implementation agreement attached to the UN Law of the Sea Convention and focused on marine biodiversity beyond national jurisdiction. Such an agreement might serve various functions, including a clarification of governance principles; fleshing out environmental impact assessment responsibilities and procedures, and providing a global mechanism for establishing marine protected areas in the high seas.

The main avenue for facilitating international discourse on these issues has been through the Ad Hoc Open-ended Informal Working Group to study issues relating to the conservation and sustainable use of marine biological diversity in areas beyond national jurisdiction. However, the Working Group has not been able to bridge the deep divide in national perspectives even after five meetings held between 2006 and 2012. A sixth meeting held in New York on August 19-23, 2013, called for a further of three meetings to develop recommendations on the scope, parameters and feasibility of an international instrument under the convention.

The unresolved UN debates represent a further "restless sea" reality for the Arctic Ocean. It remains to be seen whether new global commitments

to high seas governance will be forthcoming and, if so, what impact they would have on the Arctic.

CONCLUSION

While the "restless sea" image certainly captures the essence of present fisheries governance in the Arctic Ocean, two other nautical images round out the law and policy picture. The phrase "just leaving port" seems quite apt for a number of reasons. Arctic states have yet to develop a network of marine protected areas in the Arctic. The Arctic Council's Conservation of Arctic Flora and Fauna (CAFF) Working Group has failed to deliver on the networking front, and the PAME Working Group has only placed the possible establishment of a regional network on the Arctic agenda in its most recent Workplan 2013-2015. Ascertaining the interests and views of indigenous peoples' organizations and non-Arctic states in future Arctic Ocean fisheries has hardly begun, and avenues for future dialogue have yet to be defined. The implications of ecosystem-based management (EBM) in the Arctic have yet to be fully worked out, with a PAME-led Group of Experts on the Ecosystem Approach to Management continuing discussions on this topic. The AOR report recommended the periodic convening of Arctic Council-wide meetings on ecosystem-based management to share knowledge and experiences regarding management and science across Large Marine Ecosystems.

A "sea of challenges" is a further descriptor. Numerous transboundary fisheries-related challenges have yet to be sorted out. These challenges include: delineating the Canada-U.S. ocean boundary in the Beaufort Sea; working towards consistent national fisheries management approaches within Arctic EEZs, and ensuring effective fisheries governance under existing bilateral and regional agreements. For example, the North Atlantic Salmon Conservation Organization (NASCO) continues to struggle over the harvesting of Atlantic salmon off the coast of West Greenland. While scientists have consistently urged a precautionary halt to harvesting of a mixed stock that includes endangered North American salmon, NASCO has continued to authorize an annual take by Greenland for local consumption estimated to be about 20 tons. In 2012, Greenland's harvest was estimated to be 34 tons, with a further 10 tons likely unreported. Greenland's recent decision to allow landings for factory processing, including freezing, has

raised concerns over possible "quota creep."

How Arctic fisheries governance at the national, regional and perhaps even global levels evolves in the future will likely depend on two main drivers. The impacts of climate change and globalization promise to propagate an ongoing "restless sea."

References

Hassan, Daud. 2009. "Climate Change and the Current Regimes of Arctic Fisheries Resources Management: An Evaluation." *Journal of Maritime Law and Commerce* 40 (4): 511. Baltimore: Jefferson Law Book Company.

Huebert, Rob, and Brooks B. Yeager. 2008. "A New Sea: The Need for a Regional Agreement on the Arctic Marine Environment." WWF International Arctic Programme.

Jeffers, Jennifer. 2010. "Climate Change and the Arctic: Adapting to Changes in Fisheries Stocks and Governance Regimes." *Ecology Law Quarterly* 37 (3): 917-077(2010). Berkeley: UC Berkeley School of Law.

Johnston, Douglas M. 2003. "The Future of the Arctic Ocean: Competing Domains in International Public Policy." In *Ocean Yearbook* 17, edited by Elisabeth Mann Borgese, Aldo Chircop, Moira L. McConnell, 596-624. Chicago: University of Chicago Press.

Molenaar, Erik J. 2009. "Climate Change and Arctic Fisheries." In *Climate Governance in the Arctic*, edited by Timo Koivurova, E. Carina, H. Keskitalo and Nigel Bankes, 145-169. Berlin: Springer.

Rayfuse, Rosemary. 2007. "Melting Moments: The Future of Polar Oceans Governance in a Warming World." *Review of European Community and International Environmental Law* 16: 196-216. Oxford: Blackwell Publishing.

PAME. 2013. The Arctic Ocean Review Project. Final Report (Phase II 2011-2013), Kiruna (May 2013).

VanderZwaag, David L. 2011. "The Arctic Council at 15 Years: Edging Forward in a Sea of Challenges." *German Yearbook of International Law* 54 (2011): 281-314.

VanderZwaag, David L. 2009. "Climate Change and the Future of Arctic Governance: A Slushy Seascape and Hard Questions." *In Climate Governance in the Arctic (Environment & Policy)* 50, edited by Koivurova, Keskitalo and Bankes, 403-427. Berlin and Heidelberg: Springer.

Conservation perspective

Henry P. Huntington

Harald Loeng's perspective does a nice job of laying out current scientific understanding about the fisheries biology of the Arctic Ocean and the prospects for substantial growth of existing Arctic fish populations or the northern shift in distribution of fishes currently found farther south. He acknowledges a degree of uncertainty in any such projections and notes that fishery management may have to adapt if fishable stocks are found in Arctic waters. This last point deserves further elaboration.

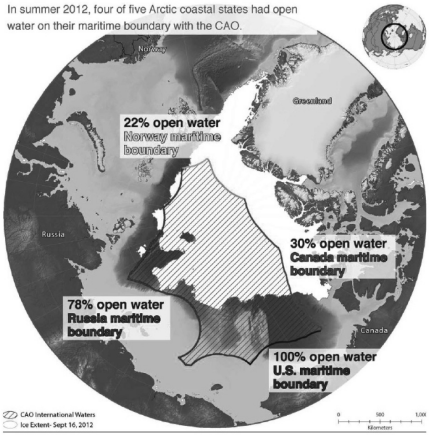
A key challenge in fisheries management is dealing with uncertainty. Fish stocks are variable in size and distribution, and estimates about both parameters often have wide margins of error. But fisheries management is fundamentally about managing human activities, and here there is less uncertainty. Humans have fished everywhere that fishermen have thought they might find fish.

In the absence of regulation, overfishing is the typical outcome, not an exception. Where sound fisheries management does exist, it has largely been implemented in response to crises, rather than as a means of creating sustainable outcomes from the start.

These two patterns – a global tendency toward overfishing and the practice of imposing rigorous management only after a problem has occurred – pose a serious challenge in the central Arctic Ocean. Beyond the EEZs of the Arctic coastal countries, these waters currently are not subject to any fisheries management, with the exception of a small sector north of Europe that falls under the auspices of the North East Atlantic Fisheries Commission (NEAFC). (Within the five Arctic coastal states' EEZs, fisheries are subject to existing national regimes, a topic not considered here.)

Some argue that the lack of a fisheries management regime for the high seas in the central Arctic Ocean is not a problem on the grounds that central Arctic fisheries do not exist yet, that there is no evidence that the region will ever be home to large stocks of commercially desirable fish, and that there is scant motivation for fishers to travel that far in search of fish. This argument neglects some critical points.

First, forecasts of future fish abundance are speculative. Forecasting is an inexact science, and more so when projections involve multiple factors, from sea ice and water temperature to primary productivity to determining



Note that most of the open water is in the Pacific sector, with no ice remaining along the outer edge of the U.S. EEZ.

Figure III-2 Ice extent in the Arctic Ocean in September 2012, in relation to the high seas area of the central Arctic Ocean

which fish will be where and in what numbers. Loeng's perspective focuses primarily on the Atlantic sector of the Arctic, with references to Atlantic fishes and a future in which open water "probably would occur" first within the EEZs of coastal states. In the Pacific sector, however, the future is here: open water has extended well into the high seas area each summer since 2007, including over 40% of the central Arctic Ocean in 2012 (Figure III-2). Furthermore, the Pacific sector is shallower than the Atlantic sector, providing more areas that may be attractive both to fish and to fishermen.

Second, the most common fish in the Arctic Ocean is the Arctic cod (*Boreogadus saida*, sometimes also called polar cod, and thus often confused with *Arctogadus glacialis*, which is also sometimes called polar cod or Arctic cod). *B. saida* can be found in large aggregations, and has been seen in the central Arctic Ocean beneath Russian ice stations. Arctic cod have been harvested since at least the early 1950s, with a peak catch of over 300,000 tonnes in 1971, and a recent catch of 19,600 tonnes in Russian waters of the Barents Sea in 2011. Most of the catch has been used for dog food, fish meal, and oil, with some for human consumption. But innovations are always possible, and it is not hard to imagine an increased interest in an untapped source of protein.

Third, Arctic cod are central to the Arctic Ocean food web, and their removal would have wide-ranging implications for the ecosystem. Polar bears, ringed seals, beluga whales, seabirds, and other species that depend,

directly or indirectly, on Arctic cod are found in the central Arctic Ocean as well as within Arctic EEZs. Those species also migrate from coastal areas to the high seas and back. Thus, impacts in the high seas may affect marine mammals and seabirds found close to the coast. In Alaska, Russia, and Canada, these same stocks of marine mammals and seabirds are hunted by Arctic residents. This means that the impacts of central Arctic Ocean fisheries could include diminished human well-being in the Arctic, alongside any possible economic benefits from a fishery.

Fourth, the newly open waters of the Arctic summer are well within reach of distant-water fishing fleets, being about two-thirds the distance from major Pacific ports as is the Antarctic, where fishermen from those ports already operate. Loeng states that fishermen are unlikely to go all the way to the Arctic high seas if they can catch more fish within the EEZ, closer to home. This is true, but only for fishermen who can legally fish within Arctic EEZs. Fishermen from other nations, such as those on the Pacific Rim, cannot stop within, say, the U.S. EEZ and start fishing. They would have to continue to the international waters. Currently, there is nothing to stop them from doing so.

Fifth, there is much room between having no fish and having large fish stocks, or between no fishing and sustainable fishing. The prospect of stocks that could support a large, sustainable fishery in the central Arctic Ocean may indeed be low. But fish are in the area, and stocks that are found mainly in one or more EEZs may occasionally move past the 200-mile limit into the high seas. As noted earlier, central Arctic waters include extensive areas of fishable depths to the north of the Chukchi Sea. Schools of fish that, for example, left the U.S. or Russian EEZ in the Chukchi Sea would be susceptible to a hit-and-run fishery within the international waters of the central Arctic Ocean. Such a fishery would undermine national fisheries management efforts, falling far short of any definition of sustainability, but still offering a quick profit. The international waters of the Bering Sea still show the effects of such an approach to fishing in the 1980s.

Sixth, recognition of the preceding points has already given rise to discussions among the five Arctic coastal states regarding an international agreement for fisheries in the central Arctic Ocean. While these discussions acknowledge that expanding an existing, or creating a new, regional fisheries management organization is premature, the five countries agree that no fishing should occur until a management system is in place. Effectively, this would mean that the area would be closed to fishing until

it is opened up by further international action, in contrast to the current status in which it is effectively open until it is closed. The role of non-Arctic countries in this discussion is not yet clear, but the increased interest in Arctic affairs shown by China, India, Japan, the Republic of Korea, Singapore, and others suggests that they, too, have an interest in what takes place in the international waters of the Arctic.

Seventh, another key point in the discussions about the central Arctic Ocean involves the state of scientific understanding of the biology and ecology of the area, for fish but also for other species in the food web. Norway is hosting a scientific meeting in October 2013 to assess the current level of scientific understanding about the central Arctic Ocean and to identify topics for which further study is important and practicable. This is a welcome step for an area undergoing rapid biophysical change, most visibly the loss of summer sea ice and increasing global interest in its resources and the potential shipping routes that transit the Arctic Ocean. Here, too, the Pacific Rim nations can contribute through their existing and future research efforts in the Arctic.

To conclude, avoiding overfishing means regulating fisheries. Preventing overfishing in the first place means creating a management regime before fishing starts. Establishing such a regime for the central Arctic Ocean would help achieve that rare thing: effective management before a crisis. The agreement currently under discussion would not create a management regime, but it would make the development of fisheries dependent upon the establishment of such a regime. If there are no fish worth catching in these waters, little harm is done. However, if commercially attractive fish stocks do reach the region, having a management regime in place will be a victory for responsible fisheries management, rewarding a willingness to prepare for uncertainty.