INDICATOR #16

Changing distribution of marine fish

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Disko Bay, West Greenland Carsten Egevang/Arc-Pic.com

Different species of fish, both marine and freshwater, are important resources for human populations in the Arctic. Fish are also prey for many species of birds and mammals, and form an essential link in Arctic food chains. Changes in the distribution and abundance of fish populations will, therefore, have consequences for the different species of prey which the fish feed on, for the predators of the fish, and for humans who depend on these fish or their predators. As an example, in times when the Barents Sea capelin, *Mallotus villosus*, stock is very low, concentrations of its zooplankton prey are higher, while the seabirds and harp seals that prey on the capelin show increased mortality and recruitment failure. During these periods, the Barents Sea cod, which also feeds on capelin and which supports an important commercial fishery, shows reduced growth and delayed maturation, and cannibalism within the stock increases [1].

Population/ecosystem status and trends

Arctic marine ecosystems have a large number of fish species, and many of them have several populations that are isolated from each other in some way. Only a few of the species have very large populations, and most of those are heavily exploited by marine fisheries.

In the northern Bering Sea, a change from ice-dominated Arctic conditions to sub-Arctic conditions with more open water tends to favor pelagic species like pollock, *Theragra chalcogramma*, over benthic and bottom-feeding species. With the recent shift to a cold period, the pollock population in 2009 is in collapse [2, 3].

In the Barents Sea/Norwegian Sea ecosystem, there is clear evidence that the biomass of another pelagic species, the Norwegian spring spawning herring, *Clupea harengus*, fluctuates with temperature [4]. The distribution of this herring stock also changes over time [5], with temperature change as one of the probable underlying causes. In the Barents Sea, capelin, *Mallotus villosus*, and cod, *Gadus morhua*, also display large variations in both biomass and distribution, with temperature change an important driving force [1, 6].

When changes in distribution occur, the causes are often complex and may be difficult to understand. In the northeast Atlantic, for example, there is ample evidence for changes in the distribution and abundance of fish populations [7]. The changes are consistent with a northward shift, or increase in abundance, in the northern part of their ranges and a decrease in southern parts. These changes are observed in both bottom-dwelling and pelagic species, and in exploited and unexploited species. It is highly likely that climate effects are part of the reason for the shifts. Other factors, however, in particular fishing, may also be important [7].

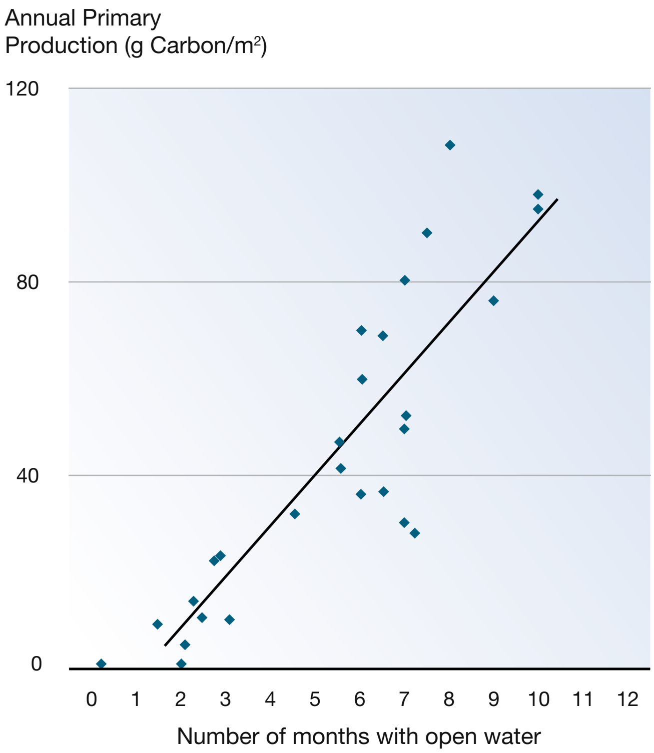

Figure 16.1: The relationship between annual primary production and the ice-free period based on measurements from several sites in the Arctic [9].

Temperature changes may influence fish populations both directly, through shifts to areas with preferred temperature, and indirectly through the food supply and the occurrence of predators. The length of the ice-free period in the Arctic, for example, affects annual primary production, which is the basis of the food chain supporting populations of fish, sea mammals, and seabirds (Figure 16.1). As the amount of ice in the Arctic has considerably reduced since the 1970s, and projections indicate that the reduction will continue [8], it seems likely that primary production in the Arctic will increase during this century.

Marine fish have complex life histories with eggs, larvae, juveniles, and adults of the same species often occurring in different geographic locations and at different depths, and temperature changes may have different effects for the different life stages of a species. Free-floating eggs and hatched larvae drift with currents from the spawning areas to nursery areas where the young may grow and develop for several years until they near maturity. When maturation starts, adults return to the spawning areas to complete the cycle. If a change in temperature causes a species to shift its spawning areas, its continued success will depend on factors such as whether current systems in the new area take the eggs and larvae to suitable nursery areas, and whether the nursery areas are adequate in terms of temperature, food supply, depth, etc. Changes in spawning and nursery areas caused by climatic changes may, therefore, also lead to changes in population or species abundance.

In addition to climate changes, there is also increasing concern about ocean acidification due to increased carbon dioxide in the atmosphere [10]. More acidic oceans will directly influence organisms with calcareous structures, among them many species of phytoplankton and zooplankton which form part of the food chains for fish and other marine animals. Increased levels of carbon dioxide in the sea will also influence fish directly, with possible short-term effects being disturbance of respiration, blood circulation, and nervous activities, while possible long-term effects include reduced growth rate, reproduction, and calcification [11]. Predicting changes in distribution and abundance of fish stocks due to climate change or acidification will, however, be difficult until we have a more complete understanding of the mechanisms through which the stocks are influenced.

Concerns for the future

There is uncertainty about the impacts of global warming already underway, and still more uncertainty about the effects it will have on Arctic ecosystems. Some of the effects which may occur can be shown through computer modeling. An example is given in Figure 16.2 which shows simulated changes in the distribution of Arctic cod[1], *Boreogadus saida*, during the next 30 years, given reasonable assumptions about ocean warming. Arctic cod is a small, pelagic gadoid fish (less than 20 cm) which lives in the Arctic seas. It feeds on zooplankton and is not itself a target for large fisheries, but it is an important prey species for larger fish and marine mammals. The modeling results indicate that both distribution and abundance of Arctic cod may be dramatically reduced. This gives rise to many concerns. If the Arctic cod disappears, what will replace it? Will its predators also disappear? Will there still be fish and marine mammals to sustain human societies dependent on them? Clearly, a reduction in distribution for Arctic cod will affect both its predators and the human societies that have based their economies on them. Arctic cod is just one of the species which might be affected by the global warming; changes can be expected in other species as well.

1. Arctic cod is also called "polar cod".

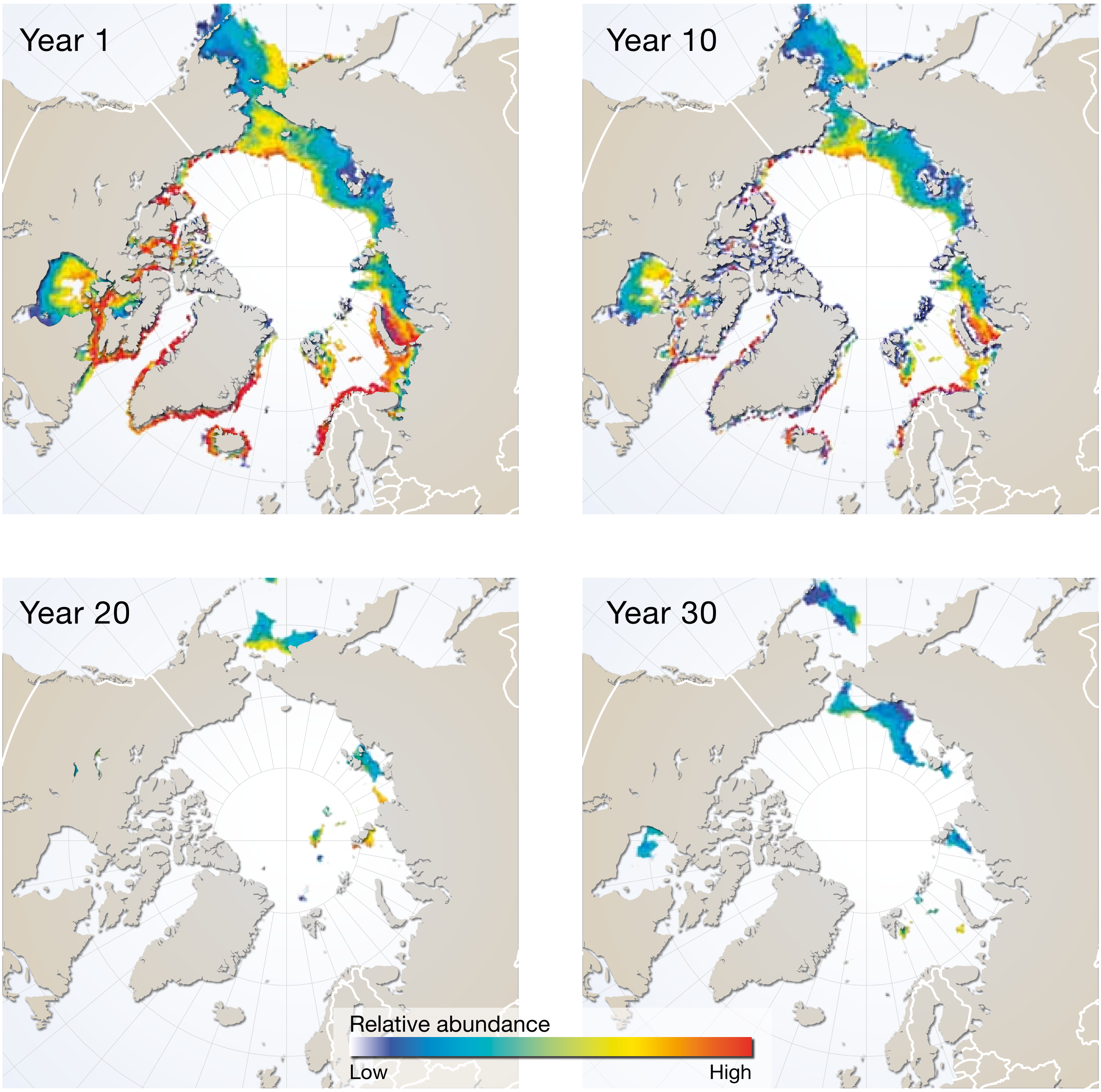

Figure 16.2: Simulated changes in distribution of polar cod after 1 year (upper left), 10 years (upper right), 20 years (lower left) and 30 years (lower right) under hypothetical scenarios of ocean warming and retreating sea ice edge at a rate of 5 km per year. Polar cod is extirpated from most of its range in 30 years [from 12].