BIODIVERSITY MATTERS
in the
Gulf of Maine

Biodiversity is the variety of life at all levels of organization, from genetic diversity within a species to the many ways that species interact with each other and with their habitats to form communities.

When we try to pick out anything by itself, we find it hitched to everything else in the universe. — John Muir

All life in the Gulf of Maine is an integral part of a dynamic ecosystem that has been shaped over millennia and is continually adapting to change. Change comes from many causes—both natural and human-driven.

The Gulf of Maine is home to more than 4,000 known species, ranging from microscopic plankton to seventy-foot fin whales. Even in this well-studied area, there may be several thousand species yet to be identified as living here, and some will be new to science.
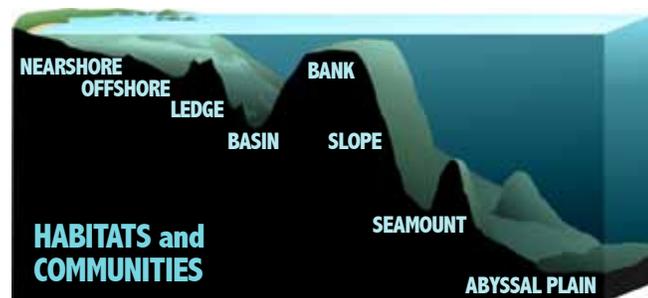
Virtually all areas of the Gulf of Maine, from the intertidal zone to deep basins, have been affected by humans. Some impacts have significant effects on the ecosystem, and have been occurring for decades, and in some cases centuries.

Predicting how ecosystems change over time is difficult, but scientists know that biodiversity plays a vital role in the essential functions provided by marine ecosystems.

Based on global and regional experience, the **conservation of biodiversity needs to be considered in ocean management.**

GENES

SPECIES

NEARSHORE
OFFSHORE
LEDGE
BANK
BASIN
SLOPE
SEAMOUNT
ABYSSAL PLAIN
HABITATS and COMMUNITIES

Multiple levels of biodiversity. The top panel represents **genetic** diversity within a species. The colored strands of DNA illustrate how genetic composition might change in a single species of fish over an area. The genetic structure shown by these patterns may reflect patterns of reproduction and adaptations to local conditions. The middle panel shows an example of **species diversity**, in this case in a coastal environment with sandy-muddy bottom and ledges. In the bottom panel, a cross-section of the Gulf of Maine shows large-scale **habitat diversity**, which supports different **communities** of organisms. Diversity at all three levels is a resource that can increase the capacity of a population, a community, or an ecosystem to persist and adapt over time.

The Census of Marine Life is a 10-year global initiative to assess and explain the diversity, distribution, and abundance of life in the oceans—past, present, and future. The world's first comprehensive Census of Marine Life was released in October 2010. The Gulf of Maine Area program is a joint US/Canadian project studying patterns of biodiversity and their role in marine ecosystem processes in order to inform ecosystem-based management of the Gulf of Maine region.

CENSUS OF MARINE LIFE

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Marine ecosystems provide many important goods and services, such as recycling nutrients, regulating atmospheric gases, and producing food. Biodiversity plays a key role in maintaining these goods and services, which can be diminished through impacts on species or their habitats.

Patterns of Biodiversity in the Gulf of Maine

New statistical analyses have shown that habitat features such as bottom type, temperature, and bottom stress due to currents and storms explain about one-third of the variation in distribution and abundance of many fish and invertebrates in gulf-wide surveys. The Gulf has several physiographic regions distinguished by depth and geologic and oceanographic features. Analyses of fish species show highest diversity in the southern coastal regions and on Georges Bank, and lowest diversity in the deep basins and on Browns Bank and the Scotian Shelf. These large-scale patterns are defined by generally abundant and well-known taxa. A rich and complex structure also exists at smaller scales everywhere. Biodiversity relationships are inherently complex, and may never be completely known for the full spectrum of ocean life. Our understanding of ecosystem function and change ultimately depends on linking available knowledge across all these scales.
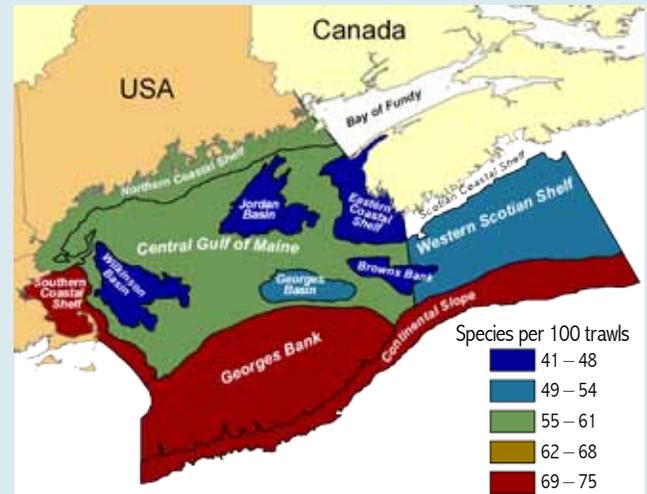
Biodiversity Provides Economic Benefits

The physical and oceanographic characteristics of the Gulf of Maine Area, including Georges Bank, contribute not only to its biodiversity but also to its status as one of the world's most productive marine regions. For example, in the US, the New England economy derives over 5 billion dollars each year from the seafood industry alone (NOAA, 2010). Combining all economic benefits from activities that rely on the Gulf of Maine ecosystem makes it a critical natural asset for the region. Competition for use of the ocean is increasing by all sectors—fisheries, recreation, aquaculture, transportation, and emerging energy industries. Along with these growing demands comes a greater need to ensure that biodiversity is adequately protected so that the system continues to provide valuable benefits into the future.

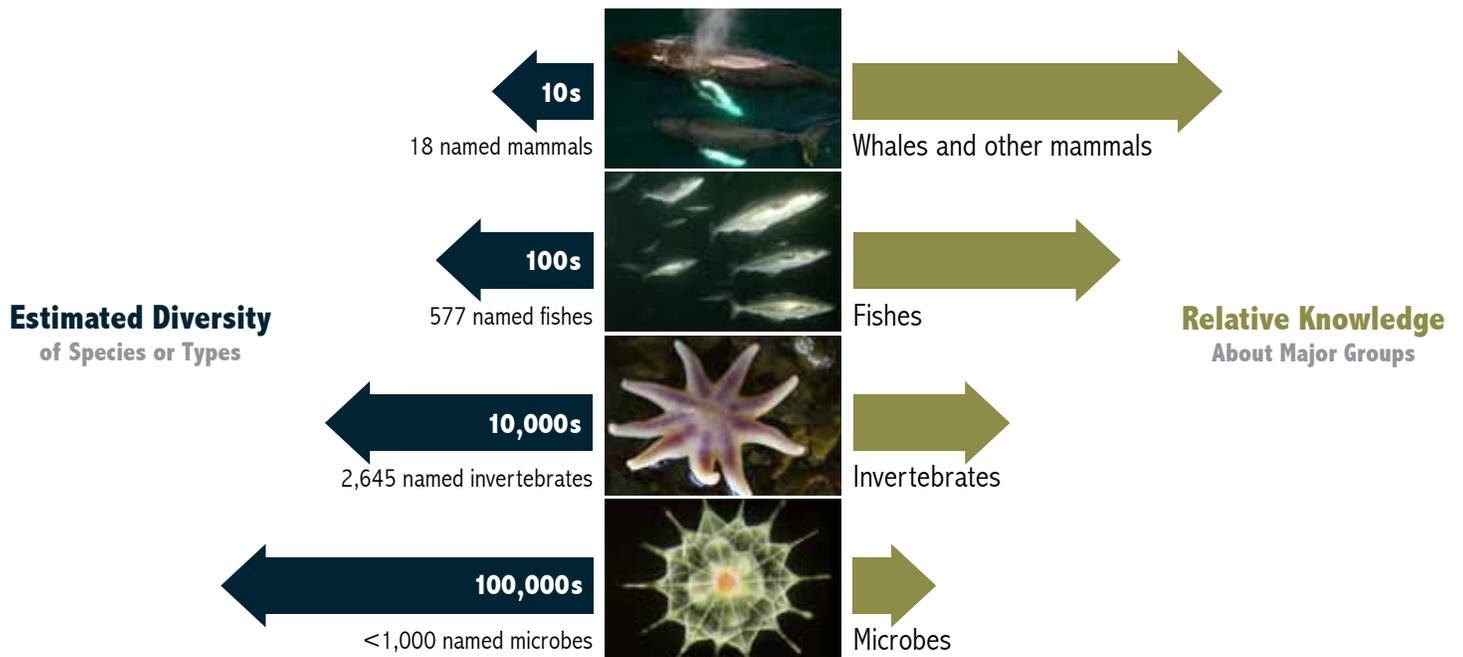## Loss of Biodiversity May Impair Ecosystem

The Great Auk and Sea Mink are the only documented species extinctions in our region, but the abundance, within-population diversity, and ecological roles of many species are currently threatened, either directly or through impacts on their habitats. Present-day human-induced threats to biodiversity include overharvesting, physical impacts on species and habitats, pollution, and invasive species. These pressures may lead to "simplification" of the regional ecosystem, with less diverse gene pools, weakened or less diverse food webs, and a reduction in organisms that create structure—such as burrowers, corals, tunicates, and sponges. The cumulative impacts of these effects, along with other factors such as climate change, need to be considered by ocean managers and stakeholders.

In the long term, economic stability depends on ecological sustainability. – Pew Oceans Report, 2003

Large-scale patterns of diversity: Based on bottom trawl surveys from more than four decades of sampling, the diversity of fish varies among physiographic regions (shown here: number of species expected per 100 trawls). Finer scale mapping would reveal greater detail related to habitats.

Species per 100 trawls
- 41 – 48
- 49 – 54
- 55 – 61
- 62 – 68
- 69 – 75

DIVERSITY VERSUS RELATIVE KNOWLEDGE IN THE GULF OF MAINE

Estimated Diversity
of Species or Types

Relative Knowledge
About Major Groups

10s
18 named mammals

Whales and other mammals

100s
577 named fishes

Fishes

10,000s
2,645 named invertebrates

Invertebrates

100,000s
<1,000 named microbes

Microbes

While our inventory of species in the Gulf of Maine area is far from complete, many key aspects of biodiversity are becoming better understood. We still know most about large conspicuous species, especially those of commercial importance. We also know more about organisms that live near the coast than those in deep water offshore. Yet, research shows that lesser known species—including microscopic organisms—play critical roles in ecosystem functioning.

Continued Efforts Are Needed to Sustain Biodiversity

In recent years, researchers in the US and Canada have made significant strides toward understanding the dynamics of the Gulf of Maine ecosystem and how this knowledge can be applied to management. There is an accumulating body of science, resource management tools, and information systems to support ecosystem-based management in the Gulf of Maine (see next page). Despite these advances, conservation efforts in the sea have lagged behind those on land, perhaps because ocean habitats are less visible and less familiar to people, and because people are often unaware of the ways in which ocean resources support coastal communities and regional economies. New marine conservation measures will need to be embraced by a broad stakeholder community in order to sustain the ecological, social and economic landscape of the Gulf of Maine region for generations to come.

Ecosystem-Based Management

Ecosystem-based management considers the integrated effects of humans and natural processes on ecosystem state and function in order to improve decision-making. When managers are faced with multiple options about the use of ocean space, they should consider how proposed uses interact with other uses to affect biodiversity and ecological functioning at the local and ecosystem level. Since our knowledge and inventory of biodiversity in the Gulf of Maine is incomplete, management options must include reducing risks to the currently unknown biodiversity.
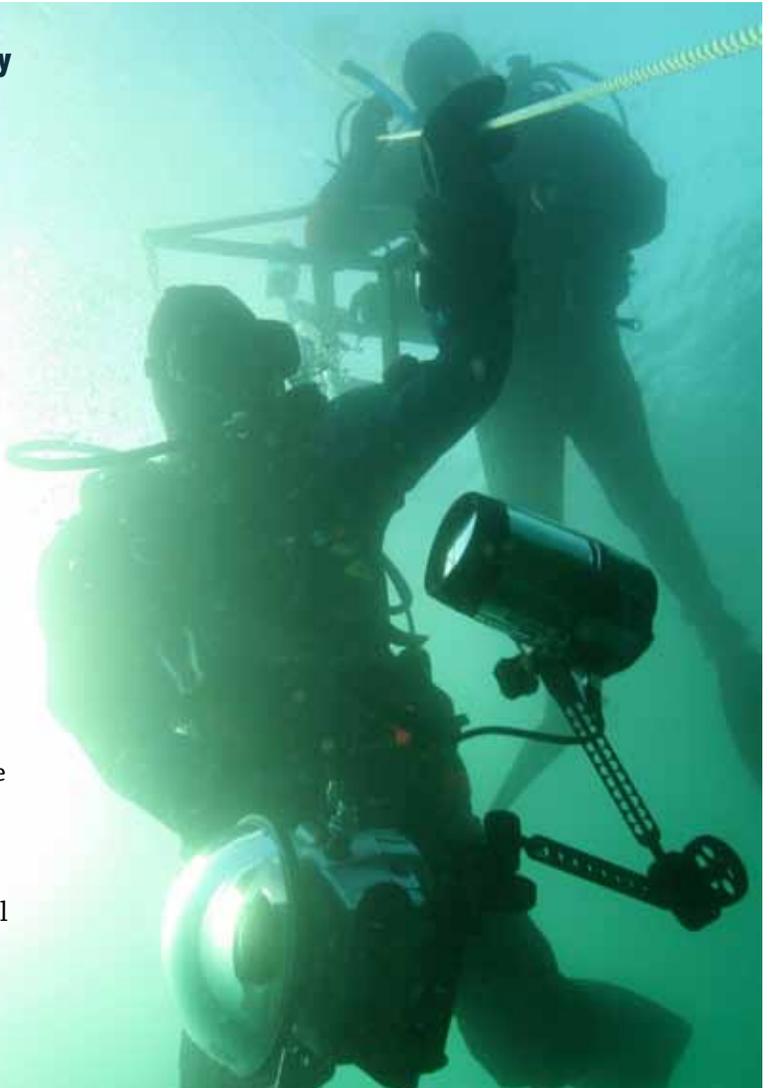
In addition to aesthetic and ethical reasons for protecting biodiversity, there are truly practical reasons for doing so. Biodiversity—in the Gulf of Maine and elsewhere—is part of our natural heritage, an encyclopedia of life itself, and it serves as the reservoir of options that an ecosystem has to adapt to change.

Networks of Protected Habitats Can Help

One widely acknowledged way to conserve biodiversity is to establish networks of representative habitats of sufficient size to accommodate local ecological processes, and distributed so as to ensure connectivity of populations. Different levels of protection can be applied at various spatial scales to provide for ecological processes as well as human uses.

Given that the system is dynamic and subject to short-term variability as well as long-term shifts such as climate change, ecosystem performance should be monitored and management strategies adapted over time to ensure that objectives continue to be met.

The American lobster, *Homarus americanus*, is part of a diverse community of bottom-dwelling species.

Biodiversity Tools and Resources

The Gulf of Maine region is poised to use biodiversity information as part of ecosystem-based management approaches, and these are a few key tools and resources that have become available in recent years through the Census and other regional programs and collaborators:

» **First regional database of known species:** Gulf of Maine Register of Marine Species (http://www.marinebiodiversity.ca/nonNARMS/classification.jsp)

» **Ocean observing, monitoring and data systems** and partnerships to make data accessible for integration and synthesis: Northeast Regional Association of Coastal Ocean Observing Systems (www.neracoos.org).

» **Online encyclopedia** of species and images as well as **global databases** linked to geographic locations: Encyclopedia of Life (www.eol.org) and Ocean Biogeographic Information System (www.iobis.org).

» **Comprehensive website** on the Gulf of Maine Area program, including research projects, publications and educational resources (www.gulfofmaine-census.org.)

In addition, there are several **regional initiatives** to incorporate integrative approaches, including biodiversity considerations, into the management of ocean space: Fisheries and Oceans (Canada), Northeast Fisheries Science Center (US), Northeast Regional Ocean Council (US), Massachusetts Ocean Partnership (US), and the Gulf of Maine Council on the Marine Environment (US/Canada).

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Centre for Marine Biodiversity

Gulf of Maine Area GoMA Census of Marine Life