

# Seafood Watch

## Seafood Report



MONTEREY BAY AQUARIUM®

### **American lobster** *Homarus americanus*



(Image © Monterey Bay Aquarium)

### **Northeast Region**

Final Report  
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## **About Seafood Watch® and the Seafood Reports**

Monterey Bay Aquarium's Seafood Watch® program evaluates the ecological sustainability of wild-caught and farmed seafood commonly found in the United States marketplace. Seafood Watch® defines sustainable seafood as originating from sources, whether wild-caught or farmed, which can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems. Seafood Watch® makes its science-based recommendations available to the public in the form of regional pocket guides that can be downloaded from the Internet ([seafoodwatch.org](http://seafoodwatch.org)) or obtained from the Seafood Watch® program by emailing [seafoodwatch@mbayaq.org](mailto:seafoodwatch@mbayaq.org). The program's goals are to raise awareness of important ocean conservation issues and empower seafood consumers and businesses to make choices for healthy oceans.

Each sustainability recommendation on the regional pocket guides is supported by a Seafood Report. Each report synthesizes and analyzes the most current ecological, fisheries and ecosystem science on a species, then evaluates this information against the program's conservation ethic to arrive at a recommendation of "Best Choices," "Good Alternatives," or "Avoid." The detailed evaluation methodology is available upon request. In producing the Seafood Reports, Seafood Watch® seeks out research published in academic, peer-reviewed journals whenever possible. Other sources of information include government technical publications, fishery management plans and supporting documents, and other scientific reviews of ecological sustainability. Seafood Watch® Fisheries Research Analysts also communicate regularly with ecologists, fisheries and aquaculture scientists, and members of industry and conservation organizations when evaluating fisheries and aquaculture practices. Capture fisheries and aquaculture practices are highly dynamic; as the scientific information on each species changes, Seafood Watch's sustainability recommendations and the underlying Seafood Reports will be updated to reflect these changes.

Parties interested in capture fisheries, aquaculture practices and the sustainability of ocean ecosystems are welcome to use Seafood Reports in any way they find useful. For more information about Seafood Watch® and Seafood Reports, please contact the Seafood Watch® program at Monterey Bay Aquarium by calling (831) 647-6873 or emailing [seafoodwatch@mbayaq.org](mailto:seafoodwatch@mbayaq.org).

### **Disclaimer**

Seafood Watch® strives to have all Seafood Reports reviewed for accuracy and completeness by external scientists with expertise in ecology, fisheries science and aquaculture. Scientific review, however, does not constitute an endorsement of the Seafood Watch® program or its recommendations on the part of the reviewing scientists. Seafood Watch® is solely responsible for the conclusions reached in this report.

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## Executive Summary

American lobster, *Homarus americanus*, is landed primarily in the Canadian Maritimes and in Maine, and is harvested with lobster pots. American lobster has a neutral inherent vulnerability to fishing pressure due to life history characteristics such as a moderate first age at maturity and long life span. Although lobsters are relatively fecund, much of the lobster catch is comprised of sexually immature individuals. The status of American lobster stocks is uncertain; despite being classified as overfished with overfishing occurring in much of the U.S., abundance hovers near record highs in Canada and the Gulf of Maine. This confusion, along with questions about the reliability of current overfishing definitions in the U.S. and the lack of definitions in Canada, leads to a stock status ranking of ‘Moderate or Unknown.’

There is minimal bycatch of fish and invertebrates in lobster pots; however, lobster pots are an important source of mortality for marine mammals, notably humpback whales and endangered North Atlantic right whales. Regular mortality of an endangered species would generally warrant a ranking of critical conservation concern; however, in this case, industry has been given the benefit of the doubt pending a new set of steps to reduce entanglement. Until this issue is resolved, whale mortality from lobster gear, and thus the nature of bycatch, rates as a high conservation concern. Lobster pots have a small to moderate impact on benthic habitats.

Management of American lobster is deemed moderately effective. While there are numerous management measures in place regulating the landing of lobsters, efforts to address “overfishing” and reduce the entanglement of marine mammals in the U.S. have not met stated management goals. This set of criteria results in an overall recommendation of “Good Alternative” for American lobster.

## Table of Sustainability Ranks

Sustainability Criteria	Conservation Concern			
	Low	Moderate	High	Critical
Inherent Vulnerability		✓		
Status of Stocks		✓		
Nature of Bycatch			✓	
Habitat Effects	✓			
Management Effectiveness		✓		

## Overall Seafood Recommendation:

Best Choices 

**Good Alternative** 

Avoid 

## **Introduction**

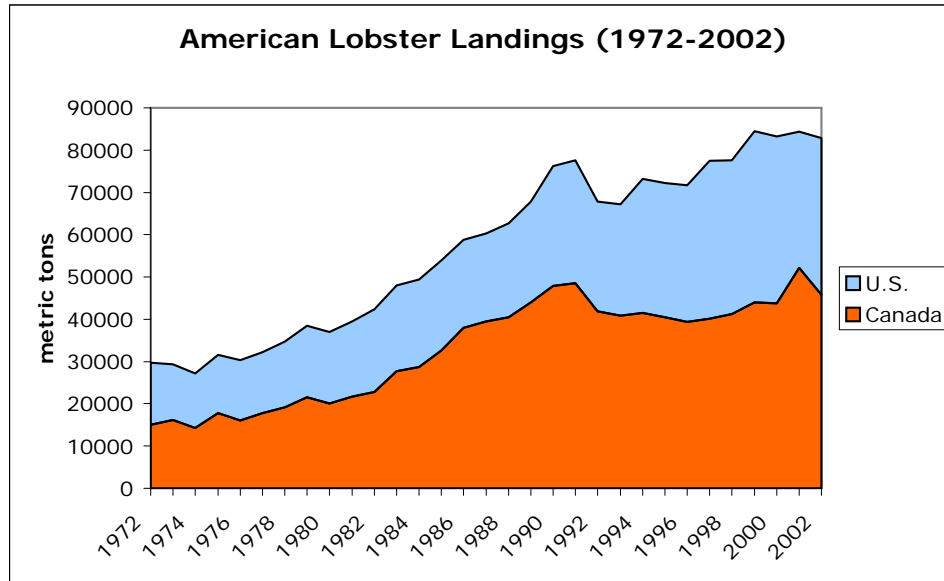
The American lobster (*Homarus americanus*) is a large-bodied crustacean that lives on the sea floor off the eastern coast of North America. Famous for its succulent meat and large claws, American lobsters are distributed across the continental shelf from Newfoundland and Labrador south to North Carolina. Historically, lobsters were highly abundant in these coastal waters, where they were fished by hand from shore. Lobster lore holds that the animal was traditionally a poor man's food. Native Americans reportedly used lobsters to fertilize their fields, while some indentured servants in Massachusetts ultimately rebelled against eating lobster more than three times a week.

Over the last two centuries, expanding markets and enhanced technology have transitioned lobster from a trash food to a delicacy and from a local to a global commodity. Starting in the middle of the 19<sup>th</sup> century lobstering moved offshore to become a trap fishery. Similarly, the development of lobster "pounds" in the late 1800s allowed fishermen and retailers to keep their catch alive for longer periods of time, while refrigeration and canning technology permitted wholesalers to distribute lobster across the globe.

Over the years, lobstering has become the life-blood of many small New England fishing communities. Though these communities traditionally employed dories and sailing sloops, by World War I gas-powered lobster boats began to replace sailing ships. Today, the modern inshore lobsterboat is a 20-40 foot, fiberglass vessel. Thousands of such lobsterboats are harbored along the east coast of North America, bringing in millions of dollars in revenue. The number of lobstermen and pots fished has increased substantially over the past fifty years, and lobster landings in the U.S. and Canada have also increased remarkably. In particular, the past two decades have seen a substantial increase in lobster landings, the causes of which are not entirely clear (Figure 1). This increase has occurred despite scientific and management assessments that indicate the lobster resource is being overfished.

Today, lobster is the most valuable species landed in New England waters. Roughly 80% of lobsters are caught in state and provincial waters (0-3 miles from shore), while the remainder is trapped further out at sea. The U.S. and Canada catch comparable quantities of American lobster, and ship large amounts across the border to each other.

The Atlantic States Marine Fisheries Commission (ASMFC), a regulatory body formed by the 15 Atlantic coast states, currently manages U.S. lobster fisheries. In the U.S., American lobster is managed under Amendment 3 to the American Lobster Fishery Management Plan (FMP), as well as several addenda to the FMP. In Canada, American lobster is under the jurisdiction of the Department of Fisheries and Oceans (DFO).



**Figure 1** – U.S. and Canadian American lobster landings, 1972–2002 (Source: NMFS landings database, 2004; DFO landings database, 2004).

**Scope of the analysis and the ensuing recommendation:**

This review focuses on American lobster sold in the U.S. market. Because a large share of U.S. supply originates in Canada, both U.S. and Canadian American lobster fisheries are assessed. Recommendations apply to both fisheries.

**Availability of Science**

Lobsters are highly valuable to New England and Canadian fishing communities. Consequently, there is relatively solid information available on historical catches of American lobster. However, there remain significant unknowns involving lobster recruitment, migration, biological parameters, and distribution in both the U.S. and Canada. In 2004, the Atlantic States Marine Fisheries Commission (ASMFC) tasked the Lobster Model Review Panel (Hilborn, Botsford et al. 2004) with assessing current management models. The review panel commented: “We found that the data available are *woefully inadequate* for the management needs of this fishery, and that the primary limitation on the ability to manage is limited data rather than choice of models” (Hilborn, Botsford et al. 2004). Particularly, the Lobster Model Review Panel would like to see improved effort, catch, and length frequency data, all with a spatial component. Similarly, in 2003, the ASMFC’s review of the American Lobster Fishery Management Plan (FMP) recommended the following high priority research activities:

- “Conduct studies of life history events in older/larger lobsters on a regular basis,
- Monitor the condition of the stocks and determine the effects of management measures and environmental changes on the abundance of the stocks and on the fisheries,
- Conduct yield-per-recruit analyses for males,
- Enhance sea and/or port sampling of offshore catches, and

- Derive standardized CPUE indices.” (ASMFC 2003)

With respect to documenting the fishery’s environmental impacts, there is a dearth of information available on the habitat effects of lobster gear. Similarly, the entanglement of large whales in lobster gear is an area of grave concern with substantial remaining unknowns.

## **Market Availability**

### **Common and market names:**

American lobster is also known as Maine lobster or Canadian lobster. It is a separate species from rock lobster or spiny lobster.

### **Seasonal availability:**

American lobster is available year-round in both retail and service markets.

### **Product forms:**

American lobsters are most often sold whole and live. Lobster may also be marketed as fresh or frozen lobster meat (tail, claw meat, etc.), canned, as lobster roe (tomalley), or as a value-added product (i.e., breaded, stuffed-tails, etc.).

### **Product sources:**

The American lobster (*Homarus americanus*) is found only in the waters of two nations: the United States and Canada. Despite research efforts, there is no broad commercial farmed lobster production. In 2002, approximately 37,000 metric tons (mt) of American lobster was landed in the United States. The U.S. catch is primarily landed at ports in Maine and to a lesser extent Massachusetts, followed by the nine other Atlantic states north of Cape Hatteras (Figure 2). For reference, the U.S. also lands small quantities of Caribbean spiny lobsters (~2,000 mt/yr), not addressed in this report. In 2002, Canada landed over 51,000 mt of American lobster. The Canadian catch is mostly taken in Nova Scotia, followed by Prince Edward Island and New Brunswick (Figure 3).

### **Certification**

The Eastern Canada offshore lobster trap fishery has been certified as sustainable to the Marine Stewardship Council (MSC) standard. The MSC is an independent non-profit organization, which has developed an environmental standard for sustainable and well-managed fisheries. It uses a product label to reward environmentally responsible fishery management and practices (<http://www.msc.org/>).

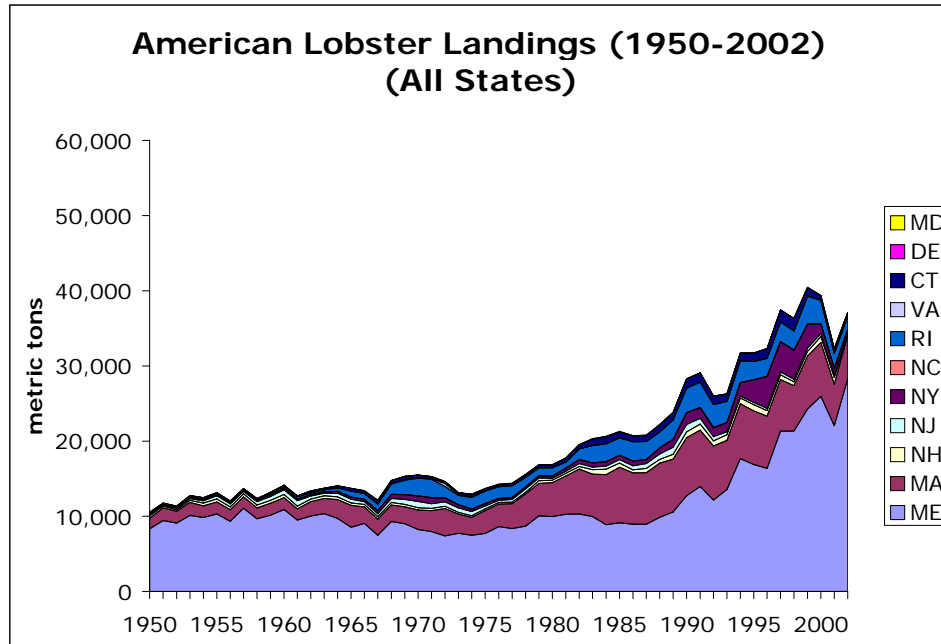


Figure 2 – American lobster landings in the United States (NMFS landings database, 2004).

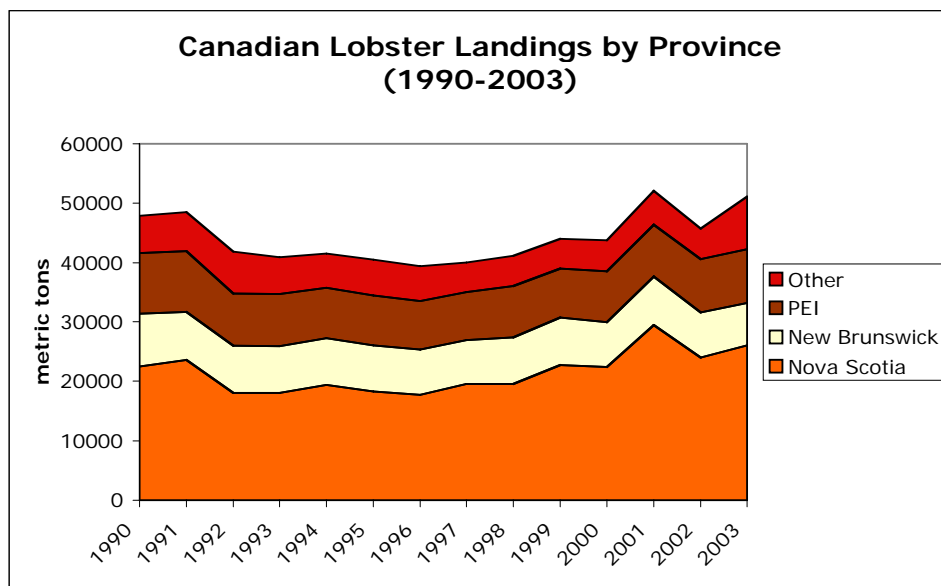


Figure 3 – American lobster landings in Canada (DFO landings database, 2004).

**Exports and imports:**

In terms of the source of lobster on the U.S. market, imports and exports between the U.S. and Canada confuse the situation. The large majority of U.S. lobster landings are exported. In 2002, around 30,000 metric tons (mt), or over 80% of the U.S. lobster harvest, was shipped out of the United States (Figure 4); just over 6,000 mt of the domestic harvest remained in the country. Sixty percent of the exports (19,000 mt) were shipped to Canada. In the same year, 2002, the U.S. imported over 50,000 mt of lobster. Over 70% of these imports were American lobster from

Canada; in 2002 Canada shipped over 37,000 mt of lobster into the United State—a quantity roughly equal to the U.S.’ entire domestic supply. The remainder of U.S. imports in 2002 was comprised entirely of other species of lobster (e.g., rock and spiny lobsters) from several warm-water nations (Figure 4).

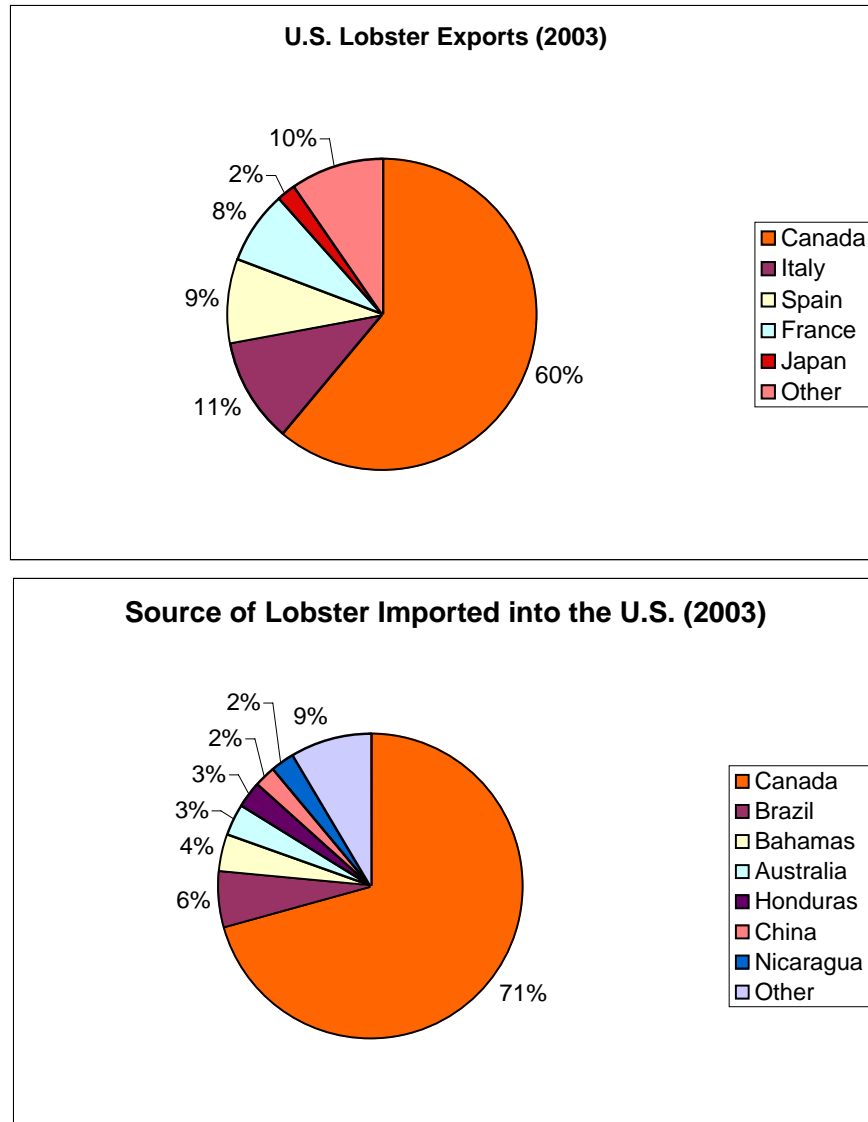
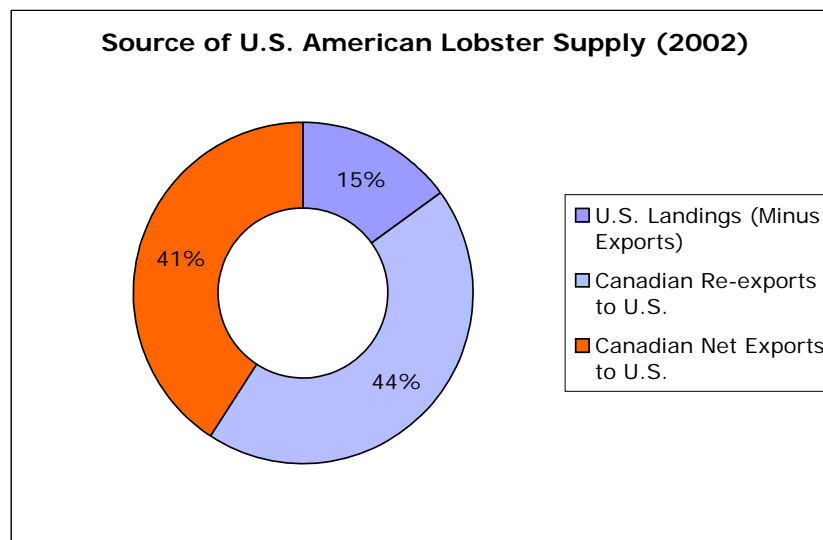
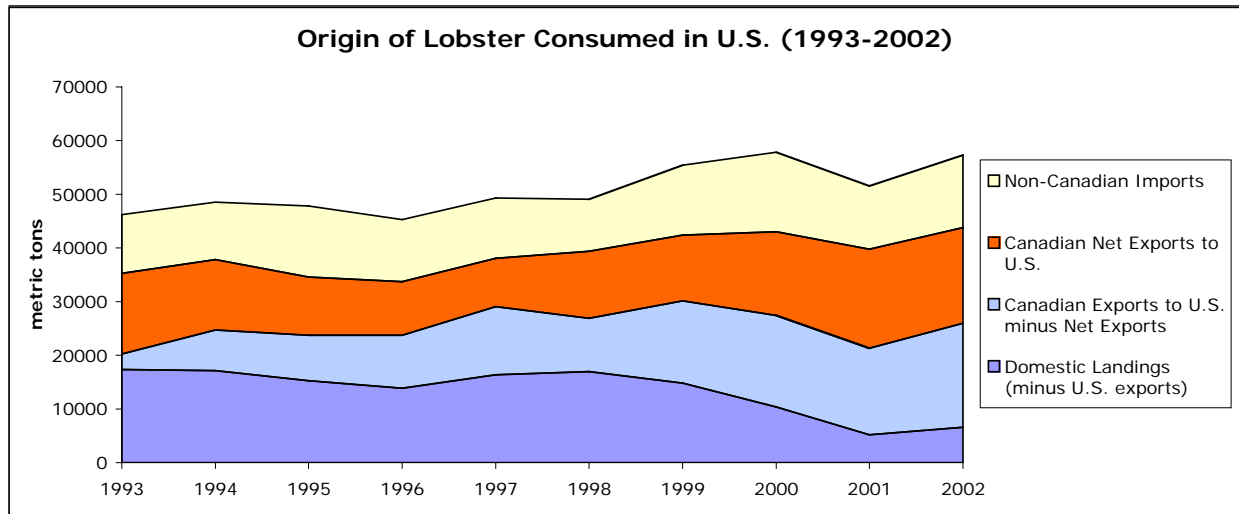


Figure 4 – American lobster exports and imports in the United States (NMFS landings database, 2004).

At first blush, it would appear that over 85% of the American lobsters on the U.S. market are landed in Canada. However, accurately determining what percentage of the U.S. supply of American lobster originated in Canada depends on the share of lobsters that the U.S. exports to Canada, which are *re-exported* back to the United States. Many lobsters shipped from the U.S. to Canada are processed and sent overseas or back to the United States. One analyst notes: “U.S. lobster exports grew by 200 percent during 1989-2001 due to increased sales to Canada, which remains the most important market for U.S. lobster exports. U.S. exports to Canada are

processed and then sent back to the U.S. market for domestic consumption or to be exported to other markets, mainly to the European Union” (Diaby 2004). As such, Canadian exports back to the U.S. include a share of lobsters landed in U.S. waters. Depending on the level of re-exports, between 40% and 85% of American lobsters in the U.S. market are of Canadian origin.

Recognizing the large degree of uncertainty, this review operates on the basic assumption that in 2002 around half of the U.S. American lobster supply was from U.S. waters, and the other half was landed in Canada (Figure 5). In any case, both the U.S. and Canadian lobster fisheries clearly play an important role in overall supply of American lobster to U.S. markets, and are integrally linked both biologically and economically.



**Figure 5** – Source of lobster consumed in the United States (NMFS landings database, 2004).

## **Analysis of Seafood Watch® Sustainability Criteria for Wild-caught Species**

### **Criterion 1: Inherent Vulnerability to Fishing Pressure**

*Guiding Principle: Sustainable wild-caught species have a low vulnerability to fishing pressure, and hence a low probability of being overfished, because of their inherent life history characteristics.*

#### **Introduction**

The American lobster (*Homarus americanus*) is one of about 30 species of clawed lobsters worldwide, and one of just two species of lobster belonging to the genus *Homarus*. The relatively large-bodied decapod (ten-legged crustacean) lives on the sea floor in the Northwest Atlantic. Lacking a backbone, American lobsters are protected by hard exoskeletons made out of chitin, a flexible material that the animal grows and sheds in progressive molts (DMR 2003; Lavalli, Cowan et al. 2004).

Notable for its particularly large claws, the American lobster is the only clawed lobster native to the Northwest Atlantic (DMR 2003). The species is distributed across the continental shelf from the Strait of Belle Isle, Newfoundland, and southern Labrador in the north, to Cape Hatteras, North Carolina in the south. Regionally, lobster abundance is highest in the shoal waters off of Maine and the Canadian Maritimes, declining as one progresses farther north or south (ASMFC 2000; DMR 2003; ASMFC 2004; Lavalli, Cowan et al. 2004; Ouellet and Plante 2004).

In terms of depth, *Homarus americanus* is found from the intertidal out to about 700 meters. Lobsters are generally most abundant in shallow coastal areas, waters between four and fifty meters in depth, though some regional variation exists (ASMFC 2000; DMR 2003; Lavalli, Cowan et al. 2004). For example, trawl surveys indicate that sexually mature female lobsters are “relatively common” to 100 meters in depth along the western Gulf of Maine and to 200 meters in the northern Gulf of Maine near Nova Scotia (Incze and Naimie 2000). Offshore, lobsters are also spread from the Canadian Maritimes through North Carolina. Deep-water lobster populations appear to be at densities more than an order of magnitude lower than coastal populations. In offshore areas, lobsters are likely to aggregate in areas with some physical structure, such as the submarine canyons on the southern edge of the continental shelf (ASMFC 2000). Juvenile and adult American lobsters are reportedly found seasonally in waters ranging from 0°C to 25°C (ASMFC 2000).

American lobster’s cousin, the smaller European lobster, *Homarus gammarus*, is found on the eastern side of the Atlantic from the Lofoten Islands in Norway to Morocco and the Azores, as well as in parts of the Mediterranean and Black Seas (Lavalli, Cowan et al. 2004). *Homarus gammarus* is the American lobster’s closest relative, and consequently one scientific study on the European fishery (Eno, MacDonald et al. 2001) was referenced in this review where North American studies were lacking.

#### **Life history and reproduction**

Lobsters are solitary and territorial animals, living on the sea floor in a range of habitats, and often employing rocks, crevices, and burrows for cover (ASMFC 2004). The lobster’s

underwater world is informed mainly by highly developed senses of smell and taste. The animal's antennules (the smaller set of antennae) are covered in hundreds of small hairs with chemoreceptors sensitive to amino acids (Lavalli, Cowan et al. 2004). From the presence of amino acids, lobsters can discern the proximity of predators, prey, or other lobsters, while the larger antennae atop the lobster's head is used in close quarters for physically touching and probing. The animals also have a sense of sight, though it may be poor. Their eyes, located on top of their heads, are capable of discerning movement or objects under the conditions of low light intensity when lobsters are most active (Lavalli, Cowan et al. 2004).

Lobsters exhibit a complex life cycle. After mating, females extrude eggs and physically carry them on the outside of their abdomens for a 9 to 12 month incubation period. The eggs hatch from the late spring to early fall, with regional variation (ASMFC 2000; Comeau and Savoie 2002). Incze and Naimie (2000) summarize: "Hatching occurs over a period of two months or more beginning in early to late June in the central and southern coastal Gulf of Maine, and about a month later in southern Nova Scotia and Browns Bank. Peak hatching may occur about a month after the initial hatch, although this probably is variable" (Incze and Naimie 2000).

Once released into the water column, the larvae remain planktonic for four life-stages before settling to the sea floor (ASMFC 2000). The time larvae spend between hatching and stage IV also varies, largely with the ocean temperature, ranging from approximately 10 days at 23°C to nearly two months at 10°C. Settling stage IV postlarvae actively select substrates that can provide them with some cover. The postlarvae tend to choose cobble, gravel, and seaweed over silt, clay, and sand substrates. These latter substrates can be used if they are the only option available, such as the silty and sandy bottom of Long Island Sound. Given postlarvae's ability to settle on the full range of sediment types, there does not appear to be a habitat-related bottleneck in the settlement process. The Atlantic States Marine Fisheries Commission (ASMFC), which is the regulatory body currently in charge of lobster management, reports: "The highest abundance of newly settled lobsters is in cobble beds but they have been found at low densities in marsh grass root mats in southern New England. Young of the year lobsters are rare or absent from sediment substrates and eel grass habitats though early benthic phase lobsters are not" (ASMFC 2000). Once settled, young lobsters generally stay hidden in protective shelters until reaching a carapace length of about 25 mm. Older juvenile lobsters are more widely spread, with high densities on sand and mud substrates in some areas as well (ASMFC 2000).

Once settled, much of the lobster's life history is shaped by the presence of its hard exoskeleton. Because the shell is inelastic, the lobster sheds it periodically in a process known as "ecdysis." This cyclical process of shedding and growing a new exoskeleton is referred to as molting. Molting is essentially a continual struggle for lobsters: when they are not undergoing ecdysis, they are generally preparing themselves for, or recovering from, the process (Lavalli, Cowan et al. 2004). Juvenile lobsters molt about 7-10 times in their first year alone, to reach a length of just 1-1.5 inches (DMR 2003; ASMFC 2004). From first stage larva to borderline-legal sized adults, American lobsters molt between 20 and 30 times each (ASMFC 2000; DMR 2003). The rate of molting slows as the animal matures, plateauing at once every several years. With each successive molt adult lobsters continue to grow significantly; they are capable of increasing their length by 14% and gaining another 40-50% in weight with each molt (DMR 2003).

### **Size and age at maturity**

One important question for fishery management is the average size and age of a lobster at maturity.<sup>1</sup> There is some regional variation to this issue, as size at maturity depends in part on water temperatures; high summer temperatures (e.g., in the Gulf of St. Lawrence and southern New England) encourage maturation at smaller sizes. For example, in Long Island Sound, half of sampled lobster females are mature at carapace lengths (CL) of 70-74 mm. Similarly, in the southern Gulf of St. Lawrence, 50% maturity is associated with 69-73 mm CL (Comeau and Savoie 2002). In contrast, offshore populations and areas with colder summer water temperatures tend mature at larger sizes (ASMFC 2000). In the Atlantic Ocean off of Long Island, lobsters are as large as 86-90 mm CL before reaching maturity, while in Gulf of Maine nearshore waters 50% maturity is associated with 89-97 mm CL (Comeau and Savoie 2002). Overall, 50% of American lobster females reach maturity between 70 and 99 mm CL, depending on location.

Because the lobster fishery is largely regulated by minimum size requirements, maturation size has substantial management implications. Minimum legal size in most management areas is 84 mm carapace length (NMFS 2002); consequently, a large proportion of the female lobsters caught in many areas are sexually immature, particularly in the northern half of the American lobster's range (ASMFC 2000; ASMFC 2002; NMFS 2002). The catch of these immature females increases the potential for overfishing; an issue that is addressed at length in subsequent criteria. Moreover, even mature female lobsters may not have reproduced yet. Small females are thought to follow a two-year reproductive cycle, with some lobsters actually shedding their first set of eggs in the molting process (Comeau and Savoie 2002).

In terms of age, because lobsters shed their exoskeletons scientists have not yet discovered any easy method to determine the age of a lobster. However, empirical research and studies indicate that lobsters reach sexual maturity (and market size) in about five to eight years, depending on water temperature (DMR 2003; ASMFC 2004); a one-pound lobster, for reference, is most likely five to seven years old. Most market lobsters fall into this size range; however, this is a relatively recent phenomenon. Prior to the intensive fishing pressure of the last two centuries, lobsters regularly weighed several pounds, and were presumably decades old. The largest *documented* lobster to date weighed 44 pounds and was four feet long. It was taken off of Nova Scotia in 1977, and scientists estimate that it may have been a century old when it was captured (Cooper and Uzmann 1980; DMR 2003; ASMFC 2004).

### **Intrinsic rate of increase and fecundity**

Though the intrinsic rate of increase for the American lobster is uncertain, lobsters are known to be prolific reproducers. Like most biological factors, fecundity in American lobsters appears to change with location, season, and environmental effects. The earliest study on this topic (Herrick 1896) was also the most comprehensive. Herrick examined nearly 5,000 female lobsters and documented egg numbers per clutch ranging from roughly 17,000 (100 mm CL) to over 220,000 (200 mm CL) per animal (ASMFC 2000). As these numbers indicate, egg production increases exponentially with lobster size. Moreover, the eggs of larger lobsters tend to have a higher energy content, which may increase survival rates. At current natural and fishing mortality

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<sup>1</sup> Size is typically expressed as the length of the lobster's carapace (or Carapace Length, CL), measured from the back of the eye socket to the hard edge at the end of the carapace, in millimeters.

levels, females can release between 7,000 and 80,000 eggs per clutch depending on their location (ASMFC 2000; NMFS 2002).

### **Lobster movement**

During their first year, lobsters are relatively stationary, typically remaining within an area of a few square meters. As they grow, their range increases. Campbell and Stasko (1985) and Campbell (1986) report that at sexual maturity, the average annual range of an adult lobster is 20 miles. This number is somewhat misleading in that most lobsters appear to move little, while some migrate hundreds of kilometers (ASMFC 2000). Essentially, lobsters express several different types of migratory behaviors. Some stay in one spot, others migrate seasonally from deep to shallow waters, and some migrate long distances. This migratory behavior varies in part with geography. Long inshore-offshore migrations have been documented in a number of locations including Georges Bank, Browns Bank, and Grand Manan Island in the Bay of Fundy (Incze and Naimie 2000; Rowe 2001). ASMFC reports: “In general, migrating lobsters move offshore in the fall and winter and inshore in the spring and summer. For ovigerous females, such behavior exposes eggs to warmer temperatures, thus enhancing egg development” (ASMFC 2000). Overall, for the most part the size structure, seasonality, and proportion of the lobster population undergoing this migration is not well known (Incze and Naimie 2000).

Lobster migration has important management implications, as the lobster fishery employs area-based management. To the extent that lobsters stay in one place, managing specific areas is more effective. Rowe (2001) comments: “In some parts of their range, such as the waters around Newfoundland, adult American lobsters are rather localized in their movements and may be ideal candidates for reserve protection” (Rowe 2001). Additionally, migrations may help to link the inshore and offshore populations and fisheries. In addition to physical movement, offshore lobsters may represent an important reproductive source for the inshore population. Larvae may be transported by currents and diurnal coastal breezes from offshore to inshore areas (Incze and Naimie 2000).

### **Factors affecting lobster abundance**

In most regions the most important factor affecting the abundance of adult lobsters appears to be fishing mortality; however, natural factors also play a role in the rise and fall of lobster populations. These factors include predator and prey interactions as well as more general environmental conditions.

Given the size of their bodies and large front claws, adult American lobsters are an important predator on the Northwest Atlantic seafloor. The omnivorous invertebrates feed on a range of other animals including crabs, mollusks, worms (polychaetes), and sea urchins, as well as fish and algae (ASMFC 2000). In heavily-fished areas, the bait contained in lobster traps (i.e., Atlantic herring) may be an important source of food for sub-legal lobsters (ASMFC 2000). The role of bait in lobster diets and more general ecosystem effects of bait use are explored in greater depth in the Habitat and Bycatch criterion. Overall, given the range of food available to lobsters as well as diet supplementation from fishery bait, this review has not found information to suggest that lack of food is a major limitation of lobster abundance.

In addition to being important predators, young American lobsters are also preyed upon by a variety of species, including fish (e.g., sculpin, cunner, tautog, black sea bass, etc.), sharks, rays, and crabs. The last ASMFC lobster stock assessment summarized that, “Atlantic cod, wolfish, goosefish, tilefish, and several species of sharks consume lobster up to 100 mm CL” (ASMFC 2000). With the decline of most of these populations of predators over the past 30 years, natural mortality of lobsters over the same time period is thought to have *decreased* significantly.

In addition to predation, disease plays a role in lobster mortality. Considerable attention has recently been directed toward disease in lobsters due to the proliferation of shell disease in Southern New England. According to ASMFC, “The etiology of shell disease is less clear, involving many species of chitinoclastic organisms. Shell disease is believed to be the result of opportunistic microorganisms exploiting an injury or poor physiological state of the host” (ASMFC 2000). While shell disease has been sporadically observed for a long period, outbreaks were reported in Rhode Island in 1996 and Massachusetts in 1997. The prevalence of shell disease has been increasing in Rhode Island since 1996, causing severe declines in the fishery; the value of Rhode Island’s lobster catch has declined by half since 1999 (Lord 2005). In Massachusetts the disease has been slowly creeping north each year, reaching Cape Ann in 2003. In April 2005, six New England senators requested \$3 million to study the disease, arguing that its spread represents a potential economic and biological disaster (Wirzbicki 2005).

The frequency of disease may be influenced by changing environmental conditions. For example, in the fall of 1999, warm water temperatures, low oxygen levels, and other stresses caused a mass mortality of lobsters in Long Island Sound, decimating the local fishery. A subpopulation of lobsters in the Sound was diagnosed with paramoeba. Researches have speculated that “One possible explanation for the presence of neoparamoebae in 1999 lobsters is to postulate that high water temperatures, which are known to support the growth of natural populations of *N. pemaquidensis* and other amoebae, combined with record-high population densities of temperature-challenged lobster under hypoxic conditions, promoted infection of a subpopulation of lobster that contributed to the die-off” (Chistoserdov, Frasca et al. 2004). A 2004 symposium on lobster health found that lobsters in the Sound continue to be afflicted by disease outbreaks and deaths, particularly in the Sound’s western half.

Overall, evidence suggests that in some instances disease may have a significant effect on lobster mortality, possibly on the same scale as predation and fishery mortality. The Lobster Technical Committee noted: “While the overall incidence of shell disease is fairly high in Area 2, there is no definitive work to date that relates shell disease to abnormal lobster mortality. At this time there is not sufficient information to characterize the impact of shell disease on the Area 2 lobster population” (ASMFC 2002). However, more recent estimates of disease-struck areas such as Narragansett Bay indicate that shell disease has increased the natural morbidity of lobsters by 15-50% per year (Lord 2005). The last ASMFC stock assessment estimated the overall natural mortality rate (including predation, disease, and extreme environmental conditions) to be 0.15/yr, which was partitioned into hardshell (0.10/yr) and softshell components (0.05/yr).

Apart from mortality, lobster populations can be affected by environmental conditions, most notably water temperature, which affects growth rates and larval survival. Koeller (1999) notes: “Temperature can affect lobster catches in the short term by altering the availability of lobsters to

traps, i.e. by changing lobster behavior on the grounds or by increasing growth of prerecruits to commercial sizes. In the long term, it could also affect population growth by influencing survival of larvae or juvenile stages.” The effects of water temperature on future harvests appear to be statistically significant. Several studies listed in the 2000 stock assessment found landings corresponded to sea temperature with a six- or seven-year time lag. For example, a study by Acheson and Steneck (1997) attributed as much as 60% in the variance in landings over four decades (1946-1986) to sea temperatures in August, seven years previously. However, the relationship between sea temperature and landings appears to have detached over the last two decades, possibly due to other environmental or management factors (Drinkwater, Harding et al. 1996).

**Synthesis**


As Rowe (2001) summarizes, the American lobster “is a long-lived, benthic invertebrate characterized by slow growth, late maturation, long intervals between matings, and egg production that increases exponentially with increasing female size.” This set of life history characteristics results in an inherent vulnerability ranking of neutral for American lobster, or a moderate conservation concern. The primary factor in this ranking is lobster’s moderate age at first maturity (5-8 years), followed by its long life span (up to ~100 years) and relatively narrow species range (Table 1).

**Table 1** – Life history characteristics of American lobsters.

Intrinsic Rate of Increase (r)	Age at Maturity	Maximum Age	Fecundity	Species Range	Special Behaviors
Unknown	~5-8 yrs	~100 yrs	High	Northwest Atlantic from Labrador to Cape Hatteras	V-notching reduces vulnerability

**Inherent Vulnerability Rank:**

Resilient 

**Neutral** 

Vulnerable 

**Criterion 2: Status of Wild Stocks**

*Guiding Principle: Sustainable wild-caught seafood species have stock structure and abundance sufficient to maintain long-term fishery productivity.*

**Introduction**

In the United States, American lobster is divided into three basic stocks for management purposes: the Gulf of Maine (GOM), Georges Bank and South (GBS), and South of Cape Cod and Long Island Sound (SCCLIS) stocks. This division was defined in 1993, based on geographic differences in life history characteristics such as growth rates and age at maturation. Despite the division, there is considerable exchange of larva and adult lobsters between areas (ASMFC 2000). In Canada, the lobster population is similarly split into several regions, the most important of which are the Southern Gulf of St. Lawrence, Southwest Nova Scotia, East Cape

Breton, and the Eastern and Southern Shores regions. In both the United States and Canada, these stocks are further subdivided into smaller management areas. In the United States the stocks are subdivided into seven lobster management areas, while Canada employs roughly 40 lobster fishing areas (LFAs). These areas collectively form a metapopulation, and management in one area can affect lobster populations and fisheries in other areas.

As of the mid-1990s, fishery managers in both the United States and Canada have reached the basic conclusion that lobster stocks are overfished, with overfishing occurring. Lobster stocks are generally considered to be growth overfished, but not recruitment overfished, meaning that future landings could be improved if fishing effort was curtailed and more lobsters survived long enough to grow larger and successfully reproduce (ASMFC 2003). In the U.S., the overfished status has been the case for an extended period of time. In 1996, the U.S. Stock Assessment Review Committee (SARC) conducted a stock assessment which concluded that GOM stocks were at high abundance, that GBS and SCCLIS stocks were at medium levels of abundance, and that *all three* stocks were overexploited (ASMFC 2000). Since then, the Lobster Stock Assessment Subcommittee has continued to classify all stock areas as growth overfished (Selberg, McBane et al. 2004). Amendment 3 to the Lobster Fishery Management Plan (FMP) outlined a rebuilding schedule to *end overfishing by 2005*. The current Technical Committee review indicates that these efforts have been unsuccessful, and that stocks remain overfished (Hilborn, Botsford et al. 2004).

The U.S. overfishing definition is based on the status of the stock in relation to its maximum spawning potential. Overfishing occurs when the fishing mortality rate (F) results in egg production per recruit (EPR) less than 10% of the EPR value in an un-fished stock (ASMFC 2000). The ASMFC's 10% EPR overfishing designation stems from the fact that the majority of lobsters landed are new recruits that may not have yet reached maturation. In 2001, the proportion of landings that were new recruits (i.e., just molted into legal size) ranged from around 80% in the Georges Bank and South region to 90% in the Gulf of Maine and nearly 98% in the South of Cape Cod to Long Island Sound region (ASMFC 2002). Allowing lobsters to grow out would arguably increase the size of harvests as well as improve the reproductive capacity of the population.

In Canada, managers similarly determined in 1995 that the risk of a recruitment collapse in lobster populations was unacceptably high due to low egg production. There was, however, considerable debate at the time over appropriate parameters and models used to define overfishing. Rather than dictate a concrete threshold of 10% EPR, in the 1998-2001 lobster management plan Canadian managers set out a goal of each LFA doubling its EPR level (Ennis, Collins et al. 2003; Gendron 2005). In this respect, the Canadian plan recommended relative improvements in EPR rather than absolute values. A series of conservation measures were implemented from 1998-2001 to improve EPR, with some success. Production figures indicate that after 1998 total American lobster landings in Canada rose back to near record levels, with some regional variation (Figure 6). On the whole, Canada still has some problems with overfishing, notably the 75-80% exploitation rate of lobsters at sizes below sexual maturity. However, the absolute volume of mature lobster biomass has remained at very high levels, even in areas with relatively high exploitation rates (Gendron 2005). This has led to the general sense that the stock is healthy, with a few regional exceptions (Miller 2005).

Despite concerns about the overfishing/overfished classification, landings and abundance of lobsters have increased dramatically over the past few decades. The relative glut of lobsters in the water indicates that the models have been poor at predicting the resiliency of lobster populations to intensive fishing. While the number of traps being fished in the Northeast increased substantially in the past forty years, landings have generally kept pace. For example, between 1967 and 2000, the number of traps in Maine increased four-fold, while landings increased six-fold (Figure 7) (ASMFC 2000). Catches in Maine broke the 30 million pounds mark in the early 1990s, 40 million pounds in 1997, 50 million pounds in 1999, 60 million pounds in 2002, and are expected to set a new record of greater than 63.6 million pounds in 2004 once the total harvest is tallied (Canfield 2005). This increase in Maine landings has been partially offset by peaked or declining landings in more southerly waters. Over the last decade, total U.S. landings increased from 60 million pounds in 1990 to over 80 million pounds in 2002 (Figure 6) (ASMFC 2004). Landings in Canadian waters have roughly paralleled those in the U.S. over the past thirty years, with record landings in 2001.

The sharp increase in American lobster landings and abundance despite the overfished status has led some to question the reliability of management models. An increase in shell disease in the species' southern range has also complicated assessments. The 2004 FMP Review summarizes:

During the 1990s, the fact that lobster stock abundance either remained stable or increased despite high and, in some cases, increasing fishing mortality rates, led to a great deal of speculation concerning the resiliency of the lobster resource to high exploitation rates. Recent declines in lobster stocks in Area 6 and Area 2 have confused the situation even more because the relative importance of high fishing mortality rates compared to lobster health issues is not known. (Selberg, McBane et al. 2004)

This assessment will briefly summarize lobster stock status in the major U.S. and Canadian regions before examining the debate on overfishing definitions.

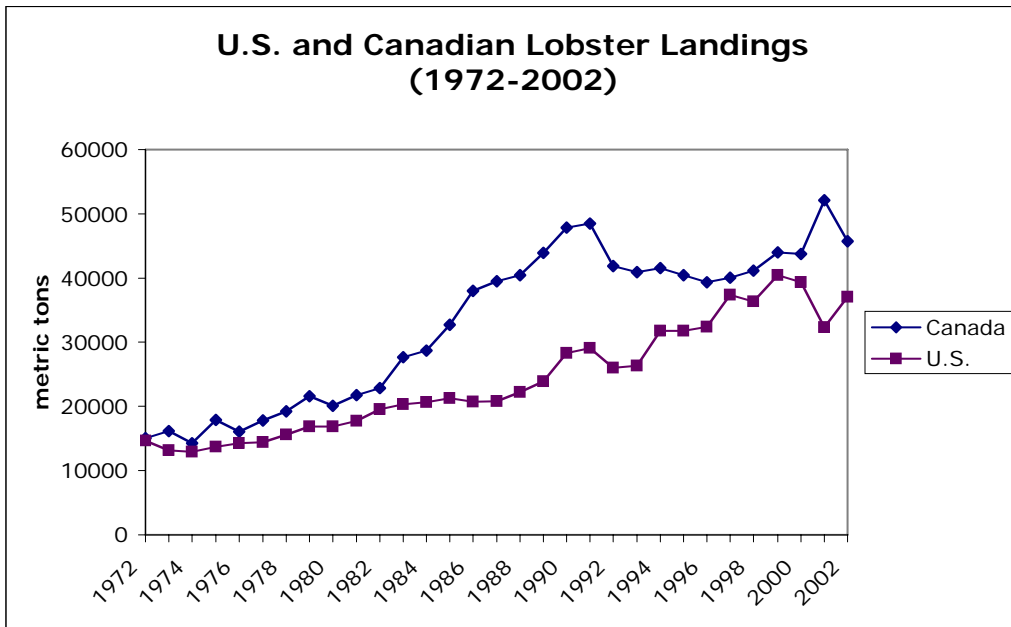


Figure 6 – U.S. and Canadian lobster landings (1972-2002) (NMFS landings database, 2004; DFO landings database, 2004).

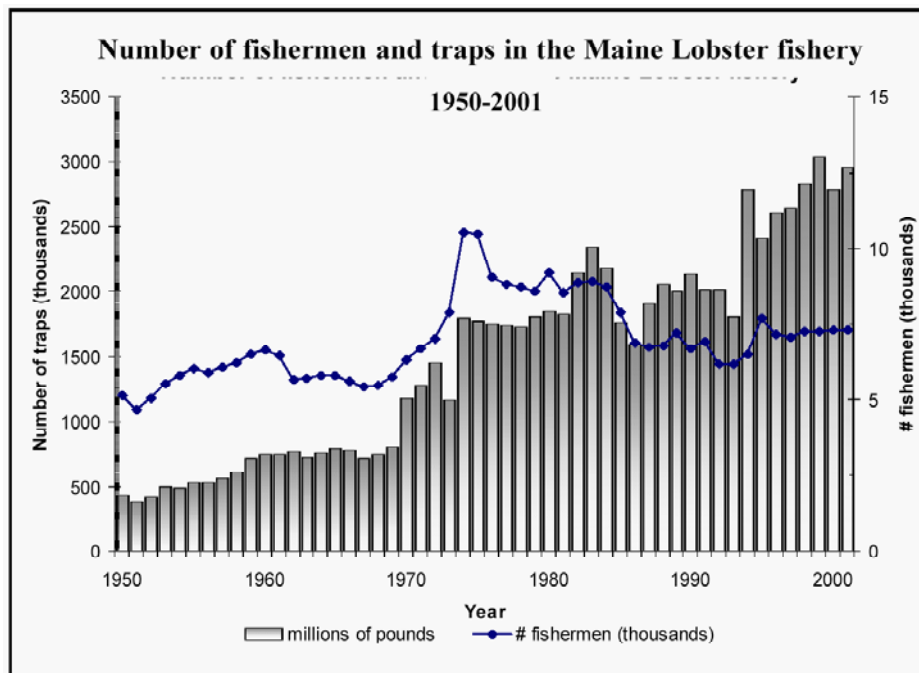


Figure 7 - Fishing effort in the Maine lobster fishery (DMR 2003).

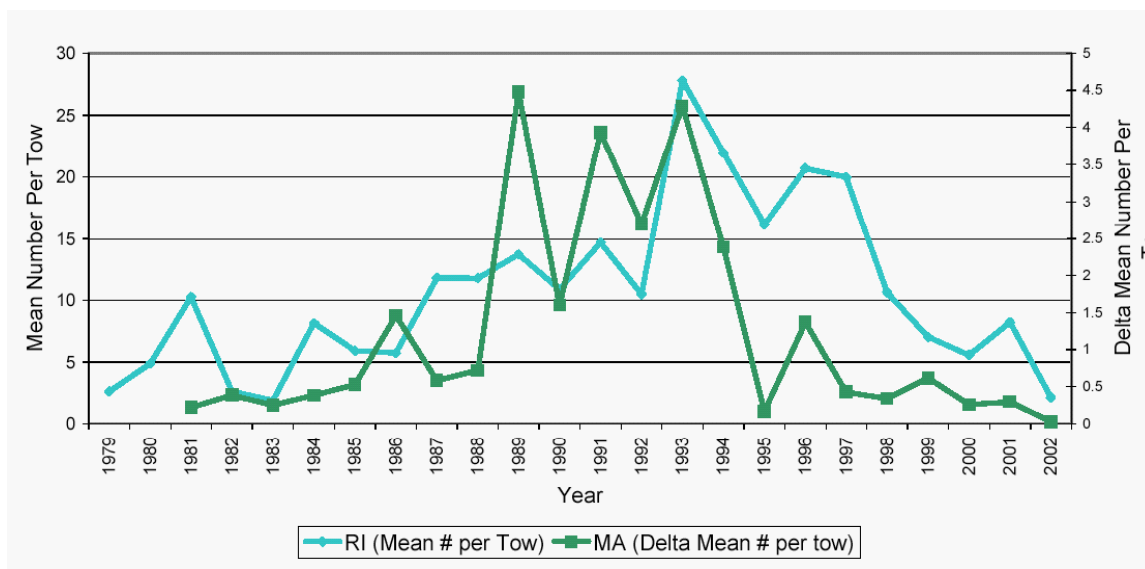
## **U.S. stocks**

### ***South of Cape Cod and Long Island Sound (SCCLIS or Southern New England)***

The last stock assessment for American lobster in the United States was completed in 2000. The assessment indicated that the egg per recruit ratio for lobsters in the SCCLIS stock was 8.3%, signifying an overfished population (ASMFC 2000). The review indicated that there was a 90% probability that overfishing had occurred during 11 of the 16 years prior to 2000 (ASMFC 2000). Despite this nominal overfishing the number of recruits in the area increased three-fold between the early 1980s and mid-1990s. Recently, however, the situation in Southern New England (SNE) has deteriorated. In 2001, total landings were less than 25% below average for both Massachusetts and Rhode Island (ASMFC 2004). Fishery-independent data for Southern New England show that lobster abundance is severely depressed in this area, with declines in pre-recruit, recruit, and legal lobsters over the past five years (Figure 8) (ASMFC 2003). As discussed in the Inherent Vulnerability criterion, above, the area has been impacted to an unknown extent by shell disease, the incidence of which has been steadily increasing (ASMFC 2003; ASMFC 2004).

In 2002, ASMFC's Lobster Technical Committee determined that existing management measures are "not sufficient to remedy the current stock declines observed in Area 2" (ASMFC 2002). Similarly, the 2004 FMP Review examined trends in biomass and abundance through 2002. The review summarized:

Upon review of the trawl survey trends there was a consensus among the [Technical Committee (TC)] that lobster abundance in the SNE stock unit is at or close to time series lows. There has been an observable consistent decline in prerecruit, recruit, and legal lobster indices among surveys, over the last 5 years. This decline follows record lobster abundance observed in the mid-1990s. The TC finds the low abundance of lobsters in the SNE stock unit particularly alarming in light of the current lobster health issues in this area, as well as the increased effort and fishing efficiency in the fishery as compared to when lobster abundance was low in the early 1980's. (Selberg, McBane et al. 2004)



**Figure 8** - American lobster: Area 2 trawl survey abundance trends 1979-2002 (all sizes, sexes) (ASMFC 2004).

***Georges Bank & South (GBS)***

Landings, recruit abundance and full recruit population size were all relatively stable throughout the 1980s and most of the 1990s. Landings peaked at about 4,300 mt in 1990 and subsequently remained stable at around 3,600 mt from 1992 through 1998. The GBS lobster stock benefits from a higher percentage of larger lobster than the other two U.S. stocks, and landings are consequently less dependent on new recruits. 1995-1997 data indicated that egg production per recruit was 6.2%, qualifying the stock as growth overfished, though not recruitment overfished. According to the model, there is a 90% probability that overfishing occurred during 8 of the 16 years prior to 2000 (Stirratt, McBane et al. 2002). The most recent FMP Review summarizes: “There was a consensus among the Technical Committee that lobster relative abundance in the GBS stock unit has remained relatively stable over the time series as measured by the NMFS Fall survey. There seems to be a slight increase in relative abundance of the legal sized category in the last 3 years” (Selberg, McBane et al. 2004).

***Gulf of Maine (GOM)***

The Gulf of Maine is the most productive of the three lobster producing areas in the U.S. Landings in this area increased by 75% between 1982 and 1997, reaching a record harvest of over 26,000 mt in 1997. Despite the increase in landings and fishing effort, fishing mortality rates declined and abundance increased over this period.<sup>2</sup> As of 2002, the ASMFC noted that fishing mortality rates were relatively stable between 1993 and the late 1990s, and were higher in the late 1980s (Stirratt, McBane et al. 2002). EPR was estimated to be just 3.2% in the period from 1995 through 1997, indicating that there is at least a 90% possibility that the stock was technically growth overfished every year between 1982 and 1997 (Stirratt, McBane et al. 2002). Despite this, the 2004 FMP Review assessment was:

<sup>2</sup> One exception in these trends was Massachusetts Bay, a sub-area that had very different characteristics from the region as a whole (Stirratt et al., 2003).

There was a consensus among the TC members that lobster relative abundance in the GOM stock unit has increased over the time series as measured by the NMFS Fall survey. Legal sized relative abundance of males and females are at or near time series highs. However, relative abundance of recruit and pre-recruit size classes has dropped in recent years from high observed in the late 1990's. Relative abundance indices from the MADMF trawl survey have varied without trend over the time series for pre-recruit, recruit and legal size classes. (Selberg, McBane et al. 2004)

In summary, U.S. lobster stocks are all technically growth overfished. Abundance remains high in both the Gulf of Maine and Georges Bank and South regions, though it has declined sharply in the South of Cape Cod and Long Island Sound region.

### **Canadian stocks**

The last overview stock assessment report for American lobster in Canada was released in 1998. Regional updates have subsequently been released in a piecemeal fashion. Assessing the status of the fishery is difficult, because no concrete overfishing standards have been set. The 1998-2001 fishery management plan created a goal of doubling EPR in each LFA, and numerous conservation measures were put in place. However, follow-up to the 1998 plan appears to have been lax. No strong incentives were put in place to encourage the fishery to actually reach conservation targets, in part because landings have remained high (Gendron 2005). As a result, while some areas have successfully doubled their EPRs, most have not, and no mandatory system of reporting exists to track success rates (Pezzack 2005).<sup>3</sup> While there is a framework for further improving the fishery, no deadlines have been set. One Department of Fisheries and Oceans (DFO) biologist comments that management no longer appears to maintain a genuine commitment to reach the 1998 EPR doubling target; for five years it was a focus, but subsequently commitment has waned (Miller 2005).

With respect to the regional distribution of lobster landings in Canada, by far the most important region is the Maritimes, which has accounted for roughly 85% of landings in recent years. In Canada, lobster is harvested throughout the Atlantic Provinces. Landings peak twice a year: once from April to June, and again in December when the southwestern Nova Scotia fishery opens. Most of the lobster fishery operates close to shore, with just eight vessels permitted to fish the deeper waters off southwestern Nova Scotia (AgriCanada 2004). Over the last century the three most important areas within the Maritimes were the Southern Gulf of St. Lawrence, Southwest Nova Scotia, and East Cape Breton regions (DFO 1998). Landings in all three regions grew substantially over the past thirty years, mostly peaking around 1990, though landings in Southwest Nova Scotia continued to increase through the late 1990s.

### ***Southern Gulf of St. Lawrence***

The Southern Gulf of St. Lawrence is the single most important lobster production area in Canada. Overall catches in the Gulf of St. Lawrence declined from a peak in 1990 of over 20,000 mt to about 17,000 mt in 2001, but remain well above historical averages. Over the past 20 years, the trend in fishing effort has been relatively flat, with the recent reduced landings reflecting a

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<sup>3</sup> There have been major improvements in the Gulf of St. Lawrence, eastern Nova Scotia, and parts of the Bay of Fundy. Other areas such as Southwest Nova Scotia, however, did not double (Gendron 2005; Miller 2005).

decrease in lobster biomass. As with fisheries in Maine, the Gulf of St. Lawrence fishery is highly intensive. As of 2002, exploitation rates were estimated between 60% and 90% by sub-region, and were primarily composed of new recruits. In its last regional stock assessment, the DFO stated: “Concerns about the high exploitation rate, high fishing effort, increasing fishing power and pattern, and low egg-per-recruit values still exist” (DFO 2002). Due to conservation efforts, such as an increase in the minimum harvest size, improvements in the egg-per-recruit ratio are expected; however, the assessment indicated that “Further measures to reduce the risk of recruitment failure are required for the entire Southern Gulf of St. Lawrence” (DFO 2002).

### ***Southwest Nova Scotia***

Since the 1980s, landings in Southwest Nova Scotia have tripled. 1999 and 2000 were banner years, with landings reaching about 18,000 mt of lobster, 90% of which were taken in near-shore traditional fishing areas. Exploitation rates during these years were estimated at nearly 70% with 85% of the landings newly recruited (DFO 2001). As of 2001, the DFO’s assessment was that the future for this fishery was unclear due to basic uncertainty around the causes of the increase in lobster production. DFO commented: “In the longer term, the causes for the historical stability of the LFA 34 lobster fishery, recent increases in landings, and the recent widespread recruitment pulse are not well understood” (DFO 2001).

### ***Cape Breton***

In the Cape Breton area, landings peaked around 1990 at about 3,000 mt. In recent years, landings have been closer to 2,000 mt (DFO 2004). While catch rates have improved since the mid-1990s the DFO comments that, “Concerns remain about high fishing mortality in much of [Lobster Fishing Area 27 – East Cape Breton’s main fishing area], and the lack of protection for large female lobsters in LFA 27” (DFO 2004).

In summary, abundance of Canadian lobsters is near record levels, though it has declined somewhat from a peak around 1990. Management has remained vague about an optimal EPR level; consequently, assessing whether stocks are overfished or have overfishing occurring is impossible to do using Canadian definitions. The closest thing to an overfishing definition is the doubling of EPR goal set out in the mid-1990s. Anecdotally, DFO fishery biologists indicate that some areas have met these goals while many have not.

### **Discussion of overfishing of lobster stocks**

As previously mentioned, overfishing is defined by Amendment 3 of the American Lobster Fishery Management Plan as occurring when any lobster stock is harvested at a rate that results in egg production less than 10% of that in an unfished population, on an egg-per-recruit (EPR) basis. The New England Fishery Management Council (NEFMC) established this standard in 1991 to incorporate long-term conditions into stock assessments (ASMFC 2000). To implement the definition, U.S. managers determine a maximum level of mortality,  $F_{10\%}$ , which will result in an EPR of 10% of an unfished population.  $F_{10\%}$  is calculated using a model that includes several variables such as lobster growth rates, mortality, and maturation. A relative EPR standard has also been employed in Canada, with the initial goal of doubling the 1996 EPR on an LFA-by-LFA basis by 2001.

There are reasons to believe that the EPR models are not particularly reliable. The model is difficult to implement because it requires knowledge of variable environmental and biological parameters. Chen and Wilson (2002) summarize:

Compared with finfish species, the EPR model for lobster is relatively complex because its life history is complex and growth is not continuous. The uncertainty in the estimation of  $F_{10\%}$  using the EPR model can originate from at least two sources: uncertainty in the model parameters, which are estimated from other studies, and natural variability in the parameters among different cohorts and geographic areas. (Chen and Wilson 2002)

At present, no quantitative estimates of uncertainty in these parameters are incorporated in the modeling process. Moreover, many of the parameter values were estimated “from some small samples collected many years ago when the status of the stock differed greatly from its current status” (Chen and Wilson 2002). Similarly, estimates of  $F_{\text{current}}$  are based on National Marine Fisheries Service (NMFS) trawl surveys that may under-sample inshore areas that are key lobster habitats (Chen and Wilson 2002). Even given set parameters, it is difficult to agree on an appropriate model. For example, in Canada, at least three models are used: the WHOI model (also employed by NMFS) is used in Nova Scotia; a more elaborate model is used in Quebec; and a third model is employed in Newfoundland (Gendron 2005).

This discussion of the reliability of the EPR model is important because, according to the EPR definition, the American lobster fishery has been overfished for two decades. In all three U.S. management areas, the fishing mortality rate ( $F$ ) exceeds the  $F_{10\%}$  reference point, and length-frequency distributions are skewed relative to their normal condition (ASMFC 2000). However, during this period both landings and abundance have doubled. Chen and Wilson (2002) comment that, “The implication of this seems to be that the [Biological Reference Point]  $F_{10\%}$  currently used is underestimated, that  $F_{\text{current}}$  is overestimated, and (or) that  $F_{10\%}$  is not an appropriate reference point for assessing the American lobster stock.” What is clear is that there has been a recruitment pulse in lobsters over the last two decades. The 2000 American Lobster Peer Review Panel concluded that high survival rates for early life history stages are at least in part a reflection of environmental conditions and the results of other human activities (e.g., increased temperature, shifts in climatic conditions, and reduced predatory groundfish stocks), and it is unknown how long these conditions will persist (ASMFC 2000). In addition to changing environmental conditions, the Habitat Effects criterion also explores the hypothesis that the increase in abundance is due in part to prolific bait use in lobster traps (Saila, Nixon et al. 2002).

Given the schism between the overfishing classification and increasing abundance, ASMFC tasked its Lobster Model Review Panel with assessing current management models (Hilborn, Botsford et al. 2004). The 2004 report delivered a stinging criticism of the current modeling practice, with the authors noting: “We found that none of the assessment methods were demonstrated to estimate absolute EPR or the  $F_{10\%}$  threshold with any reliability, and we would have to say that there is no possibility of using the models being considered, given the available data, to reasonably manage on this basis” (Hilborn, Botsford et al. 2004). The panel recommended that management agencies *abandon* the use of absolute EPR reference points or estimations of  $F_{10\%}$  as thresholds for fishery health. Instead, the Lobster Model Review Panel

suggested using catch statistics and relative fishing mortality. For example, “A candidate for fishing mortality could be  $F_{current}/F_{(average\ 1983-1987)}$  recognizing the fact that strong recruitment was generated by the spawners during those years” (Hilborn, Botsford et al. 2004). In a sense, this is what the Canadian management system has focused on. By recommending relative changes rather than absolute targets, DFO has sponsored a conservation strategy with regional variation.

Given the existing debate over modeling techniques, it is difficult for this review to definitively characterize American lobster fisheries. Stocks are near record abundances but have officially been defined as overfished with overfishing occurring for two decades. Moreover, as briefly discussed, there is significant regional variation, particularly with stocks in the American lobster’s southern range, which have been substantially less productive and which have been impacted by outbreaks of shell disease.

### **Age, size, and sex distribution**

In addition to affecting lobster abundance, size-selective fishing has shifted the size, age, and sex distribution of lobsters. Lobster size is important, particularly in females, because it is related to the quantity of eggs that can be produced. As with most egg-bearing animals, larger females are more fecund. Moreover, different sized lobsters employ different reproductive strategies and migratory patterns, such that a diversity of lobster sizes may be important in maintaining the resilience of the stock. The natural size distribution of American lobster stocks has been significantly truncated. Historically lobsters lived long enough to grow much larger, ranging up to four feet in length. Prior to the last century, lobster populations are believed to have been composed of much larger lobsters, and the egg-bearing population included a considerably higher share of older, larger females (ASMFC 2000). In the 1840s, for example, 10-12 pound lobsters were commonly found in markets, with *average* weights closer to 4 pounds. Today, young lobsters, on average less than the 1-1/4 to 1-1/2 pound animals most frequently found in the market, dominate lobster populations. Even in the past half-century, shifts in size distributions are evident; for example, a comparison of lobster size frequencies from outer Cape Cod landed in 1957 and 1998 demonstrated a dramatic change in size structure (Estrella and McKiernan 1989; ASMFC 2000). In many areas, this pressure on older lobsters is being addressed through maximum size limits, which prohibit retention of lobsters above a specified length, and in some regions skewed size and age distributions are improving (Miller 2005).

In addition to shifts in the size and age distribution of lobsters, fisheries exert a selective pressure against male lobsters. Berried females are protected in most areas through a practice referred to as V-notching (wherein the lobster fin is clipped to permanently mark the animal), while males lack comparable protections.

Despite these pressures there is no evidence to date that the harvesting of young lobsters has selected for faster-reproducing animals (a phenomenon observed with other intensively harvested species, such as Atlantic cod). ASMFC notes: “Although speculation about the impact of exploitation in reducing size at maturity is a popular notion, a comparison of the smallest ovigerous females observed in southern Massachusetts waters across a 100-year period provided no evidence of change in the size at onset of sexual maturity” (Estrella and Cadrin 1995).

### Synthesis

In the U.S., American lobster is officially considered growth overfished with overfishing occurring. Barring other considerations, this combination would automatically result in a “critical conservation concern,” and an overall Seafood Watch® ranking of Avoid. However, as discussed, there is considerable controversy surrounding the use of the EPR model. For reasons that are not entirely clear, American lobster abundance has increased substantially over the past thirty years and remains high in the Gulf of Maine and Canadian waters, despite the overfished designation of this stock. In contrast, abundance has recently fallen in Southern New England. Concern centers on the ability of the lobster stock to maintain its high productivity in uncertain environmental conditions. In Canada, less information is published on the state of stocks, but conditions appear similar to those in the Gulf of Maine; abundance and exploitation are both high. Given management’s inability in both countries to reach stated conservation targets along with the substantial uncertainties surrounding optimal EPR levels, future environmental conditions, and high exploitation rates, the current stock status of American lobster is considered ‘Unknown,’ and rates as moderate conservation concern (Table 2).

**Table 2** – Stock status of American lobster.

Classification Status	B/B <sub>MSY</sub>	Occurrence of Overfishing	F/F <sub>MSY</sub>	Abundance Trends/CPUE	Age/Size/Sex Distribution	Degree of Uncertainty in Stock Status
Growth overfished	Undefined	Yes	Undefined	Short-term trends increasing in GOM, variable in GBS, and falling in SCCLIS. Canadian stocks peaked ~1990.	Skewed relative to natural condition	High

### Status of Wild Stocks Rank:



### Criterion 3: Nature of Bycatch

*Guiding Principle: A sustainable wild-caught species is captured using fishing techniques that successfully minimize the catch of unwanted and/or unmarketable species (i.e., bycatch). Bycatch is defined as species that are caught but subsequently discarded (injured or dead) for any reason. Bycatch does not include incidental catch (non-targeted catch) if it is utilized, accounted for and/or managed in some way.*

### Introduction

The term “bycatch” refers to the unintentional landing and discarding of animals not specifically targeted by fishing vessels. Animals may be discarded for a variety of reasons, both economic and regulatory. Commonly discarded animals include those that are of an undesirable size, sex,

or species. In addition to discards, fishing typically involves some degree of unobserved animal mortality associated with fishing gear (e.g., animals entangled in nets, breaking free of hooks or lines, and ghost fishing). This incidental or “collateral” mortality is also identified as bycatch in this review.

Globally, bycatch has been recognized as a major problem associated with commercial fisheries. It was estimated in the early 1990s that fishery discards sum to between 18 and 40 million tons of marine life per year worldwide, representing approximately one-third of wild fishery landings (Alverson, Freeberg et al. 1994). In addition to comprising a large share of marine productivity, bycatch has led to the decline of several species of sharks, sea turtles, whales, and seabirds. This unintentional destruction of marine life represents one of the most significant but least well-documented pathways through which fisheries impact marine ecosystems.

In general, the pots used in commercial lobster fisheries are among the more selective types of fishing gear. As a result of this selectivity, overall *levels* of bycatch in pots are low in lobster fisheries, relative to other marine fisheries. The most common types of bycatch in lobster pots are juvenile lobsters and crabs, as well as some bottom fish and other invertebrates. The discard mortality rates (the percentage of discarded animals that die) associated with animals caught in traps is low, particularly when compared against the mortality rates linked with mobile fishing gears such as trawls and dredges.<sup>4</sup>

One issue associated with bycatch that will also be reviewed in this section is the use of bait. Lobster fishermen generally use bags of baitfish such as herring and mackerel to attract lobsters into traps. While bait is not technically bycatch, the issues surrounding baitfish removal are closely aligned with this criterion. Harvesting fish for bait represents an indirect effect that the lobster fishery has on marine ecosystems, analogous to that of bycatch.

A less common, but far more acute concern than day-to-day bycatch and bait use is the entanglement of marine mammals in lobster gear, most notably North Atlantic humpback and right whales. While such interactions with whales are relatively uncommon from the perspective of the lobster fishermen, who rarely if ever see these animals, the interactions appear to be alarmingly frequent for the whales. With right whales officially endangered and humpback whales listed as vulnerable on the IUCN (World Conservation Union) Red List, even occasional mortality from entanglement is a very grave concern. Entanglements with right and humpback whales led the National Marine Fisheries Service (NMFS) to list the U.S. lobster fishery as a Category I fishery, technically defined as one that is by itself responsible for the annual removal of 50% or more of any stock’s Potential Biological Review (PBR) level. In part as a consequence of this listing, considerable management attention has been devoted to the issue of marine mammal entanglements in recent years.

This review will characterize typical bycatch and bait use in the lobster industry before turning to the more difficult topic of marine mammal entanglements.

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<sup>4</sup> All gear types have some incidental mortality. One commenter noted: “All major fishing gear types involve some degree of injury to fish by internal and external wounding, crushing, scale loss, and hydrostatic effects, with the severity of injury dependant on gear type. Contact among fish in gear ranges from little in hook and line and gill-netting to moderate in traps and abundant in trawling and purse-seining with brailing” (Davis 2002).

### **General bycatch**

There is little quantitative information available detailing the composition of bycatch in U.S. or Canadian lobster fisheries. Currently, no U.S. bycatch monitoring program exists for the lobster fishery in the United States or Canada (NMFS 2003; Gendron 2005). While there has been no systematic review, bycatch in lobster traps is reported to consist of a variety of animals attracted to bait and capable of entering traps. Types of fish occasionally caught in lobster traps include tautog, scup, black sea bass, cod, cusk, eels and flounder. A study monitoring bycatch in the lobster fishery off New York found that tautog (23%) and scup (30%) were the two species of finfish most commonly taken in lobster pots (ASMFC 1997). In addition to fish, a variety of invertebrates are found in and attached to lobster traps. These include rock crabs, Jonah crabs, red crabs, starfish, urchins, whelks and conchs (ASMFC 1997; Butler 2004; Miller 2005). In Canada, cod and one species of cusk are species of concern, but bycatch rates of these species are low and vary by area. At present, no efforts are underway to limit the very small bycatch of these species (Miller 2005; Pezzack 2005). Ironically, the animal perhaps most commonly discarded from lobster traps is American lobster. Regulations prohibit lobstermen from landing a variety of lobster, including small and juvenile lobsters, berried females and V-notched females in some areas, and lobsters above maximum size limits in some areas. Given the frequency with which discarded lobsters are re-caught, discard mortality of these regulatory discards seems to be very low.

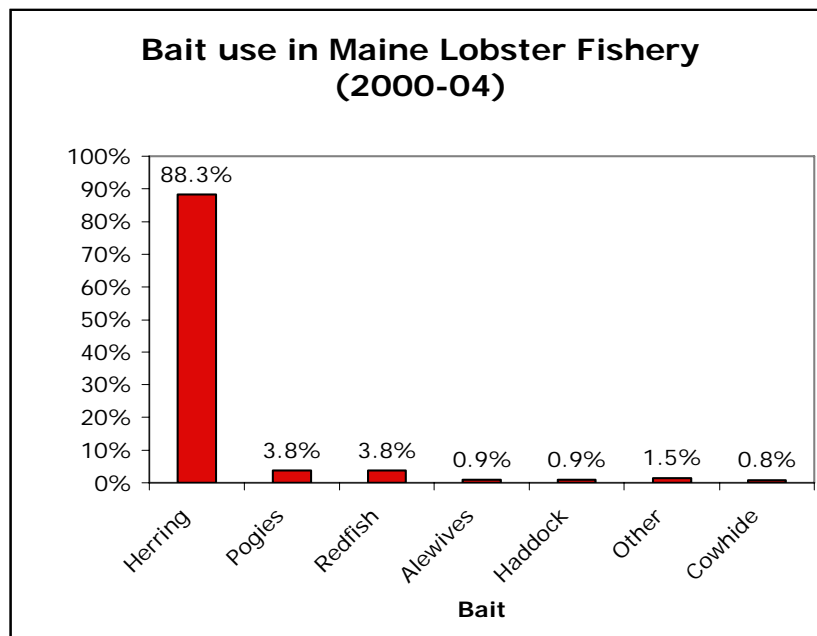
In more general terms, the effects of bycatch from pot fisheries are thought to be low. For example, a recent workshop of fisheries experts assessed different gear types for levels of bycatch; by consensus, pots and traps were ranked “Very Low” for bycatch of sharks, seabirds, and turtles, “Low” for bycatch of finfish, “Medium” for interactions with marine mammals (addressed below), and “High” only for bycatch of shellfish and crabs (Chuenpagdee, Morgan et al. 2003). Because of the nature of trap fisheries, fish and invertebrates landed in traps are likely to be discarded with lower mortality rates than those landed with other gear types such as trawls and dredges (Davis 2002). The number of animals that die after being caught and discarded in the American lobster fishery appears small compared to actual lobster landings. Recognizing that uncertainty persists, typical bycatch would result in a green to yellow ranking; however, ordinary bycatch is overshadowed as a conservation issue by the two remaining issues: bait use and marine mammal entanglement.

### **Bait use**

In contrast to discards, more quantitative information is available for bait use. Clearly, bait is not technically “bycatch” by any definition; it is an important *input* into the trap fishery, rather than an *output* or a direct effect of the fishery. However, the use of bait shares one major factor in common with bycatch: it represents an area where a fishery may be responsible for a loss of marine life not directly measured in its landings. Due to the structure of the Seafood Watch® review, the bycatch criterion appears to be the most appropriate place to examine this issue.

Bait is an integral component of the lobster fishery. Each time a lobster pot is set, lobstermen place a bag of bait inside to attract lobsters. The type of bait used varies by region and season. Atlantic herring (*Clupea harengus*) is the major source of lobster bait in the United States, reportedly comprising about 90% of the bait used in Maine (Gosselin 2004). The remaining 10%

is mostly other fish such as pogies, alewives, and redfish (Figure 9). In Canada, Atlantic mackerel (*Scomber scombrus*) is reportedly the most common bait source in lobster fisheries, but other sources of bait include herring, mackerel, rock crabs, flounder, gaspereaux, and processing wastes from fish plants (Romanowsky 2000; Butler 2004; Pezzack 2005).



**Figure 9** – Source of bait in the Maine lobster fishery (2000-2004) (Gosselin 2004).

It is important to address at least two potential objections to incorporating bait use into the bycatch criterion:

- First, there is an argument to be made that the effects of removing/fishing baitfish such as herring ought to conceptually be kept separate from the lobster fishery. By rolling them into the same review, there is the danger of double-counting the bait fisheries, and conflating the two scores. However, insofar as this report exists to inform consumers, the only opportunity to assess commodities not sold directly to consumers (e.g., bait fish) is to incorporate some recognition of their use in the end product. Otherwise, the one-third of the global fisheries harvest that is *not* destined for direct human consumption cannot be incorporated into this review system. By the same rationale, when wild fish are processed into fishmeal and fish oil and sold to fish farming operations, the use of fishmeal and fish oil is taken into consideration in Seafood Watch® assessments of aquaculture operations.
- Second, in an economic framework, baitfish represent a market commodity governed by an existing regulatory structure. To the extent that this commodity is limited by supply (e.g., catch limits) rather than demand, it is possible that if the lobster fishery were to cease to purchase baitfish, the fish would continue to be harvested and the bait would be purchased by other end-users. In reality, while some degree of substitution is likely, at present the lobster fishery appears to be the primary source of demand for at least the

herring fishery. According to the Maine Department of Marine Resources, the emergence of large-scale fisheries for herring in the Gulf of Maine, Georges Bank, and southern New England waters is a relatively new occurrence, promoted in large by demand from the lobster industry. Commercial landings of Atlantic herring are currently between 70,000 and 100,000 mt of which roughly 60% (~50,000 mt) goes to the lobster baitfish market (DMR 2004). The Atlantic States Marine Fisheries Commission (ASMFC) has noted that at present the Atlantic herring plays a “vital role” as a bait source for the “dependent” lobster fishery (Gamble 2003). Given the importance of the bait fishery to the lobster fishery, and *vice versa*, herring and mackerel fisheries appear to be tightly linked with lobster. Fortunately, herring is currently ranked as a “Best Choice” in the Seafood Watch® system.

In terms of the effects of bait use, the removal of herring and mackerel is important because extraction of these fish can impact the marine ecosystem. Atlantic herring and mackerel are both abundant oceanic schooling fishes distributed in the western Atlantic between Labrador and Cape Hatteras. They represent a vital food source for a range of other fish, marine mammals and seabirds (DMR 2004). A recent review on the ecological effects of fishing (Dayton, Thrush et al. 2002) notes:

Low trophic-level species—like sardines, herring, and anchovies—typically mature rapidly, live relatively short lives, and are extremely abundant. As a result, they are among the most heavily exploited species in the world. Single-species models, particularly those based on maximum sustainable yield, suggest that lower trophic-level species have tremendous potential for sustainable exploitation. Ecosystem models, on the other hand, present a more sobering view. First, these models suggest that heavy exploitation could affect increased populations of their competitors, and declines in populations of their predators. Second, ecosystem models suggest that large removals of forage species could work synergistically with heavy nutrient loading to exacerbate problems of eutrophication in enclosed coastal ecosystems.

While for this review Seafood Watch® found no such ecosystem models specific to herring or mackerel, these remain important concerns to recognize. That said, the biomass of herring stocks is very high at present, such that the removal of herring for the lobster fishery appears unlikely to have major ecosystem effects.

With respect to incorporating bait into this review, bait use is conceptually similar to the use of wild fish inputs (i.e., fishmeal and fish oil) in aquaculture operations. One of the characteristics of unsustainable aquaculture is a dependence on large quantities of wild fish as feed inputs. For *farmed* species, a ratio of wild inputs to farmed outputs of greater than 2.0:1 is considered by the Seafood Watch® program to be an extensive use of marine resources, resulting in a high conservation concern for the related criterion. A ratio between 2.0:1 and 1.1:1 is considered to be a moderate use, meriting a ranking of moderate conservation concern.

In terms efficiency, it has been estimated that 50,000-60,000 tons of bait are used in the U.S. lobster fishery annually, to yield approximately 35,000 tons of adult lobsters. Presumably this

ratio is similar in Canadian lobster fisheries. The ratio of bait inputs to lobster landings is therefore approximately 1.5:1 for the industry as a whole. If bait use in the lobster fishery were assessed using farmed fish criteria (and several have made the argument that lobster fisheries represent a quasi-farmed species—e.g., Saila, Nixon et al. 2002; Yund 2004) it would merit a moderate ranking for the use of marine resources criterion. Given that bait is a substitutable market commodity, the closest analogue to the bait used in the lobster fishery is feed used in carnivorous aquaculture operations. Overall, assessing bycatch only in terms of bait use would result in a moderate conservation concern ranking for the bycatch criterion.

### **Protected species**

In contrast to commercial lobster bycatch, which predominantly consists of animals attempting to enter traps, marine mammal entanglements usually result from animals accidentally running into the lines or gear. Entanglement is a major issue for marine mammals worldwide, and one that emerged with the proliferation of synthetic net and rope in fisheries starting in the middle of the 20<sup>th</sup> century (NMFS 2003).

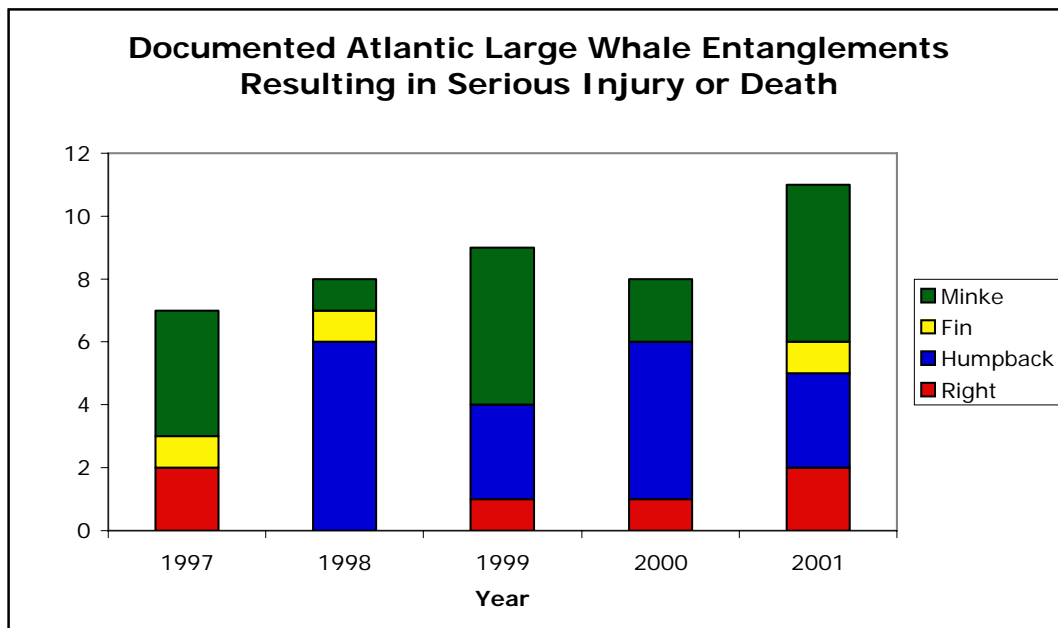
In the North Atlantic, entanglements are increasingly coming for whales, which become ensnared in both horizontal and vertical lines. Generally these lines are 3/8 to 1/2-inch ropes, made out of synthetics such as polypropylene (Moore, Reeb et al. 2001). Polypropylene is an inert plastic, which has the disadvantage in this context of being both buoyant, causing horizontal lines between traps to float on the water's surface, and not quickly biodegradable (NMFS 2003).

In some cases entanglement causes immediate mortality through suffocation. Clapham et al. (2001) comment: "Some fishing gear (notably that involving long strings of large traps) is heavy enough to render an entangled whale immobile, and if the entanglement occurs below the surface, death will inevitably result. This has been frequently observed off eastern Canada, where significant numbers of humpback and minke whales have been killed by such entanglements." In other cases, entanglements are not immediately fatal. Large whales in particular are often strong enough to continue moving, even when wrapped in line or gear. Even apparently innocuous entanglements, however, can reduce an animal's ability to feed or move, or lead to serious infections (Clapham et al. 2001).

In the Northwest Atlantic, nearly a dozen different species of whales and seals have been entangled in fishing gear. In recent years, over half of reported large whale entanglements in New England involved humpback whales (55%), with the remainder comprised of North Atlantic right whales (29%), minke whales (12%), and fin whales (4%) (Figure 10).<sup>5</sup> Blue whales are occasionally entangled as well (NMFS 2003). Often the specific fishery responsible for the entanglement remains unknown; the only evidence of an interaction being a length of anonymous line snared on the whale's body. For example, preliminary analysis of gear entanglements in 2003 by NOAA Fisheries indicated that of 42 reported entanglements involving right, humpback, fin and minke whales, gear was identified or recovered in only 18 cases. In those instances, the identified types of gear were gillnets, lobster pots, and vessel anchors (ALWTRT 2004).

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<sup>5</sup> There are strong reasons to believe that these percentages are not entirely representative. Unreported mortality is substantial (see the right whale section). Because fin and minke whale carcasses sink they are less likely to be observed than right whales carcasses.



**Figure 10** – Large whale entanglements resulting in serious injury or death (1997-2001) (NMFS 2005).

With respect to the American lobster fishery specifically, lobster gear is officially recognized as potentially dangerous to several species of whale including the North Atlantic right whale, North Atlantic humpback whale, fin whale, and minke whale (Register 2004). Because of entanglements with humpback and right whales, the American lobster fishery was classified by the NMFS as a Category I fishery; it poses the most serious risk to a protected species. While it is often difficult to trace the line back to specific fisheries, a number of factors—including the sheer volume of gear—suggest that the largest single source of entanglements on the Atlantic coast may be the American lobster fishery (Bowman 2004; NMFS 2005). In addition to large whales, smaller marine mammals such as harbor seals are regularly snared in fishing gear, though for different reasons. Harbor seals are more likely to drown while trying to enter or poach food out of traps than to become snared in lines (Cairns, Keen et al. 2000).

This section will present an overview of marine mammal entanglements in the Northwest Atlantic, with an emphasis on what is known about connections to the lobster fishery. It will briefly summarize the state of entanglements with minke whales, fin whales and harbor seals, before addressing the more acute problem of humpback and right whale entanglement.

### ***Minke whales (*Balaenoptera acutorostrata*)***

The American lobster fishery interacts with the Canadian East Coast stock of minke whales. This stock, which ranges down the eastern seaboard of the U.S., is one of the minke whale's four North Atlantic populations. It is not listed as endangered or vulnerable in the United States. As of December 2003, NMFS' best estimate for abundance in the Canadian East Coast stock was just over 4,000 animals. While there are insufficient data to determine a population trend for this stock, the Potential Biological Removal (PBR) can be estimated from known life-history parameters. PBR as defined by the Marine Mammal Protection Act (MMPA) is an estimate of

the maximum number of animals (excluding natural mortalities) that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population (NMFS 2005). The PBR for minke whales is estimated at 35 whales per year (Waring, Pace et al. 2004).

While minke whales are occasionally entangled in lobster and other fishing gear, NMFS' calculations indicate that current interactions are not jeopardizing the stock. From 1990 through 1996, 8 recorded minke whale mortalities were attributed to the lobster fishery in the Gulf of Maine and mid-Atlantic region. From 1997 to 2001, only one minke whale mortality was specifically attributed to the lobster fishery (a female whale was observed entangled in lobster gear off the coast of Maine in August 1997). However, over the same five-year period 13 other minke whale mortalities were incurred by unidentified fishing gear (Waring, Pace et al. 2004). Total *documented* fishing mortality (all gears) during this period summed to an average of 3.4 animals per year: roughly one tenth of PBR. The potential for undocumented mortality is discussed later in this section in connection with right whales. Based on the above data, NMFS concludes that fishing gear is not threatening the continued existence or recovery of the minke whale stock.

#### ***Fin whales (Balaenoptera physalus)***

In addition to minke whales, the American lobster fishery is known to have infrequent interactions with the western North Atlantic stock of fin whales. Due to historic whaling pressure on this stock, which continued even into the early 1970s in Canada, fin whale populations are depressed enough to be listed as an endangered species in the United States. Despite this listing, fin whales are thought to be the most abundant large cetacean on Georges Bank and in the Gulf of Maine. The best population estimate for this stock of fin whales is 2,800 animals, with unknown population trends (Waring, Pace et al. 2004).

NMFS estimates the PBR for the western North Atlantic fin whale to be 4.7 whales per year. At present, the main documented source of human-caused mortality for fin whales is ship strikes; seven fin whales were recorded as struck and killed by commercial vessels between 1997 and 2001 (Waring, Pace et al. 2004). In contrast, documented interactions of fin whales with fishing gear are relatively uncommon. NMFS records list just three serious injury/mortality events from 1997 through 2001, with one each in Canadian, U.S., and Bermudan waters: an average of 0.6 mortality events per year. The current stock assessment does not indicate what type of gear or fishery was responsible for these mortalities (Waring, Pace et al. 2004). In addition to the three documented entanglements, the stock assessment reports that there were “four records within the period that lacked substantial evidence of the severity of the entanglement for a serious injury determination, or that did not provide the detail necessary to determine if an entanglement had been a serious factor in the mortality” (Waring, Pace et al. 2004).

Considerable uncertainty surrounds fishing interactions with fin whales. While observed fin whale mortalities are less than the estimated PBR, the frequency of unobserved/unreported mortality events is unknown (see the section on right whales for an extended discussion of this point). Lobster gear was not specifically implicated in any fin whale mortality events between 1997 and 2001.

***Harbor porpoises (Phoca vitulina) and seals***

Unlike minke and fin whales, the population of harbor porpoises in New England is clearly and rapidly increasing. Since the passage of the Marine Mammal Protection Act in 1972, the New England population of harbor porpoises has increased roughly nine-fold (Waring, Pace et al. 2004). A best estimate for the current population is approximately 100,000 porpoises. The species is not listed as an endangered or threatened species. The PBR for harbor porpoises in U.S. waters is just under 5,500 porpoises per year.

Due in part to their large numbers, porpoises are the most commonly-killed marine mammal in the North Atlantic. NMFS estimates the current annual mortality from humans is nearly 1,000 per year in the U.S., predominantly from fisheries. This “take” is less than 20% of the PBR, and as such is not believed to be a serious threat to the population.

In Canada, a Department of Fisheries and Oceans (DFO) technical report estimated that nearly 800 seals died in Prince Edward Island (PEI) waters in 1997 alone due to interaction with fishing gear (Cairns, Keen et al. 2000). With respect to the lobster fishery specifically, pots do not appear to be a major source of seal mortality. Most of the seal mortality on PEI was due to interactions with smelt trap-nets, tuna hooks, and gillnets. Lobster traps were estimated to account for about 50 of the 800 seal deaths (Cairns, Keen et al. 2000). In the U.S., the current stock assessment reports:

Incidental takes in lobster traps in inshore waters off Maine are reportedly rare. Captures of approximately two seal pups per port per year were recorded by mid-coastal lobstermen off Maine (Gilbert and Wynne 1985). Porpoises have been reported to rob bait from inshore lobster traps, especially in the spring, when fresh bait is used. These incidents may involve only a few individual animals. (Waring, Pace et al. 2004)

Given the rapid increase in porpoise populations and the resiliency of the population, current rates of porpoise mortality in lobster traps are not jeopardizing the population. Moreover, lobster fisheries do not appear to be a major contributor to current porpoise or seal mortality.

***Humpback whales (Megaptera novaeangliae)***

In the western North Atlantic, humpback whales are found from the eastern coast of the United States east to Greenland and Norway. The current population size of this stock is estimated at over 7,500 individuals, with a best estimate of 11,500. The Gulf of Maine supports a substock, the minimum population of which is estimated at approximately 650 animals. Current data suggest that the population in the Gulf of Maine and North Atlantic is increasing, albeit slowly. Based on assumed productivity rates, NMFS has set the PBR for the humpback whale substock in the Gulf of Maine at 1.3 whales per year.

From 1997 through 2001, documented human-caused mortality for the Gulf of Maine substock was 2.6 whales per year—double the PBR. This documented mortality was caused by interactions with fishing gear (an average of 2.2/year; 1.6 in U.S. waters, 0.6 in Canadian waters) and ship strikes (0.4/year in Canadian waters) (Waring, Pace et al. 2004). With respect to entanglement in fishing gear, on average of four to six entanglements are reported each year in

the southern Gulf of Maine. From 1990 to 1994, there were 11 documented entanglements of humpback whales specifically involving lobster gear. From 1997 through 2001, 17 entanglements were documented for North Atlantic humpbacks, with only one clearly attributed to lobster gear (an adult humpback anchored by offshore lobster gear near Montauk, New York). Of the other 16 entanglements reported between 1997 and 2001, at least six involved netting of some kind, indicating the lobster fishery was not involved. The ten remaining documented entanglements were not clearly attributable to any specific fishery (Waring, Pace et al. 2004). The same assessment notes that humpback entanglements also “occur in relatively high numbers in Canadian waters” with the most frequent gear interactions there from gillnets and cod traps (Waring, Pace et al. 2004).

These reported mortality rates appear too high for the humpback whale stock to support it comfortably. The PBR has been regularly exceeded in recent years by documented cases alone. In addition, significant numbers of entanglements go unreported each year. NMFS reports: “Robbins and Mattila (2001) estimated from scarring around the caudal peduncle that at least 71% of humpback whales in a sample of 99 animals from the Gulf of Maine had been entangled at one time or another, and that, on average, *between 10% and 31% of the population had such encounters each year*” (emphasis added) (NMFS 2003). Given a Gulf of Maine population of over 650 animals, these statistics suggest that the range for humpback whales entangled in the Gulf of Maine is 65-200 animals per year. With a PBR of 1.3, this encounter rate is clearly unsustainable. Even in the mid-1990s it was estimated that human-caused and natural mortality of humpback whales in the Gulf of Maine and off of Newfoundland and Labrador was 5% greater than the birth rate (Volgenau, Kraus et al. 1995). Interactions in recent years do not appear to have fallen. The 2002 Large Whale Entanglement Report released by NMFS recorded 14 live entangled humpback whales and 5 dead entangled humpbacks (Whittingham, Hartley et al. 2003).

Overall, human mortality of humpback whales is alarmingly high, with entanglements in fishing gear being the primary cause. While there is poor information available for determining which fisheries are mainly responsible for the interactions, horizontal and vertical lines attached to lobster pots appear to be one of the most likely sources of mortality. The extent of these lines is examined in greater detail in the following section on right whales.

### ***Right whales (Eubalaena glacialis)***

Three discrete populations of right whales exist in the world: one in the North Atlantic, one in the North Pacific, and a third in the Southern hemisphere. The North Atlantic stock can be further divided into western North Atlantic and eastern North Atlantic stocks, with the western North Atlantic stock distributed from northern Florida through the Bay of Fundy (Fujiwara and Caswell 2001). These baleen whales typically calf off of the southern United States in winter, migrating north in the spring to the Gulf of Maine and Canadian waters for feeding and nursing their young (Baumgartner, Cole et al. 2003; Waring, Pace et al. 2004). There are at least six major congregation areas for western North Atlantic right whales: Georges Bank/Gulf of Maine, Cape Cod and Massachusetts Bay, the Bay of Fundy, the Scotian Shelf,<sup>6</sup> the coastal waters of the

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<sup>6</sup> In Canadian waters, the Department of Fisheries and Oceans (DFO) reports: “In the past, the Northern Atlantic Right whales were found in the Gulf of St. Lawrence during the summer and in the shore off Newfoundland. Currently, they are occasionally seen off the coasts of Newfoundland and Nova Scotia” (DFO 2004). The St.

southeastern United States, and the Great South Channel, all of which, apart from the southeast, support an active lobster fishery (Waring, Pace et al. 2004).

Today, North Atlantic and North Pacific right whales are arguably the two most endangered great whale populations in the world. Whaling fleets drove the right whale stock in the North Atlantic down from about 12,000 animals in the 11<sup>th</sup> century to the brink of extinction by 1900 (Waldick, Kraus et al. 2002). After commercial whaling ceased, the population started a gradual recovery. However, new surveys indicate that over the past fifteen years this progress has halted or even reversed (Fujiwara and Caswell 2001). Population growth rates are thought to have declined, falling to an estimated 0.94 (Waring, Pace et al. 2004). The population estimates are based on photo-identification, and indicate a current western North Atlantic stock totaling about 300 animals. In 1992, the best estimate was 295 individuals; in 1998 it had fallen to 291 individuals (DFO 2004; Waring, Pace et al. 2004). With such a limited population size some have speculated that the species may already be functionally extinct due to demographic stochasticity (Fujiwara and Caswell 2001). As a result, North Atlantic right whales in U.S. waters are protected not only under the Marine Mammal Protection Act, but also listed as Endangered under the Endangered Species Act of 1977. In Canadian waters, right whales are listed as Endangered (Schedule 2) under Canada's Species At Risk Act (SARA), with a Schedule 1 listing pending public consultation (Canada 2004). Despite the legal protection provided under these statutes, right whales do not appear to be recovering. NMFS' 2005 Recovery Plan notes: "There has been no apparent sign of recovery in the past fifteen years and the species may be rarer and more endangered than previously thought" (NMFS 2005).

It is believed that the reversal in population growth is the combination of two basic factors: reduced birth rates and increased mortality. With respect to birth rates, the average number of new calves has been very low for several years. The reproductive rate of North Atlantic right whales is significantly depressed relative to its cousins in the southern ocean.<sup>7</sup> A number of factors may be involved in this decline, including biotoxins in the North Atlantic, nutritional deficits, disease, and genetic factors (Pettis, Rolland et al. 2004). Explanations are confounded by the fact that there has been significant variation in annual calving numbers. For example, in 1999-2000, only one new calf was sighted. The following year (2000-2001), more than 30 calves were observed.

In addition to lower birth rates, survival rates have fallen over the last decade, particularly for female right whales (Fujiwara and Caswell 2001). While there may be any number of potential contributors, such as changes in the food web and climatic fluctuations, the most obvious causes are the direct result of human activity. Foremost among these are collisions with vessels<sup>8</sup> and

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Andrews' research station adds: "Portions of the population aggregate seasonally in two high-use habitat areas in Scotia-Fundy waters. During the summer and fall in recent years, for example, approximately two thirds of the population has aggregated in the lower Bay of Fundy. Historically (prior to 1993), and beginning again in 2000, a portion of the population aggregated for feeding in the vicinity of Roseway Basin during the same time period. Smaller aggregations and individual right whales are seen over a very wide area (SABS 2004).

<sup>7</sup> The winter of 2000 and spring of 2001 was a notable exception, with 26 new calves (DFO 2004). This production suggests that allee effects are not currently limiting population growth (Fujiwara and Caswell 2001).

<sup>8</sup> Ship strikes are not explored in depth in this report, but continue to be a very serious issue for right whales. Right whale calving grounds in the southern U.S. are unfortunately near active shipping lanes. At least two pregnant right

entanglement in fishing gear (DFO 2004; Waring, Pace et al. 2004). Young right whales are particularly vulnerable to mortality from a variety of sources including ships, fishing gear, and natural causes. In 1990, one study estimated that over the first four years of their lives, North Atlantic right whale mortality rates range between 2% and 17%. Stranding data and other information sources indicate that roughly one-third of these deaths are caused by humans (Kraus 1990).

As a consequence of the tenuous population and growth numbers, NMFS has determined the PBR for right whales to be zero. In other words, no anthropogenic mortality of these animals can be tolerated from a fisheries management perspective (Waring, Pace et al. 2004). The following section examines the role of fishing gear, and particular lobster gear, in right whale mortality.

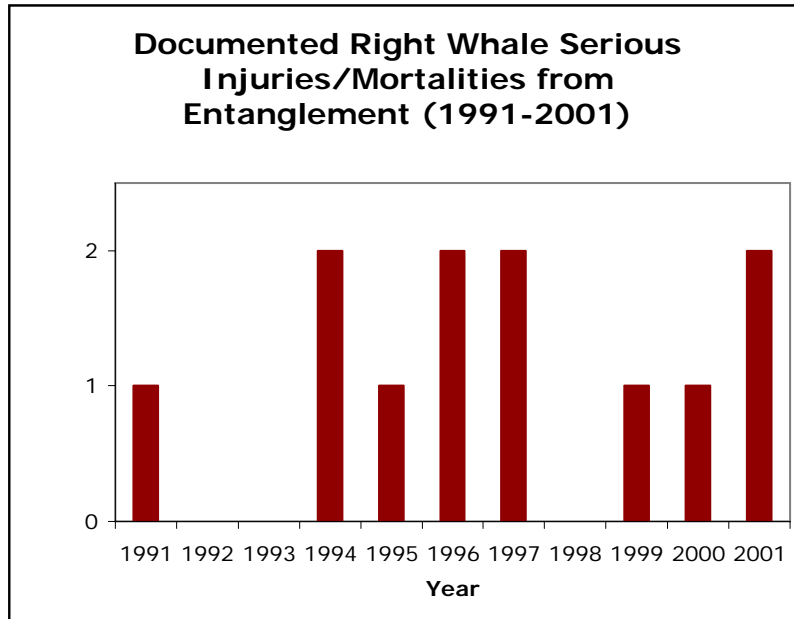
#### *Fishing interactions*

Over the three decades between 1970 and 1999, 56 right whales in the western North Atlantic were reliably documented as severely injured or killed by an encounter with humans. 55% of the documented injuries/deaths resulted from entanglement, and 45% from ship strikes. Of the entanglements, 3 were fatal, 10 were possibly fatal, and 20 were not fatal. In comparison, 16 of the ship strikes were fatal, 2 were possibly fatal, and 7 were not fatal.

From 1997 through 2001, *documented* mortality and serious injury to right whales averaged 2.0 whales per year. This estimate was comprised of an average of 0.8 serious injuries or deaths per year from ship strikes and 1.2 serious injuries or deaths from gear entanglements. Reported mortality from fisheries interaction was split equally between U.S. and Canadian waters (Waring, Pace et al. 2004). In 2002 and 2003, a substantial increase in entanglements was reported. In 2002, at least 8 entanglements occurred, though levels of injury/mortality were not reported (Waring, Pace et al. 2004). In 2003, the Stranding Network, NMFS, and the Center for Coastal Studies documented 9 verified cases of entangled right whales (ALWTRT 2004; CCS 2004). Over the last decade, there does not appear to have been a decreasing trend in right whale entanglements (Figure 11).

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whales were struck and killed in U.S. waters in 2004 alone; one off of Georgia and a second off of North Carolina (Anonymous 2004b).



**Figures 11** – Documented mortality or serious injury to right whales resulting from entanglements with fishing gear (not necessarily lobster gear) (Waring, Pace et al. 2004).

The injury/mortality figures employed in the NMFS stock assessment (Waring, Pace et al. 2004) are significant underestimates of actual mortality. NMFS only includes whale mortality when the carcass is observed, and only includes those injuries that meet the agency’s criteria of “serious” nature. As with humpback whales, there is very strong evidence that a substantially larger number of right whale injuries and deaths go unobserved and/or unreported. Knowlton and Kraus (2001) documented that between 1986 and 1999, 84 right whales were not re-sighted in at least six years and were presumed to have died. It is likely that many of these deaths were due to ship strikes and entanglement. Similarly, in 2002 and 2003 at least six right whales were thought to have been fatally entangled and have not been re-sighted. Only one mortality and one fatal injury from entanglement were confirmed over this period (ALWTRT 2004). Knowlton and Kraus (2001) comment: “Entanglements can result in long term deterioration of an animal and may be responsible for higher levels of mortality than previously thought. Considering that some animals become entangled, drown, and never return to the surface, even these levels may be underestimated.”

Scarring on right whales can be used as a proxy for past-entanglements. Scarring studies indicate that for both humpback and North Atlantic right whales, *just 10-20% of actual entanglements are observed and reported* (Robbins and Mattila 2001). NMFS summarizes: “Hamilton *et al.* (1998) estimated that 61.6% of the North Atlantic right whale population has been entangled in fishing gear. A subsequent study by Knowlton *et al.* (2001) indicates that between 10% and 28% of the right whale population contacts fishing gear each year” (NMFS 2003). These statistics suggest that on average, 30-85 right whales are scarred by fishing gear each year—a range that calls into question NMFS’ estimate of 1.2 serious injuries/mortalities per year.

Gear caught in the mouth is believed to be the primary cause of severe entanglement, followed by lines entangled around flippers and the tail. These entanglements are most likely to occur

while the whales are feeding, mouth open. Pitch and roll data from sensors attached to right whales suggest that during feeding, whales orient themselves along any number of planes. It is believed that the whales seek out high-density layers of plankton, such as copepods, which occur at physical and oceanographic interfaces including along the surface, directly above the seafloor, and at the thermocline. Floating groundline attached between multiple lobster pots is one gear type that has raised concern, as it is likely to be aligned horizontally, parallel to the seafloor (ALWTRT 2004). Vertical lines, such as those attaching gear on the sea floor to surface buoys, represent the other main area of concern. A review by Johnson et al. (2005) identified four types of fixed gear involved in large whale entanglements: buoy lines, groundlines, floatlines (gillnets) and surface system lines. For right whales, 7 entanglements occurred in buoy lines, 4 in groundlines, and 2 in surface system lines (Johnson, Salvador et al. 2005).

The lobster fishery is known to be a major contributor to these entanglements. For example, in 1995 a two-year-old male was killed due to lobster line embedded in his mouth and around his right flipper. Similarly, in 1993 a right whale entangled in lobster gear ultimately died in a pelagic drift gillnet (Waring, Pace et al. 2004). In 2001, NMFS biological consultations indicated that four fisheries were likely to jeopardize the continued existence of right whales: the Gulf of Maine/U.S. mid-Atlantic lobster trap/pot fishery; the multi-species groundfish fishery; the monkfish fishery; and the spiny dogfish fishery (ALWTRT 2004). As previously mentioned, both floating polypropylene groundlines attached between lobster pots and vertical lines attached to buoys present serious entanglement threats (ALWTRT 2004). The majority of right whale entanglements appear to be coming from single lines such as these, rather than from nets (NMFS 2003). While in most cases the source of rope entwined around the whale is not definitively identified, the millions of lobster pots along the eastern seaboard suggest that the lobster fishery is the major contributor. NMFS estimates that the lobster fishery accounts for *95% of floating groundline* presently used in the region. Similarly, the lobster fishery is responsible for an estimated *93% of the buoy line* in the region (NMFS 2005). Presumably, these numbers are comparable in Canadian waters.

Due to the entanglement threat, in 2001 the NMFS Office of Protected Resources' Biological Opinion on the effects of the lobster fishery management plan determined that "NMFS' prosecution of federal fisheries managed under the American Lobster FMP, as modified by the Atlantic Large Whale Take Reduction Plan, *is likely* to jeopardize the continued existence of the western North Atlantic right whale" (Knowles 2001). The opinion identified a "reasonable and prudent alternative" (RPA) to reduce fishery effects on right whales, and anticipated that the fishery under the RPA would not result in the incidental mortality of right whales. The RPA included the implementation of dynamic area management (DAM) and seasonal area management (SAM) programs that reduce fishing effort in areas where right whales are observed or seasonally present. Regulations enacted in 2002 also required gear modifications such as the use of weak links and non-floating groundlines. These actions are discussed in greater detail in the management criterion in this report.

While this list of management measures may have been partially effective, they have not reduced mortality to the PBR (zero for right whales). In 2002, despite requirements for gear modifications and seasonal and dynamic area management, 9 fatal entanglements and 22 live entanglements of Atlantic large whales were observed, including at least 1 dead and 7 live right

whales. In 2003, another 26 live entanglements occurred (including 4 right whales), and 10 whales died (NMFS 2005). With right whale numbers not increasing, these interactions can only be due to higher entanglement rates or better reporting. As the scarring numbers demonstrate, there is every reason to believe that the number of entanglements occurring along the several thousand miles of U.S. and Canadian coastline is substantially larger than those actually observed and reported. The Biological Opinion clearly states that if even one right whale is seriously injured or killed in lobster gear or unidentified fishing gear, that encounter will serve as evidence that the RPA measures “are not demonstrably effective at reducing right whale injuries or death” (Knowles 2001). In that case, formal consultation is reinitiated, which it now has been. However, management *is not required* to stop the actions that led to the whale’s death during the consultation period.

At the time of this review, NMFS was preparing an Environmental Impact Statement (EIS) for the next set of regulations under the Atlantic Large Whale Take Reduction Plan (Colligan 2004). The Draft EIS was released in February 2005 and proposes a broad set of gear modifications (mainly weak links and the phasing out of floating groundlines) rather than area-based management. While NMFS believes that addressing the risks associated with groundlines “will reduce injury and mortality of large whales” (NMFS 2005), it is unlikely to solve the problem entirely. The current proposed regulatory changes do little to address vertical lines other than through requirements for weak links, and actually roll back dynamic and seasonal area management. The draft Environmental Impact Statement notes: “NMFS believes that further research and discussions with the ALWTRT are needed to address risks associated with vertical line” (NMFS 2005). Several members of the Atlantic Large Whale Take Reduction Team (ALWTRT) have publicly suggested that the future rule is unlikely to reduce right whale mortality to zero (ALWTRT 2004).

Right whale entanglement is an issue in lobster fisheries in Canada as well. Right whales are commonly observed in the summer in the Bay of Fundy and Gulf of St. Lawrence, and also found off of Newfoundland, Labrador, and Nova Scotia. Based on data collected over the past five years, NMFS has estimated that ship strikes accounted for 47% of known human-induced serious injury and mortality to right whales, while U.S. fishing gear is responsible for 35%, and Canadian fishing gear 18% (NMFS 2003).<sup>9</sup> The 2000 Canadian recovery plan states: “It appears that gillnets, longlines, and offshore lobster and crab ‘trawl’<sup>10</sup> gear pose particular threats to right whales” (Canada-Plan 2000).

As of 2000, eight right whale entanglements had been reported in Canadian waters (Canada-Plan 2000). The Canadian recovery plan reports:

Eight instances of entanglement have been documented in Canadian waters. Four of these were in gillnet gear, two in lobster gear, one in a cod trap, and one reportedly in crab-pot gear (modified lobster gear). All but the last two of these entanglements were in the Bay of Fundy. One whale was found drowned in a 25-pot lobster trawl. Another that began towing a paired lobster trawl in December 1995 while in the Bay of Fundy was found dead three months later off Cape Cod,

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<sup>9</sup> E.g., in 2000 and 2001, there were at least three right whales found entangled in fishing gear in Canadian waters.

<sup>10</sup> A lobster or crab trawl is a line of pots connected together in one long tow.

Massachusetts. It had died after being struck by a ship, but gear was still entangled through the mouth and around the tail. (Canada-Plan 2000)

There are reasons to suggest that Canadian lobster fisheries are less likely to entangle right whales than U.S. lobster fisheries. To date, lobster entanglement has not played a significant role in lobster management in Canada (Gendron 2005; Harris 2005; Miller 2005). According to Lei Harris, the Species at Risk Act biologist supervising right whale interactions for the Department of Fisheries and Oceans (DFO), the main difference between U.S. and Canadian lobster fisheries with respect to right whales is the timing of the fisheries. Right whales are in Canadian waters during the summer months, mainly from the end of June through mid-November, though they are sometimes seen in November and December. Most lobster fisheries in Canada are closed during these months. The few exceptions include the Gulf of St. Lawrence, which is iced over in the winter but infrequently visited by right whales, and the “gray zone,” a disputed area in the Bay of Fundy fished year-round by both U.S. and Canadian fishermen (Harris 2005). In November, at the beginning of the fishing season, vessels normally target areas closer to shore, while whales are more likely to be further offshore in the Grand Manan channel. The St. Andrews Biological Station similarly comments:

Commercial lobster gear has been implicated in marine mammal entanglements in the U.S. where commercial fishing is prosecuted year round. It is thought to pose the greatest risk to the right whales due to location and time of deployment and the design of the gear (loose, vertical lines). The Canadian lobster fishery that overlaps the Bay of Fundy right whale conservation area (LFA 38) is open from November through to the end of June. It has been suggested that there is little to no overlap between this fishery and the right whale distributions as the fishery moves offshore mid-season, when the whales have left the area. (SABS 2004)

In summary, entanglement of right whales in Canadian lobster gears appears less frequent than entanglement in U.S. waters, but is not at zero. Very little attention is dedicated to the issue by the DFO. Actions taken in Canada are discussed in greater detail in the Management criterion.

#### *Encounter rates*

Whereas right whale entanglements are alarmingly frequent from the perspective of the whale, they are highly uncommon from the perspective of the fisherman. Given that there are millions of traps set annually, each used dozens of times, the average interaction rate appears to be substantially less than one in a million for any given lobster pot. Until recently fishermen had no reason to suspect that whales were responsible for any significant portion of lost gear (Bowman 2004). Notably, only 1-2% of fishermen report having ever seen a right whale (Anonymous 2004).

Cooperation with fishermen remains a critical component of an effective response to the problem of whale entanglement. Entanglement reporting is absolutely essential, as is willingness to modify fishing methods to protect whales.<sup>11</sup> Unfortunately cooperation appears to have declined, with fewer fishermen reporting whale entanglements in recent years. Some have speculated that

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<sup>11</sup> For example, the International Fund for Animal Welfare is currently partnering with the Massachusetts Lobsterman’s Association to swap out floating lobster line with sinking lines.

the apparently decreased cooperation is due to concerns about the effects of whale protection efforts (e.g., dynamic fishery closures) on fishing effort (NMFS 2003). Other fishermen have expressed concern with gear modifications, noting that sinking rope increases the probability of gear becoming snagged and lost, particularly in offshore rocky areas (ALWTRT 2004).

### ***Protected species summary***

Overall, entanglement of right and humpback whales (and possibly fin and minke whales) represents a grave conservation issue for the American lobster fishery. Entanglement in fishing gear may contribute to the eventual extinction of these species, and lobster gear appears to be the primary source of such entanglements along the East Coast. Management efforts to address right whale entanglements over the past few years have not been entirely successful, with the number of entangled Atlantic large whales substantially above the PBR for these species. NMFS continues to implement new gear modifications to address the issue, but it is unlikely that these modifications will reduce entanglement levels to zero.

### **Synthesis**

The effects of typical bycatch within the traps used in the American lobster fishery are relatively low. Similarly, the use of baitfish (e.g., herring) in the lobster fishery represents an ecosystem effect on par with moderate bycatch. These issues would merit a moderate conservation concern (yellow) ranking for bycatch in the American lobster fishery; however, both issues are overshadowed by concern over the entanglement of marine mammals, particularly humpback whales and North Atlantic right whales. Both humpback and right whales are protected in the U.S. under the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA), and in Canada under the Species at Risk Act (SARA). Although management measures have been implemented to reduce the entanglement of marine mammals in lobster gear, entanglement continues to pose a threat to the survival and recovery of large whale species.

Interactions with lobster gear are undeniably a factor limiting the recovery and/or contributing to the decline of both humpback whales and right whales. Over the past fifteen years the trend in these entanglements is unclear and possibly up. One key question posed in this review is whether bycatch “regularly” includes large Atlantic whales, or not. From the perspective of the marine mammals, such interactions are all too frequent, with scarring studies indicating an annual encounter rate of 10% to 30% for right whales. However, given the continued efforts of U.S. management agencies to address this issue, as well as the important role that lobstermen will play in management efforts, this review suggests that it is important to give management and the fishing community a chance to address the issue in the near term. Since recent efforts may be reducing right whale mortality, this review temporarily gives the benefit of the doubt to the lobster industry. Subsequently, bycatch of North Atlantic right whales in the American lobster fishery ranks as a high conservation concern (Table 3), as opposed to a critical conservation concern. If no significant improvements are made regarding this bycatch, it is expected that this issue will become a critical conservation concern.

**Table 3** – Bycatch characteristics of the American lobster fishery.

<b>Gear</b>	<b>Composition of Bycatch</b>	<b>Population Consequences of Bycatch</b>	<b>Bycatch/Target Species Ratio</b>	<b>Trend in Quality &amp; Quantity of Bycatch</b>	<b>Ecosystem Effects</b>
Lobster traps/pots	Regularly includes species of special concern	Severe	Unknown	Unknown with respect to the lobster fishery	Unknown

**Nature of Bycatch Rank:**



**Criterion 4: Effect of Fishing Practices on Habitats and Ecosystems**

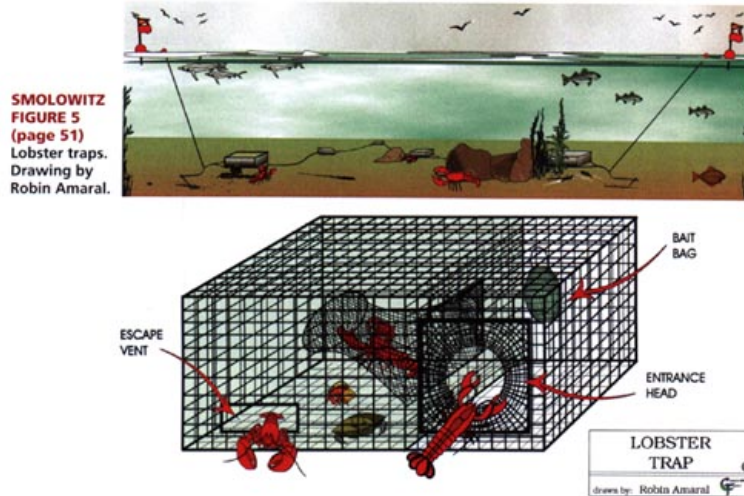
*Guiding Principle: A sustainable wild-caught species maintains natural functional relationships among species in the ecosystem, conserves the diversity and productivity of the surrounding ecosystem, and does not result in irreversible ecosystem state changes.*

In addition to the direct effects of fishing gear on lobsters and other animals, large-scale commercial fishing has the potential to affect the physical and biological components of marine habitats. This criterion examines three distinct pathways through which lobster fisheries can impact habitat: the physical effects of gear use; the ecological effects of reducing the abundance of lobsters; and the biochemical and ecological effects of bait use.

**Habitat effects of gear use**

Most of the work on habitat effects of fisheries has examined the physical and biological alteration of benthic habitats resulting from contact with mobile gear. Auster and Langton (1999) synthesized the results of more than 90 gear impact studies, the vast majority of which documented some degree of habitat impact from mobile fishing gear, typically involving a reduction in habitat complexity, an alteration of community structure, and some change in ecosystem processes (Auster and Langton 1999).

American lobsters are taken almost entirely in lobster pots, a gear type generally thought to have small to moderate effects on habitat. Traditionally made of wood, about 95% of lobster pots today are made of plastic-coated steel mesh (Figure 12). These pots (traps) are dropped onto the sea floor and hauled up by attached ropes after a day or so of resting on the ocean bottom. Lobstermen can fish these traps as a single pot per buoy or in sets of multiple pots per buoy. Two pots per buoy, for example, are commonly used in Cape Cod Bay, three pots per buoy are often used in Maine, and trawls of up to 100 pots may be used in offshore areas (NREFHSC 2002). In Canada, most fishermen use traps in strings of ten, or as singles (Butler 2004).



**Figure 12** – Depiction of a typical lobster trap (Smolowitz 1998).

The number of pots attached to a buoy varies in part with the substrate over which the pots are set. Lobsters are fished in a range of bottom habitats including “coastal, hard substrate areas, offshore canyons, and in mud substrate with a high clay content where they produce burrows” (NREFHSC 2002). Sandy, muddy, and rocky bottoms are most frequently fished. Typically, single traps are used in rougher areas where groundline is more likely to snag on the bottom, and trawls of pots are typically used on flatter bottoms. Offshore pots are larger and heavier (>4’ long, and ~100 lbs in weight), and reportedly used in sets averaging around 40 pots/trawl with over 40 trawls/vessel (NREFHSC 2002).

It is believed that the main habitat effects of pots occur if they scour the seafloor. When pots are pulled to the surface, they can scrape along the ocean bottom, damaging epifaunal organisms beneath. Compared to mobile gear such as trawls and dredges, the area of seafloor impacted by a single pot or string of pots is very small. The impact is limited to an area proportional to the footprint of the trap. However, it has also been speculated that millions of traps hauled several times a week may produce “a significant cumulative effect” in areas that are fished intensely (Smolowitz 1998).

Despite the speculation, there is a paucity of scientific information available on the habitat effects of pots and traps. A 2002 National Oceanic and Atmospheric Administration (NOAA) technical memorandum that surveyed domestic and international literature found only *one* study, Eno, MacDonald et al. (2001), that examined the effects of pots in temperate waters (Johnson 2002). The study, which occurred in the eastern North Atlantic, found no lasting effects of pots on the abundance of epifauna such as sea pens, sea fans, and sponges, even on rocky substrates. Even four weeks of relatively intensive fishing with pots did not produce obvious detrimental effects on the abundance of the species studied, though long-term effects on deep-water corals remained a concern (Eno, MacDonald et al. 2001).

Apart from the single study mentioned above, the only readily available scientific information on habitat damage from fishing gears comes from professional judgment provided by panels or workshops of experts (Gordon, Schwinghamer et al. 1998; Johnson 2002; Morgan and

Chuenpagdee 2003). For example, a consensus workshop of fisheries experts assembled by Chuenpagdee et al. (2003) assessed different gear types for the level of damage caused to habitat. Pots and traps were ranked “Low” for habitat damage to biological components and “Medium” for damage to physical components (Chuenpagdee, Morgan et al. 2003). The Northeast Region Essential Fish Habitat Steering Committee (NREFHSC 2002) assembled another such workshop in late 2001. The professional judgment of the Steering Committee was that the lobster fishery’s impacts to biological and physical structures in mud, sand, and gravel habitats appear to be low. The Steering Committee added:

Although panel members agreed that the habitat impacts caused by individual lobster pots were minimal, they believed that the cumulative effects of so many pots could be significant, especially in sensitive habitat areas of high structural complexity. Panel members also mentioned that lobster pots normally remain on the same place on the bottom for days at a time and that they are set repeatedly in certain heavily-fished areas; both of these factors further magnify their site-specific impacts on benthic habitats. (NREFHSC 2002)

In Canada, no studies have looked at lobster fishing and habitat effects (Gendron 2005; Robichaud 2005). It has been assumed that traps are not a serious problem relative to bottom trawls and metal dredges. The most vulnerable areas (e.g., coral banks) are not fished intensively by lobster gear (Pezzack 2005). In summary, professional judgment appears to indicate that physical effects from lobster pots are low, with the potential for a cumulative effect in the more vulnerable areas that are fished.<sup>12</sup>

### **Habitat effects of lobster removal**

A second habitat effect of the lobster fishery occurs through the removal of lobsters themselves. Lobsters, like all animals, are components of the food web. They are both predators and prey, and changes in their abundance can shift the ecological pressures on other marine life. The lobster fishery has reduced the abundance of lobsters in some areas, probably reduced overall abundance relative to a baseline of improving environmental conditions, and skewed the size distribution of American lobster populations. These changes, in turn, have ecological effects on other animals, a process often referred to as a “trophic cascade.”

Little hard research is available on trophic cascades and lobster fisheries. One recent article (Steneck, Vavrinc et al. 2004) suggests that the kelp forest ecosystem of the western North Atlantic has already undergone major shifts due to fishing pressure on other species. Prior to the 1930s, predatory groundfish such as cod were the dominant presence in this region. Industrial fishing on these species led to severe population declines in groundfish and reduced their predation on sea urchins, populations of which subsequently boomed. In many areas of the North Atlantic, kelp forests were replaced by sea urchin “barrens.” This phase lasted until the late 1980s and mid-1990s when a fishery for sea urchins developed in the region. The resulting

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<sup>12</sup> It should be mentioned that lobster pots have potentially positive effects on some aspects of habitat. For example, pots may temporarily act as reef habitat for fish. Similarly, they may provide temporary shelter, or even protect large areas of the seafloor by making them inaccessible to mobile gear (i.e., trawls and dredges) (NREFHSC 2002). Workshop on the Effects of Fishing Gear on Marine Habitats off the Northeastern United States. Boston, MA, Northeast Region Essential Fish Habitat Steering Committee: 86..

decline in sea urchin populations allowed macro-algae to return, and created conditions favorable for large predatory crustaceans, such as crabs and the American lobster. In this scenario, the increases in lobster abundance and recruitment seen over the past few decades are due in part to the overfishing of other animals, such as cod and urchins. By the same logic, a depletion of lobster populations could trigger a similar broad-scale trophic cascade.

While there have been no studies documenting a trophic cascade stemming from the American lobster fishery, these effects are possible. An example of this type of effect was recently documented near California's Channel Islands marine reserve (Lafferty 2004). The study noted that fishing pressure outside the reserve reduced the abundance of spiny lobsters by a factor of five. In areas where lobster abundance had been culled, populations of purple urchins swelled until urchin disease epidemics limited population growth. Lafferty (2004) summarizes these observations:

Historically, lobsters, and perhaps other predators (such as sea otters), kept urchin populations at low levels and kelp forests developed as a result of a community-level trophic cascade. Where the main predators were fished, urchins overgrazed algae and ultimately starvation limited urchin population growth. In 1992 an urchin-specific disease entered the area that had urchin populations well exceeding the host-threshold density for epidemics. Epidemics were more probable and led to higher mortality in dense urchin populations so that disease acted as a density-dependent mortality source.

With respect to the North Atlantic specifically, no such effects have been documented. The potential for a trophic cascade exists if lobster populations were to be fished down, but is difficult to predict. Steneck et al. (2004) comment: "Most trophic levels in the Gulf of Maine consist of only one or a few strongly interacting species. Declines in those species can result in trophic-level dysfunction, with cascading effects to lower trophic levels."

Overall, the fishery's removal of lobsters, particularly large lobsters, almost certainly has follow-on habitat effects in the western North Atlantic. However, no effects have been demonstrated, and the size, shape, and duration of those effects are not well understood. While this is an issue that applies to any fishery, the fact that lobsters are now an apex predator in the relatively simple Gulf of Maine trophic web suggests that caution may be merited. To the extent that a habitat effect follows, it will be tied to the stock status of the lobster population, which is currently near record highs in most areas.

### **Habitat effects of bait use**

A third habitat effect of the American lobster fishery involves its use of bait. As discussed in the bycatch criterion, large quantities of bait are employed to attract American lobster. In 1996, about 50,000 tons of bait were used in New England alone (Saila, Nixon et al. 2002). Bait use has increased significantly over the past three decades, generally tracking increases in the number of traps fished. It has been speculated that this bait use may be enriching benthic environments and increasing the abundance of some types of organisms (NREFHSC 2002).

There are two basic observations concerning the effects of bait use on habitat. The first observation is that bait represents an input of nutrients to the fished areas, which could potentially increase primary productivity. Estimates by Saila et al. (2002) indicate that the yearly input of bait in the Gulf of Maine is about 85 kilograms (kg) per hectare (ha); a quantity on the same order as the yield from fisheries in very productive areas. However, in terms of organic matter, 85 kg/ha is a relatively small contribution to coastal primary production, particularly given the quantity of marine life being removed from the same areas. As such, bait use is unlikely to have significant effects on primary productivity.

The more notable observation is that bait use appears to be increasing the abundance and growth rates of lobsters in heavily fished areas. Lobster pots not only provide food for juvenile lobsters, but the presence of vents allows young lobsters to enter traps, feed, and leave the traps unharmed. In this manner, fishing effort (and bait use) can actually have a positive feedback on juvenile lobster abundance. There is some empirical evidence that supports this notion. For example, Grabowski et al. (2003) compared stomach contents of lobsters in the Gulf of Maine. Lobsters in areas closed to fishing had low amounts of herring in their diets (Grabowski, Clesceri et al. 2003), while, in contrast, herring comprised 34-55% of the stomach contents of larger sub-legal lobsters (65-83 mm CL) in fished areas. Herring formed just 11-15% of the stomach contents in smaller lobsters (45-65 mm CL) in fished areas, but the author posits that bait availability may reduce competition for other sources of food between small and large lobsters, allowing the smaller animals to forage more efficiently (Grabowski 2003). In addition to stomach contents, the study documents that lobsters recaptured in fishing areas grew more quickly than their closed-area counterparts (Grabowski, Clesceri et al. 2003).

On a broader scale, Saila et al. (2002) applied estimates of bait use to models of the growth efficiency of juvenile American lobsters. Their method indicates that bait use in the inshore area of the Gulf of Maine “could potentially support one-quarter to one-third of the recent American lobster landings” (Saila, Nixon et al. 2002). This finding is supported by unpublished data from Yund and Grabowski (Yund 2004). The broader implications of this herring subsidy on the Gulf of Maine’s benthic community remain unclear. It seems evident that on some level, fishing is helping to stimulate growth and survival in juvenile lobsters. This supplementation of lobster populations is likely to partially offset the effects of lobster removal. Apart from lobsters, the ecological effects of bait use on other animals (e.g., crabs and groundfish that also enter traps) have not been examined.

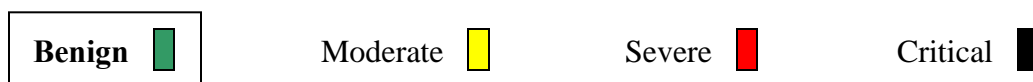
### **Synthesis**

Lobster pots have low to moderate effects on ocean bottom habitat, and the resilience of bottom habitat to these effects is considered moderate to high, depending on the specific substrate. While there are some concerns about the potential ecological effects of the lobster fishery if population abundances were to decline, at present there is no evidence that the fishing method or the removal of American lobsters have substantially disrupted the foodweb other than by increasing the productivity of targeted stocks. Overall, the effect of fishing practices on habitats and ecosystems in the American lobster fishery appears relatively benign and thus rates as a low conservation concern (Table 4).

**Table 4** – Habitat effects of the American lobster fishery.

<b>Gear</b>	<b>Effects on Physical/Biogenic Habitats</b>	<b>Resilience of Habitats to Disturbance</b>	<b>Extent of Impacts</b>	<b>Disruption of Food Web</b>	<b>Ecosystem Effects</b>
Lobster traps/pots	Small to moderate	Mostly high, some moderate	Moderate	Unknown	Unknown

**Effect of Fishing Practices Rank:**



**Criterion 5: Effectiveness of the Management Regime**

*Guiding Principle: The management regime of a sustainable wild-caught species implements and enforces all local, national and international laws and utilizes a precautionary approach to ensure the long-term productivity of the resource and integrity of the ecosystem.*

**Introduction and the role of science in management**

This criterion examines the U.S. and Canadian management systems for American lobster along several lines, including: the role of stock assessments, monitoring, and scientific advice in management; the presence and effectiveness of bycatch reduction and habitat protection efforts; the enforcement of regulations; and the overall management track record.

In the United States, the American lobster fishery is overseen by the Atlantic States Marine Fisheries Commission (ASMFC) under Amendment 3 to the American Lobster Fishery Management Plan (FMP), as well as Addenda I, II, III, IV, and V to the FMP. Adopted in December 1997, Amendment 3 created seven U.S. lobster management areas: Inshore Gulf of Maine (Area 1); Inshore Southern New England (Area 2); Offshore Waters (Area 3); Inshore Northern Mid-Atlantic (Area 4); Inshore Southern Mid-Atlantic (Area 5); New York and Connecticut State Waters (Area 6); and Outer Cape Cod (OCC) (Figure 13). In each of these areas, Lobster Conservation Management Teams (LCMTs), composed of industry representatives, exist to advise the American Lobster Management Board and recommend changes to the FMP within their area (NMFS 2005). A 21-member Lobster Advisory Panel of lobstermen also helps to craft ASMFC decisions. The extensive use of local industry members, commonly referred to as community-based management, is intended to address the needs of local areas while meeting conservation and fisheries targets established in the FMP. To determine appropriate harvest levels and review the health of the fishery, the ASMFC employs an 8-member Lobster Technical Committee, comprised of state fishery managers.

The main goal of the American Lobster FMP is to maintain a healthy lobster resource by restoring egg production (DMR 2003). In addition to creating the LCMTs, Amendment 3 established a number of regulatory limits on the fishery. These include:

- Minimum size limits—a 3 1/4-inch minimum carapace length is required coast-wide for lobster landings, with more restrictive minimum lengths existing in some areas (Table 5);

- Restrictions on the capture of ovigerous females (lobsters carrying eggs on their abdomens);
- A prohibition on the possession of lobster meat and/or lobster parts;
- A prohibition on the capture of V-notched lobsters (ovigerous lobsters which have had their tail fin clipped by fisherman to signify that they are reproducing females);
- Gear restrictions such as the mandatory use of biodegradable “ghost” panels and escape vents, which allow lobsters and other marine life to escape from old and lost lobster pots;
- A maximum trap size of 22,950 cubic inches in all areas except Area 3, which has a maximum trap size of 30,100 cubic inches; and
- Effort control measures such as trap limits and limited entry provisions. (ASMFC 2004; NMFS 2005).

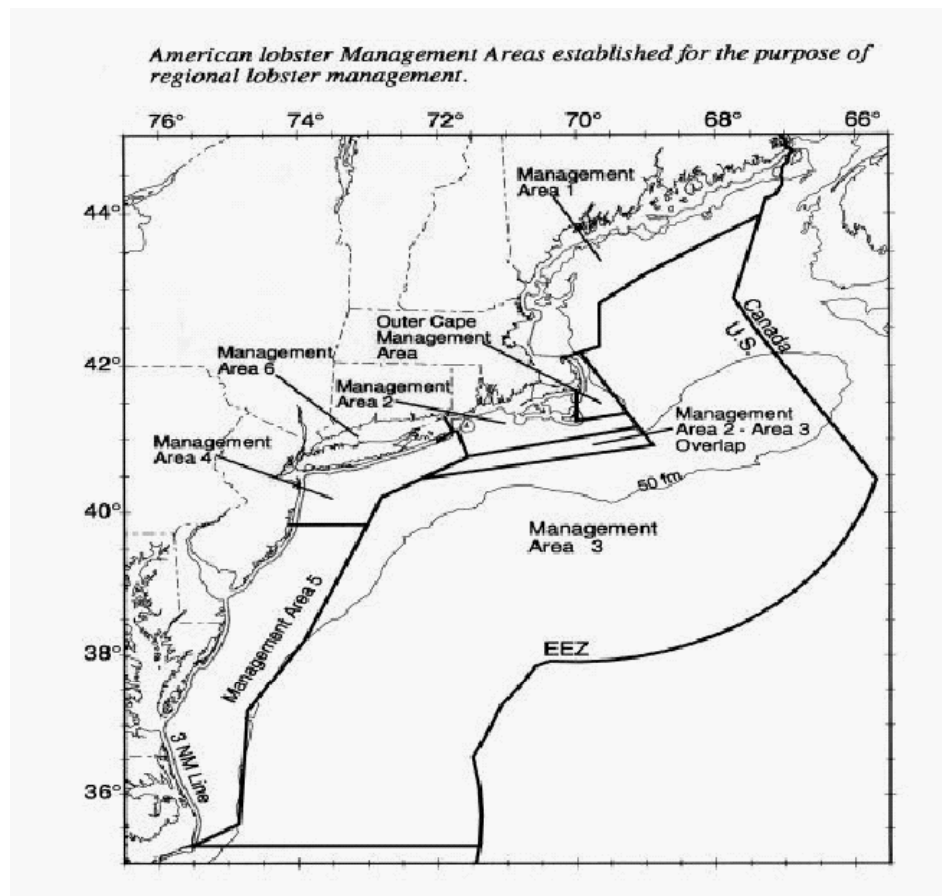


Figure 13 – Lobster management areas in U.S. waters.

Following Amendment 3, several addenda added further elements to these restrictions. For example, Addendum V created a trap limit of 2,200 traps per vessel in Area 3, and established a conservation tax (passive reduction) of 10% for trap transfers below 1,800 traps (ASMFC 2004). Addendum IV increased the minimum size for lobsters in Area 2 in response to declining trends in biomass and landings. Addendum III incorporated alternative management measures for the purposes of meeting abundance goals ( $F_{10\%}$ ) by 2008, while Addendum I incorporated effort control measures recommended in LCMT proposals. Management also added a *maximum* size

limit for lobsters caught in Areas 1, 4, and 5 in an effort to preserve population size structures and to increase egg-per-recruit (EPR) levels as the fecundity of American lobsters increases exponentially with female size (Rowe 2001).

In the United States, managers issue stock assessment reports for American lobster on roughly a 5-year basis. The last complete stock assessment was conducted in 2000, with a new assessment due in 2005. Between assessments the Lobster Technical Committee annually reviews trends in landings and abundance. Managers examine landings, catch-per-unit-effort (CPUE), and size distribution of landings to estimate current resource status. In addition, trawl surveys along the Atlantic coast help to establish abundance statistics. A NMFS fall survey and regional surveys such as the Massachusetts Division of Marine Fisheries (MADMF) trawl survey are employed to estimate relative abundance of recruit and pre-recruit size classes.

**Table 5** – Area-specific bycatch management measures (Selberg, McBane et al. 2004).

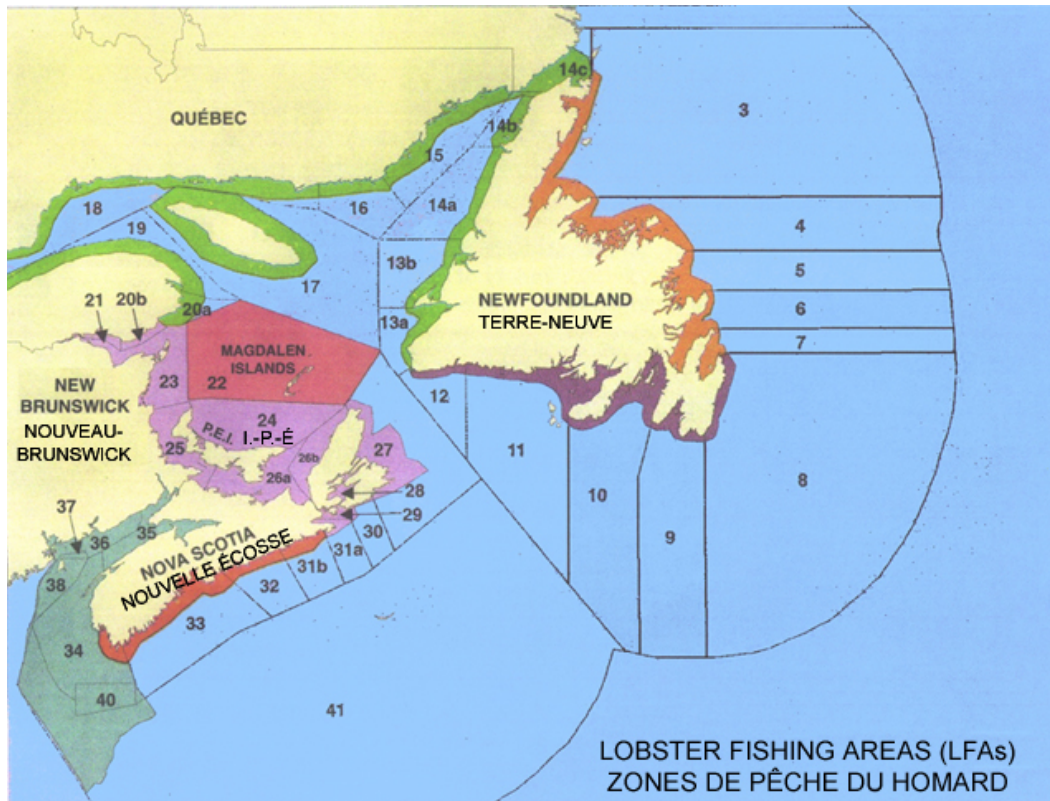
Management Measure	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	OCC
Gauge size (2001)	3-1/4"	3-9/32"	3-9/32"	3-1/4"	3-1/4"	3-1/4"	3-9/32"
Gauge size (2002)	3-1/4"	3-5/16"	3-5/16"	3-5/16"	3-5/16"	3-1/4"	3-5/16"
Gauge size (2003)	3-1/4"	3-11/32" 3-3/8"	3-11/32"	3-11/32"	3-11/32"	3-1/4"	3-11/32"
Gauge size (2004)	3-1/4"	3-3/8"	3-3/8"	3-3/8"	3-3/8"	3-9/32"	3-3/8"
Gauge size (2005)	3-1/4"	3-13/32"	3-13/32"			3-5/16"	3-13/32"
Gauge size (2006)	3-1/4"	3-7/16"	3-7/16"				3-7/16"
Gauge size (2007)	3-1/4"	3-15/32"	3-15/32"				3-15/32"
Gauge size (2008)	3-1/4"	3-1/2"	3-1/2"				3-1/2"
Escape vent size	2 x 5-3/4" (2007)	Increase w/ gauge	Increase w/ gauge	Increase w/ gauge	Increase w/ gauge	Increase w/ gauge	Increase w/ gauge
V-notch definition	Zero tolerance	ASMFC	ASMFC	ASMFC	ASMFC	ASMFC	ASMFC
Mandatory V-notching	Mandatory		Mandatory above 42° 30'				
Maximum size	5"			5-1/4"	5-1/2"		

In the U.S., management primarily uses fishery-dependent data (e.g., landings, CPUE), with supplementation from fishery-independent data such as trawl surveys and measurements of recruitment and larval settlement. Managers appear to listen to scientific advice and have made relatively good use of the data available in terms of setting minimum size limits to reduce mortality. However, U.S. managers have not successfully met their overfishing targets of 10% EPR. Amendment 3 to the American Lobster FMP outlined a rebuilding schedule to *end*

*overfishing by 2005*. The current Lobster Technical Committee review indicates that these efforts have been unsuccessful and that stocks remain overfished (Hilborn, Botsford et al. 2004).

In Canada, the lobster fishery is managed primarily by the Department of Fisheries and Oceans (DFO) as laid out under the Fisheries and Oceans Acts. Similar to the U.S. system, DFO divides management into a number of Lobster Fishing Areas (LFAs), each with its own advisory committee (primarily fishermen) (Figure 14). The main goal of Canadian management is to protect a minimum number of young mature adults to maintain sufficient egg-per-recruit levels. To do so, management employs most of the same tools used in the U.S. fishery, including seasonal and trap limits, as well as limited entry and restrictions on types of lobsters landed (minimum size, no berried females, no one-armed females, and V-notching in some areas). Protection of larger females through a maximum size limit is under consideration (Ouellet and Plante 2004). Seasonal limits also play a substantially larger role in the Canadian fishery. Gendron and Brêthes (2002) note:

Like many crustacean fisheries, the American lobster (*Homarus americanus*) fishery has been traditionally managed by input controls. Controls on fishing effort and fishing activity are presently being used to limit fishing mortality, in addition to escapement measures such as size limits and protection of berried females. All those measures are expected to prevent growth overfishing and maintain an acceptable level of egg-per-recruit production to prevent recruitment overfishing.



**Figure 14** – Canadian lobster fishing areas (LFAs) (AgriCanada 2004).

Canadian managers issue stock status reports on a semi-regular basis. DFO stock assessments are less detailed than U.S. assessments and lack estimates of uncertainty of area-specific exploitation rates (Claytor and Allard 2003). The reports are issued regionally, typically with several years between reports (Table 6). Lobster stock assessments are only updated on a five-year time frame due to the relatively slow change in stock status, but consequently lack a rapid response plan should conditions deteriorate quickly (Miller 2005; Pezzack 2005). Regional stock assessments rely on a variety of information; the DFO calculates stock status by evaluating trends in landings and the size distribution of the catch along with CPUE. Most of the information employed is fishery-dependent data (Miller 2005; Pezzack 2005). Other sources of information include voluntary logbook programs, trawl surveys in some areas (e.g., off the Magdalen Islands), and cooperation with groups such as the Fishermen and Scientists Research Society (FSRS), which sets lobster recruitment traps. Some regions, such as the Bay of Fundy, employ out-of-season dive surveys in lobster nursery areas (Robichaud 2005).

In terms of process, conservation targets are coordinated in bi-annual meetings of DFO's Science, Management, and Enforcement branches (Robichaud 2005). If a regulation already exists (e.g., minimum size limits) the DFO's Director General can tighten or modify the regulation at any point. If a proposed regulation is entirely new (e.g., a closed area), a requirement exists for local consultation. The Fisheries Management Branch is obligated to meet with industry and DFO Science before making a recommendation to the Director General, and the federal cabinet ultimately has to approve the change (Miller 2005).

Canadian regional assessments indicate substantial improvements in egg-per-recruit (EPR) over the last decade. However, given the lack of concrete overfishing targets and assessments and a background of improving environmental conditions, it is difficult to determine the effectiveness of the current management system. As with the United States, several Canadian regions have fallen short of stated rebuilding targets.

**Table 6** – Lobster stock assessments available by Lobster Fishing Area (LFA): 1998-2004.

	LFAs	1998	1999	2000	2001	2002	2003	2004
<b>Newfoundland</b>	3-14						x	
<b>Inshore Quebec</b>	15-22					x	x	x
<b>Maritimes (overview)</b>	23-41	x						
<b>Southern Gulf</b>	23-26					x		
<b>Eastern Cape Breton</b>	27-30	x						x
<b>Eastern Shores</b>	31-32	x						x
<b>South Shore Nova Scotia</b>	33	x						x
<b>Southwest Nova Scotia</b>	34	x			x			
<b>Bay of Fundy</b>	35-38				x			
<b>Offshore</b>	41			x				

### Bycatch management

Bycatch of undersize and ovigerous lobsters is effectively controlled through the minimum size requirements and escape vents described previously in this criterion (Table 5), while bycatch of other marketable species is not a major management focus at present. As discussed under the bycatch criterion, the primary management concern with respect to bycatch in the lobster fishery is the entanglement of marine mammals. North Atlantic right and humpback whales are protected in the United States under both the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA). Efforts to reduce entanglements of marine mammals in U.S. waters are coordinated by the National Marine Fisheries Service (NMFS) through the Atlantic Large Whale Take Reduction Plan (ALWTRP). In Canadian waters, right whales are listed as Endangered (Schedule 1) under Canada's Species At Risk Act (SARA) (DFO 2004). In accordance with this listing, the DFO approved a Recovery Plan for the North Atlantic Right Whale in 2000.

The initial goals of the U.S. ALWTRP were to “reduce serious injuries and mortalities of right whales in U.S. commercial fisheries to below 0.4 animals per year by January 1, 1998 and to reduce by April 30, 2001 entanglement-related serious injuries and mortalities of right, humpback, fin, and minke whales to insignificant levels approaching a zero mortality and serious injury rate” (ASMFC 2000). The stated long-term objectives of the Canadian plan are to stabilize North Atlantic right whale populations at a minimum of 1,200 individuals, and to reduce mortality and injury rates from ship strikes and entanglement (DFO 2004). Unfortunately, the conservation goals set by U.S. and Canadian management have not been met. The Biological

Opinion issued in June 2001 found that NMFS' administration of the lobster fishery and three other fisheries, as modified by the ALWTRP requirements in effect at that time, was likely to jeopardize the continued existence of the western North Atlantic right whale (NMFS 2005). Similarly, the current Draft Environmental Impact Statement of the ALWTRP notes that existing regulations are insufficient to achieve conservation objectives, and that more regulations are needed: "There would likely be additional incidents of serious injury and mortality to large whales due to entanglement in commercial fishing gear rather than a reduction in these interactions" (NMFS 2005).

In the United States, current entanglement reduction efforts consist of a combination of gear modifications and area closures. Gear restrictions stipulated under the ALWTRP include:

- *No floating line at the surface* – No person may fish with a lobster trap that has any portion of the buoy line that is directly connected to the gear on the ocean bottom floating at the surface at any time. If more than one buoy is attached to a single buoy line or if a high flyer and a buoy are used together on a single buoy line, floating line may be used between these objects.
- *No wet storage of gear* – Lobster traps must be hauled out of the water at least once every 30 days.
- *Knots* – Fishermen are encouraged, but not required, to maintain knot-free buoy lines (DEIS 2005).
- *Gear marking* – Lobster traps are required to possess a single four-inch mark on buoy lines midway in the water column.
- *Weak links* – Existing requirements for lobster gear in regulated waters stipulate that buoy lines be attached to the main buoy with a "weak link." The concept behind weak links is that if a whale hits a line, the weak link would break, thereby preventing entanglements. Breaking strengths vary by location and season. In inshore waters, a breaking strength of 600 pounds is mandated. In offshore waters, a breaking strength of 1,500-2,000 pounds is required (NMFS 2005).

In addition to these gear restrictions, NMFS presently employs both Seasonal Area Management (SAM) and Dynamic Area Management (DAM). SAM identifies areas where right whales are seasonally present in high abundance and creates a stricter management regime in those areas. DAM places similar temporary restrictions on areas where whales have been observed. The area-based strategy has been extremely unpopular and not particularly successful. In practice, DAM has required several weeks to implement, and compliance has only been voluntary in some instances. Once initiated, closed areas have led to more intensive fishing effort around the edges of the area, arguably creating a "fence" for the whales inside.

Whatever their shortcoming may be, this review does not examine the SAM and DAM efforts in detail because it is unlikely that they will remain in place for long. At present, NMFS is considering a new round of regulations under the ALWTRP that will scrap the area-based management entirely in favor of stricter gear requirements. The types of gear and gear practices affected fall into five basic categories: sinking groundline; sinking buoy line; weak links and anchors; set restrictions and gear stowing; and improved gear marking (NMFS 2005). In addition to groundline requirements, weak links are to be installed on all devices attached to buoy lines

(e.g., surface buoys and toggles). It is important to note that the breaking strength for weak links was established not by biological parameters relating to whales, but by tests intended to determine the minimum tensile strength that gear can be used without compromising the fishing practice (Bowman 2004). Consequently, the effectiveness of weak links at reducing entanglements has not been effectively verified.

The Draft Environmental Impact Statement summarizes the proposed changes:

NMFS identifies two preferred broad-based gear modification strategies to replace its Dynamic Area Management (DAM) and Seasonal Area Management (SAM) programs in the Draft Environmental Impact Statement, with the intent of implementing only one of the preferred alternatives. The proposed broad-based gear modifications are designed to further reduce the risk of serious injury and mortality to Atlantic large whales due to incidental interactions with commercial fishing gear. The primary difference between the two preferred alternatives concerns when the DAM program would be replaced, and what the time/area restrictions and gear modifications requirements for the SAM program would entail. Both broad-based gear modification strategies include the following: groundlines must be composed of sinking and/or neutrally buoyant line; additional weak link requirements for net panels and buoy lines; and expanded gear marking. (NMFS 2005)

The preferred alternatives listed in the Environmental Impact Statement will phase DAM and SAM out by 2008 or sooner. Given the urgency of the situation, the timing of this gear strategy is contentious. Conservationists have argued that NMFS should reduce groundline immediately. It has also been pointed out that the present plan does not address the threats to whales posed by vertical lines. In contrast, NMFS argues that, "Although the broad-based sinking/neutrally buoyant groundline requirement will not be fully in effect until 2008, it is NMFS' belief that the changeover to sinking and/or neutrally buoyant groundline may begin prior to 2008 as fishermen replace their groundline as it naturally wears out" (NMFS 2005). NMFS does not intend to consider management options to reduce entanglement risk associated with vertical line until a future rulemaking action (NMFS 2005). In the meantime, management agencies continue to investigate gear-based solutions. For example, the National Fish and Wildlife Foundation, in conjunction with NMFS, the Northeast Consortium, and the Gulf of Maine Lobster Foundation, have sponsored a Large Whale Gear Competition. The \$10,000 grants offered in this competition are intended to spur the development of fishing gear that could further reduce whale entanglements.

Fishing is not the only source of anthropogenic mortality for right and humpback whales. Ship strikes appear to pose an even larger and arguably more intractable problem. However, even incremental improvements in entanglement rates could be the difference between recovery and extinction at least for right whales. Analysis by Fujiwara and Caswell (2001) indicates that preventing just a few deaths per year can substantially improve the species' chances of survival. By their estimates, saving two female right whales annually would halt the estimated population decline. The authors note:

Our analysis also shows that the population was experiencing a positive growth rate in the early 1980s. This implies that it is not necessary to return the vital rates to those of the pre-whaling period to obtain a positive growth rate. There is every reason to hope that prompt management intervention can improve survival enough to permit the recovery of the North Atlantic right whale. (Fujiwara and Caswell 2001)

In Canada, right whale entanglements have been less of a focus for management agencies. The Canadian Recovery Plan for North Atlantic Right Whales was published in 2000, and lays out a general goal of reducing the frequency and intensity of entanglement and entrapment in fishing gear. Unlike the U.S., no numeric goals were created, other than a long-term goal of achieving a minimum population of 1,200 right whales in the North Atlantic. The specific recommendations are primarily action steps (e.g., setting up a disentanglement network and educating fishermen), with no gear modifications or closed areas specified. While Canada has designated two “conservation areas”—one in the Bay of Fundy and the second in Roseway Basin on the western Scotian Shelf—they do not have any active restrictions associated with them. “Although these two areas have been officially designated since 1993, and their boundaries are found in nautical publications and on the back of two nautical charts, there is no legislated framework that governs human activities in them” (COSEWIC 2003). And while a recovery team is in place to work on the issue, there have been no recovery publications released in the last five years, making it difficult to judge the progress achieved. Lei Harris, Species at Risk Act biologist for the DFO, confirms that there are no gear modification or area closure programs in place, though research by DFO is presently underway in conjunction with Dalhousie University as well as the World Wildlife Fund and the New England Aquarium (Harris 2005).

DFO signed an agreement with the Center for Coastal Studies (CCS) in 2003, which authorized the sharing of research, expertise, and rescue equipment in the Bay of Fundy and Gulf of Maine. DFO has also begun to store disentanglement equipment use by CCS, and has adopted the center's whale entanglement reporting system. DFO and the Canadian Whale Institute have also sponsored gear modification competitions. Apart from research, the most active steps taken in Canada have addressed ship strikes, with shipping lane regulations in summering areas modified to protect the species.

### **Fishing practices and habitats**

Few, if any, mitigative measures are in place to address habitat effects of lobster fisheries, in large part because pots are believed to have only low to moderate effects on habitat. Limits on the number of traps in a trawl can reduce the footprint of traps, as can existing size limits on traps. Similarly, effort and trap limits in general reduce cumulative effects. With respect to protecting specific habitats, in Canada there are at least three Marine Protected Areas (MPAs) along the Atlantic coast: the Gully (2,400 square kilometers), and two smaller closed areas for corals. LFA 40 is a closed area off southwest Nova Scotia, on Browns Bank. This offshore area, closed for the last two decades, is believed to be home to a high concentration of female lobsters (Robichaud 2005). The U.S. has no substantial closed areas for lobster habitat. Section 303(a)(7) of the amended Magnuson-Stevens Act directed NMFS and the fishery management councils to identify Essential Fish Habitat (EFH) for managed species and minimize the adverse effects of fishing on that habitat; however, an EFH analysis for lobster is not available.

### **Enforcement**

Relative to many other fisheries, there appears to be rigorous enforcement in the American lobster industry. In the United States, each state monitors lobster landings and patrols for illegal activities, then reports to the Atlantic States Marine Fisheries Commission (ASMFC) annually on lobster fishery enforcement. As can be expected, effectiveness of enforcement varies by state. In Maine, for example, the Bureau of Marine Patrol conducts enforcement, and rates their enforcement in the lobster fishery as very high. In Maine in 2002, there were nearly 10,000 commercial and non-commercial lobster license holders. Howard (2003) reports that in Maine “officers issued 208 summonses and 933 warnings during 2002. The Commissioner of Marine Resources suspended 12 lobster licenses in 2002” (Howard 2003).

Massachusetts reports no significant problems with enforcement, while enforcement in Rhode Island has been more problematic, particularly given the recent period of poor landings. The majority of violations in Rhode Island have been for gear infractions (e.g., people fishing untagged lobster traps). Similarly, several dealer inspections have revealed license violations, which have been prosecuted in court. “Other violations documented during this period have been for possession of undersized lobsters, possession of egg bearing lobsters, landing lobsters without a license, selling lobsters without a license, fishing unmarked lobster gear and fishing lobster gear without escape vents” (Howard 2003). Rhode Island and Connecticut both report a shortage of staff to effectively enforce these restrictions due to budgetary issues. A separate enforcement issue reported by ASMFC is that a delay in federal implementation of area-specific management measures has created a difference in management measures between state and federal governments “that is impeding uniform enforcement across the region” (Selberg, McBane et al. 2004).

In Canada, the DFO’s Conservation and Protection Program (C&P) is responsible for monitoring compliance with legislation and regulations regarding the conservation of fisheries resources and fish habitat. Fishery Officers enforce fisheries regulations and management plans as well as the habitat provisions of the Fisheries Act, and can haul illegal traps or conduct dock inspections (Miller 2005). No statistics were found to indicate the level of enforcement in Canada, though DFO news releases comment on local efforts to address lobster poaching (DFO 2004). DFO recently organized a lobster fishery enforcement forum for LFAs in the Gulf of St. Lawrence.

In both the U.S. and Canada, it should be noted that self-enforcement plays a large role in the American lobster fishery. Both lobsters and lobstermen are territorial and unlikely to tolerate blatant disregard for the regulations created in a community-management framework.

### **Management track record**

In both the United States and Canada, management has been unable to meet its own stock conservation goals (i.e., EPR goals), *yet despite this failure*, lobster abundance is near record levels. Stock productivity has increased over time due at least in part to management efforts such as minimum size limits and the protection of ovigerous females, as well as reduction in predatory groundfish populations. Whether the lobster fishery is vulnerable to a future stock collapse is a matter of continuing debate; however, the existing productivity track record has been positive.

**Synthesis**

Lobster management employs a relatively rigorous management structure, with intensive monitoring of landings and CPUE. Management is divided along smaller geographic lines to encourage flexibility to local environmental conditions and needs. However, management appears not to have met stated goals with respect to stock status and marine mammal entanglements in the United States. This is a serious and ongoing concern. In Canada, there is a dearth of information available to assess the effectiveness of the management system, as few publications are available for reviewing stock status or occurrences of marine mammal entanglements. As a consequence, management is ranked only as moderately effective. If management were to address marine mammal entanglement and to resolve the abundance-modeling issues it would be ranked higher.

**Table 7** - Management of American lobster.

<b>Stock Status</b>	<b>Monitoring</b>	<b>Scientific Advice</b>	<b>Bycatch</b>	<b>Habitat Effects</b>	<b>Enforcement</b>	<b>Track Record</b>
Stock status assessments issued on ~5 year time frame. Not meeting stock goals.	Regular monitoring of fishery-dependent data. Less regular fishery-independent data.	Scientific advice used.	Marine mammal plans have not met goals.	Not applicable	High enforcement.	Stocks near record abundance.

**Effectiveness of Management Rank:**

Highly Effective 

**Moderately Effective** 

Ineffective 

Critical 

## **Overall Evaluation and Seafood Recommendation**

American lobsters have a neutral inherent vulnerability to fishing pressure due to their life history characteristics, such as a moderate first age at maturity and high longevity. Although lobsters are relatively fecund, much of the American lobster catch is composed of sexually immature individuals. The status of American lobster stocks is uncertain. U.S. stocks are classified as overfished with overfishing occurring, as determined under current questionable models. While abundance is falling in Southern New England, it remains near historic highs in the Gulf of Maine and throughout Canadian waters. Because of the high abundance and unresolved questions about management models, stock status is considered “Moderate or Unknown” despite the overfishing classification. The questions surrounding stock status are of a lesser order than current concerns over interactions with marine mammals. Though there is minimal bycatch of fish and invertebrates in American lobster pots, regular entanglement of endangered North Atlantic right and humpback whales in lobster gear is a very serious issue; bycatch thus rates as a high or critical conservation concern. If mortality rates for large whales do not fall substantially in the near future, lobster will be ranked in the “Avoid” category. In the meantime, benefit of the doubt has been given to the industry and it is assumed that recent management measures are reducing entanglement rates for large whales. Lobster pots have a small to moderate impact on benthic habitat. Management of American lobster is deemed moderately effective, due to the inability of management to achieve its own stock status and marine mammal interaction goals. The preceding suite of criteria results in an overall recommendation of “Good Alternative” for American lobster.

### **Table of Sustainability Ranks**

Sustainability Criteria	Conservation Concern			
	Low	Moderate	High	Critical
Inherent Vulnerability		✓		
Status of Stocks		✓		
Nature of Bycatch			✓	
Habitat Effects	✓			
Management Effectiveness		✓		

### **Overall Seafood Recommendation:**

Best Choices 

**Good Alternative** 

Avoid 

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