Seafood Watch
Seafood Report

MONTEREY BAY AQUARIUM®

Goosefish/Monkfish
Lophius americanus

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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 www.seafoodwatch.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® 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® 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 1-877-229-9990.

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Executive Summary

Monkfish (goosefish) is a fast-growing, short-lived benthic marine species belonging to the family Lophiidae. It commonly occurs between the Grand Banks and northern Gulf of St. Lawrence, Canada south to Cape Hatteras, North Carolina. It may be found on sand, mud and broken shell bottoms from shallow, coastal waters to over 800 meters (m) depth. Traditionally, this species was considered 'trashfish' and discarded from the Atlantic groundfish and scallop fisheries. However, as other commercial fisheries in the Northwest Atlantic declined, monkfish has become an important species, landed in both directed and multi-species fisheries. Due to intense fishing effort, monkfish has been overfished in the past. While a recent stock assessment suggests that monkfish are no longer overfished and overfishing is not occurring, these data are highly uncertain. In addition, the new biological reference points proposed have not been accepted, the stock is recovering from a previously overfished condition, and the average size of monkfish caught has declined since the beginning of the available time series. Overall, the stock status of monkfish is considered "poor" according to Seafood Watch® criteria. Most monkfish in the US are caught using a bottom otter trawl, which results in significant disturbance to the sea floor, impacting marine habitats critical to the survival of groundfishes and other species. Trawling is relatively indiscriminate, and along with targeted catch the gear takes unmarketable, illegal, or undersized species that are fatally discarded, adding to the overall fishing mortality of many groundfish species. Sink gill nets, which are also used to catch monkfish, have been shown to interact with several protected species of marine mammal and sea turtles. Management has attempted to address these issues by closing some areas, and using fishing effort and gear restrictions to reduce fishing mortality.

This report was updated on August 11, 2008. Please see Appendix 3 for a summary of the changes made at this time.

Table of Sustainability Ranks

	Conservation Concern			
Sustainability Criteria	Low	Moderate	High	**Critical**
Inherently Vulnerability	√			
Status of Stocks			√	
Nature of Bycatch			√	
Habitat Effects			√	
Management Effectiveness		√		

About the Overall Seafood Recommendation:

- A seafood product is ranked **Best Choice** if three or more criteria are of Low Conservation Concern (green) and the remaining criteria are not of High or Critical Conservation Concern.
- A seafood product is ranked **Good Alternative** if the five criteria "average" to yellow (Moderate Conservation Concern) OR if the "Status of Stocks" and "Management Effectiveness" criteria are both of Moderate Conservation Concern.
- A seafood product is ranked **Avoid** if two or more criteria are of High Conservation Concern (red) OR if one or more criteria are of Critical Conservation Concern (black) in the table above.

Overall Seafood Recommendation:

Best Choice | Good Alternative | **Avoid**

Introduction

Monkfish (*L. americanus*) is a sedentary, bottom-dwelling species in the family Lophiidae (goosefishes) that inhabits the Atlantic Ocean from the Gulf of St. Lawrence (Canada) to Cape Hatteras, North Carolina (Steimle et al. 1999). This species may also be found as far south as northern Florida (Steimle et al. 1999; NAFO 2001), and in the lower Chesapeake Bay from late fall to early spring (DNR 1999). South of Cape Hatteras, it is sympatric with a similar anglerfish species, the blackfin goosefish (*L. gastrophysus*) (Caruso 1983; Armstrong et al. 1992), which is believed to comprise a small portion of southern landings (NEFMC/NMFS 2001; NEFSC 2002). Directed fisheries for monkfish exist in state and federal US waters from the Gulf of Maine and Grand Banks through Cape Hatteras, North Carolina, year-round (Figure 1) (NEFMC 2001), as well as off the southern coast of Canada, in the Gulf of Saint Lawrence, and the Scotian Shelf (Figure 2) (DFO 2000; Kulka and Miri 2001).

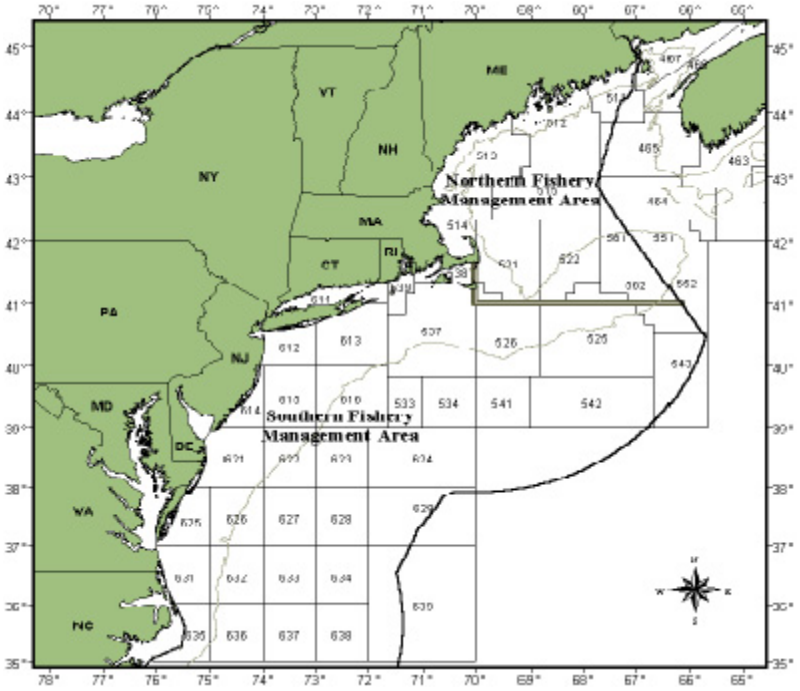

Figure 1. US monkfish management areas (Figure from NEFMC 2001).

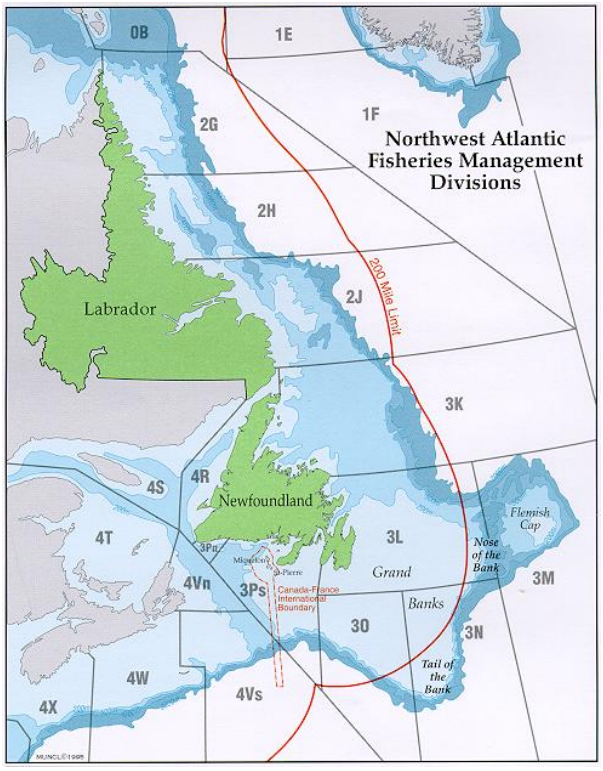

Figure 2. Management divisions regulated by the North Atlantic Fisheries Organization (NAFO online).

Prior to 1990, monkfish were considered bycatch and discarded in the Northwest Atlantic groundfish and scallop fisheries (DNR 1999). In the last 20 years a directed fishery has developed for tails, livers, and whole fish, which are consumed domestically and abroad (DNR 1999). Reported US landings (live weight) averaged 2,500 metric tons (mt) in the 1970s to over 8,000 mt in the 1980s and greater than 20,000 mt throughout the 1990s (Figure 3) (NMFS 2007a).

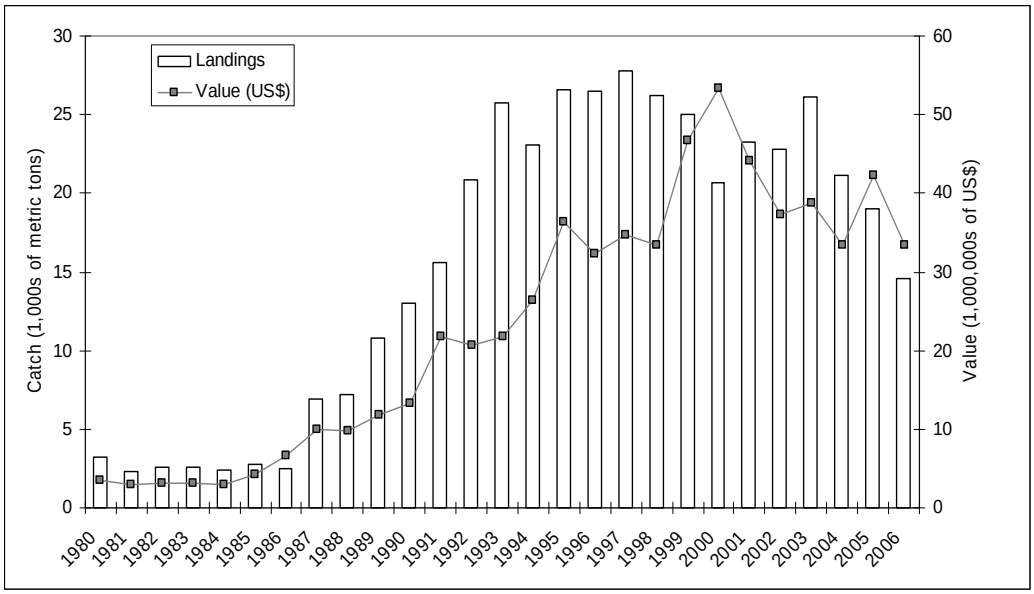

Figure 3. Trends in US monkfish landings (mt) and value (US$), 1980 – 2006 (NMFS 2007a).

In 2000, monkfish earned the fifth highest revenues among commercially fished Northeast Atlantic species, bringing in $52.7 million on 45 million pounds (20,412 mt) landed from Maine to North Carolina (Press 2002). The port of New Bedford, Mass., had the highest monkfish landings of any US port, averaging 7 million pounds (3,175 mt) from 1995-1999, declining in 2000 to 5.5 million pounds (2,494 mt) (NEFMC/NMFS 2001).

The monkfish fishery is entirely commercial. Most of the catch is taken in the Multispecies Groundfish fishery, which targets cod, haddock and flounders. This fishery uses bottom otter trawls almost exclusively. Monkfish are also targeted by sink gillnetters and sea scallop dredgers (Figure 4). A sink gillnet is a vertical wall of netting (usually monofilament line) with a weighted leadline that allows the net to hang slightly above the seafloor (NMFS 1996). In 2006, 44% of monkfish were landed using trawls, while 36% were landed using sink gillnet (Figure 5). However, the predominant gear type varies widely by port and state. For example, in 2006, the state of Maine landed 96% of its monkfish catch by otter trawl, while the states of New Jersey and Massachusetts landed 69% and 49% of their monkfish catch using gillnets and otter trawls respectively (NMFS 2007c). Overall from 2002 -2006, 51% of monkfish were landed using trawls, 37% were landed with gillnets, 8% using dredges, and 4% were landed using various other gears (NMFS 2007c). It appears that the volume of monkfish caught by scallop dredges is declining.

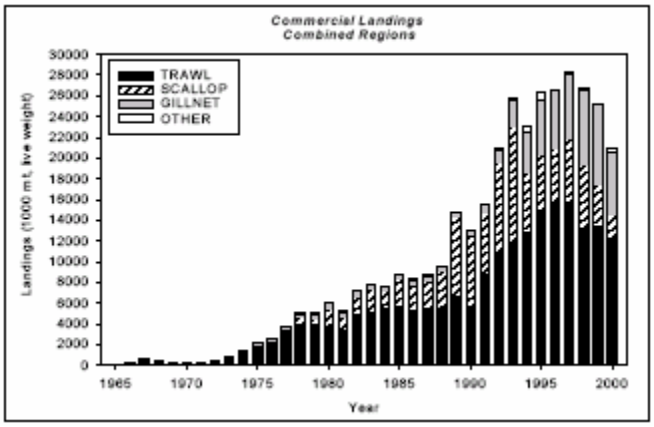

Figure 4. US landings (live weight, mt) by gear type both regions combined (NMFS 2002).

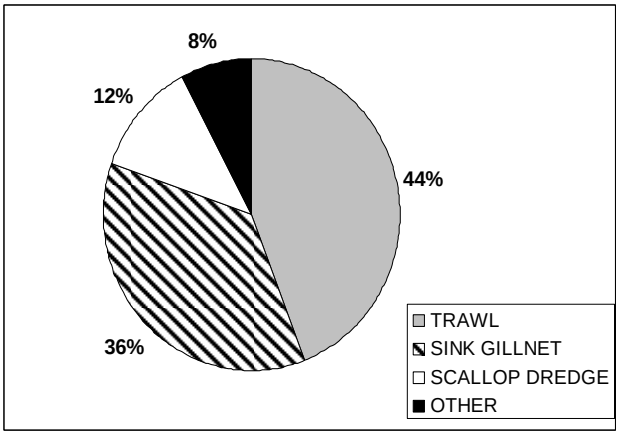

Figure 5. Gear type composition of U.S. monkfish landings in 2006 (NMFS 2007c).

In Canada, gillnets are the predominant gear type in the directed fishery (DFO 2000; Kulka and Miri 2001). Monkfish are also taken as bycatch in the skate and white hake trawl fisheries (Kulka and Miri 2001). They have also accounted for approximately 85% of the groundfish by-catch landed by offshore scallop vessels (which fishers are required to retain) (DFO 1997). Annual landings of monkfish in Canada are much smaller than that of US fishers; throughout the late 1990s they have averaged 320 mt (Kulka and Miri 2001). Following the decline of other commercially important species in the Grand Banks, Canadians fishers began an experimental fishery for monkfish in the late 1980s. Prior to that, monkfish were discarded from gillnet or trawl fisheries (Kulka and Miri 2001). Before 1991, the Canadian monkfish catch was less than 200 mt annually, but rose sharply in the early 1990s as a lucrative market developed for their meat and liver (Kulka and Miri 2001). In 1995, a 200 mt annual quota was instituted for the

emerging fishery; current landings average 320 mt annually (Figure 6) (Kulka and Miri 2001). Effort is increasing, however, as traditional groundfish fisheries off the Canadian coast (such as cod, rockfish, and hake, and yellowtail) are reduced or closed (DFO 2001).

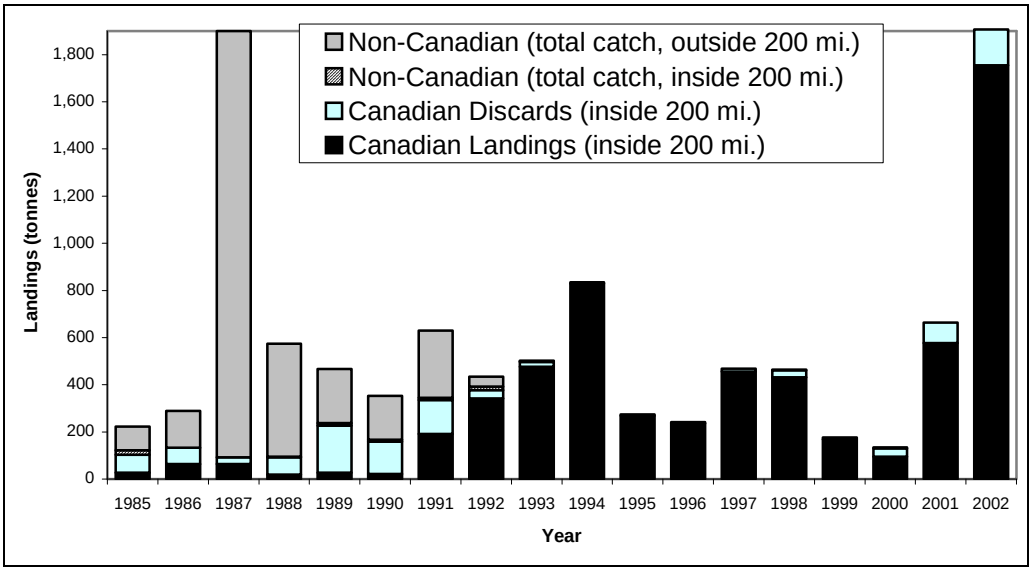

Figure 6. Canadian and non-Canadian landings of monkfish in 3LNOPs, 1985-2002. Courtesy DFO (Note: 2002 data are preliminary) (Kulka and Miri 2001)

Scope of the analysis and the ensuing recommendation:
This report is focused on U.S. stocks of monkfish, with some reference to Canadian stocks. However, the ensuing recommendation is based on U.S. stocks only, as this represents the vast majority of the national market. A directed fishery for two related monkfish species (*L. budegassa and L. piscatorius*) occurs off the west coast of Scotland, but since it is not exported to the US, is not covered here.

Availability of Science
Literature pertaining to taxonomy and general life history of this species is adequate. Other aspects, however, such as stock structure (Richards 2000; NEFSC 2002), larval biology and ecology, estimates of abundance and distribution, location of critical spawning areas, survival requirements of recently settled juveniles, and recruitment variability are not as well known (Steimle et al. 1999). Fishing mortality and biomass estimates are also relatively uncertain. Intrinsic rate of increase (r) for this species is not known.

Market Information

Common/Market Names
The accepted common name is goosefish, while monkfish is the name used in commerce (Steimle et al. 1999). They are also called anglerfish, angler, allmouth, lotte (Europe), molligut, bellyfish, lawyerfish, and fishing frog (Bigelow and Schroeder 1953). When used for sushi or sashimi, monkfish is commonly sold as *ankoh* and *ankimo* (monkfish liver).

Seasonal Availability
The monkfish fishing year (FY) runs year-round, but the majority of landings occur in the spring (May and June), during the spawning season (NEFMC/NMFS 2001). A secondary, but lesser peak, typically occurs in November and December, partly in response to higher market prices during the winter months because of Asian demand for livers and European demand for meat (NEFMC/NMFS 2001).

Product Forms
Monkfish products are fresh (whole/head-on, tail fillets/skinless, whole tails/skin-on) or frozen (tail fillets/skinless, whole tails/skin-on). There is also a foreign market for tails, cheeks, and livers, mostly to Japan and Europe (DNR 1999). Landings of tails rose throughout the 1980s, and have declined since 1997 (7,191 mt in 1997) (NEFSC 2002). As tails declined, markets for gutted whole fish as well as livers have increased. Landings of livers increased from only 10 mt in 1982 to an average of greater than 600 mt between 1998 and 2000 (NEFSC 2002). Prices for liver are extremely high, ranging to US$19/pound in some seasons (NEFSC 2002).

Import/Export Statistics
The US is a primary exporter of monkfish (Table 1), with approximately 5,295 mt worth US$25.9 million exported in 2007 (NMFS 2007b). Imports of monkfish are predominantly from Canada and more recently China, averaging just over 212.5 mt/year from 1995-2007 (NMFS 2007b).

Table 1. Top 5 destination countries for US caught monkfish exports in 2002 (NMFS 2007b).

COUNTRY	AMOUNT (MT)	VALUE (US DOLLARS)
South Korea	3,249	14,787,199
France	966	4,993,893
Portugal	317	1,355,600
Belgium	238	988,610
United Kingdom	164	1,238,951
Canada	88	714,806

Analysis of Seafood Watch® Sustainability Criteria for Wild-Caught Species

Criterion 1: Inherent Vulnerability to Fishing Pressure

Monkfish are scaleless and soft-bodied, with very broad, depressed heads (the head is as wide as the fish is long) and enormous mouths. They have long, sharp teeth and a modified spine called an "esca," which can be angled forward so it can dangle in front of the fish's mouth and is wiggled like bait to lure its prey. They have been known to eat prey at least half their size or more (Bigelow and Schroeder 1953), using the powerful vacuum created by the rapid expansion of their mouth. Generally speaking, they are sedentary bottom-dwellers, moving slowly or "walking" with their pectoral fins (Steimle et al. 1999). Adults often hide in shallow depressions or partially cover themselves in sediment, waiting to ambush a passing fish or invertebrate (Steimle et al. 1999). Cannibalism has been observed; this may explain higher mortality of smaller males (Armstrong et al. 1996). Seasonal migrations seem to be related to spawning and food availability (Richards 2000), as well as temperature (Steimle et al. 1999). In the northern Atlantic (off Canada), monkfish are thought to be largely concentrated in a narrow band on the southern Grand Banks, with no significant seasonal shifts (Kulka and Miri 2001).

Spawning occurs throughout the spring and into early fall, peaking in May to June (Armstrong et al. 1992). Observations of fertilization *in situ* have rarely been reported, but are thought to occur on inshore shoals (Scott and Scott 1988). Females lay a large, buoyant egg mass that is "a ribbon-like, non-adhesive, mucoid veil" 6-12 m long and weighing more than 5 kg (Martin and Drewry 1978). The veils have a complex, chambered structure, each chamber containing one to three eggs and an opening for water circulation, and are believed to be unique among fishes (Armstrong et al. 1992). Eggs may incubate from seven to 22 days, depending on seawater temperature (Steimle et al. 1999). Egg masses have been reported to hold between 300,000 and 3.2 million eggs (Armstrong et al. 1992; Steimle et al. 1999). After hatching, larvae and juveniles spend several months in a pelagic phase before settling on the bottom at approximately 8 cm (3 inches) (Richards 2000). A morphological transition occurs when pelagic juveniles prepare to settle on the benthos, but the areas in which this occurs are poorly known (Steimle et al. 1999).

Monkfish are fast growing (k[1] = 0.06-0.1; Table 2) and relatively short-lived compared to other deep-living fishes, maturing at three to five years and as small as 30 cm total length (TL) (Steimle et al. 1999). Like most fishes, juveniles grow rapidly (10-11cm/yr) and both sexes grow at a similar rate until reaching maturity. After that females exhibit faster growth and are heavier due to the presence of ovaries (Armstrong et al. 1992). Fifty percent maturity for males is 36 cm TL; almost all males (99%) are mature by 48 cm (NEFSC 2002). Females mature slightly larger, 50% at 43 cm TL, and 99% at 63 cm TL (NEFSC 2002). Age at first maturity is approximately 4 years for males and 5 years for females (Almeida et al. 1995). Based on enumeration of growth increments in vertebral sections, females are reported to live at least 12 years, while males have not been found to live more than 9 years (Armstrong et al. 1992). Males

[1] The growth coefficient, k, is a parameter described by the Von Bertalanffy Growth Function (VBGF): a commonly used growth function in fisheries science for elucidating age and growth characteristics of fishes. After von Bertalanffy (1938).

and females reach a maximum length of 90 and 100 cm, respectively (Richards 2000), with a maximum recorded size of 138 cm TL[2].

Table 2. Life history information for monkfish.

COMMON NAME	SPECIES RANGE	GROWTH RATE/MAX SIZE	AGE at MATURITY	LONGEVITY	FECUNDITY	References
Monkfish/ Goosefish	Nova Scotia to Cape Hatteras (occasionally northern FL)	k=0.06-0.1; 120 cm TL max. published weight: 22.6 kg	Males: A1st = 4 yr, L50% = 36cm; Females: A1st = 5 yr, L50% =43cm	Females to 12 yrs; males to 9 yrs	Reproductive females range between 300,000 and 3.2 million eggs	(Armstrong et al. 1992; Steimle et al. 1999; Froese and Pauly 2004)

Synthesis
Because it is a very fast growing and quickly maturing species, monkfish is resilient to fishing pressure. It may be more vulnerable during spawning periods.

Inherent Vulnerability Rank:

Resilient Moderately Vulnerable Highly Vulnerable

Criterion 2: Status of Wild Stocks

Status of Stocks – US
There are two separate stock units of monkfish in US waters; the dividing line runs east-west from Cape Cod to the Hague Line (see Fig. 1). These are titled the Northern and Southern Fishery Management Areas (NFMA and SFMA respectively). Fishing pressure in both areas has been heavy through the late 1980s and early 1990s. In 2000, a year after the rebuilding plan was implemented, both management areas surpassed their target TACs, the NFMA by almost 200% (11,674 mt landed vs. 5,673 mt TAC) and SFMA by just over 30% (7,921 mt landed, 6,024 mt TAC) (NEFMC/NMFS 2001). As a consequence, both stocks have been classified as overfished and undergoing overfishing for much of the last decade. In addition, monkfish size (measured as length) has declined significantly in both stocks since the 1960s (NEFSC 2007).

The most recent stock assessment classifies both stocks as neither overfished nor undergoing overfishing based on the development of new biological reference points. Based on the previously used reference points, the stock is considered overfished in both regions (Figures 7, 8) (NEFSC 2007). For monkfish stocks, indices of abundance are no longer measured as catch per effort (kilograms, kg/ per tow), but rather as total stock biomass.

[2] Anne Richards. 2003. Personal Communication. Research Scientist. NMFS Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543-1097.

The target biomass (B_{target}) is defined as the average of total biomass from 1980-2006; this new definition assumes a natural mortality (M) of 0.3 compared to the previous definition, which used M=0.2 (NEFSC 2007). The minimum biomass threshold ($B_{threshold}$) is defined as the lowest total biomass calculated between 1980-2006 (NEFSC 2007).

NFMA stock data reflect a decrease in stock abundance (total biomass) from 1980 to the late 1990s (1997-1999) and an increase in stock abundance since 1999 (Figure 9) (NEFSC 2007). Total biomass for the stock has been estimated at 118,700 mt in 2006, above both B_{target} (92,200 mt) and $B_{threshold}$ (65,200 mt). Current fishing mortality (F) for NFMA is estimated at 0.09 per year, well below F_{max} (0.31) and F_{target} (0.18). F_{max} is the overfishing threshold.

SFMA stock data indicate an increase in stock abundance until the late 1980s, followed by a decline during the 1990s, and an increase since 2000 (Figure 10) (NEFSC 2007). Total biomass was estimated at 135,500 mt in 2006, also above the B_{target} and $B_{threshold}$ of 122,500 and 96,400 mt respectively (NEFSC 2007). Current fishing mortality for the stock is estimated at 0.12 per year, which is below F_{max} (0.40) and F_{target} (0.31). Therefore, according to the new reference points, neither stock is overfished nor undergoing overfishing (Table 3).

However, "there are significant uncertainties associated with the assessment results" (NEFSC 2007, pg. 4). These uncertainties are related to:

1. Under-reported landings data;
2. Unknown quantity of monkfish discards in the 1980s;
3. Incomplete knowledge of key life history parameters such as maximum age and stock structure;
4. Inclusion of a shorter time series (1980 – 2006) compared to the previous assessment (1963 – 2006);
5. The fact that the model used is relatively new (NEFSC 2007) and the proposed reference points have not been accepted.

There is substantial uncertainty associated with the new stock assessment for monkfish, and the current biological reference points indicate that monkfish in the northern and southern regions is overfished. **Overall, the stock status for monkfish is considered "poor" according to Seafood Watch® criteria.**

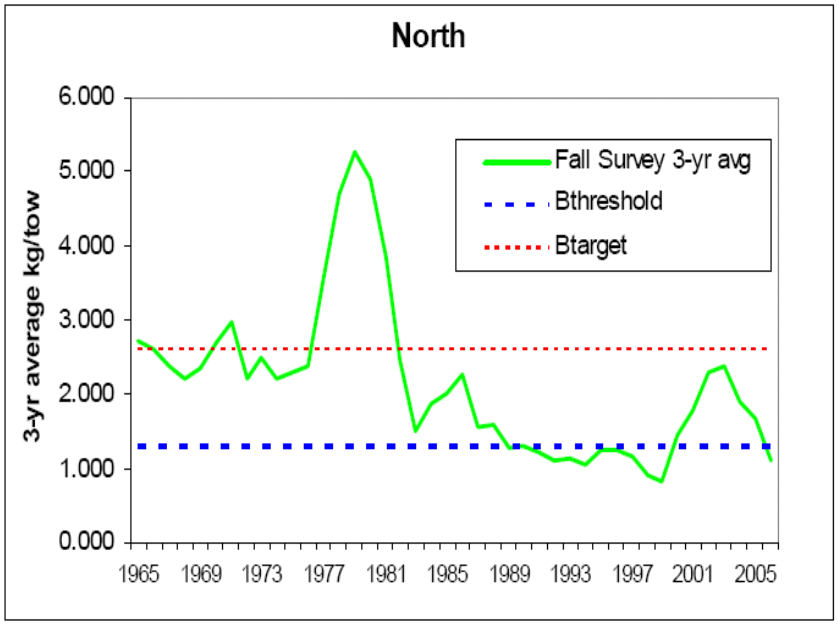

Figure 7. NFMA biomass trends (1965-2006) using current biological reference points (Figure from NEFSC 2007).

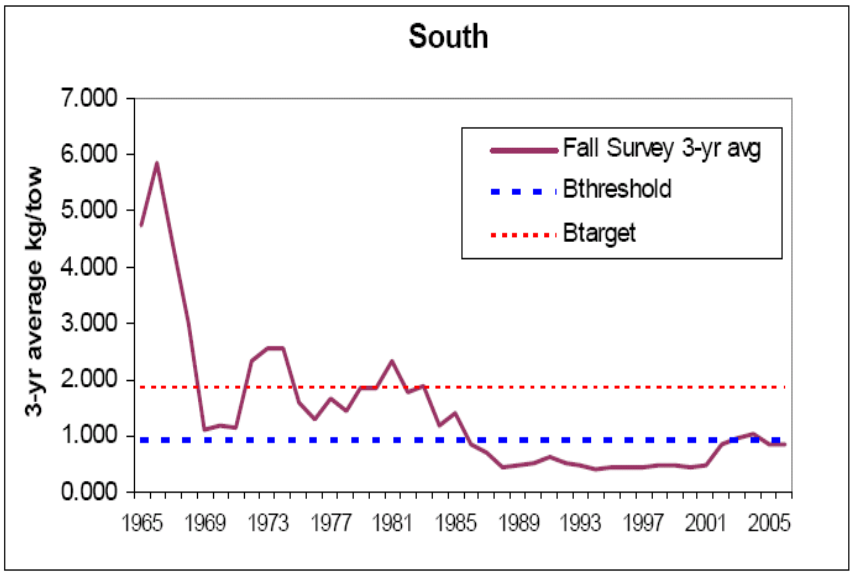

Figure 8. SFMA biomass trends (1965-2006) using current biological reference points (Figure from NEFSC 2007).

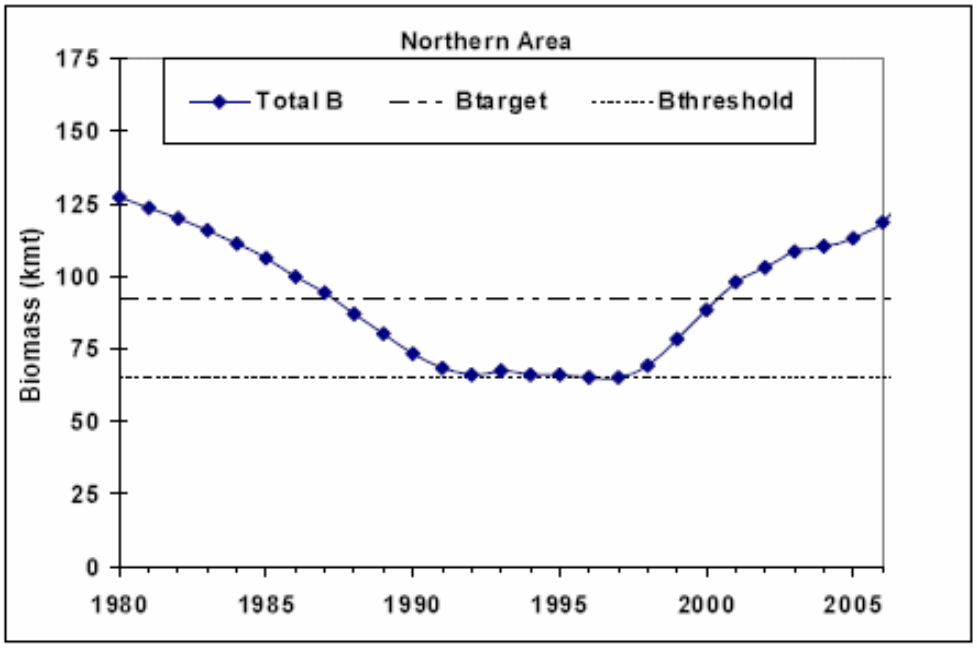

Figure 9. NFMA biomass trends (1980-2006) using proposed reference points. Below the dotted lined indicates an overfished condition (Figure from NEFSC 2007).

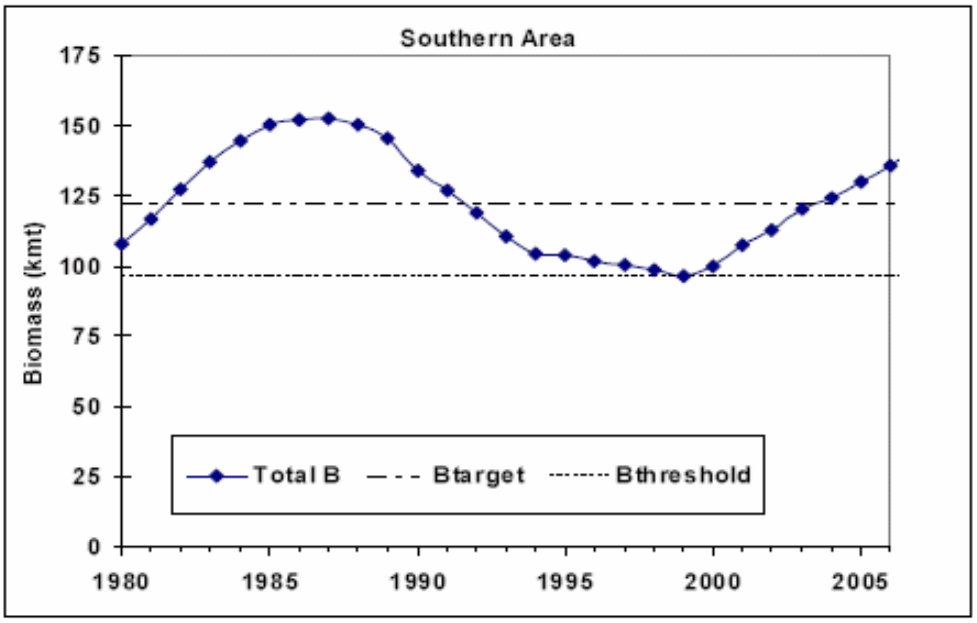

Figure 10. SFMA biomass trends (1980-2006) using proposed reference points. Below the dotted lined indicates an overfished condition (Figure from NEFSC 2007).

Status of Stocks – Canada

In Canadian waters, monkfish stocks are assessed by area, with the primary focus areas being the Laurentian Channel near the Grand Banks (off Newfoundland) and the Scotian Shelf southeast of Nova Scotia. A 2002 assessment of the monkfish stock fished off Scotian Shelf and Grand Banks reported that "Abundance of adult monkfish in [the area] remains at or below average. The proportion of large fish (>70cm) continues to decline and biomass remains low…there is evidence of improved immature abundance since 1992, particularly in 1995 and 2000. This does not appear to be resulting in biomass increase" (p. 1) (DFO 2002c). Other indicators of stock health, such as size composition and reproductive condition, are reduced in current stocks from previous decades. In summary, abundance for the adult monkfish population off the Atlantic Canadian provinces remains depressed (DFO 2002c).

Table 3. Stock status and trends for monkfish in the US and Canada.

Stock	Classification Status	B/B_{MSY}	Occurrence of Overfishing	F/F_{MSY}	Abundance Trends/CPUE	Age/Size/Sex Distribution	Degree of Uncertainty in Stock Status	Sources	SFW Rank
Northern Monkfish	Not overfished[3]	B/B_{target} = 1.29	No	F/F_{MAX} = 0.29	Increasing since 1999	Truncated	High	NEFSC 2007	Poor
Southern Monkfish	Not overfished[3]	B/B_{target} = 1.11	No	F/F_{MAX} = 0.30	Increasing since ~ 2000	Truncated	High	NEFSC 2007	Poor
Monkfish, Canada	Fully exploited to depleted	N/A	N/A	N/A	Fluctuating	Truncated size	High	DFO 2002c	Poor

Synthesis

According to the proposed biological reference points in the most recent monkfish stock assessment, neither NFMA nor SFMA stocks are overfished or experiencing overfishing. However, these data are highly uncertain and size distribution data indicate that both stocks have experienced long term decreases in length overtime. Additionally, stocks are still considered overfished according to the current biological reference points. Overall the status of US monkfish stocks is considered "poor". Canadian monkfish biomass continues to be depressed and stock status in this region is also ranked as "poor".

Status of the Stocks Rank:

Healthy Moderate/Rebuilding **Poor** **Critical**

[3] Values in Table 3 reflect new biological reference points proposed in the most recent monkfish stock assessment. These data however, are highly uncertain and the new reference points have yet to be accepted. Based on the current biological reference points in the fishery management plan, stocks are still considered overfished.

Criterion 3: Nature of Bycatch

Seafood Watch® defines sustainable wild-caught seafood as marine life 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 managed in some way.

Fishing gear types used in Atlantic groundfish and/or monkfish fisheries have been shown to interact, often adversely, with marine mammals and turtles (NEFMC/MAFMC 2002), as well as sharks and rays, some of which are themselves commercially important (e.g. spiny dogfish). According to a NMFS Biological Opinion (June 2001), monkfish fishing activity has the potential to "adversely affect, but not jeopardize, the continued existence of humpback, fin, blue, sei, and sperm whales, and green, leatherback, loggerhead, and Kemp's ridley turtles" (NEFMC/MAFMC 2002).

There have been a number of observed interactions with marine mammals and sea turtles in the trawl fisheries. In 2003, Fishery Observers on 590 trawling (bottom otter) trips recorded a total of 21 interactions with marine mammals, and 4 interactions with sea turtles (NMFS 2004a). In the Northeast sink gillnet fishery north of 40˚ N, harbor porpoise (*Phocoena phocoena*), white-sided dolphins (*Lagenorhynchus acutus*), common dolphins (*Delphinus delphis*), harbor seals (*Phoca vitulina*), gray seals (*Halichoerus grypus*), and harp seals (*Phoca groenlandica*) have been taken incidentally in recent years (Table 4; Bisack 2003). Two of these species are listed as strategic[4] stocks (harbor porpoise and common dolphin), and four are listed as nonstrategic (white-sided dolphins, harbor seals, gray seals, and harp seals; Waring et al. 2002).

Atlantic fishery observers have recorded minor numbers of turtle mortalities, especially for loggerhead turtles. Between 1996 and 2001, a total of 21 sea turtle interactions were observed in the sink gillnet fishery (mostly loggerhead, *Caretta caretta*); of those, seven resulted in mortality (NEFMC 2001). Most of the interactions occurred off Virginia and North Carolina (NEFMC 2001). Management responded to these problems with the implementation of a Take Reduction Plan (TRP, December 1998), which includes time/area closures relating to occurrence of marine mammals and/or turtles, gear modifications, observer coverage, and acoustic deterrents ("pingers") (NEFMC/MAFMC 2002). NMFS has also used Emergency Actions to close the monkfish gillnet fishery off the coasts of North Carolina and Virginia to protect migrating sea turtles (Plant 2002).

[4] A species is listed as 'strategic' if the total fisheries bycatch is greater than the Potential Biological Removal Rate (PBR). The PBR, as defined by the Marine Mammal Protection Act (16 U.S.C. 1362 {20}), is defined as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population (FR V68,N7, January 10, 2003, p. 1415).

Table 4. Total estimated bycatch (with CV[5]) of marine mammals in the Northeast sink gillnet fishery, by species, 1993-1996 (Bisack 2003).

Species	1993	1994	1995	1996
Harbor Porpoise	1,400 (18)	2,100 (19)	1,400 (27)	1,185 (29)
Harbor Seal	698 (19)	1,330 (25)	1,182 (21)	855 (27)
White-sided Dolphin	205 (31)	240 (51)	80 (116)	116 (61)
Common Dolphin	0	0	0	69 (139)
Gray Seal	18 (100)	19 (95)	117 (42)	49 (56)
Harp Seal	0	861 (58)	694 (27)	90 (55)
Hooded Seal	0	0	28 (96)	0
Total	2,321	4,550	3,501	2,364

There have also been interactions between some monkfish (and other pelagic/groundfish) fisheries and Atlantic sturgeon (*Acipenser oxyrinchus*), which is protected under the 1973 Endangered Species Act (ESA). Stein et al. (2004) analyzed bycatch of Atlantic sturgeon for otter trawl, sink gill net and drift gill net gear off the U.S. east coast from Maine to North Carolina. They estimated an annual mortality of approximately 1,500 individuals per year, with the greatest mortality from sink gill nets off North Carolina, Virginia and Maryland.

Other issues regarding bycatch in the US monkfish fishery relate to forced discards of otherwise marketable monkfish, largely due to trip limits and minimum fish sizes (NEFMC/MAFMC 2002). The discard rate in the southern area is estimated to be between 6 and 22% of the catch, while in the northern area 7 to 15% of the catch is discarded (NEFSC 2002). Discards also include Jonah Crab, skates, and dogfish (NEFMC 2002). Fatal discards of these species may threaten the health of their own stock condition. Spiny dogfish was designated overfished in 1998, and 4 out of 7 species of Atlantic skate (winter, barndoor, thorny, and smooth skate) were determined to be in overfished condition when assessed in November 1999 at the 30th SAW. According to the 2004 Report to Congress on the Status of US Stocks in 2003, the barndoor skate, thorny skate, and the spiny dogfish are still overfished (NMFS 2004b).

Bycatch - Canada

In the Canadian portion of the Atlantic, interactions with turtles and other marine mammals have not been well recorded from the Grand Bank fisheries. According to DFO scientist David W. Kulka, who works closely with the monkfish fishery, “no turtles have been taken in trawls in Canadian waters (including the Scotian shelf) because the leatherbacks spend most of their time on or near the surface and trawling occurs in deeper waters”. Use of gillnets, however, has been known to take whales and dolphins (Read 1994), but these reports were not related to the directed monkfish fishery. A recent report on interactions of Atlantic Canadian fisheries with

[5] Coefficient of Variation, a statistical term used to define the amount of variability around an estimate.

leatherback turtles indicates most problems are linked to pelagic and fixed gear fisheries (DFO 2004).

Synthesis

There are bycatch problems with all three of the main gear types used to catch monkfish (otter trawl, scallop dredge, and sink gill net). Otter trawls and scallop dredges are indiscriminate and induce a large percentage of unmarketable or regulatory discards. Sink gill nets have been observed to interact regularly with marine mammals, two of which are classified as strategic stocks under the MMPA, and one species of endangered sea turtle. The nature and extent of bycatch for these gear types is considered a high conservation concern.

Nature of Bycatch Rank: Low Moderate **High** Critical

Criterion 4: Effect of Fishing Practices on Habitats and Ecosystems

Habitat Effects

Monkfish are caught mainly using otter trawl (Figure 11), sink gill net, and scallop dredge. The effects of various gear types on benthic habitat are poorly understood, and the degree to which monkfish fishing effort contributes to habitat damage is difficult to quantify. Generally speaking, trawling impacts sea-floor communities by scraping the ocean bottom causing 1) sediment re-suspension (turbidity) and smoothing, 2) removal and/or damage to non-target species, and 3) destruction of three-dimensional habitat (biotic and abiotic; Auster and Langton 1999). The degree of impact is determined by many factors, most notably 1) the type and weight of gear used; 2) the resilience of the seabed; and 3) the amount and frequency of the disturbance. Although studied to a lesser extent than otter trawls, mid-water trawls may also reduce available habitat by disturbing aggregations of gelatinous zooplankton and other floating matter, which has been shown to provide pelagic habitat for fish aggregations (Auster *et al.* 1992, Brodeur in press *in* NEFMC 1998).

Several studies on the effects of bottom trawling have focused on the heavily trawled fishing grounds in the northwest Atlantic (Collie et al. 1997; Collie et al. 2000). Prena et al. (1999), for example, conducted an experimental trawl study on the Grand Banks off Newfoundland and reported that "otter trawling on a sandy bottom ecosystem can produce detectable changes on both benthic habitat and communities, in particular a significant reduction in the biomass of large epibenthic fauna". At a workshop to assess the effects of fishing gear on marine habitats off the northeastern U.S., experts concluded that the "greatest impacts from otter trawls occur in low and high energy gravel habitats and in hard clay outcroppings" (NOAA 2002; p 24). Based on the results of this and other studies, it is apparent that otter/bottom trawling may alter the surrounding ecosystem, as well as reduce survival of the target species, by reducing or altering available habitat and food resources.

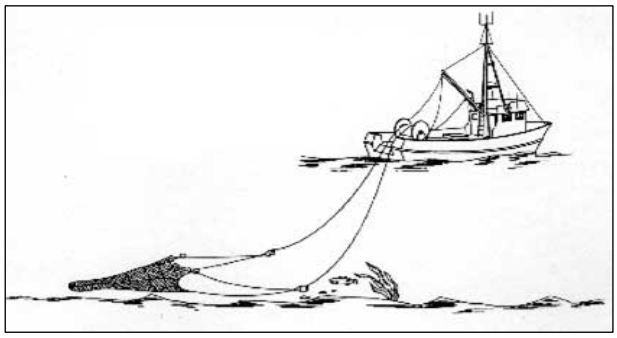

Figure 11. General diagram of an otter trawl (Courtesy Matt Squillante, Monterey Bay Aquarium).

Bottom trawl disturbance of the seabed is mainly a function of bottom type (rock, sand, mud, etc.) and gear type (dredge, beam, otter trawl, etc.). Some types of trawling gear cause less damage (i.e., otter trawls vs. scallop dredge) and some sediment types (and their associated ecosystems) are more resilient to disturbances caused by trawling. In a review of fishing effects, Collie et al. (2000) found that fauna associated with sandy (coarser) sediments were less affected by disturbance than those in soft, muddy (biogenic) sediments. Recovery rate appears to be slower in muddy and structurally complex habitats, while mobile sandy sediment communities can withstand 2-3 trawl passes per year without significant (adverse) change (Collie et al. 2000). The bathymetry of the Atlantic continental shelf, and habitat preferences of monkfish (sand, mud, broken shell bottoms), is such that groundfish trawlers targeting groundfishes (including monkfish) off the U.S. East Coast encounter both types of substrate. Otter trawling has been ranked as causing less disturbance to the sea floor than other types of trawling, such as inter-tidal and scallop dredging (Collie et al. 2000; NOAA 2002), but it is probable that repetitive trawling in these areas causes significant, and possibly adverse change to seabed ecosystems along the U.S. East Coast.

The third type of gear, sink gillnets, was reported to have negligible effects on benthic habitats (Barnette 2001).

Ecosystem Effects

The fishing grounds of the Gulf of Maine, Georges Bank, and the continental shelf off New England represent one of the most productive oceanic ecosystems in the world. Tidal cycles and strong current flows lead to an extremely productive clockwise gyre in which a diverse array of life flourishes. Analyses of food web structure show that this area is rich in species diversity and abundance, and has a high degree of complexity and connectivity (Brodziak and Link 2002). Consequently, heavy fishing pressure over the last few centuries has resulted in a notable shift from a largely benthic fish community towards a largely pelagic fish community (Fogarty and Murawski 1998; Brodziak and Link 2002). It is extremely difficult to quantify the effects of this shift, but certain outcomes have been theorized, such as changes in predator-prey interactions and species survival rates, and decreases in overall productivity and perturbation of food web dynamics (Brodziak and Link 2002). One example is the increased predation on groundfish larvae by small pelagic species such as mackerel and herring, and a shift in the dominant fish predator from cod to spiny dogfish during the 1980s (Brodziak and Link 2002). In addition to fishing impacts, natural and anthropogenic environmental impacts (i.e., temperature shifts, such as the North Atlantic Oscillation) may also be resulting in changes to the ecosystem, and

separating the effects of fishing and the effects of environmental changes may be close to impossible.

Synthesis
Based on the published literature noting the adverse effects of trawling on the various habitat types where monkfish are found, as well as the significant amount of fishing effort along the continental shelf over the last 50 years, it is reasonable to assume that trawling for monkfish (directly and indirectly) has significantly altered a large portion of the seabed and the ecosystem. The degree of recovery from these actions is largely unknown and therefore the effects of these fishing practices on habitats and ecosystems is ranked "severe".

Effect of Fishing Practices Rank:

Benign | Moderate | **Severe** | Critical

Criterion 5: Effectiveness of the Management Regime

Management – US
The New England and Mid-Atlantic Fishery Management Councils (NEFMC, MAMFC) jointly manage the US monkfish fishery in the Atlantic Ocean (Table 5), with the NEFMC having lead authority. The stock is divided into two zones termed the Northern and Southern Fishery Management Areas (NFMA and SFMA), and are divided by a line running east-west from Cape Cod to the Hague Line (see Fig. 1). The Northeast Fisheries Science Center (NEFSC) contributes independent fishery data, which aids in stock assessments.

Table 5. Summary of management regulations for monkfish (NEFMC/MAFMC 1998; NOAA 2004).

Jurisdiction and Agencies	TAC	Size Limits	Trip Limits	Gear Restrictions	Observer Program	Closed Seasons/Areas
NEFMC MAMFC	Yes, annually set for NFMA and SFMA	Yes, 11inches for tails, 17 inches whole fish	Yes, 550lb tail weight for Category A/C and 450lb for Category B/D in SFMA; 1250 lb for Category A/C and 470 lb for Category B/D in NFMA; DAS allocations of 31 and 23 in NFMA and SFMA respectively	Yes, minimum mesh size (see FMP for details)	Yes, although minor; VMS implemented	Yes, on occasion to protect spawning aggregations and/or endangered species (marine mammals, sea turtles)

Federal permits to catch monkfish were not required until the Monkfish Fishery Management Plan (FMP) was implemented in November 1999 (NEFMC/NMFS 2001). The FMP contains such control measures as limited access (permits), target catch levels, days-at-sea (DAS) limitations, trip limits, minimum fish size, gear restrictions, spawning season closures, and bycatch allowances (NMFS 2000; NEFMC/NMFS 2001). The goal of the FMP was to stop overfishing and rebuild monkfish stocks by 2009 (10-yr plan), using a "four-year phasing in of management measures to reduce fishing effort", beginning 1 May 1999 (NEFMC/NMFS 2001). The original "default measures" of the plan would have closed the directed fishery entirely in May 2002 (NEFMC/MAFMC 2002). In an October 2000 review of the FMP, attendees of the 31st Northeast Regional Stock Assessment Workshop (SAW) conducted by NMFS (and the Monkfish Monitoring Committee, MMC) concluded "the best available information, combined with concerns raised about the validity of current biological reference points, do not provide sufficient basis for justifying the Year 4 [2002] default measures or for making other adjustments to the current management program" (NEFMC/NMFS 2001). Because of this, the Councils agreed in February 2002 to delay closure by one year. NMFS, however, did not approve the Framework Adjustment 1 (to delay one year and keep the fishery open), so the fishery was closed on 1 May 2002. It was later reopened through an emergency interim rule (67 FR 99) and its extension (67 FR 215).

The 2002 stock assessment indicated the original default measures in the 1999 FMP are no longer appropriate, and that fishing mortality (F) reference points are invalid. As a result, the Councils (in consultation with NMFS) added Framework Adjustment 2 to the Monkfish FMP. This framework adjustment made revisions to the minimum biomass threshold and fishing mortality target reference points, as well as a rule that sets annual target TACs based on the ratio of a three year running average of NMFS fall biomass trawl surveys and commercial landings from the previous fishing year (NEFMC/MAFMC 2003a; 72 FR 183). Framework Adjustment 2 also allocated 40 DAS for limited access monkfish vessels in both management areas (NEFMC/MAFMC 2002), and established monkfish trip limits in the SFMA of 550 lbs/DAS for category A and C limited access vessels and 450 lbs/DAS for category B and D limited access vessels (NEFMC/MAFMC 2003a). Under Framework Adjustment 2, DAS allocation in the NFMA did not change significantly from FY 2002-2006; however, DAS allocation in the SFMA has varied from year to year, being adjusted to 28 in FY 2004, 39.3 in FY 2005, and 12 DAS in FY 2006 in response to changes in stock status (NEFMC/MAFMC 2006). SFMA Trip limits under Framework Adjustment 2 also varied from year to year. In 2003 management raised trip limits in the SFMA to 1,250 lbs/DAS and 1,000 lbs/DAS (NEFMC 2003a), returned them to 550 lbs/DAS and 450 lbs/DAS in 2004 (69 FR 36), raised them to 700 lbs/DAS and 600 lbs/DAS in 2005 (70 FR 81; NEFMC/MAFMC 2006), and returned once again to 550 lbs/DAS and 450 lbs/DAS in 2006 (NEFMC/MAFMC 2006). This framework adjustment did not establish trip limits in the NFMA.

Following the implementation of Framework Adjustment 2, biomass indexes for both stocks increased for several years before dropping below minimum biomass threshold (approximately 50% below their respective annual biomass targets) by fall 2006. Management responded by initiating Framework Adjustment 4 to replace Framework Adjustment 2, due in part to the potential of Framework Adjustment 2 to allow target TAC increases when biomass rebuilding targets are not met (72 FR 183). Effective FY 2007-2009, Framework Adjustment 4 established a

"backdrop provision" that enables management to re-allocate DAS for FY 2009 in either management area, should target FY 2007 TACs be exceeded (72 FR 183); and established TACs of 5,000 mt and 5,100 mt in the NMFA and SMFA respectively based on analysis conducted by the Monkfish Plan Development Team (Table 6). Additional provisions of Framework Adjustment 4 established DAS allocations of 31 and 23 DAS per vessel for the NFMA and SFMA respectively, and NMFA trip limits of 1,250 lbs/DAS for category A and C limited access vessels and 470 lbs/DAS for category B and D limited access vessels (72 FR 183). Framework Adjustment 6, if approved, will eliminate the framework's "backstop provision" (NEFMC/MAFMC 2008b).

Framework Adjustment 5 accepted the newly proposed biological reference points put forth in the August 2007 monkfish stock assessment (see Criterion 2) (73 FR 82). To account for the high degree of uncertainty associated with these reference points, Framework Adjustment 5 initiated additional measures to ensure that landings stay within target TACs (73 FR 82). These include reducing the permitted number of unused DAS transferable between fishing years from 10 to 4; charging vessels a minimum of 15 hours for all trips 15 hours or less in duration[6]; and revising the monkfish incidental catch limit for large-mesh fishing vessels fishing in the Southern New England Regulated Mesh Area to 5% (tail weight) of their total catch, which is also not to exceed 50 pounds per day (73 FR 82).

The US monkfish fishery has had a mixed record of adhering to target TACs from FY 2001-2007 (Table 6). NMFA landings have been under target TACs from 2003-2006, and SMFA landings have been under target TACs in 2002, 2004, and 2005(NEFSC 2007; NEFMC/MAFMC 2008a). From 2001-2007 monkfish landings in the NMFA and SMFA averaged 113.7% and 124.5% of their respective TACs (NEFMC/MAFMC 2003a ; 69 FR 67; NEFMC/MAFMC 2006; 72 FR 183; NEFSC. 2007; NEFMC/MAGMC 2008a &b).

Table 6. Landings and TACs for the NFMA and SFMA by fishing year (2001-2007). Parenthesis denote the percentage of TACs comprised by landings (NEFMC/MAFMC 2003a ; 73 FR 67; NEFMC/MAFMC 2006; 72 FR 183; NEFSC. 2007; NEFMC/MAGMC 2008a &b).

FY	NMFA (landings)	NFMA (TAC)	SFMA (landings)	SFMA (TAC)
2001	14,853 mt (261.8%)	5,673 mt	11,069 mt (183.7%)	6,024 mt
2002	14,491 mt (124.1%)	11,674 mt	7,478 mt (94.4%)	7,921 mt
2003	14,155 mt (79.9%)	17,708 mt	12,198 mt (119.5%)	10,211 mt
2004	11,750 mt (69.2%)	16,968 mt	6,193 mt (91.5%)	6,772 mt
2005	9,656 mt (73.4%)	13,160 mt	9,533 mt (98.6%)	9,673 mt
2006	6,677 mt (86.3%)	7,737 mt	5,509 mt (150.2%)	3,667 mt
2007	5,043 mt (100.9%)	5,000 mt	6,817 mt (133.7%)	5,100 mt

The monkfish resource is assessed through the use of both fisheries-independent and -dependent data, including NEFSC research survey catch-per-tow indices and commercial fishery data from vessel trip reports, dealer records and on-board fishery observers (NMFS 2000). Enforcement of differential trip limits between different gear types (gillnets vs. trawls) in the management areas has been a problem. A federal court order in 2001, however, mandates calculating trip limits in

[6] This was designed to close a loophole which allowed vessels to exceed DAS limits.

the SFMA so that each gear type (in each permit category) has equal limits (NEFMC/MAFMC 2002).

Management – Canada

The Canadian Department of Fisheries and Oceans (DFO) has regulated the groundfish fisheries off the coasts of Atlantic Canada since extension of fisheries jurisdiction on January 1, 1977 (DFO 2001). The first groundfish fishing plan was announced on December 21, 1976 (DFO 2001). Total Allowable Catch (TAC) controls, which were already in widespread use by the International Commission for Northwest Atlantic Fisheries, were chosen as the primary method for control of exploitation rate (DFO 2002b). Limited entry licensing, first introduced for the large trawler fleet in 1973, was extended to all groundfish vessels in 1976 (DFO 2002b).

Staff at DFO through the Pacific Scientific Advice Review Committee (PSARC) routinely conducts stock assessments. Canada's groundfish are managed through an individual transferable quota (ITQ) system, and the Department introduced the Dockside Monitoring Program (DMP) to verify and report landings on a timely basis (DFO 2001). Fishermen's organizations are now required to contract, at their own expense, independent monitoring companies situated throughout the Scotia-Fundy Sector to carry out dockside monitoring, as required by DFO (DFO 2002b). Other management measures include: a prohibition on discarding undersize target species (undersized), gear restrictions, seasonal closures, and no-fishing zones to protect habitat (DFO 2002a). The directed monkfish fishery has a conservative quota set around 200 mt, and is regulated only by bycatch restrictions, mainly for cod and haddock (Kulka and Miri 2001).

The monkfish fishery is managed within the DFO's groundfish (mixed) fishery, and a Conservation Harvest Plan is in place to provide regulatory guidelines. Fishery observers are deployed to a portion (20%-100%) of the fleet activity to monitor regulations and collect data on catch amounts and lengths, while 100% dockside monitoring is in effect (DFO 2002a). Standard spring research surveys have covered the Grand Banks since the late 1970s and these data are used to monitor abundance trends[7]. Canada also has a Coast Guard, which monitors fishing vessels.

[7] David Kulka. 2002. Personal Commun. Northwest Atlantic Fisheries Center, Box 5667 Whites Hills, St. Johns, Newfoundland.

Synthesis

Managers of the US monkfish resource assess stocks on a relatively timely basis (bi-annually) and use both fisheries dependent and independent data to determine stock status and fishing levels. Managers require specific mesh sizes and gear types to reduce wasteful discard, implement seasonal and permanent closure areas to reduce trawling impacts, enact trip limits and DAS limits, and annually-adjusted TACs to maintain stock status. Uncertainty however, remains regarding the status of the monkfish stock. Overall, management is deemed moderately effective.

Effectiveness of Management Rank:

Highly Effective | **Moderately Effective** | Ineffective | Critical

Overall Evaluation and Seafood Ranking

Monkfish is a fast-growing, short-lived species that has become increasingly important to commercial fishers in the Atlantic US and Canada. It may be found on sand, mud and broken shell bottoms from shallow, coastal waters to over 800 meters (m) depth. Due to intense fishing effort, monkfish has been overfished for several years. Data suggests that both stocks no longer experiencing overfishing, but these data are highly uncertain. Most monkfish in the US are caught using a bottom otter trawl, which results in significant disturbance to the sea floor, impacting marine habitats critical to the survival of groundfishes and other species. Trawling is relatively indiscriminate, and along with targeted catch the gear takes unmarketable, illegal, or undersized species that are fatally discarded, adding to the overall fishing mortality of many groundfish species. Sink gill nets, which are also used to catch monkfish, have been shown to interact with several protected species of marine mammal and sea turtles. Management has attempted to address these issues by closing some areas, and using fishing effort and gear restrictions to reduce fishing mortality.

Table of Sustainability Ranks

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

Overall Seafood Recommendation:

Best Choice | Good Alternative | **Avoid**

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Scientific review does not constitute an endorsement of the Seafood Watch® program, or its seafood recommendations, on the part of the reviewing scientists. Seafood Watch® is solely responsible for the conclusions reached in this report.

References

Almeida, F. P., D.-L. Hartley and J. Burnett. 1995. Length-weight relationships and sexual maturity of goosefish off the northeast coast of the United States. *N. Am. J. Fish. Management* 15: 14-25.

Armstrong, M. P., J. A. Musick and J. A. Colvocoresses. 1992. Age, growth and reproduction of the goosefish, Lophius americanus (Pisces: Lophiiformes). *Fish. Bull. (U.S.)* 90: 217-230.

Armstrong, M. P., J. A. Musick and J. A. Colvocoresses. 1996. Food and ontogenetic shifts in feeding of the goosefish, Lophius americanus. *J. Northwest Atl. Fish. Sci.* 18: 99-103.

Auster, P. J. and R. W. Langton. 1999. The Effects of Fishing on Fish Habitat. *American Fisheries Society Symposium* 22: 150-187.

Barnette, M. C. 2001. A review of the fishing gear utilized within the Southeast Region and their potential impacts on essential fish habitat. NOAA Technical Memorandum NMFS-SEFSC-449**:** 62pp.

Bigelow, H. B. and W. C. Schroeder. 1953. Fishes of the Gulf of Maine. *U.S. Fish Widl. Serv., Fish. Bull.* 53: 577p.

Bisack, K. D. 2003. Estimates of marine mammal bycatch in the Northeast (New England) multispecies sink gillnet fishery in 1996. Northeast Fisheries Science Center Reference Document 03-18. http://www.nefsc.noaa.gov/nefsc/publications/crd/crd0318/index.htm

Brodziak, J. K. T. and J. Link. 2002. Ecosystem-based fishery management: What is it and how can we do it? *Bulletin of Marine Science* 70(2): 589-611.

Caruso, J. H. 1983. The systematics and distribution of the lophiid angler fisher: II. Revision of the general *Lophiomus* and *Lophius*. *Copeia* 1: 11-30.

Collie, J. S., G. A. Escanero and P. C. Valentine. 1997. Effects of bottom fishing on the benthic megafauna of Georges Bank. *Marine Ecology Progress Series* 155: 159-172.

Collie, J. S., S. J. Hall, M. J. Kaiser and I. R. Poiner. 2000. A quantitative analysis of fishing impacts on shelf-sea benthos. *Journal of Animal Ecology* 69: 785-798.

DFO. 1997. 1997 SCOTIA-FUNDY OFFSHORE SCALLOP INTEGRATED FISHERIES MANAGEMENT PLAN, MARITIMES REGION. Department of Fisheries & Oceans, Canada. http://www.mar.dfo-mpo.gc.ca/fisheries/res/imp/97offsca.html#V. CURRENT

DFO. 2000. Monkfish in Divisions 3L, 3N, 3O and Subdivision 3Ps. Canadian Department of Fisheries and Oceans**:** A2-20.

DFO. 2001. Integrated Fisheries Management Plan: Groundfish, Newfoundland Region (Grand Banks, Labrador Shelf, Davis Strait and NAFO Stocks). Department of Fisheries & Oceans, Canada**:** 111pp.

DFO. 2002a. Fisheries Management Planning for the Canadian Eastern Georges Bank Groundfish Fishery. Regional Fisheries Status Report 2002/01E. Department of Fisheries & Oceans, Canada: online. http://www.mar.dfo-mpo.gc.ca/science/rap/internet/fsr(2002)1E.pdf

DFO. 2002b. GROUNDFISH INTEGRATED FISHERIES MANAGEMENT PLAN SCOTIA-FUNDY FISHERIES MARITIMES REGION APRIL 1, 2000 - MARCH 31, 2002. Department of Fisheries & Oceans, Canada: online. http://www.mar.dfo-mpo.gc.ca/fisheries/res/imp/2000grndfish.htm#1.%20OVERVIEW

DFO. 2002c. Monkfish on the Scotian Shelf and Northeast Georges Bank (Div. 4VWX and 5Zc). DFO Sci. Stock Status Report A3-30(2002). http://www.mar.dfo-mpo.gc.ca/science/rap/internet/A3-30(2002)E.pdf

DFO. 2003. Monkfish in Divisions 3L, 3N, 3O and Subdivision 3Ps. 2003/045. Department of Fisheries & Oceans Canada: 5 p. http://www.dfo-mpo.gc.ca/CSAS/CSAS/English/Status/Status_Reports2003_e.htm

DFO. 2004. Allowable harm assessment for Leatherback Turlte in Atlantic Canadian Waters. DFO Science Stock Status Report 2004/035: 6 p.

DNR. 1999. Monkfish Fact Sheet. Maryland Department of Natural Resources (Available online). http://www.dnr.state.md.us/fisheries/education/monkfish/monkfish.html

Federal Register. 2002. Fisheries of the Northeastern United States; Monkfish Fishery; Framework 1; Emergency Measures. Vol. 67, No. 99, pp.35928-35931. May 22, 2002.

Federal Register. 2002. Fisheries of the Northeastern United States; Magnuson-Stevens Fishery Conservation and Management Act Provisions; Monkfish Fishery. Vol. 67, No. 215, pp.67568-67571. November 6, 2002.

Federal Register. 2004. Fisheries of the Northeastern United States; Monkfish Fishery. Vol. 69, No. 36, pp. 8364-8367. February 24, 2004.

Federal Register. 2004. Fisheries of the Northeastern United States; Monkfish Fishery. Vol. 69, No. 67, pp.18291-18293. April 7, 2004.

Federal Register. 2005. Fisheries of the Northeastern United States; Monkfish Fishery; Annual Adjustments. Vol. 70, No 81, pp. 22241-22244. April 28, 2005.

Federal Register. 2007. Magnuson-Stevens Fishery Conservation and Management Act Provisions; Fisheries of the Northeastern United States; Monkfish Fishery; Framework Adjustment 4. Vol. 72, No. 183, pp. 53942-53952. September 21, 2007.

Federal Register. 2008. Magnuson-Stevens Fishery Conservation and Management Act Provisions; Fisheries of teh Northeastern United States; Monkfish Fishery; Framework Adjustment 5 to the Monkfish Fishery Management Plan. Vol. 73, No. 82, pp. 22831-22835. April 28, 2008

Fogarty, M. J. and S. A. Murawski. 1998. Large-scale disturbance and the structure of marine systems: Fishery impacts on Georges Bank. *Ecological Applications* 8 (Supplement)(1): S6-S22.

Froese, R. and D. Pauly. 2004. FishBase. World Wide Web electronic publication. June 2004. www.fishbase.org.

Kulka, D. W. and C. M. Miri. 2001. Status of Monkfish (Lophius americanus) in NAFO Divisions 3L, 3N, 3O and Subdivision 3Ps. SCR Doc. 01/47. Northwest Atlantic Fisheries Organization**:** 1-6. http://www.dfo-mpo.gc.ca/CSAS/CSAS/DocREC/2001/RES2001_004e.pdf

Martin, F. D. and G. E. Drewry. 1978. Lophiidae. *In*: Development of fishes of the mid-Atlantic Bight - An atlas of egg, larval and juvenile stages, U.S. Fish & Wildlife Service, OBS 78/12. 6**:** 357-366.

NAFO. 2001. The status of monkfish (Lophius americanus) in NAFO Divisions 2J, 3K, 3L, 3N, 3O and Subdivision 3Ps.

NEFMC. 1998. Essential Fish Habitat. New England Fishery Management Council/NOAA/NMFS/NEFSC. http://www.nefmc.org/habitat/index.html

NEFMC. 2001. Monkfish Stock Assessment and Fishery Evaluation (SAFE) Report for the 2000 fishing year. New England Fishery Management Council & National Marine Fisheries Service**:** 69. http://www.nefmc.org/

NEFMC. 2002. Monkfish 2001 SAFE Report for the 2001 Fishing Year (May 1, 2001 - April 30, 2002). New England Fishery Management Council; National Marine Fisheries Service**:** 82pp. http://www.nefmc.org

NEFMC. 2004. Framework Adjustment 40A to the Northeast Multispecies Fishery Management Plan. New England Fishery Management Council (NEFMC); Mid-Atlantic Fishery Management Council (MAFMC); National Marine Fisheries Service (NMFS)**:** 341 p. http://www.nefmc.org/nemulti/index.html

NEFMC/MAFMC. 1998. Monkfish Fishery Management Plan. New England Fishery Management Council (NEFMC); Mid-Atlantic Fishery Management Council (MAFMC)**:** 446p. http://www.nefmc.org/monk/index.html

NEFMC/MAFMC. 2002. Final Framework Adjustment 1 to the Monkfish Fishery Management Plan. New England Fishery Management Council; Mid-Atlantic Fishery Management Council**:** 63. http://www.nefmc.org

NEFMC/MAFMC. 2003a. Final Framework Adjustment 2 to the Monkfish Fishery Management Plan. New England Fishery Management Council; Mid-Atlantic Fishery Management Council**:** 59. http://www.nefmc.org

NEFMC/MAFMC. 2003b. Monkfish 2001 Safe Report. *In*: Framework Adjustment 2 to the Monkfish Fishery Management Plan. New England Fishery Management Council; Mid-Atlantic Fishery Management Council**:** 82pp. http://www.nefmc.org

NEFMC/MAFMC. 2006. Monkfish Fishery Management Plan Annual Specifications for the 2006 Fishing Year. NMFS. Accessed 2008. http://www.nefmc.org/monk/index.html.

NEFMC/MAFMC. 2008a. Monkfish Fishery Management Plan Framework Adjustment 5. NMFS. Accessed 2008. http://www.nefmc.org/monk/index.html.

NEFMC/MAFMC. 2008b. Monkfish Fishery Management Plan Framework Adjustment 6. NMFS. Accessed 2008. http://www.nefmc.org/monk/index.html.

NEFMC/NMFS. 2001. Monkfish Stock Assessment and Fishery Evaluation (SAFE) Report for the 2000 fishing year. New England Fishery Management Council & National Marine Fisheries Service**:** 69. http://www.nefmc.org/

NEFSC. 2002. Report of the 34th Northeast Regional Stock Assessment Workshop (34th SAW), Stock Assessment Review Committee (SARC), Consensus Summary of Assessments. Woods Hole, MA**:** 346pp. http://www.nefsc.nmfs.gov/nefsc/publications/crd/crd0206/

NEFSC. 2007. Monkfish Assessment Summary for 2007. NMFS. Accessed 2008. http://www.nefmc.org/monk/index.html.

NMFS. 1996. Fisheries Sampling Branch Observer Manual. Northeast Fisheries Science Center, 166 Water St., Woods Hole MA 0254301026**:** 33p.

NMFS. 2000. 31st Northeast Regional Stock Assessment Workshop, Public Review. Woods Hole, MA**:** 16-23. http://www.nefsc.nmfs.gov/nefsc/saw/saw31/saw31prw.pdf

NMFS. 2002. Fisheries Statistics & Economics Database. website. National Marine Fisheries Service; Department of Commerce 2004. http://www.st.nmfs.gov/st1/.

NMFS. 2004a. 2003 Incidental Take Report. Northeast Fisheries Observer Program, NOAA/NEFSC 2004. http://www.nefsc.noaa.gov/femad/fsb/.

NMFS. 2004b. Annual Report to Congress on the Status of US Fisheries - 2003. US Department of Commerce, NOAA, Natl. Mar. Fish. Serv.**:** 24 p. Silver Spring, MD. http://www.st.nmfs.gov/sfa/sfweb/index.htm

NMFS. 2006. Annual Report to Congress on the Status of US Fisheries - 2006. US Department of Commerce, NOAA, Natl. Mar. Fish. Serv. http://www.nmfs.noaa.gov/sfa/statusoffisheries/SOSmain.htm

NMFS. 2007a. Annual Commercial Landing Statistics. NMFS. Accessed 2008. http://www.st.nmfs.noaa.gov/st1/commercial/landings/annual_landings.html.

NMFS. 2007b. US Foreign Trade. NMFS. Accessed 2008. http://www.st.nmfs.noaa.gov/st1/trade/index.html.

NMFS. 2007c. Annual Commercial Landings by Gear Type. NMFS. Accessed 2008. http://www.st.nmfs.noaa.gov/st1/commercial/landings/gear_landings.html.

NOAA. 2002. Workshop on the Effects of Fishing Gear on Marine Habitats off the Northeastern United States, October 23-25, 2001. Northeast Region Essential Fish Habitat Steering Committee**:** 86 pp. Boston, Massachusetts. http://www.nefsc.nmfs.gov/nefsc/publications/crd/crd0201/

Plant, J. M.2002. NMFS bans monkfish gillnets of NC/VA. Commercial Fisheries News. Stonington, ME. http://www.fish-news.com/cfn.html

Press, A.2002. Monkfish Shutdown Averted. Boston Gazette. http://www.gazettenet.com/01262002/news/10900.htm

Read, A. J. 1994. Interactions between cetaceans and gillnet and trap fisheries in the northwest Atlantic. *Report of the International Whaling Commission.* Special Issue 15: 133-147.

Richards, A. 2000. Goosefish. In: Status of the Fishery Resources of the Northeastern US. NEFSC/NOAA http://www.nefsc.nmfs.gov/sos/spsyn/og/goose/.

Scott, W. B. and M. G. Scott.1988. Atlantic fishes of Canada. Canadian Bulletin Fish. Aquat. Sci. 731pp.

Steimle, F. W., W. W. Morse and D. L. Johnson. 1999. Essential fish habitat source document: goosefish, Lophius americanus, life history and habitat characteristics. NOAA Tech. Memorandum NMFS-SE 127**:** 31. http://www.nefsc.nmfs.gov/nefsc/publications/text/nefscseries/current/techmemo/GooseFish127.pdf

Stein, A. B., K. D. Friedland and M. Sutherland. 2004. Atlantic sturgeon marine bycatch and mortality on the continental shelf of the Northeast United States. *North Amer. J. Fish. Man.* 24: 171-183.

Waring, G. T., J. M. Quintal and C. Fairfield. 2002. US Atlantic and Gulf of Mexico marine mammal stock assessments -2002. NOAA Tech. Memo. NMFS-NE-169**:** 180p.

Appendix 1 (June 6, 2007 update)

Prior to the 2005 fall survey, biomass in the NFMA and SFMA had been increasing and the stocks were not overfished. However, the three-year average biomass index from the 2005 fall survey was below threshold and target biomass levels defined by the FMP, indicating the stocks are overfished (NEFMC/MAFMC 2006). Due to the overfished and overfishing designation, we changed the U.S. stock status from "Poor" to "Critical". There is no change in the overall recommendation for Monkfish, which remains an "Avoid".

Appendix 2 (April 9, 2008 update)

Prior to the August 2007 monkfish stock assessment, NFMA and SFMA stocks were considered overfished and undergoing overfishing. Based on proposed biological reference points stocks are no longer considered to be overfished, and overfishing is no longer occurring. However, there is significant uncertainty associated with these data. Seafood Watch® has changed the US stock status from "critical" to "poor"; there is no change in the overall recommendation for monkfish, which is recommended as "Avoid".

Appendix 3 (August 11, 2008)

Prior to August 2008 criterion 5 of the Monkfish Seafood Watch Report covered only rules and regulations dating back to 2002 (Framework Adjustment 2) for US management. Criterion 5 was updated with information pertaining to Framework Adjustments 4 and 5. These frameworks, which replaced Framework Adjustment 2, established new rules and regulations pertaining to DAS, trip limits, and TAC. Management rank remains "moderate" and the overall recommendation for monkfish remains "Avoid."