Seafood Watch
Seafood Report

MONTEREY BAY AQUARIUM®

Wild-caught Clams

Atlantic surfclam (*Spisula solidissima*)
Ocean quahog (*Arctica islandica*)
Softshell clam (*Mya arenaria*)
Hard clam (*Mercenaria mercenaria*)

Hard clam, *Mercenaria mercenaria*
(Image © Robert Donahue)

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) or obtained from the Seafood Watch® program by emailing 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.

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

The most common types of wild-caught clams in the Northeast and Mid-Atlantic regions are the Atlantic surfclam, ocean quahog, softshell clam, and hard clam. Farmed clams are not evaluated in this seafood report.

Atlantic surfclams are inherently resilient to fishing pressure due to life history characteristics such as an early age at sexual maturity. U.S. stocks of surfclams are abundant, are not overfished and overfishing is not occurring. Surfclams are harvested from federal waters with hydraulic clam dredges, which cause a great amount of damage to the benthic habitat; harvesting with such gear rates as a high conservation concern. However, there is very little bycatch associated with this gear type. Surfclams are managed by the Mid-Atlantic Fishery Management Council, under the Atlantic Surfclam and Ocean Quahog Fishery Management Plan. Management is considered highly effective, although Seafood Watch® remains concerned about the habitat effects of hydraulic clam dredging. The preceding suite of criteria results in the recommendation of "Good Alternative" for Atlantic surfclams.

Ocean quahogs are relatively long-lived and late-maturing, and are considered inherently neutral to fishing pressure. Ocean quahog stocks are abundant, are not overfished, and overfishing is not occurring. Hydraulic clam dredges are the gear type most commonly used to harvest ocean quahogs. Clam dredges cause a great amount of damage to the benthic habitat, and harvesting with such gear rates as a high conservation concern. There is very little bycatch associated with this fishery. Ocean quahogs are managed by the Mid-Atlantic Fishery Management Council, under the Atlantic Surfclam and Ocean Quahog Fishery Management Plan. Management is considered highly effective, although Seafood Watch® remains concerned about the habitat effects of hydraulic clam dredging. The preceding suite of criteria results in the recommendation of "Good Alternative" for ocean quahogs.

Softshell clams are commercially harvested primarily from Maine state waters. As they reach sexual maturity at an early age, softshell clams are considered inherently resilient to fishing pressure. The status of softshell clam stocks is considered unknown due to a lack of consistent population data. Softshell clams are harvested with hand rakes, which result in less habitat effects than clam dredging, and there is little bycatch in this fishery. The commercial softshell clam fishery is managed by the Maine Department of Marine Resources. Although stock assessments are not consistently conducted in all locations, management only allows softshell clams to be harvested with hand implements. The preceding suite of criteria results in the recommendation of "Best Choice" for softshell clams.

Hard clams are commercially harvested primarily in Connecticut, New York, Massachusetts, and Rhode Island state waters. Hard clams reach maturity at an early age, and are considered inherently resilient to fishing pressure. The status of hard clam stocks is considered unknown due to a lack of consistent population assessment data. Hard clams are harvested using both hand rakes and clam dredges, and there is little bycatch associated with either of these gear types. The commercial hard clam fishery is managed by various state agencies in Connecticut, New York, Massachusetts, and Rhode Island. The preceding suite of criteria results in the recommendation of "Good Alternative" for hard clams.

Table of Sustainability Ranks

	Conservation Concern			
Sustainability Criteria	**Low**	**Moderate**	**High**	**Critical**
Inherent Vulnerability	√ (Atlantic surfclam, softshell clam, hard clam)	√ (Ocean quahog)		
Status of Stocks	√ (Atlantic surfclam, ocean quahog)	√ (Softshell clam, hard clam)		
Nature of Bycatch	√ (Hand rakes and clam dredges)			
Habitat Effects		√ (Hand rakes)	√ (Clam dredges)	
Management Effectiveness	√ (Atlantic surfclam, ocean quahog, softshell clam)	√ (Hard clam)		

About the Overall Seafood Recommendation:

- 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.
- 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 **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.

Overall Seafood Recommendation:

Softshell clam: **Best Choice** 🟩 Good Alternative 🟨 Avoid 🟥

Atlantic surfclam,
Ocean quahog,
Hard clam: Best Choices 🟩 **Good Alternatives** 🟨 Avoid 🟥

Introduction

There are four types of clams commonly available in the Northeast and Mid-Atlantic regions: Atlantic surfclams (*Spisula solidissima*), ocean quahogs (*Arctica islandica*), softshell clams (*Mya arenaria*), and hard clams (*Merceneria merceneria*). Clams are bivalve molluscs and suspension feeders, consuming particulate matter from the water. Clams burrow into the sediment in which they occur, and the depth of burrowing depends on the species. Surfclams and ocean quahogs are harvested with hydraulic clam dredges, which use pressurized water jets to wash clams out of the sediment (NEFSC 2002). Stern rig dredges and side rig dredges are the two types of clam dredges used; stern rig dredges are more commonly used, and cause less damage to small clams (NEFSC 2002). Clam dredges are only operated in sandy sediments to avoid damaging the gear and reducing the quality of the harvested clams (NEFSC 2002). Softshell clams are harvested with hand rakes from intertidal areas. There are different types of clam rakes; some have a basket that collects clams, sediment, shells, seagrass, and debris (Peterson et al. 1983). The type of clam rake used depends on the habitat type, and different rakes have varying habitat effects (Peterson et al. 1983). Hard clams are harvested with both clam dredges and hand rakes, as well as with tongs and grabs, by hand, and by treading (fishermen using their feet to feel the clams burrowed in the mud).

Atlantic surfclams

Atlantic surfclams are found in the western Atlantic from the Gulf of St. Lawrence to Cape Hatteras, North Carolina (Merrill and Ropes 1969). Since the mid-1980s, the majority of commercial surfclam catch has been off New Jersey (NEFSC 2003a). In 2002, surfclams were landed by clam dredges primarily in offshore federal waters (Figure 1) (NEFSC 2003a). Since the 1980s, approximately 75% of surfclam landings have been in federal, rather than state, waters in the Mid-Atlantic region (NEFSC 2003a). Surfclam landings exhibited a steady increase from 1950 until the mid-1970s, when a hypoxic event caused a massive die-off of the surfclam population. Since 1980, the average annual value of Atlantic surfclams has been US$31.5 million (NMFS 2004a). Atlantic surfclams occurring in federal waters are managed under the Atlantic Surfclam and Ocean Quahog Fishery Management Plan (FMP), while surfclams occurring in state waters are managed by the individual states.

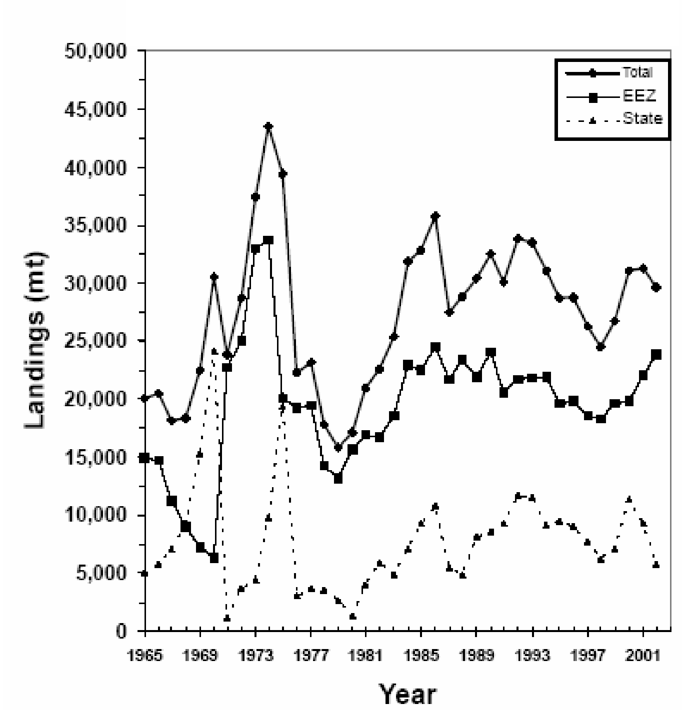

Figure 1. U.S. commercial landings of Atlantic surfclams, 1965 – 2002 (Figure from NEFSC 2003b).

Ocean quahogs

Ocean quahogs are found in the eastern and western Atlantic, as well as around Iceland. The ocean quahog fishery on the east coast of the U.S. developed rapidly in the late 1970s due to an Atlantic surfclam die-off (Figure 2). Since 1985, annual ocean quahog landings from federal waters have been approximately 17,000 mt (NEFSC 2004a). The ocean quahog fishery has occurred in different regions throughout time (Figure 3) (NEFSC 2004a). In 2002, the fishery moved back to the Long Island region – landings from this region contributed 52% of the total landings from federal waters in 2002 (NEFSC 2004a).

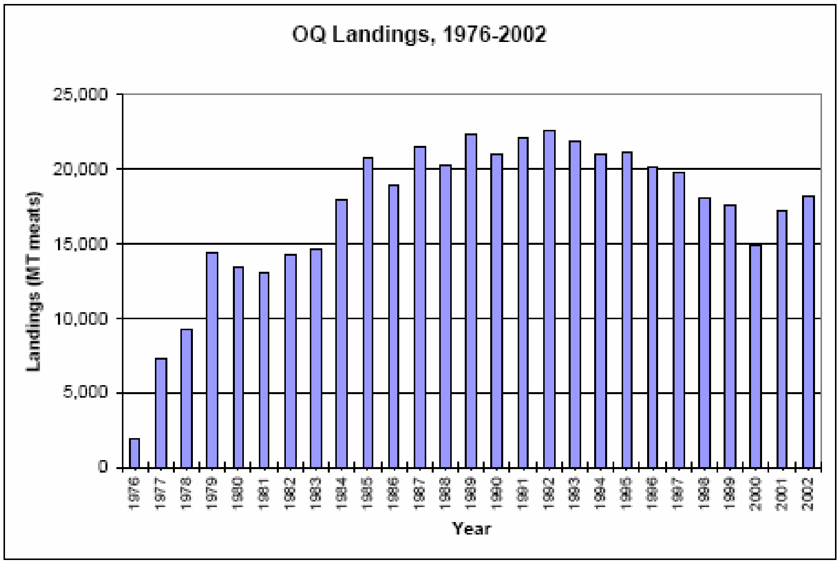

Figure 2. U.S. commercial landings of ocean quahogs from federal waters, 1976 – 2002 (Figure from NEFSC 2004a).

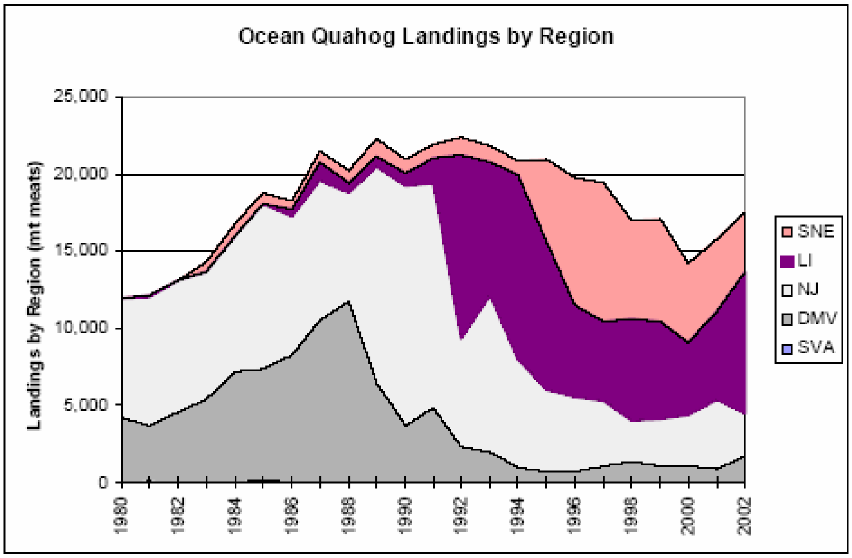

Figure 3. Ocean quahog landings by weight from US federal waters, by stock assessment region, 1980 – 2002 (Figure from NEFSC 2004a).

In general, ocean quahog landings have been declining since the mid-1990s, due in part to quota reductions in the late 1990s as a result of inadequacies in the federal survey – these inadequacies have since been addressed, and the quota issues have been resolved (E. Powell, pers. comm.). Clam dredges accounted for all ocean quahog landings in 2002 (NMFS 2004a). Ocean quahogs are primarily harvested from federal waters, accounting for 95 – 100% of U.S. commercial ocean quahog landings (NEFSC 2004b). There is a smaller fishery for ocean quahogs, called mahogany quahogs, off the coast of Maine, where the resource occurs in both state and federal waters (NEFSC 2004a). The Maine fishery is different from the offshore fishery in that mahogany quahogs are harvested for the half-shell market (NEFSC 2004a). In the Mid-Atlantic, ocean quahogs harvested in offshore waters are larger than 70 mm in shell length, while mahogany quahogs are smaller individuals (Weinberg 1998b). The Maine fishery lands a lower volume of quahogs than the offshore fishery; although it occurs on a smaller scale, effort has increased from 1993 to 2002 (NEFSC 2004a). Ocean quahogs in federal waters are managed by the Mid-Atlantic Fishery Management Council under the Atlantic Surfclam and Ocean Quahog FMP, while ocean quahogs occurring in nearshore waters are managed by the state in which they occur.

Softshell clams

In 2002 softshell clams were landed primarily in Maine (86%) (NMFS 2004a), where they were the second most valuable commercial species harvested in Maine; at approximately $14 million, the value was preceded only by American lobster landings (NMFS 2004a). Despite fluctuations in landings, the value of softshell clams steadily increased from 1950 to 2002 (Figure 4) (NMFS 2004a). Softshell clams inhabit intertidal mud flats, and though a small number of softshell clam landings are harvested with clam dredges (7%), the majority of softshell clams are harvested with hand rakes or hoes (NMFS 2004a). Softshell clam harvesters are commonly known as “diggers”. Commercial sized softshell clams generally burrow to as deep as 15 cm in the sediment (Zwarts and Wanink 1989). In Maine, the Department of Marine Resources Division of Shellfish Management is responsible for the management of softshell clams occurring in state waters. Shellfish management programs are established by individual municipalities. There is no federal FMP for softshell clams, as they are harvested only from state waters.

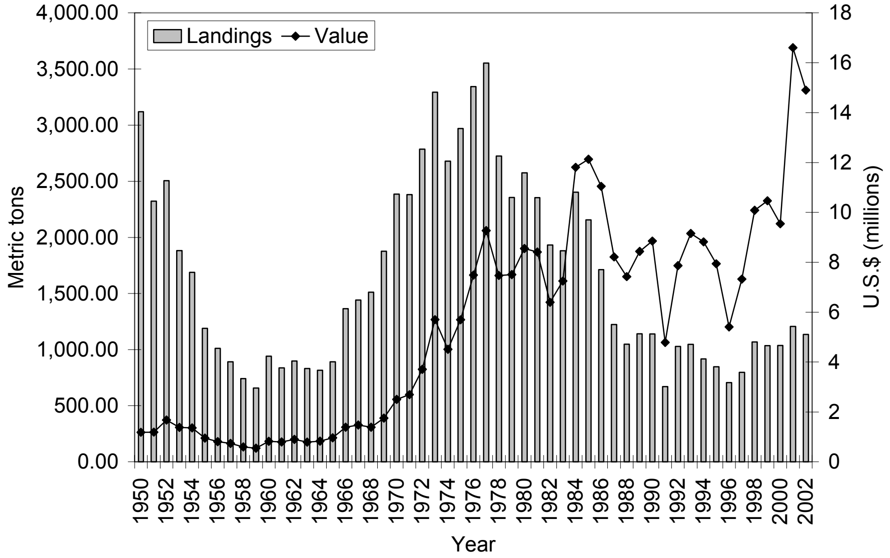

Figure 4. Softshell clam landings and value in Maine, 1950 – 2002 (NMFS 2004a).

Hard clams

Since the 1880s, hard clams have been harvested commercially and recreationally in New England and the Mid-Atlantic (Fegley 2001). From 1950 to 1992, hard clam landings declined by approximately 56%, due primarily to overfishing and poor water quality (McHugh 2001). However, pollution concerns have also resulted in closed areas, thereby protecting a portion of the hard clam population from harvest while maintaining its reproductive capacity. In 2002, hard clams were commercially landed primarily in Connecticut (36%), New York (15%), Massachusetts (15%), and Rhode Island (12%) (NMFS 2004a). Landings of hard clams have exhibited a general decline, with 2002 landings (4,500 mt) approximately half of what they were in 1950 (9,400 mt) (Figure 5) (NMFS 2004a). Hard clams were the most valuable fisheries in both Connecticut ($9.2 million) and New York ($12.2 million) in 2002 (NMFS 2004a). Hard clams were harvested with a number of different gears in 2002, 34% of which is listed as “Uncoded” by the National Marine Fisheries Service (NMFS) (Figure 6) (NMFS 2004a). Management measures for hard clams vary by state, and individual town regulations such as minimum size and catch limits may differ from state regulations. In general, management measures include time and area closures, as well as size and possession limits. There is no federal FMP for hard clams, as they are harvested from state waters.

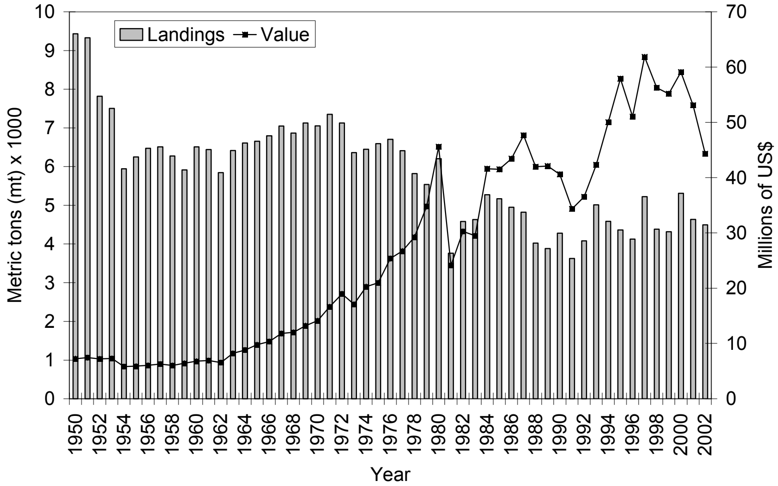

Figure 5. U.S. commercial landings and value of hard clams, 1950 – 2002 (NMFS 2004a).

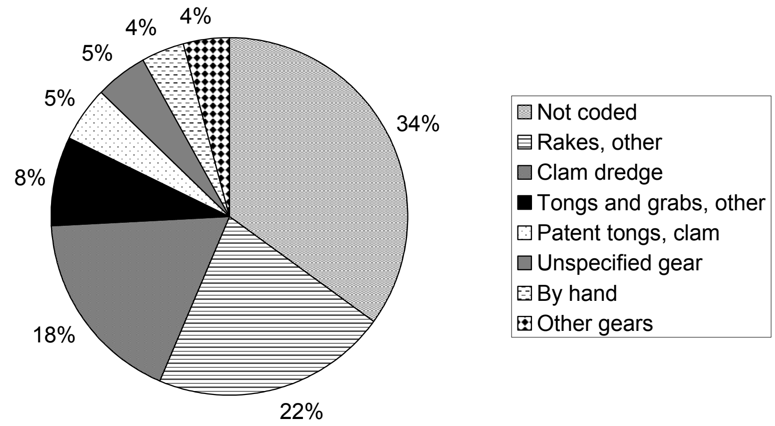

Figure 6. Gears used to commercially harvest hard clams in the U.S. in 2002 (NMFS 2004a).

Scope of the analysis and the ensuing recommendation:
This analysis encompasses the wild-caught Atlantic surfclam, ocean quahog, softshell clam, and hard clam commercial fisheries in the Northeast and Mid-Atlantic. Farmed clams are not evaluated in this report.

Availability of Science

Future needs for Atlantic surfclam research include accurate estimates of population sizes, and the effects of dredging on settlement and recently settled clams (Cargnelli et al. 1999a). For mahogany quahogs, there is a need for more accurate estimates of population sizes (Cargnelli et al. 1999b). The true size of the ocean quahog population is unknown, due to the limited ability of clam dredges to reach deeply burrowed clams (Cargnelli et al. 1999b). There is also a need for field data on the early life history of ocean quahogs and data on the life history characteristics of the population south of New Jersey (Cargnelli et al. 1999b). It has been recommended that the rate of incidental mortality for ocean quahogs by commercial dredges be researched (NEFSC 2004a). A major source of uncertainty for the hard clam fishery is the status of the populations, as there are little data on the population dynamics and abundance of hard clams (Fegley 2001). For softshell clams, there are little data concerning the status of the resource. Management information for each of the clam species discussed in this report is available as grey literature, although management information for the federally-managed Atlantic surfclam and ocean quahog is more readily available.

Market Availability

Common and market names:

Hard clams are sold according to their size, and market names include littleneck, top neck, cherrystone, and chowder. Littlenecks and cherrystones are the smallest and most valuable sizes (Walton and Walton 2001), while chowders are the largest hard clams. Common names for hard clams include hard shell clam, quahog, quahag, and northern quahog (Krauter and Castagna 2001). Common market names for softshell clams include steamer, longneck, belly clam, fryer, and squirt clam. Ocean quahogs are sold whole, and juvenile surfclams sometimes appear in the market as golden necks.

Seasonal availability:

Atlantic surfclams, ocean quahogs, softshell clams, and hard clams are available year-round. Softshell clam landings are greatest during the summer months (NMFS 2004a).

Product forms:

Surfclams are generally not sold whole in restaurants and markets, but occur in the market as chopped or minced clam meat, breaded clam strips, or in soups and chowders (NYSC 2004). Softshell and hard clams are generally sold whole, and hard clams are often eaten raw on the half-shell. Ocean quahogs are also sold whole.

Import and export sources and statistics:

In 2003, the U.S. imported a total of 15,898 mt of clams, 42% of which were imported from Canada (Figure 7) (NMFS 2004b). The NMFS Foreign Trade Information database does not separate imports and exports of clams by species, but rather by product name (e.g., frozen/dried/salted/brine, live/fresh, prepared/preserved, and boiled/canned). Of the live/fresh clams imported to the U.S., approximately 90% were imported from Canada in 2003 (NMFS 2004b). In 2003, the U.S. exported approximately 4,500 mt of clams, primarily to Canada (71%), Japan (11%), and China (7%) (NMFS 2004b). Because imports and exports of clams are not distinguished by species, this information was not incorporated into the evaluation of wild-caught clams available in the market in the Northeast region.

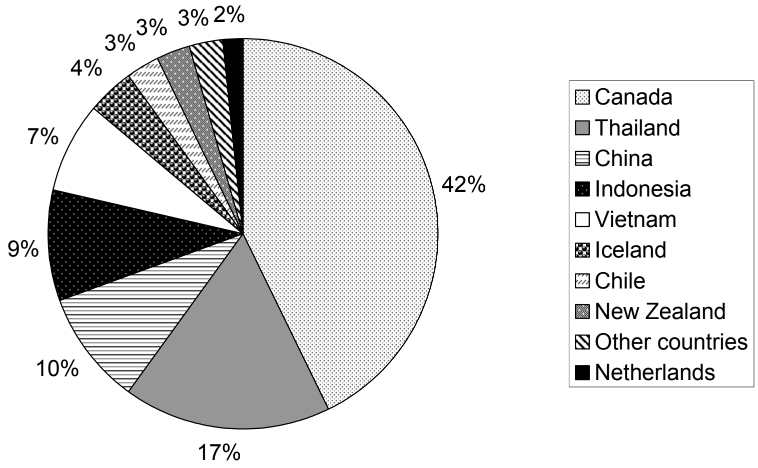

Figure 7. Imports of all clam species to the U.S. in 2003 (NMFS 2004b).

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

Criterion 1: Inherent Vulnerability to Fishing Pressure

Atlantic surfclams

Atlantic surfclams are found on the continental shelf from the southern Gulf of St. Lawrence to Cape Hatteras, North Carolina (Table 1) (Merrill and Ropes 1969; Weinberg 1998a). Recent evidence suggests that the distribution of surfclams is getting smaller along the southern and inshore boundaries of its range due to increased sea temperatures (Kim and Powell 2004). The 1997 NMFS surveys found that surfclams are concentrated in northern New Jersey, Georges Bank, and the Delmarva Peninsula (NEFSC 1998). Surfclams burrow in silty to course sand, and gravel substrates (Cargnelli et al. 1999a). The size and age at which surfclams reach sexual maturity varies with their geographic location. Surfclams may reach maturity three months after settlement, and at less than 20 mm in length in New Jersey (Chintala and Grassle 1995). However, surfclams may not reach sexual maturity until 4 years of age and 80 – 95 mm in length in Prince Edward Island (Sephton 1987; Sephton and Bryan 1990). The maximum size for surfclams is 226 mm (Ropes 1980). Annual growth rates are similar in the different locations from ages 3 – 5 (Ambrose et al. 1980; Sephton and Bryan 1990), but vary after about year five, with offshore clams growing faster and reaching larger sizes (Jones et al. 1978). The maximum age for surfclams is 35 years (Weinberg 1999), and they reach a commercially harvestable size in approximately 6 years (Weinberg 1998a). Atlantic surfclams are most commonly found at depths of 8 – 66 m (Fay et al. 1983). Population variability may be affected by environmental conditions; low levels of dissolved oxygen (DO) can decimate a population of surfclams (Ogren and Chess 1969; Garlo et al. 1979). In 1976 anoxic water developed over surfclam beds and reduced their biomass by 78.5% (Ropes et al. 1979). The intrinsic rate of increase for Atlantic surfclams is unknown, but like most shellfish it is thought to be very high. Atlantic surfclams are broadcast spawners, and fecundity is thought to be similar to that of the southern species of surfclam, which ranges from 0.14 – 13 million eggs for individuals with 26 – 50 mm shell height (Walker et al. 1996).

Ocean quahogs

Ocean quahogs are found in the eastern North Atlantic from Norway to Spain, as well as across the North Atlantic (NEFSC 2004b). In the western Atlantic, ocean quahogs are found on the continental shelf from Newfoundland to Cape Hatteras (Weinberg 1998b). However, increases in sea temperature as a result of climate change have affected the southern boundary of ocean quahog distribution (Weinberg et al. 2002). Further warming could result in a northward contraction of this species' range, as well as an offshore migration (Weinberg et al. 2002). Ocean quahogs are found in medium to fine grain sand, sandy mud, and silty sand (Cargnelli et al. 1999b). The ocean quahog is a relatively slow-growing, long-lived species, and may reach a maximum age of 225 years (Ropes and Murawski 1983). A large proportion of the ocean quahog population is older than 100 years (MAFMC 1998). Annual growth rates vary in different geographic locations; ocean quahogs off Long Island were recorded to grow between 0.56 and 1.17 mm/yr, while ocean quahogs off New Jersey were recorded to grow an average of 0.63 mm/yr (Kennish et al. 1994; Kennish and Lutz 1995). Ocean quahogs mature late, with a mean age of sexual maturity of 13.1 years for males and 12.5 years for females (Rowell et al. 1990); age of maturity may depend on growth rate and geographic location (Thompson et al. 1980). Rowell et al. (1990) found that the earliest age and size at maturity was 7 years and 49 mm shell length. Juvenile ocean quahogs are found offshore in the Mid-Atlantic Bight at depths of 45 – 75 m and at salinities of 32 – 34 ppt (parts per trillion) (Cargnelli et al. 1999b), while adults burrow just below the surface of sandy sediments in dense beds (Fogarty 1981; Beal and Kraus 1989). Because ocean quahog growth is so slow, the recovery period is long for intensely harvested clam beds (NEFSC 2004a). The maximum size for ocean quahogs is 110 mm shell length (NEFSC 2004a). The intrinsic rate of increase is unknown for ocean quahogs. There is no evidence of high population variability driven by physical environmental change. Although there have been several instances of severe dissolved oxygen depletion causing ocean quahog mortalities (MAFMC 1998), the percent decrease in biomass has not been large. In 1976, anoxic water developed over ocean quahog clam beds and resulted in a 7.1% decrease in biomass off New Jersey (Ropes et al. 1979). Ocean quahogs have a protracted spawning season, suggesting that recruitment may occur at low levels over several months (Cargnelli et al. 1999b). The relatively long life span and late age of sexual maturity for ocean quahogs may be correlated with the depths at which they occur (Thompson et al. 1980).

Softshell clams

Softshell clams are found in the western and eastern Atlantic; in North America softshell clams are found from Labrador to Georgia, and are concentrated from the Bay of Fundy to Chesapeake Bay (MacKenzie and McLaughlin 2000). Softshell clams can live to ages 7 to 12 years (Brousseau 1978). Softshell clam recruitment varies both temporally and spatially, and results in population changes in different areas and in different seasons (Gulmann et al. 2001). Softshell clams begin reproducing by the beginning of their first year, and there is a single annual breeding season (Brousseau and Baglivo 1988). Fecundity increases with female body size, and ranges from 1.1 – 1.5 million eggs for softshell clams at age 1 (Brousseau and Baglivo 1988). The intrinsic rate of increase for softshell clams is unknown. There is no evidence of high population variability driven by physical environmental changes.

Hard clams

Hard clams are sexually mature at ages 1 – 2 years and 30 – 35 mm shell length (Eversole 1989). The minimum shell length of sexually mature hard clams is 20 – 35 mm (Eversole et al. 1980; Knaub and Eversole 1988; Hesselman et al. 1989). In the northern areas where hard clams occur, they reach this size at age 3, while in the southern areas they may reach this size in one year (Eversole et al. 1980; Stanley and DeWitt 1983; Hesselman et al. 1989). In general, hard clams reach sexual maturity at 25% of their maximum shell length (Eversole 1989). The maximum reported age for hard clams varies with location – the oldest maximum age reported is 46 years, from a hard clam sampled in North Carolina (Peterson 1983; Peterson et al. 1984; Peterson 1986). Hard clams are highly fecund; the average number of eggs spawned per female is 7.39×10^6 (Eversole 2001). Growth rates of juvenile hard clams are similar through their geographic distribution, but adult growth rates vary with the latitudinal distribution of the clams, with faster growth occurring in the southern range of hard clams (Grizzle et al. 2001). In Florida, it takes an average of 1.9 years for hard clams to reach market size, while in Canada it takes an average of 13.0 years (Grizzle et al. 2001). The maximum mean shell length for hard clams is approximately 100 mm (Carriker 1959). Temperature and water quality changes can affect hard clam reproduction, thereby affecting the number of clams available for harvest (McHugh 2001). The intrinsic rate of increase for hard clams is unknown. Major environmental changes in some locations in the past 30 to 40 years have coincided with hard clam declines (MacKenzie 2003).

Table 1. Life history characteristics of the Atlantic surfclam, ocean quahog, softshell clam, and hard clam.

Species	Intrinsic Rate of Increase (r)	Growth Rate	Age at First Maturity	Max Age	Fecundity	Species Range	Special Behaviors	Population Variability	Sources
Atlantic surfclam	Unknown	vBgf[1]: L_∞ = 164.0 mm, k = 0.18	3 mo – 5 yrs, depending on location	35 yrs	0.14 – 13 million eggs for clams 26 – 50 mm shell length	western Atlantic	None	Driven by physical environmental change	Merril & Ropes 1969; Garlo et al. 1979; Ropes et al. 1979; Sephton & Bryan 1990; Chintala & Grassle 1995; Walker et al. 1996; Weinberg 1999
Ocean quahog	Unknown	0.63 mm/yr in NJ; vBgf: L_∞ = 107.06 mm, k = 0.02	7 yrs	225 yrs	Unknown	eastern North Atlantic from Norway to Spain; western Atlantic from Newfound-land to Cape Hatteras	None	No evidence of *high* population variability due to physical environmental change	Murawski et al. 1982; Ropes & Murawski 1983; Rowell et al. 1990; Kennish & Lutz 1995; Weinberg 1998b; Cargnelli et al. 1999b; NEFSC 2004b
Softshell clam	Unknown	34 mm/yr	1 yr	7 – 12 yrs	1.1 – 1.5 mil eggs at age 1; 8.4 – 8.7 mil eggs at age 10	eastern North Atlantic; western Atlantic from Labrador to Georgia	None	No evidence of *high* population variability due to physical environmental change	Brousseau 1978; Brosseau & Baglivo 1988; Rasmussen & Heard 1995
Hard clam	Unknown	Lmax = 110 mm in unfished area	1 –2 yrs	46 years	Average is 7.39 x 10^6 eggs spawned/female	western Atlantic from Gulf of St. Lawrence to Florida	None	Driven by physical environmental change	Peterson 1983; Eversole 1989; Rice et al. 1989; Eversole 2001; MacKenzie 2003

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[1] vBgf = a commonly used growth function in fisheries science to determine length as a function of age. L_∞ is maximum length, and k is body growth coefficient.

Synthesis

Atlantic surfclams, softshell clams, and hard clams are considered inherently resilient to fishing pressure due to life history characteristics such as a low age at first maturity, low to moderate longevity, and high fecundity. There is evidence that both surfclams and hard clams exhibit high population variability driven by physical environmental change. Ocean quahogs, however, first reach sexual maturity at a moderate age (7 years), and are a long-lived species with a maximum age of 225 years. Due to these life history characteristics, ocean quahogs are considered moderately vulnerable to fishing pressure.

Inherent Vulnerability Rank:

Atlantic surfclam, Softshell clam, Hard clam:	**Resilient** 🟩	Moderate 🟨	Vulnerable 🟥
Ocean quahog:	Resilient 🟩	**Moderate** 🟨	Vulnerable 🟥

Criterion 2: Status of Wild Stocks

Atlantic surfclams

Atlantic surfclams are not overfished, and overfishing is not occurring (Table 2) (NMFS 2004c). The stock is considered overfished when stock biomass falls below $B_{THRESHOLD}$, and overfishing occurs when the fishing mortality rate (F) is greater than $F_{THRESHOLD}$ (NEFSC 2003b). The target biomass, a B_{MSY}[2] proxy, is 730,000 metric tons (mt) and B_{2002} was estimated at 803,000 mt (NEFSC 2003a). The fishing mortality threshold is set at the natural mortality (M), which has been estimated at 0.15 (NEFSC 2003a). In 2002, the fishing mortality rate (F) was estimated at 0.033 for the entire surfclam stock (NEFSC 2003a). There is no fishery for Atlantic surfclams on Georges Bank due to concerns over paralytic shellfish poison (PSP). Fishery independent biomass indices are similar to the landings trend (Cargnelli et al. 1999a), although some of the changes in clam biomass have been attributed to changes in dredge efficiency (Weinberg 1998a). In the late 1970s, a hypoxic event in New Jersey waters resulted in decreased landings and biomass of surfclams (Figure 8) (Weinberg 1998a). From 1997 (1.1 million mt) to 1999 (1.5 million mt), total fishable biomass was relatively stable, but declined in 2002 to 803,000 mt (NEFSC 2003a). Excluding the fishable biomass from Georges Bank, where fishing does not occur, biomass was 915,000 mt in 1997, 1.1 million mt in 1999, and 566,000 mt in 2002 (NEFSC 2003a). Fishery independent data indicate that the short-term trend in population biomass is declining after an increase in the 1990s. The long-term trend in population biomass based on fishery independent data is variable.

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[2] B_{MSY} is the biomass at which maximum sustainable yield is produced.

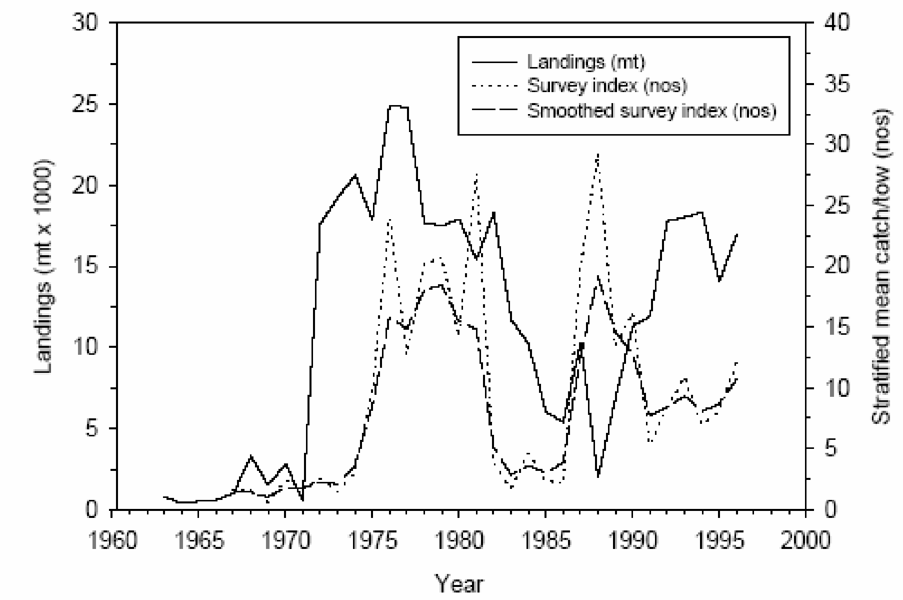

Figure 8. Atlantic surfclam commercial landings and survey indices from the NEFSC surveys from the Gulf of Maine to the Mid-Atlantic (Figure from Cargnelli et al. 1999a).

Commercial catch rates of surfclams are measured in units of bushels of clams per hour fishing; from the early 1980s to the 1990s, landings per unit effort (LPUE) across all the regions was increasing (NEFSC 2003a). In northern New Jersey LPUE declined steadily from 1031 kg/hr in 1991 to 801 kg/hr in 2002, but has remained relatively stable compared to LPUE in the Delmarva region (Figure 9) (NEFSC 2003a). LPUE is at a relatively low level in each of the northern New Jersey, southern New Jersey, and Delmarva regions (NEFSC 2003a). The mean length of surfclams in the Delmarva Peninsula declined from 159 mm in 1982 to 123 mm in 1998, but increased to 136 mm in 2002 (NEFSC 2003a). The mean length of surfclams landed in New Jersey remained stable over the same time period (NEFSC 2003a). Differing regional trends in LPUE and survey data are an important source of uncertainty in the surfclam stock (NEFSC 2003a). There is a moderate level of uncertainty associated with the stock status of surfclams.

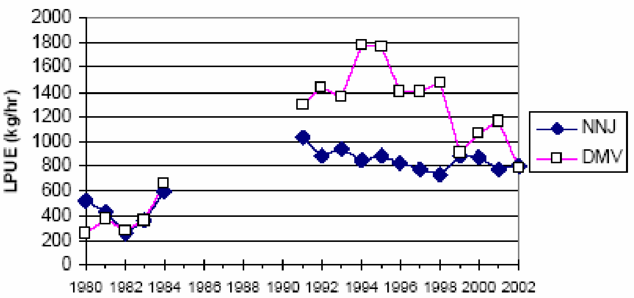

Figure 9. Surfclam catch rates for medium and large vessels in the Delmarva and northern New Jersey regions, 1980 – 2002 (Figure from NEFSC 2003b).

Ocean quahogs

Ocean quahogs are not overfished, and overfishing is not occurring (NMFS 2004c). The overfished threshold is ½ B_{MSY} (B_{MSY} = 1.15 million mt) (NEFSC 2004a), and in 2002 the stock biomass was estimated at 2.1 million mt for federal waters, including Georges Bank. The Georges Bank region accounts for 35% of the biomass (NEFSC 2004a), which is not fished due to concerns of PSP. The overfishing threshold is $F_{25\%MSP}$ (0.080 per year) (NEFSC 2004a), while the current fishing mortality rate (F = 0.014 for the exploited area) is 50% of the target fishing mortality rate (NEFSC 2004b). The F_{MSY}[3] proxy is 0.0275 per year and maximum sustainable yield is estimated at 96,000 mt of meats per year for the entire stock (NEFSC 2004b). The biomass of ocean quahogs has declined slowly since the late 1970s when the fishery started; 2002 biomass levels were 80% of 1977 biomass levels in all regions, and 72% of 1977 biomass levels in exploited regions (NEFSC 2004b). Estimates of the stock in 1977 were 1.7 million mt excluding Georges Bank, and 2.3 million mt including Georges Bank (NEFSC 2004b). Model projections suggest that stock biomass will steadily decrease over time (Figure 10) (NEFSC 2004a). The long and short-term fishery independent estimates of population abundance show a declining trend; however; the stock biomass is well above B_{MSY}.

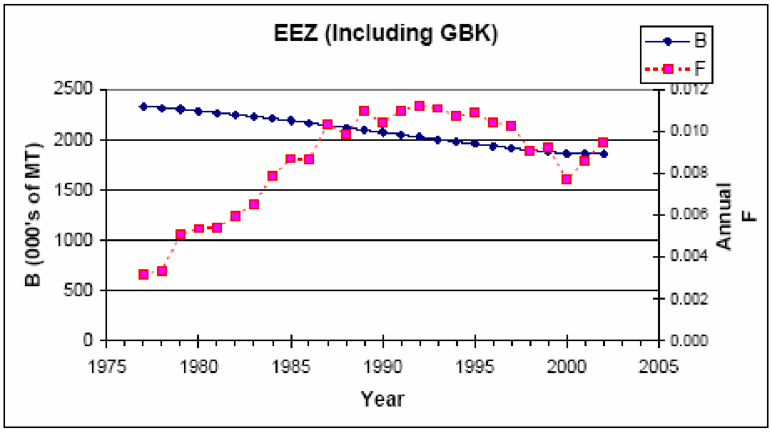

Figure 10. Projected biomass and fishing mortality rate of ocean quahogs in federal waters, including Georges Bank (Figure from NEFSC 2004b).

The long-term population abundance as estimated from fishery independent CPUE show a declining trend, while the short-term trend is increasing. From 1986 to 1994, fishery independent CPUE declined from 146 bushels per hour (bph) to 75 bph; in 1996 CPUE increased to 100 bph (Cargnelli et al. 1999b). Commercial concentrations of ocean quahogs occur on the continental shelf off the coast of Maine and between Georges Bank and the Delmarva Peninsula (NEFSC 2004b). The LPUEs for the majority of the ten-minute squares (TNMSs) fished in each region have decreased over the past 10 – 20 years (NEFSC 2004a). For the 12 TNMSs with the highest cumulative landings, the catch rate was high for the first five years of fishing (600 kg/hr fished) but then declined and remained low for more than 10 years (300 – 400 kg/hr fished) (Figure 11) (NEFSC 2004a). In the Mid-Atlantic, both commercial catch rates and landings have declined since the late 1980s and early 1990s (NMFS 2002). Although annual landings are approximately only 2% of the total estimated stock, greater landings are not likely to be sustainable (Weinberg 1998b) due to the life history characteristics of ocean quahogs.

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[3] F_{MSY} is the fishing mortality rate at which maximum sustainable yield can be obtained.

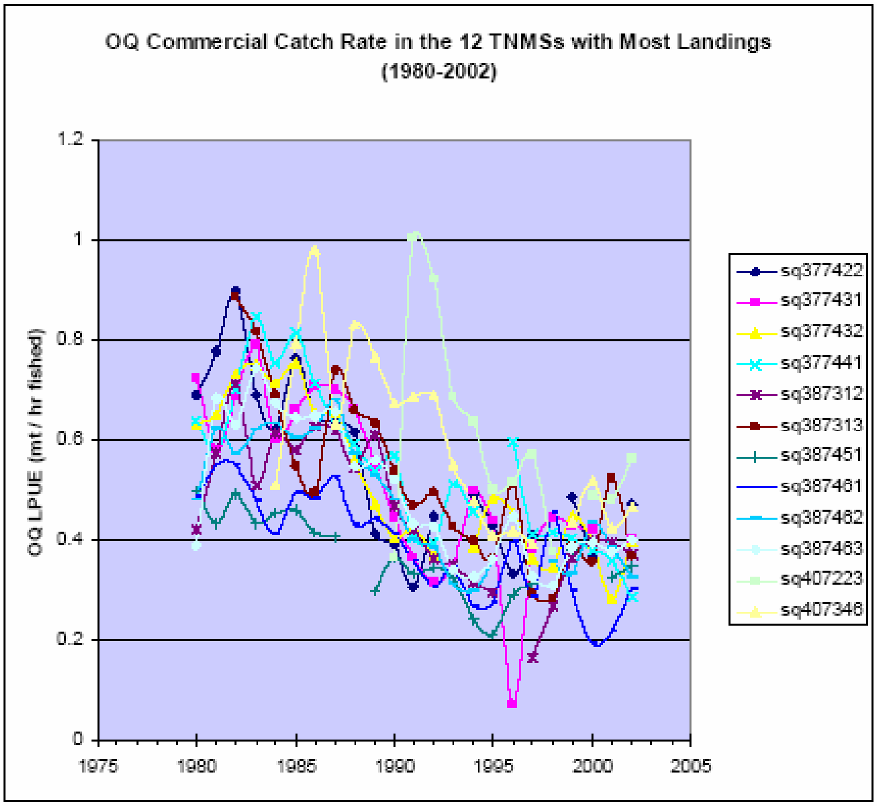

Figure 11. Commercial catch rates of large vessels in the 12 TNMSs from federal waters that have the largest cumulative catch of ocean quahogs, 1980 – 2002 (Figure from NEFSC 2004a).

Ocean quahogs are typically harvested between shell lengths of 80 and 100 mm (NEFSC 2004a). Although the Georges Bank population of ocean quahogs is not exploited due to concerns of PSP contamination, size distributions in the 1980s were unimodal, and the population was dominated by individuals 75 – 90 mm in length (Lewis et al. 2001). In the 1990s, size distributions were bimodal due to spawning in the 1980s; 20 – 50% of the survey catch was less than 70 mm in length (Lewis et al. 2001). Because ocean quahogs are not fully retained by clam dredges until lengths of 70 mm (or age 10), the details of recruitment events are difficult to determine (Lewis et al. 2001). Determining recruitment trends requires the use of a smaller-mesh dredge or other quantitative sampling gear (E. Powell, pers. comm.). Annual recruitment is approximately 0 – 2% of stock biomass (NEFSC 2004b). The size composition of landings varies by geographic region. The mean length of clams landed in New Jersey has remained stable from 1982 – 2003, while the mean length of clams from the Delmarva region declined from 92.5 mm in 1994 to 83 mm in 1999, but increased in recent years (NEFSC 2004a). Although the mean length of southern New England landings decreased in 1997 and 1998, it was a result of targeting clam beds composed of smaller individuals, rather than a decrease in the mean shell size (NEFSC 2004a). In the Long Island region, mean length of clams declined from 89 mm in 1997/98 to 81 mm in 2002/03 due to a large fishery recruitment event (NEFSC 2004a). There is a moderate level of uncertainty associated with the stock status of ocean quahogs, as the estimated abundance trend for ocean quahogs is based on a single survey abundance index for each region (NEFSC 2004a).

Mahogany quahogs

The biomass and exploitation status of mahogany quahogs in the Gulf of Maine are unknown due to uncertainties associated with the efficiency of the dredge used to complete the Maine survey (NEFSC 2004b). In 2002 the state of Maine surveyed the mahogany quahog resource in Maine state waters, and estimated abundance at 1,288,564 Maine bushels (1 Maine bushel = 35.25 L) (NEFSC 2004a). The catch rate of mahogany quahogs has declined in recent years (Figure 12) (NEFSC 2004a).

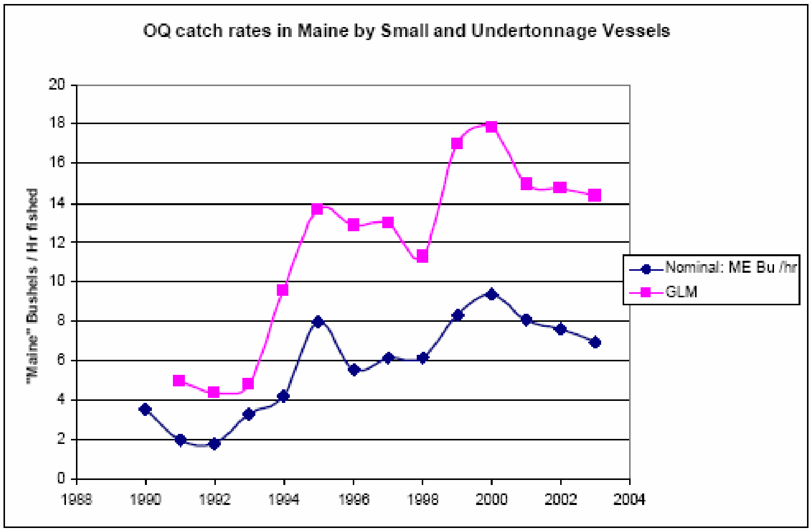

Figure 12. Mahogany LPUE from the coast of Maine (Figure from NEFSC 2004a).

Softshell clams

Softshell clams are primarily landed in Maine, where they are managed by individual towns; there is no statewide assessment of softshell clams in Maine. In Maine state waters, clam flat surveys are conducted by some individual municipalities to determine the status of the softshell clam resource available for recreational and commercial fishermen. Data for one region, Scarborough, were available from 1998 to 2003 (Figure 13) (DMR 2004a). In Scarborough, the short-term trend in population abundance appears to be slightly decreasing. However, these data can not be extrapolated to other clam flats in Maine. There are currently insufficient data to evaluate the status of the softshell clam stock in Maine state waters, and uncertainty is considered high, as there is little or no current fishery dependent or independent information on stock status.

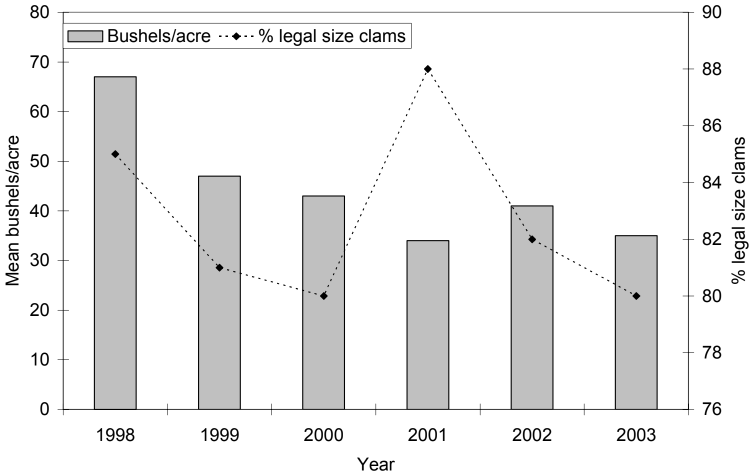

Figure 13. Survey assessment for softshell clams in Scarborough, Maine, 1998 – 2003 (DMR 2004a).

Hard clams

There is little information concerning the minimum viable population size for hard clams (Fegley 2001). Rice et al. (1989) found that intensive shellfish harvesting, compared to areas closed to fishing, results in fewer mature adults and increased juvenile settlement. Connecticut, New York, Massachusetts, and Rhode Island were the principal states landing hard clams in 2002. The stock status of hard clams varies according to the state in which they are harvested. In Connecticut, New York, and Massachusetts there are insufficient data with which to evaluate the stock status, and there is high uncertainty associated with the status of the stocks. In Rhode Island in 2002, stock biomass was approximately 62% of that needed to support MSY, while the fishing mortality rate was below the overfishing definition ($F_{MSY} = 0.25$) at $F = 0.18$ (RIDFW 2003). The biomass of hard clams in Narragansett Bay, Rhode Island is fully exploited (Figure 14) (RIDFW 2003). The declining fishing mortality rate observed over the past decade is partially related to the low stock levels which are a result of heavy overfishing (Figure 15) (RIDFW 2003). Fishery independent estimates of population abundance show a relatively stable long-term trend and a declining short-term trend. There is a moderate level of uncertainty associated with Rhode Island hard clams due to the lack of CPUE data.

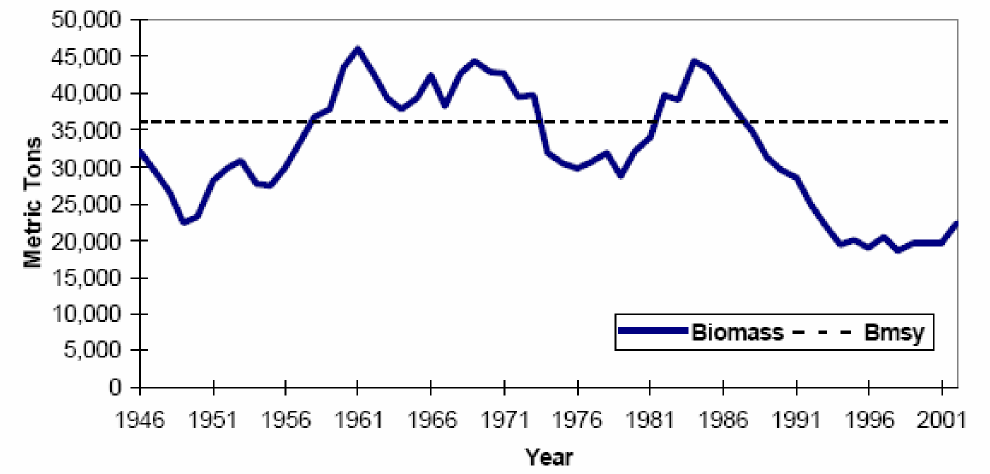

Figure 14. Estimated stock biomass of hard clams in Narragansett Bay, 1946 – 2001 (Figure from RIDFW 2003).

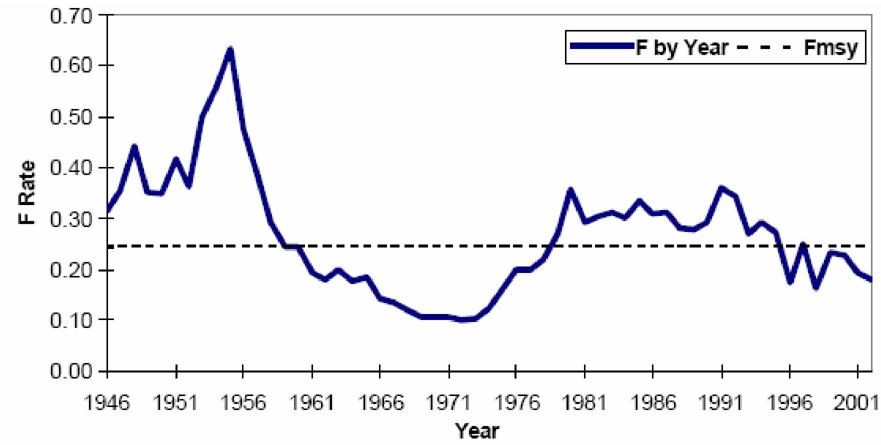

Figure 15. Fishing mortality rate for hard clams in Narragansett Bay compared to F_{MSY}, 1946 – 2001 (Figure from RIDFW 2003).

Table 2. Stock status of Atlantic surfclams, ocean quahogs, softshell clams, and hard clams.

Species	**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**
Atlantic surfclam	Not overfished	1.14	Overfishing not occurring	0.22	Short-term fishery independent and long-term CPUE trends declining	Not skewed relative to normal condition	Moderate	NEFSC 2003a; NMFS 2004c
Ocean quahog	Not overfished	1.82	Overfishing not occurring	0.51	Fishery independent trends declining; short-term CPUE trend increasing	Not skewed relative to normal condition	Moderate	NEFSC 2004a; NEFSC 2004b; NMFS 2004c
Softshell clam	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	High	None
Hard clam	Unknown for CT, NY, MA; fully exploited in RI	Unknown for CT, NY, MA; 62% of B_{MSY} in RI	Unknown	Unknown for CT, NY, MA; 0.72 in RI	Short-term fishery independent trend stable, long-term trend declining	Unknown	CT, NY, MA: High RI: Moderate	RIDFW 2003

Synthesis

Atlantic surfclam and ocean quahog stocks are considered healthy, as both stocks are above B_{MSY}. These stocks are not considered overfished, and overfishing is not occurring. There is a high level of uncertainty associated with the stock status of softshell clams, and the majority of factors are unknown; stock status of softshell clams is therefore considered unknown. In Connecticut and Massachusetts, the majority of the factors relating to stock status of hard clams are unknown, and uncertainty regarding the status of hard clam stocks is high. Although stock status is poor in Rhode Island, these landings represent only 12% of the total U.S. landings. The status of hard clam stocks is therefore considered unknown.

Status of Wild Stocks Rank:

Atlantic surfclams, Ocean quahogs: [✓ **Healthy** 🟩] Unknown 🟨 Poor 🟥 Critical ⬛

Softshell clams, Hard clams: Healthy 🟩 [✓ **Unknown** 🟨] Poor 🟥 Critical ⬛

Criterion 3: Nature and Extent 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/or managed in some way.

The bycatch for each of the clam fisheries discussed in this report is likely similar and does not include a high diversity of species or any species of special concern (Table 3). In one study, clam predators caught by a clam dredge included 10 lady crabs, 26 starfish, and 1 horseshoe crab in one tow, and 33 lady crabs, 22 starfish, and one moon snail in another tow (Meyer et al. 1981). Based on the NMFS 1997 clam survey data, live surfclams and ocean quahogs composed approximately 82% of the catch (MAFMC 1998). The species with the highest bycatch in the clam survey were rock crabs (3%) and margined seastars (2%) (MAFMC 1998). Other research has found similar results, with live surfclams and ocean quahogs composing almost 85% of the total catch in numbers (Wallace and Hoff 2004). Of 1,577 tows, only 210 fish were caught – half of which were little skate (Wallace and Hoff 2004).

The quantity of bycatch in the commercial clam fisheries is not thought to have an impact on the population levels of the bycatch species. The percentage of bycatch species relative to targeted landings is unknown for the softshell clam and hard clam fisheries. The trend in quantity and/or diversity of bycatch is not applicable because bycatch is low in these fisheries. There is no evidence that the ecosystem has been altered in response to the continued removal of the bycatch species.

Table 3. Bycatch characteristics of the Atlantic surfclam, ocean quahog, softshell clam, and hard clam fisheries.

Gear	Composition of Bycatch	Population Consequences of Bycatch	Bycatch/Target Species Ratio	Trend in Quality & Quantity of Bycatch	Ecosystem Effects	Sources
Hand rakes & hydraulic clam dredges	Low diversity of organisms	Quantity of bycatch not thought to impact population levels	< 10% of the mass or number of targeted species	Not applicable due to low bycatch rate	None	Meyer et al. 1981; MAFMC 1998; Wallace and Hoff 2004

Synthesis

There is little bycatch associated with both hand rakes and hydraulic clam dredges, and there is no bycatch of protected species occurring with use of either of these gear types. Hand rakes and hydraulic clam dredges are efficient at harvesting the targeted clam species, with bycatch composing only 15 – 18% of the total catch. Bycatch in the Atlantic surfclam, ocean quahog, softshell clam, and hard clam fisheries rates as a low conservation concern.

Nature of Bycatch Rank:

Low 🟩 Moderate 🟨 High 🟥 Critical ⬛

Criterion 4: Effect of Fishing Practices on Habitats and Ecosystems

Mobile fishing gear such as trawls and dredges have a greater impact on bottom habitat than fixed gear such as longlines and gillnets (Chuenpagdee et al. 2003). Trawls and dredges have the potential to affect both the physical and biological components of bottom habitat, by disturbing the sediment and benthic structure. Clams are harvested with both hand rakes and hydraulic clam dredges. In general, mechanical harvest methods (e.g., hydraulic clam dredges) for hard clams are thought to be more damaging to the physical environment than hand-harvest methods (e.g., hand rakes) (Table 4) (Peterson et al. 1987). Mechanical methods are also more efficient at harvesting clams (Peterson et al. 1987).

The impact of clam harvesting on the habitat and ecosystem depends on several factors, including sediment type, exposure to wave action, the suspended sediment load in the water column, and the type of gear used (Collie et al. 2000; Kaiser et al. 2001). These factors affect the rate at which trenches and depressions are filled in on the ocean bottom (Kaiser et al. 2001). On the southern New England/Mid-Atlantic Bight shelf, the predominant sediment type is sand (NEFSC 2002). In general, mobile fishing gear such as dredges have a lower impact on sandy sediments than on mud and gravel substrates (Kaiser et al. 1998). Another important factor in determining the effect of hand raking and clam dredging is the composition of the benthic community. Communities with large, relatively sessile organisms that recruit infrequently and those that contain organisms that influence the stability of the sediment are less tolerant of physical disturbance (Dayton et al. 1995; Collie et al. 2000). Glude and Landers (1953) examined the effect of hand-raking and power dredging (the dredge tested was different than the hydraulic dredges used today), and found that the appearance of the surface was similar for both gear types, as well as the control. The only discernable difference was that mixing of the top layers of sediment was more pronounced in the fished areas compared to the control (Glude and Landers 1953). The benthic community was affected by clam harvesting using both gears, as fewer benthic species were observed after fishing, particularly tube worms (Glude and Landers 1953).

Hand rakes

Softshell clams are primarily harvested from the intertidal zone using hand rakes; these rakes leave a large depression and a mound of mud when they are used (L. Watling, pers. comm.). Bull rakes are used from a small boat to harvest hard clams; these rakes differ from those used to harvest softshell clams in that they are pulled through the sand, and the clams are collected in the rake without overturning the sediment (L. Watling, pers. comm.). Certain habitat types are more sensitive to clam raking than other habitat types. Peterson et al. (1987) found that the biomass of seagrass beds decreased by about 25% as a result of clam raking – the loss of seagrass beds may reduce their value as nursery habitat for commercially important fish species (Peterson et al. 1983). Peterson et al. (1987) found that the density of bay scallops decreased with a reduction in seagrass biomass. However, in areas where clamming intensity is low compared to the density of the seagrass beds, the reduction in seagrass biomass may not have a large effect (Peterson et al. 1983). In other habitat types, clam raking causes sediments to become courser and leads to decreased organic matter content (Anderson and Meyer 1986). While some studies have concluded that polychaete density and the total number of taxa are reduced by commercial clam digging (Brown and Wilson 1997), others have concluded that benthic invertebrates such as polychaetes are not affected by clam raking because they recover rapidly from disturbances (Peterson et al. 1987). Brown and Wilson (1997) determined that commercial clam digging affects deeper sediments than most natural disturbances, and results in a highly modified benthic community structure. Habitat changes caused by clam raking may negatively affect nontarget species (Hall and Harding 1997; Spencer et al. 1998), although the effects may be short term for species that are shallow burrowers (Beal and Vencile 2001). While the effects of hand raking may be significant within a year of raking, it is unlikely that these effects will persist for longer than a year (Kaiser et al. 2001). Hand rakes cause a moderate amount of damage to the physical and biogenic habitats from which clams are harvested, and the fishery has a moderate geographic extent. Mud and sand bottoms are considered moderately resilient to disturbances caused by clam rakes. There is no evidence to date that the removal of any of the clam species evaluated in this report has, or will likely, substantially disrupt the food web. There is no evidence to date that clam raking is likely to cause ecosystem state changes.

Harvesting effects on clam populations
Harvesting of softshell clams with hand rakes is 60 – 85% efficient (Beal and Vencile 2001). One concern in the softshell clam fishery is incidental mortality, which contributes negatively to the loss of softshell clams (Beal and Vencile 2001) and has the potential to affect clam stocks by decreasing yields (Robinson and Rowell 1990). Clam raking also has an impact on future clam production, as clam harvesting in seagrass beds and sandy substrates may reduce hard clam recruitment (Peterson et al. 1987). Hand-digging for softshell clams in Maine can damage softshell clam shells, bury them deeper in the sediment than they normally occur, or expose clams to increased risk of predation (Ambrose et al. 1998). Additionally, breakage rates are higher when softshell clams are at higher densities, and when they occur in more compact sediments (Kyte and Chew 1975).

Hydraulic clam dredges
Mobile fishing gear such as hydraulic clam dredges have both physical and biological effects on benthic habitat. A panel of fishery experts concluded that dredge gear (all types) had "very high" physical and biological habitat impacts (Chuenpagdee et al. 2003). Mobile gear damages both species on the surface of the ocean bottom, as well as those burrowed beneath it (Gaspar et al. 2002). Physical effects of clam dredging include trenches, windrows, and sediment re-suspension; physical impacts to bottom habitat last for a longer time period in low energy environments than in high energy environments (NEFSC 2002). An expert workshop on the effects of fishing gear on marine habitats concluded that changes in physical and biological structure as a result of clam dredging occur at "high" levels, similar to the impact level of scallop dredges in low energy environments (NEFSC 2002). Intertidal dredging (e.g., for hard clams) has a more negative impact on benthic organisms compared to scallop dredging, intertidal raking, beam trawling, and otter trawling (Collie et al. 2000). Biogenic effects include the removal of structure-forming organisms such as anemones and sponges, which provide habitat for commercially important juvenile fish species such as black sea bass (NEFSC 2002). Although storm action also disturbs bottom habitat, the cutting or shearing forces associated with dredging differ from the forces generated by storms (Gilkinson et al. 2003).

Several studies have examined the impact of clam dredging on the benthic environment and its inhabitants. Meyer et al. (1981) found that, initially, the dredge track was evident with a smooth track shoulder, sharply angled walls, and a flat floor. Twenty four hours later, the track had rapidly deteriorated and appeared more like a series of shallow depressions as a result of slumping and biological activity (Meyer et al. 1981). Other ecosystem effects include an increase in predator density immediately after dredging, which returned to predredging levels after 24 hours (Meyer et al. 1981). Gilkinson et al. (2003) examined the impacts of hydraulic clam dredging on sandy ocean bottom over a 3-year period, and found that there was a dramatic change in seabed topography. Features such as burrows, tubes, and shells were lost through sedimentation and although dredge furrows were not visible in video taken one year after dredging, sidescan sonograms revealed that furrows were present (Gilkinson et al. 2003). Burrows and other small topographic features play an important role in the behavior of some fish species and invertebrates (Burrows et al. 2003). The study also found that hydraulic clam dredging had long-lasting effects on sediment structure. According to Gilkinson et al. (2003), "…hydraulic dredges produce the most dramatic, immediate effect on seabed topography", relative to other mobile fishing gear. Other research has shown that hydraulic clam dredging off the coast of New Jersey has no detectable effect on the abundance or species composition of the benthic macroinvertebrates, given the methodology used (MacKenzie 1982).

In 2000, approximately 110 square miles of bottom habitat in federal waters was directly impacted by hydraulic clam dredging (NEFSC 2002). In the state waters of New Jersey, New York, and Massachusetts, 15 square miles of bottom habitat was dredged (NEFSC 2002). A 100 square mile area is approximately equal to one TNMS; there are 1200 TNMSs in the federal waters from Georges Bank to Cape Hatteras (MAFMC 1998). According to the Mid-Atlantic Fishery Management Council (1998), the relatively small geographic area affected by clam dredging, as well as the small number of boats clamming (50 in 1997) suggests that no effort to address habitat damage as a result of clam dredging needs to be made. However, although surfclam dredging occurs in a limited area, there may be important local effects of dredging on essential fish habitat (NEFSC 2002). Hydraulic clam dredges have a moderate geographic extent, and cause a great amount of damage to physical and biogenic habitats. However, there is no evidence to date that the removal of any of the clam species evaluated in this report has, or will likely, substantially disrupt the food web. In addition, there is no evidence to date that clam dredging is likely to cause ecosystem state changes.

Harvesting effects on clam populations

Although incidental mortality does occur in hydraulic clam dredges, the rate is estimated to be below 10% due to quota management (NEFSC 2002). It is also likely that these mortality rates have since decreased, due to higher efficiency of clam dredges. Haskin and Wagner (1986) estimated surfclam mortality due to dredging at 17 – 18%, while mortality due to sorting and discarding was estimated at 17 – 19%. Indirect mortalities of surfclams also occur when surfclams not captured by the dredge are seriously injured, or are attacked by predators before they reburrow (NEFSC 2003a). Discard levels of surfclams have decreased since the 1980s (NEFSC 2003a). Settling and recently-settled Atlantic surfclams may be negatively affected by clam dredging; there are no data concerning younger clams (Cargnelli et al. 1999a). Dredges have been shown to remove 91% of the available clams when dredge efficiency is high and 80% of available clams when dredge efficiency is low (Meyer et al. 1981). Mortality also varies according to dredge efficiency. When dredge efficiency is high, mortalities are 30%, but at low dredge efficiency, the larger clams that burrow deeper in the sediment experienced mortalities of 92% (Meyer et al. 1981).

Table 4. Habitat effects of gear used to harvest Atlantic surfclams, ocean quahogs, softshell clams, and hard clams.

Gear Type	Effect of Fishing Gear on Habitats	Habitat Resilience to Disturbance	Geographic Extent of Fishery Effects	Evidence of Food Web Disruption	Evidence of Ecosystem Changes	Sources
Hand rakes	Moderate damage	Moderate	Medium area	None	None	Peterson et al. 1987; Brown and Wilson 1997; Hall and Harding 1997; Kaiser et al. 2001
Hydraulic clam dredges	Great damage	Moderate	Medium area	None	None	Kyte and Chew 1975; Meyer et al. 1981; NEFSC 2002; Gilkinson et al. 2003

Synthesis

Hand rakes used to harvest softshell and hard clams have a moderate impact on the bottom habitat where clams are harvested, and the effects of hand raking vary according to the habitat in which it occurs. Hydraulic clam dredges used to harvest surfclams and ocean quahogs have been shown to have severe impacts on bottom habitat, including long-term modification of the physical structure through the creation of furrows, as well as the removal of topographic features. Dredging for surfclams and ocean quahogs rates as a high conservation concern, while hand raking rates as a moderate conservation concern.

Effect of Fishing Practices Rank:

Hand raking:

Benign 🟩 **Moderate** 🟨 Severe 🟥 Critical ⬛

Hydraulic clam dredging:

Benign 🟩 Moderate 🟨 **Severe** 🟥 Critical ⬛

Criterion 5: Effectiveness of the Management Regime

Atlantic surfclams

Atlantic surfclams are managed by the Mid-Atlantic Fishery Management Council (MAFMC) under the Atlantic Surfclam and Ocean Quahog Fishery Management Plan (FMP) of 1977. The FMP has been amended 12 times since its implementation. The MAFMC manages surfclam populations occurring in federal waters off the east coast of the U.S. Surfclams occurring in state waters are managed by the state in which they occur. Surfclam stock assessments were conducted in 1992, 1994, 1997, 1999, and 2002. Commercial landings and effort data from 1980 to 2002 from mandatory vessel logbooks were used in the most recent assessment. In 1990, an individual transferable quota (ITQ) system was established via Amendment 8, reducing the number of boats fishing for surfclams from 75 vessels in 1991, to 31 vessels in 1998 (Weinberg 1998a). The surfclam fishery in federal waters is also managed by a total allowable catch (TAC), a limited entry system, permit and logbook requirements, an annual quota, and closed areas (Table 5). The largest state fishery for surfclams is in New Jersey state waters, where the surfclam fishery is a limited-entry fishery, requiring a license to commercially harvest surfclams (NJDFW 2004). The annual harvest quota for New Jersey state waters is divided equally among the surfclam license holders (NJDFW 2004). The annual quota was 600,000 bushels (10.2 million pounds) in 1997, and the fishery operates from October to May (MAFMC 1998). In Rhode Island state waters, the minimum size for surfclams is five inches measured parallel to the longest axis of the clam (RIDFW 2004a). A license is required to commercially harvest all clams in Rhode Island, and the daily take limit for surfclams is 200 bushels (RIDFW 2004b). In Massachusetts state waters, the minimum size limit for surfclams is 5 inches, and the possession limit is 400 bushels/48 hours (MDMF 2004).

A recent stock assessment was conducted for surfclams and there is regular collection and assessment of both fishery independent and dependent data. There is no bycatch plan in place because bycatch in this fishery is considered low. Management has not addressed the habitat effects of hydraulic clam dredging. The fishery is adequately enforced. Overall, management has maintained stock productivity, although estimates of population biomass have fluctuated greatly since the 1950s.

Ocean quahogs

Ocean quahogs are managed by the MAFMC under the Atlantic Surfclam and Ocean Quahog FMP of 1977. The MAFMC manages ocean quahog populations occurring in federal waters off the east coast of the U.S., while ocean quahogs occurring in state waters are managed by the state in which they occur. Ocean quahogs were assessed in 1994, 1997, 1999, and 2002 (NEFSC 2004a). The 2002 assessment was based on data from annual commercial landings and effort, commercial catch shell lengths, experiments to estimate efficiency of the NMFS dredge, NMFS surveys, a recruitment survey conducted by Rutgers University and the clam industry, and a survey conducted by the State of Maine (NEFSC 2004a). As of 1998, nearly all of the U.S. commercial ocean quahog landings were from federal waters (MAFMC 1998). Like the surfclam fishery, the ocean quahog fishery is managed by a TAC, an ITQ system, and permit and logbook requirements. A recent stock assessment was conducted, and there is regular collection and assessment of both fishery independent and dependent data. There is no bycatch plan in place because bycatch in this fishery is considered low. Management has not addressed the effect of clam dredging on habitats and ecosystems. The fishery is adequately enforced, and overall, management has maintained stock productivity and limited ecosystem change.

Mahogany quahogs

Amendment 10 to the Atlantic Surfclam and Ocean Quahog FMP was approved in 1998, and provided management measures for the mahogany quahog fishery occurring in the inshore waters of Maine (MAFMC 1998). As a small artisanal fishery, the management measures for the offshore ocean quahog fishery were not appropriate. Amendment 10 established an initial maximum quota, which was to be adjusted once a survey and assessment had been completed (MAFMC 1998). In addition, there a moratorium on entry into the fishery (MAFMC 1998). In Maine state waters, a license is required to commercially harvest mahogany quahogs (DMR 2002).

Softshell clams

Maine

Maine was the primary source of softshell clams landed in the U.S. in 2002. In Maine, the Department of Marine Resources (DMR) Division of Shellfish Management and Coastal Permit Review is responsible for softshell clam management in state waters, and supports three regional offices. The Softshell Clam Management Program coordinates with municipal, academic, and industry representatives to improve management of the softshell clam resource. The minimum size limit for softshell clams harvested in Maine and Massachusetts is 2 inches in the largest diameter (DMR 2004b; MDMF 2004). Regulations in Maine are enforced by state, county, and municipal wardens, as well as enforcement officers (DMR 2004b). A shellfish license is required to harvest shellfish in Maine state waters (DMR 2002). Areas may be closed to shellfish harvesting due to contaminated waters. Harvesting by hand (i.e., with rakes) is the only method allowed to commercially harvest softshell clams in Maine state waters (DMR 2002). Individual municipalities are given the authority to regulate the possession of shellfish and the amount of shellfish that may be taken (DMR 2002). DMR reseeds mudflats by transplanting softshell clams from dense beds to areas that may be productive (DMR 2002). Shellfish management programs are established by individual municipalities, rather than state-wide, with advice from the shellfish committee. While some municipalities conduct clam flat surveys, others manage the resource by actions such as limiting license sales and through reseeding efforts (R. Aho, pers. comm.). Although softshell clam population assessments have been conducted for many years in Maine, there is some controversy about using the assessments for effort management (i.e., determining how many licenses should be given out) (GMA 2001). Population assessments are conducted in certain regions in Maine on a regular basis, but these data are insufficient to make any definitive conclusions concerning the status of the resource. There is no bycatch plan in place, as bycatch in this fishery is considered low. Hand rakes are the only permissible gear in this fishery. The fishery is adequately enforced, but it is difficult to determine whether or not management measures have maintained stock productivity, as the stock status is unknown. However, landings have remained relatively stable since the 1990s, following a dramatic decline in the late 1970s.

Hard clams

Connecticut

In Connecticut, commercial harvesters must obtain a license from the Department of Agriculture, Bureau of Aquaculture (DOA 2004). The Department of Agriculture, Bureau of Aquaculture is responsible for leasing submerged lands, classifying shellfish waters, monitoring water quality, and licensing commercial shellfish operations. The hard clam fishery in Connecticut is enforced by the Department of Environmental Protection (DEP) Law Enforcement Division and municipal enforcement officers.

New York

In New York state waters, hard clams are managed by the Department of Environmental Conservation Shellfisheries Section. Commercial harvest of hard clams in New York is managed by a 1-inch (thickness across the hinge) size limit and a gear restriction prohibiting mechanically operated gear (NYSDEC 2004). There is no catch limit for hard clams in New York (NYSDEC 2004). Although there are state-wide regulations for hard clam harvesting, there is no state-wide management plan, as each municipality manages its own hard clam resources. There is also no state-wide population assessment, although some municipalities do conduct annual population surveys. Regulations managing the hard clam fishery vary by town, and may differ from state law. By 2005, the State of New York plans to develop a Comprehensive Wildlife Conservation Strategy (CWCS) under the State Wildlife Grants Program that will include conservation and management actions for more than 400 “Species of Greatest Conservation Need”, including the hard clam and other marine molluscs. The CWCS will identify threats, critical habitats, research/survey/monitoring needs and proposed conservation actions for the hard clam and other species identified on the list of greatest conservation need. The State Wildlife Grants Program was established through federal legislation in fall 2001 to provide funds to state wildlife agencies for conservation of fish and wildlife species of greatest conservation need (D. Barnes, pers. comm.).

Massachusetts

In Massachusetts, hard clams are managed by individual municipalities, although they are encouraged to comply with guidelines set by the state’s Division of Marine Fisheries (MacFarlane 1998). Management responsibilities are split between the municipalities and the state. For instance, the state sets size limits and fees for shellfish licenses, surveys potential lease sites and manages contaminated areas (MacFarlane 1998). The municipalities enforce local regulations, issue harvesting licenses, and determine which state waters to harvest from (MacFarlane 1998). Although there is no statewide management for hard clams, Resource Management Plans do exist for certain municipalities (MacFarlane 1998). In Massachusetts state waters, the minimum size for hard shell clams is 1 inch thickness, and there is no closed season or possession limit for hard clams (MDMF 2004).

Rhode Island

In Rhode Island state waters, the commercial hard clam fishery is managed by the Department of Environmental Management with advice from the Rhode Island Marine Fisheries Council (RIDFW 2003). Management measures include pollution closures, seasons, possession limits, and management closures (RIDFW 2003). In Rhode Island state waters, the minimum size for hard clams is 1-inch shell thickness (RIDFW 2004a), and the daily take limit is 12 bushels

(RIDFW 2004b). Gear restrictions for hard clam harvesting in Rhode Island state waters include the prohibition of mechanically powered rakes or dredges (RIDFW 2004b). Hard clams in the state waters of Rhode Island are managed under a Management Plan for the Shellfish Fishery Sector (RIDFW 2003).

Hard clam summary

Population assessments of hard clams are conducted in some states on a regular basis, but these data are insufficient to make any definitive conclusions concerning the status of the hard clam resource. There is no bycatch plan in place, as bycatch in this fishery is considered low. Hand rakes are the only permissible gear in New York, Massachusetts, and Rhode Island. It is difficult to determine whether or not management measures have maintained stock productivity, due to the unknown status of hard clam stocks. Hard clam landings in the U.S. have slowly declined since the 1950s, but have remained relatively stable since the 1980s. Most states do not have sufficient enforcement (McHugh 2001). "Under present management regimes, the future of the hard clam stocks is not promising in the long run" (McHugh 2001).

Table 5. Commercial harvest management measures for the Atlantic surfclam, ocean quahog, softshell clam, and hard clam fisheries.

Species	Management Jurisdictions & Agencies	Total Allowable Landings	Size Limit	Gear Restrictions	Trip Limit	Area Closures	Sources
Atlantic surfclam	Mid-Atlantic Fishery Management Council	3.25 mil bushels	Suspended	None	None	Georges Bank closed due to PSP	MAFMC 2003
Ocean quahog	Mid-Atlantic Fishery Management Council	4.5 mil bushels; Mahogany quahog quota is 100,000 bushels	None	None	None	Georges Bank closed due to PSP	MAFMC 2003
Softshell clam	Maine Dept. of Marine Resources	Varies by municipality	2 inches	Harvest by hand implement only	Varies by municipality	None	DMR 2002
Hard clam	Connecticut Bureau of Aquaculture, New York Bureau of Marine Resources, Massachusetts Division of Marine Fisheries, and Rhode Island Dept. of Env. Management	Varies by state	1 inch	Varies by state – dredging and raking permitted in CT state waters	Varies by state	Varies by state	DOA 2004; NYSDEC 2004; MDMF 2004; RIDFW 2004a; RIDFW 2004b

Synthesis
Atlantic surfclams and ocean quahogs are managed under a federal FMP, and recent stock assessments have been conducted for both species. Both fishery independent and dependent data are used to assess the surfclam and ocean quahog resources. Management measures have been implemented and overall, management has been maintained stock productivity. A bycatch plan is not deemed necessary due to the low bycatch levels associated with clam dredging. Management of ocean quahogs and Atlantic surfclams is considered highly effective. For softshell clams harvested in Maine, there is no state-wide, consistent stock assessment. However, management has prohibited the use of dredging to commercially harvest softshell clams. The suite of preceding factors results in a rank of highly effective management for the softshell clam fishery. Similar to softshell clams, there are limited data concerning the population status of hard clams in the various states where hard clams are harvested. However, the habitat effects of dredging have not been addressed. The suite of preceding factors results in a ranking of moderately effective management for the hard clam fishery.

Effectiveness of Management Rank:

Atlantic surfclam, ocean quahog, softshell clam:

Highly Effective 🟩 Moderately Effective 🟨 Ineffective 🟥 Critical ⬛

Hard clam:

Highly Effective 🟩 **Moderately Effective 🟨** Ineffective 🟥 Critical ⬛

Overall Evaluation and Seafood Recommendation

Atlantic surfclams are inherently resilient to fishing pressure due to such life history characteristics as low age at sexual maturity. Ocean quahogs are moderately resilient to fishing pressure due to life history characteristics such as a moderate age at sexual maturity and increased longevity. The stock status of both surfclams and ocean quahogs is considered healthy due to a number of factors such as high population levels; both species are not overfished, and overfishing is not occurring. The gear used to harvest surfclams and ocean quahogs, hydraulic clam dredges, results in little bycatch but severe habitat impacts. Management of surfclams and ocean quahogs is considered highly effective, as stock productivity has been maintained, although Seafood Watch® remains concerned about the habitat effects of hydraulic clam dredging. Overall, the preceding suite of criteria results in a recommendation of “Good Alternatives” for Atlantic surfclams and ocean quahogs. Softshell clams are commercially harvested primarily from Maine state waters. Softshell clams are considered inherently resilient to fishing pressure due to life history characteristics such as low age at sexual maturity. Hard clams are commercially landed primarily in Connecticut, New York, Massachusetts, and Rhode

Island state waters. Hard clams also reach maturity at an early age, and are thus also considered inherently resilient to fishing pressure. The status of both softshell and hard clam stocks is considered unknown due to a lack of consistent population assessment data. Softshell clams are harvested by hand raking, which has fewer habitat effects than clam dredging and rates as only a moderate conservation concern. Hard clams are harvested using both hand rakes and clam dredges. Bycatch is low in the softshell and hard clam fisheries. The commercial softshell clam fishery is managed by the Maine Department of Marine Resources. Although stock assessments for softshell clams are not consistently conducted in all locations, management has addressed the impact of dredging by only allowing softshell clams to only be harvested with hand implements. The commercial hard clam fishery is managed by various state agencies in Connecticut, New York, Massachusetts, and Rhode Island. Although management has maintained stock productivity overall, the issue of habitat damage as a result of dredging has not been addressed I the hard clam fishery. The preceding suite of criteria results in an overall recommendation of "Best Choice" for softshell clams and "Good Alternative" for hard clams.

Table of Sustainability Ranks

	Conservation Concern			
Sustainability Criteria	**Low**	**Moderate**	**High**	**Critical**
Inherent Vulnerability	√ (Atlantic surfclam, softshell clam, hard clam)	√ (Ocean quahog)		
Status of Stocks	√ (Atlantic surfclam, ocean quahog)	√ (Softshell clam, hard clam)		
Nature of Bycatch	√ (Hand rakes and clam dredges)			
Habitat Effects		√ (Hand rakes)	√ (Clam dredges)	
Management Effectiveness	√ (Atlantic surfclam, ocean quahog, softshell clam)	√ (Hard clam)		

Overall Seafood Recommendation:

Softshell clam:	**Best Choice** 🟩	Good Alternative 🟨	Avoid 🟥
Atlantic surfclam, Ocean quahog, Hard clam:	Best Choices 🟩	**Good Alternatives** 🟨	Avoid 🟥

Supplemental Information

Although potential health effects are not included in the overall seafood recommendation, the consumption of raw or undercooked clams may be a health concern for certain individuals. As clams are filter feeders, they naturally accumulate any toxins or metals present in the water. The health concern associated with consuming raw clams is the presence of *Vibrio vulnificus* bacteria. Most healthy individuals are not affected by the ingestion of *V. vulnificus*; however, high-risk individuals are those with cancer, diabetes, liver disease or disorders, cancer, and individuals with compromised immune systems. From 1989 to 2002, only 2% of the reported illnesses associated with *Vibrio* were due to consumption of hard clams (ISSC 2004).

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