Blue Mussel
_Mytilus edulis_

Maine, Massachusetts, Rhode Island, New York

Hand Rake and Dredge
Fisheries Standard Version F3.1

January 8, 2017
_The Safina Center Seafood Analysts_

**Disclaimer:** Seafood Watch and The Safina Center strive to ensure that all our Seafood Reports and recommendations contained therein are accurate and reflect the most up-to-date evidence available at the time of publication. All our reports are peer-reviewed for accuracy and completeness by external scientists with expertise in ecology, fisheries science or aquaculture. Scientific review, however, does not constitute an endorsement of the Seafood Watch program or of The Safina Center or their recommendations on the part of the reviewing scientists. Seafood Watch and The Safina Center are solely responsible for the conclusions reached in this report. We always welcome additional or updated data that can be used for the next revision.
About The Safina Center

The Safina Center (formerly Blue Ocean Institute) translates scientific information into language people can understand and serves as a unique voice of hope, guidance, and encouragement. The Safina Center (TSC) works through science, art, and literature to inspire solutions and a deeper connection with nature, especially the sea. Our mission is to inspire more people to actively engage as well-informed and highly motivated constituents for conservation.

Led by conservation pioneer and MacArthur fellow, Dr. Carl Safina, we show how nature, community, the economy and prospects for peace are all intertwined. Through Safina’s books, essays, public speaking, PBS television series, our Fellows program and Sustainable Seafood program, we seek to inspire people to make better choices.

The Safina Center was founded in 2003 by Dr. Carl Safina and was built on three decades of research, writing and policy work by Dr. Safina.

The Safina Center’s Sustainable Seafood Program
The Center’s founders created the first seafood guide in 1998. Our online seafood guide now encompasses over 160-wild-caught species. All peer-reviewed seafood reports are transparent, authoritative, easy to understand and use. Seafood ratings and full reports are available on our website under Seafood Choices. TSC’s Sustainable Seafood Program helps consumers, retailers, chefs and health professionals discover the connection between human health, a healthy ocean, fishing and sustainable seafood.

- Our online guide to sustainable seafood is based on scientific ratings for more than 160 wild-caught seafood species and provides simple guidelines. Through our expanded partnership with the Monterey Bay Aquarium, our guide now includes seafood ratings from both The Safina Center and the Seafood Watch® program.
- We partner with Whole Foods Market (WFM) to help educate their seafood suppliers and staff, and provide our scientific seafood ratings for WFM stores in the US and UK.
- Our website features tutorials, videos, blogs, links and discussions of the key issues such as mercury in seafood, bycatch, overfishing, etc.

Check out our Fellows Program, learn more about our Sustainable Seafood Program and Carl Safina’s current work at www.safinacenter.org.

The Safina Center is a 501 (c) (3) nonprofit organization based in the School of Marine & Atmospheric Sciences at Stony Brook University, Long Island, NY. www.safinacenter.org admin@safinacenter.org | 631.632.3763
About Seafood Watch®

Monterey Bay Aquarium’s Seafood Watch® program evaluates the ecological sustainability of wild-captured and farmed seafood commonly found in the United States marketplace. Seafood Watch® defines sustainable seafood as originating from sources, whether wild-captured 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®’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 1-877-229-9990.
Guiding Principles

The Safina Center and Seafood Watch define sustainable seafood as originating from sources, whether fished\(^1\) or farmed, that can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems.

Based on this principle, Seafood Watch and the Safina Center have developed four sustainability criteria for evaluating wild-catch fisheries for consumers and businesses. These criteria are:

- How does fishing affect the species under assessment?
- How does the fishing affect other, target and non-target species?
- How effective is the fishery’s management?
- How does the fishing affect habitats and the stability of the ecosystem?

Each criterion includes:

- Factors to evaluate and score
- Guidelines for integrating these factors to produce a numerical score and rating

Once a rating has been assigned to each criterion, we develop an overall recommendation. Criteria ratings and the overall recommendation are color-coded to correspond to the categories on the Seafood Watch pocket guide and the Safina Center’s online guide:

**Best Choice/Green**: Are well managed and caught in ways that cause little harm to habitats or other wildlife.

**Good Alternative/Yellow**: Buy, but be aware there are concerns with how they’re caught.

**Avoid/Red**: Take a pass on these for now. These items are overfished or caught in ways that harm other marine life or the environment.

---

\(^1\) “Fish” is used throughout this document to refer to finfish, shellfish and other invertebrates.
Summary

This report assesses the U.S. wild blue mussel (*Mytilus edulis*) fisheries in Maine, Massachusetts, New York, and Rhode Island.

The blue mussel is a marine bivalve that is found in the Arctic, North Pacific, and North Atlantic. In North America, it is found from Labrador, Canada to North Carolina. Blue mussel anchors to the bottom substrate and forms dense beds.

Maine has accounted for the majority of blue mussel catches in the U.S., but small catches of blue mussels also occur in Massachusetts, New York, and Rhode Island. There has been limited monitoring of U.S. blue mussel populations and abundance, and fishing mortality levels are unknown. But declines in blue mussels have been reported in Maine. All states have some regulations in place to control fishing.

Fishers capture blue mussels with hand rakes and mussel drags (dredges). Bycatch in blue mussel fisheries is typically low. When fishing with hand rakes, most non-target species are returned to the habitat unharmed, so effects on non-target species are negligible. Mussel dredges may cause some harm to incidentally captured invertebrates. Mussel dredges also cause more damage to the bottom habitat than hand rakes, but there are measures in place to limit the impacts of dredge gear in most states.

Blue mussels are ecologically important in coastal ecosystems, so the removal of blue mussels due to fishing could have negative ecosystem impacts. Blue mussel beds provide important habitat and shelter for numerous species, as well as shoreline protection. Additionally, mussels are an important food source for many species, and as filter feeders they help to remove pollutants from the water. Some spatial management is in place to help protect the ecological role of blue mussels, but more robust policies are needed.

Overall, the blue mussel hand rake and dredge fisheries in Maine, Massachusetts, New York, and Rhode Island are rated Yellow or “Good Alternative.”
### Table of Conservation Concerns and Overall Recommendations

<table>
<thead>
<tr>
<th>Species</th>
<th>Fishery</th>
<th>Criterion 1</th>
<th>Criterion 2</th>
<th>Criterion 3</th>
<th>Criterion 4</th>
<th>Overall Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue Mussel</td>
<td>Maine, Dredge</td>
<td>Yellow 2.64</td>
<td>Yellow 2.64</td>
<td>Yellow 3.00</td>
<td>Yellow 2.74</td>
<td>YELLOW/GOOD ALTERNATIVE 2.751</td>
</tr>
<tr>
<td>Blue Mussel</td>
<td>Maine, Rake</td>
<td>Yellow 2.64</td>
<td>Green 5.00</td>
<td>Yellow 3.00</td>
<td>Yellow 3.00</td>
<td>YELLOW/GOOD ALTERNATIVE 3.301</td>
</tr>
<tr>
<td>Blue Mussel</td>
<td>Massachusetts, Dredge</td>
<td>Yellow 2.64</td>
<td>Yellow 2.64</td>
<td>Red 2.00</td>
<td>Yellow 2.45</td>
<td>YELLOW/GOOD ALTERNATIVE 2.417</td>
</tr>
<tr>
<td>Blue Mussel</td>
<td>Massachusetts, Rake</td>
<td>Yellow 2.64</td>
<td>Green 5.00</td>
<td>Red 2.00</td>
<td>Yellow 3.00</td>
<td>YELLOW/GOOD ALTERNATIVE 2.983</td>
</tr>
<tr>
<td>Blue Mussel</td>
<td>New York, Dredge</td>
<td>Yellow 2.64</td>
<td>Yellow 2.64</td>
<td>Yellow 3.00</td>
<td>Yellow 2.74</td>
<td>YELLOW/GOOD ALTERNATIVE 2.751</td>
</tr>
<tr>
<td>Blue Mussel</td>
<td>New York, Rake</td>
<td>Yellow 2.64</td>
<td>Green 5.00</td>
<td>Yellow 3.00</td>
<td>Yellow 3.00</td>
<td>YELLOW/GOOD ALTERNATIVE 3.301</td>
</tr>
<tr>
<td>Blue Mussel</td>
<td>Rhode Island, Dredge</td>
<td>Yellow 2.64</td>
<td>Yellow 2.64</td>
<td>Yellow 3.00</td>
<td>Yellow 2.74</td>
<td>YELLOW/GOOD ALTERNATIVE 2.751</td>
</tr>
<tr>
<td>Blue Mussel</td>
<td>Rhode Island, Rake</td>
<td>Yellow 2.64</td>
<td>Green 5.00</td>
<td>Yellow 3.00</td>
<td>Yellow 3.00</td>
<td>YELLOW/GOOD ALTERNATIVE 3.301</td>
</tr>
</tbody>
</table>

### Scoring Guide

Scores range from zero to five where zero indicates very poor performance and five indicates the fishing operations have no significant impact.

Final Score = geometric mean of the four Scores (Criterion 1, Criterion 2, Criterion 3, Criterion 4).

- **Best Choice/Green** = Final Score >3.2, and either Criterion 1 or Criterion 3 (or both) is Green, and no Red Criteria.
- **Good Alternative/Yellow** = Final score >2.2, and no more than one Red Criterion, and does not meet the criteria for Best Choice/Green (above)
- **Avoid/Red** = Final Score ≤2.2, or two or more Red Criteria, or Management is Critical.
Introduction

Scope of the analysis and ensuing recommendation
This report assesses the U.S. North Atlantic fisheries for blue mussel (*Mytilus edulis*). The states covered in the report are Maine, Massachusetts, New York, and Rhode Island. These states account for nearly all the wild blue mussel catch. Fishers use hand rakes and drags (dredges) to capture mussels.

Overview of the species and management bodies
Blue mussel is found in the Arctic, North Pacific, and North Atlantic. Along the North American coast, it is are found from Labrador, Canada to Cape Hatteras, North Carolina, with the population centered in Maine (Seed 1976) (Tam and Scrosati 2011).

Blue mussel is a semi-sessile bivalve that anchors to the bottom substrate in intertidal shallow areas and forms dense beds (Newell and Moran 1989). It typically reaches sexual maturity between 1 and 2 years, and on average lives up to 12 years (Newell and Moran 1989) (Massie 1998) (MDMR 2016a). It can grow to a maximum size of 6–10 cm (2–4 in) (Rodhouse 1986). Blue mussel spawns in the spring and summer and is typically caught in the winter before spawning, when its meat is considered to have the best market value (MDMR 2016a). Blue mussel is a suspension feeder and filters plankton from the seawater for food (Bayne 1983). It is vulnerable to predation when it is a planktonic juvenile, and predators range from jellyfish to larval and adult fish (Newell and Moran 1989). As mussels grow, they are susceptible to larger predators such as sea stars, sea urchins, crabs, lobsters, whelks, fish, and birds (Seed and Suchanek 1992).

The U.S. commercial catch of blue mussels has fluctuated over time but is at relatively low levels compared to the catch of other shellfish species. The majority of blue mussel fishing occurs in the state of Maine but small fisheries also take place in Massachusetts, New York, and Rhode Island. Blue mussels are captured by hand with the use of a bull rake, or by boat with the use of a mussel drag (also called a dredge) (MDMR 2016a). Blue mussel is managed at the state level by the Maine Department of Marine Resources, Massachusetts Department of Marine Fisheries, New York Department of Environmental Conservation, and Rhode Island Department of Environmental Management. There is a growing aquaculture industry for blue mussel, but this report only covers the wild fishery.

Production statistics
In the state of Maine, where the majority of blue mussel fishing occurs, commercial landings were relatively low from 1950–1974 and rarely exceeded 2 million whole lbs annually. In the late 1970s and 1980s, landings gradually increased. The highest landings occurred in 1995 at approximately 37 million whole lbs. Since the mid-1990s, landings have fluctuated but decreased overall. From 2000–2015, the annual landings ranged from 13 to 28 million whole lbs and averaged 17 million lbs ($2.5 million in value) (MDMR 2016c). In 2015, 5% of the catch
(662,306 lbs) was taken with hand rakes, while the remaining 95% (12,448,031 lbs) was caught with mussel dredges.

In the state of New York, blue mussels have been commercially fished since the 1950s, but landings have been significantly lower than in Maine. Blue mussel landings in New York have fluctuated greatly, and the highest annual catch was 3,752,815 whole lbs (68,233 bushels) in 1973. Since the 1970s, landings have decreased and have remained low since 2000. From 2000–2014, the annual landings ranged from approximately 5,115 whole lbs (93 bushels) to 69,960 whole lbs (1,272 bushels) (pers. comm., Jennifer O’Dwyer 2016). [Note: New York landings for blue mussels are reported in bushels. For this report, landings were converted to estimated pounds using a conservation factor of 55 pounds per bushel (pers. comm. Jennifer O’Dwyer 2016).]

The blue mussel supports a very small commercial fishery in Rhode Island, and landings are variable. The only available and reliable information for blue mussel commercial landings in Rhode Island is in value rather than pounds. In years when catches were considered high, such as 2009 and 2010, blue mussel landings value was $145,000, and the average landings value from 2007–2013 was approximately $48,100 (CRC 2014). There were no reported mussel landings in 2013 (RIDEM 2016b).

There is currently no available information on blue mussel landings in the state of Massachusetts.
Figure 1. Commercial landings (in whole pounds) of blue mussel (*Mytilus edulis*) in Maine from 1950–2015 (Data from MDMR 2016c).

**Commercial Harvest of Blue Mussels in New York (1950-2014)**

Figure 2. Commercial landing (in whole pounds) of blue mussel (*Mytilus edulis*) in New York from 1950–2014 (Data from pers. comm., Jennifer O’Dwyer 2016).

**Importance to the U.S./North American market**

Blue mussel is an economically important species in the northwest Atlantic, especially in Maine. Mussels are both imported and exported in the U.S. domestic fish market. The following import and export values do not solely reflect the wild blue mussel, but all mussel species from both wild and farmed harvest. In 2013 and 2014, the U.S. exported 920,000 lbs ($1.66 million) and 1,098,000 lbs ($2.2 million) of mussels, respectively. U.S. imports of mussels in 2013 and 2014 were 56,308,000 lbs ($93 million) and 58,102,000 lbs ($112 million), respectively (NOAA Fisheries 2015b). The majority of exports are to China, Japan, and Canada, and the majority of imports are from New Zealand, Chile, Canada, and China.

**Common and market names**

The blue mussel is occasionally referred to as sea mussel, edible mussel, bay mussel, common mussel, or mussel (CRC 2014) (Newell and Morgan 1989).

**Primary product forms**

Blue mussels are sold fresh (live), frozen, or cooked. They are typically broiled, sautéed, smoked, or steamed and eaten in the shell.
Assessment

This section assesses the sustainability of the fishery(s) relative to the Seafood Watch Criteria for Fisheries, available at http://www.seafoodwatch.org.

Criterion 1: Impact on the Species Under Assessment

This criterion evaluates the impact of fishing mortality on the species, given its current abundance. When abundance is unknown, abundance is scored based on the species’ inherent vulnerability, which is calculated using a Productivity-Susceptibility Analysis. The final Criterion 1 score is determined by taking the geometric mean of the abundance and fishing mortality scores. The Criterion 1 rating is determined as follows:

- Score >3.2=Green or Low Concern
- Score >2.2 and <=3.2=Yellow or Moderate Concern
- Score <=2.2=Red or High Concern

Criterion 1 Summary

<table>
<thead>
<tr>
<th>Species</th>
<th>Fishery</th>
<th>Factor 1.1. Abundance</th>
<th>Factor 1.2 Fishing Mortality</th>
<th>Criterion 1 Score</th>
<th>Criterion 1 Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue Mussel</td>
<td>Maine, Dredge</td>
<td>Moderate Concern (2.33)</td>
<td>Moderate Concern (3)</td>
<td>2.64</td>
<td>Yellow</td>
</tr>
<tr>
<td>Blue Mussel</td>
<td>Maine, Rake</td>
<td>Moderate Concern (2.33)</td>
<td>Moderate Concern (3)</td>
<td>2.64</td>
<td>Yellow</td>
</tr>
<tr>
<td>Blue Mussel</td>
<td>Massachusetts, Dredge</td>
<td>Moderate Concern (2.33)</td>
<td>Moderate Concern (3)</td>
<td>2.64</td>
<td>Yellow</td>
</tr>
<tr>
<td>Blue Mussel</td>
<td>Massachusetts, Rake</td>
<td>Moderate Concern (2.33)</td>
<td>Moderate Concern (3)</td>
<td>2.64</td>
<td>Yellow</td>
</tr>
<tr>
<td>Blue Mussel</td>
<td>New York, Dredge</td>
<td>Moderate Concern (2.33)</td>
<td>Moderate Concern (3)</td>
<td>2.64</td>
<td>Yellow</td>
</tr>
<tr>
<td>Blue Mussel</td>
<td>New York, Rake</td>
<td>Moderate Concern (2.33)</td>
<td>Moderate Concern (3)</td>
<td>2.64</td>
<td>Yellow</td>
</tr>
<tr>
<td>Blue Mussel</td>
<td>Rhode Island, Dredge</td>
<td>Moderate Concern (2.33)</td>
<td>Moderate Concern (3)</td>
<td>2.64</td>
<td>Yellow</td>
</tr>
<tr>
<td>Blue Mussel</td>
<td>Rhode Island, Rake</td>
<td>Moderate Concern (2.33)</td>
<td>Moderate Concern (3)</td>
<td>2.64</td>
<td>Yellow</td>
</tr>
</tbody>
</table>
Criterion 1 Assessment

**BLUE MUSSEL**

Factor 1.1 Abundance

**Scoring Guidelines**

- **5 (Very Low Concern)**—Strong evidence exists that the population is above an appropriate target abundance level (given the species’ ecological role), or near virgin biomass.
- **3.67 (Low Concern)**—Population may be below target abundance level, but is at least 75% of the target level, OR data-limited assessments suggest population is healthy and species is not highly vulnerable.
- **2.33 (Moderate Concern)**—Population is not overfished but may be below 75% of the target abundance level, OR abundance is unknown and the species is not highly vulnerable.
- **1 (High Concern)**—Population is considered overfished/depleted, a species of concern, threatened or endangered, OR abundance is unknown and species is highly vulnerable.

**Maine, Massachusetts, New York and Rhode Island; Hand Rake and Mussel Dredge**

**Moderate Concern**

**Key relevant information:**

There are currently no efforts in place by state management bodies to monitor the U.S. blue mussel populations, so abundance of blue mussels is largely unknown. In several states (MA, NY, and RI) fishing effort is low and abundance is assumed to be high (NYSDEC 2005) (pers. comm., Jennifer O’Dwyer 2016) (pers. comm., Tom Shields 2016).

But in the Gulf of Maine, which is the center of the blue mussel’s range and of fishing activity (Tam and Scrosati 2011), there have been a few independent studies that have examined the abundance of blue mussels. A quite recent study (Sorte et al. 2016) compared recent abundance levels of blue mussels (2013–2014) to historical estimates of mussel abundance from 1972–2007 at seven sites in the Gulf of Maine, from Cape Cod to the northernmost point in Maine. The study found that blue mussels have declined over the past 40 years at all seven sites, with declines of > 60% on average (Sorte et al. 2016), suggesting some concern over the abundance of mussels in this area. Maine fishery managers also report declines of blue mussels statewide over the last 5 years. The level of decline and reasons for decline are unknown, but are potentially due to warming water temperature, green crab predation, overfishing, and/or increasing acidification affecting larvae and shell formation (pers. comm., Pete Thayer 2016).

Because of the limited abundance information and the lack of defined target abundance reference points for the blue mussel populations evaluated in this assessment, the Productivity-Susceptibility Analysis (PSA) scoring tool was used to evaluate the vulnerability of blue mussels
and to score abundance. According to the PSA, blue mussel has a medium vulnerability (see detailed scoring below). Abundance is therefore scored as “moderate” concern.

Detailed Rationale:

Productivity-Susceptibility Analysis

Scoring Guidelines

1.) Productivity score \( P \) = average of the productivity attribute scores \( (p1, p2, p3, p4 \text{ (finfish only)}, p5 \text{ (finfish only)}, p6, p7, \text{ and } p8 \text{ (invertebrates only)}) \)

2.) Susceptibility score \( S \) = product of the susceptibility attribute scores \( (s1, s2, s3, s4) \), rescaled as follows: \[ S = \left[ (s1 \times s2 \times s3 \times s4) - 1/40 \right] + 1. \]

3.) Vulnerability score \( V \) = the Euclidean distance of \( P \) and \( S \) using the following formula: \[ V = \sqrt{P^2 + S^2} \]

Vulnerability Score Range

- \( o < 2.64 = \text{Low vulnerability} \)
- \( o \geq 2.64 \text{ and } \leq 3.18 = \text{Medium vulnerability} \)
- \( o > 3.18 = \text{High vulnerability} \)

For details on the PSA method and scoring, please see the Seafood Watch Criteria

The PSA score for blue mussels is 2.77, which corresponds to a medium vulnerability. Detailed scoring of each attribute is shown below.

<table>
<thead>
<tr>
<th>Productivity Attribute</th>
<th>Relevant Information</th>
<th>Score (1 = low risk, 2 = medium risk, 3 = high risk)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average age at maturity</td>
<td>1–2 years (Massie 1998)</td>
<td>1</td>
</tr>
<tr>
<td>Average maximum age</td>
<td>12 years (MDMR 2016a)</td>
<td>2</td>
</tr>
<tr>
<td>Fecundity</td>
<td>High productivity: females release approximately 500,000 to 10,000,000 eggs (Thompson 1979) (Bayne et al. 1983)</td>
<td>1</td>
</tr>
<tr>
<td>Average maximum size (fish only)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Average size at maturity (fish only)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Reproductive strategy</td>
<td>Broadcast spawner (Massie 1998)</td>
<td>1</td>
</tr>
<tr>
<td>-----------------------</td>
<td>----------------------------------</td>
<td>---</td>
</tr>
<tr>
<td>Trophic level</td>
<td>Second trophic level &lt; 2.75 (Newell and Moran 1989)</td>
<td>1</td>
</tr>
<tr>
<td>Density dependence (invertebrates only)</td>
<td>Depensatory dynamics at low population sizes (Allee effects) demonstrated or likely (Commoto et al. 2014)</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Susceptibility Attribute</th>
<th>Relevant Information</th>
<th>Score (1 = low risk, 2 = medium risk, 3 = high risk)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Areal overlap (Considers all fisheries)</td>
<td>Unknown level of overlap, but the majority of fishing occurs in Maine, the center of the species’ range (Tam and Scrosati 2011)</td>
<td>3</td>
</tr>
<tr>
<td>Vertical overlap (Considers all fisheries)</td>
<td>Unknown</td>
<td>3</td>
</tr>
<tr>
<td>Selectivity of fishery (Specific to fishery under assessment)</td>
<td>Species is targeted and is not likely to escape the gear</td>
<td>2</td>
</tr>
<tr>
<td>Post-capture mortality (Specific to fishery under assessment)</td>
<td>Retained species</td>
<td>3</td>
</tr>
</tbody>
</table>

**Factor 1.2 Fishing mortality**

*Scoring Guidelines*

- **5 (Low Concern)** — Probable (>50%) that fishing mortality from all sources is at or below a sustainable level, given the species ecological role, OR fishery does not target species and fishing mortality is low enough to not adversely affect its population.

- **3 (Moderate Concern)** — Fishing mortality is fluctuating around sustainable levels, OR fishing mortality relative to a sustainable level is uncertain.

- **1 (High Concern)** — Probable that fishing mortality from all source is above a sustainable level.
Maine, Massachusetts, New York and Rhode Island; Hand Rake and Mussel Dredge
Moderate Concern

Key relevant information:
There have been no assessments of blue mussel to estimate fishing mortality. Maine has accounted for the majority of blue mussel commercial catches in the U.S. Landings in Maine have fluctuated over time, with the highest catches occurring in the mid-1980s, mid-1990s, and early 2000s (MDMR 2016c). From 2000–2015, annual landings have ranged from 13 to 27 million whole lbs, and averaged 17 million lbs (MDMR 2016c). The majority of the catch is taken with mussel dredges. Much smaller catches of blue mussel occur in Massachusetts, New York, and Rhode Island. Reliable catch data are not available for Massachusetts or Rhode Island. Catches in New York peaked at just fewer than 4 million whole lbs in 1973 but have since declined. From 2000–2014, annual landings have ranged from 5,115 whole lbs (93 bushels) to 69,960 whole lbs (1,272 bushels). New York issued only nine dredge permits for 2014–2016, which indicates quite low fishing pressure (pers. comm., Jennifer O’Dwyer 2016). There are also recreational fisheries for blue mussel, but catches are unknown. Because fishing levels relative to a sustainable level are unknown in all states, fishing mortality is rated “moderate” concern.
**Criterion 2: Impacts on Other Species**

All main retained and bycatch species in the fishery are evaluated under Criterion 2. Seafood Watch® defines bycatch as all fisheries-related mortality or injury to species other than the retained catch. Examples include discards, endangered or threatened species catch, and ghost fishing. Species are evaluated using the same guidelines as in Criterion 1. When information on other species caught in the fishery is unavailable, the fishery’s potential impacts on other species is scored according to the Unknown Bycatch Matrices, which are based on a synthesis of peer-reviewed literature and expert opinion on the bycatch impacts of each gear type. The fishery is also scored for the amount of non-retained catch (discards) and bait use relative to the retained catch. To determine the final Criterion 2 score, the score for the lowest scoring retained/bycatch species is multiplied by the discard/bait score. The Criterion 2 rating is determined as follows:

- **Score >3.2** = Green or Low Concern
- **Score >2.2 and <=3.2** = Yellow or Moderate Concern
- **Score <=3.2** = Red or High Concern

**Criterion 2 Summary**

Information on non-target or bycatch species caught in the blue mussel fisheries is limited. But bycatch is generally considered to be low and does not regularly include threatened, endangered, or protected species (MDMR 2007a) (FR 2015). Because mussels form dense, aggregate beds, fishers are able to selectively target mussels by dragging or raking directly over the beds. When blue mussels are captured with hand rakes, most non-target catch is likely able to be released alive. Impacts on non-target species in the hand rake fisheries are therefore considered negligible and no other main species are evaluated.

Impacts to non-target species by the dredge fisheries are more uncertain. Species reported to be captured in low levels with mussel dredges include bottom dwelling fish and other benthic invertebrates such as worms, sea urchins, crabs, and starfish that live within the mussel beds (Mesher and Doidge 1995). Non-target species are typically returned to the habitat but they may be harmed due to tumbling and crushing during the fishing process. To account for potential impacts to non-target species, we have evaluated “unknown invertebrates” using the Seafood Watch unknown bycatch matrix, which is based on a synthesis of peer-reviewed literature and expert opinion on the bycatch impacts of each gear type (see Appendix 2 in the Seafood Watch Wild Fisheries Assessment Criteria). Typically, the impact of dredge fisheries on benthic invertebrates is considered to be of high concern, but because the mussel dredges are restricted in size and the fishery is fairly selective for the capture of mussels, we consider the overall impacts on potential bycatch species to be of moderate concern.
Maine, Massachusetts, New York and Rhode Island; Hand Rake

<table>
<thead>
<tr>
<th>Species</th>
<th>Factor 2.1 Abundance</th>
<th>Factor 2.2 Fishing Mortality</th>
<th>Subscore</th>
<th>Criterion 2 Score (subscore*discard/bait modifier (1.00))</th>
<th>Criterion 2 Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>No other main species caught</td>
<td>N/A</td>
<td>N/A</td>
<td>5.00</td>
<td>5.00</td>
<td>Green</td>
</tr>
</tbody>
</table>

Maine, Massachusetts, New York and Rhode Island; Mussel Dredge

<table>
<thead>
<tr>
<th>Species</th>
<th>Factor 2.1 Abundance</th>
<th>Factor 2.2 Fishing Mortality</th>
<th>Subscore</th>
<th>Criterion 2 Score (subscore*discard/bait modifier (1.00))</th>
<th>Criterion 2 Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invertebrates, Unknown</td>
<td>Moderate (2.33)</td>
<td>Moderate (3)</td>
<td>2.64</td>
<td>2.64</td>
<td>Yellow</td>
</tr>
</tbody>
</table>

Criterion 2 Assessment

INVERTEBRATES, UNKNOWN

Factor 2.1 Abundance

Scoring Guidelines (same as Factor 1.1 above)

Maine, Massachusetts, New York and Rhode Island; Mussel Dredge

Moderate Concern

Key relevant information:
The species of benthic invertebrates affected by the blue mussel fishery are unknown, but species that have been reported to be caught in mussel dredges include worms, sea urchins, crabs, and starfish (Mesher and Doidge 1995). The Seafood Watch Unknown Bycatch Matrix was used to score unknown invertebrates. Because these are unlikely to be highly vulnerable species, this factor receives a score of “moderate” concern (Seafood Watch 2016).
Factor 2.2 Fishing Mortality

Scoring Guidelines (same as Factor 1.2 above)

Maine, Massachusetts, New York and Rhode Island; Mussel Dredge
Moderate Concern

Key relevant information:
Non-target species captured in the dredge fisheries are typically returned to the habitat (Mesher and Doidge 1995). But some species may be harmed due to tumbling and crushing during the fishing process, or may die due to handling disturbance (pers. comm., Pete Thayer 2016). Based on the Seafood Watch Unknown Bycatch Matrix, fishing mortality for unknown benthic invertebrates caught with dredge gear is typically considered a “high” concern (see Appendix 2 in the Seafood Watch Wild Fisheries Assessment Criteria). But the dredges used in the blue mussel fishery are restricted in size and bycatch is considered low, due to the selective targeting of mussels. Given the characteristics of the gear and fishery, impacts to unknown invertebrates are considered of “moderate” concern.

Factor 2.3 Modifying Factor: Discards and Bait Use

Scoring Guidelines
The discard rate is the sum of all dead discards (i.e. non-retained catch) plus bait use divided by the total retained catch.

<table>
<thead>
<tr>
<th>Ratio of bait + discards/landings</th>
<th>Factor 2.4 score</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;100%</td>
<td>1</td>
</tr>
<tr>
<td>≥100</td>
<td>0.75</td>
</tr>
</tbody>
</table>

Maine, Massachusetts, New York and Rhode Island; Mussel Dredge
<100% (1)

Key relevant information:
The discard level for the blue mussel drag fisheries is unknown. The average discard rate for other dredge fisheries (based on whelk, scallop, and clam fisheries) is 24.8% (Kelleher 2005). There is no bait used in the fishery. The ratio of discards plus bait to landings is likely < 100%.
Criterion 3: Management Effectiveness

Five factors are evaluated: Management Strategy and Implementation, Bycatch Strategy, Scientific Research/Monitoring, Enforcement of Regulations, and Inclusion of Stakeholders. Each is scored as either ‘highly effective’, ‘moderately effective’, ‘ineffective,’ or ‘critical’. The final criterion 3 score is determined as follows:

- 5 (Very Low Concern)—Meets the standards of ‘highly effective’ for all five factors considered.
- 4 (Low Concern)—Meets the standards of ‘highly effective’ for management strategy and implementation and at least ‘moderately effective’ for all other factors.
- 3 (Moderate Concern)—Meets the standards for at least ‘moderately effective’ for all five factors.
- 2 (High Concern)—At minimum, meets standards for ‘moderately effective’ for Management Strategy and Implementation and Bycatch Strategy, but at least one other factor is rated ‘ineffective.’
- 1 (Very High Concern)—Management Strategy and Implementation and/or Bycatch Management are ‘ineffective.’
- 0 (Critical)—Management Strategy and Implementation is ‘critical’.

The Criterion 3 rating is determined as follows:

- Score >3.2=Green or Low Concern
- Score >2.2 and <=3.2=Yellow or Moderate Concern
- Score <=2.2 = Red or High Concern

Rating is Critical if Management Strategy and Implementation is Critical.

Criterion 3 Summary

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Maine, Rake</td>
<td>Moderately Effective</td>
<td>Highly Effective</td>
<td>Moderately Effective</td>
<td>Highly Effective</td>
<td>Highly Effective</td>
<td>Moderate Concern (3)</td>
<td>Yellow</td>
</tr>
<tr>
<td>Maine, Dredge</td>
<td>Moderately Effective</td>
<td>Moderately Effective</td>
<td>Moderately Effective</td>
<td>Highly Effective</td>
<td>Highly Effective</td>
<td>Moderate Concern (3)</td>
<td>Yellow</td>
</tr>
<tr>
<td>Massachusetts, Rake</td>
<td>Moderately Effective</td>
<td>Highly Effective</td>
<td>Ineffective</td>
<td>Highly Effective</td>
<td>High Concern (2)</td>
<td>Red</td>
<td></td>
</tr>
<tr>
<td>Massachusetts, Dredge</td>
<td>Moderately Effective</td>
<td>Moderately Effective</td>
<td>Ineffective</td>
<td>Moderately Effective</td>
<td>Highly Effective</td>
<td>High Concern (2)</td>
<td>Red</td>
</tr>
<tr>
<td>-----------------------</td>
<td>----------------------</td>
<td>----------------------</td>
<td>-------------</td>
<td>----------------------</td>
<td>------------------</td>
<td>--------------------</td>
<td>-----</td>
</tr>
<tr>
<td>New York, Rake</td>
<td>Moderately Effective</td>
<td>Highly Effective</td>
<td>Moderately Effective</td>
<td>Moderately Effective</td>
<td>Highly Effective</td>
<td>Moderate Concern (3)</td>
<td>Yellow</td>
</tr>
<tr>
<td>New York, Dredge</td>
<td>Moderately Effective</td>
<td>Moderately Effective</td>
<td>Moderately Effective</td>
<td>Moderately Effective</td>
<td>Highly Effective</td>
<td>Moderate Concern (3)</td>
<td>Yellow</td>
</tr>
<tr>
<td>Rhode Island, Rake</td>
<td>Moderately Effective</td>
<td>Highly Effective</td>
<td>Moderately Effective</td>
<td>Moderately Effective</td>
<td>Highly Effective</td>
<td>Moderate Concern (3)</td>
<td>Yellow</td>
</tr>
<tr>
<td>Rhode Island, Dredge</td>
<td>Moderately Effective</td>
<td>Moderately Effective</td>
<td>Moderately Effective</td>
<td>Moderately Effective</td>
<td>Highly Effective</td>
<td>Moderate Concern (3)</td>
<td>Yellow</td>
</tr>
</tbody>
</table>

**Criterion 3 Assessment**

**Factor 3.1 Management Strategy and Implementation**

Considerations: What type of management measures are in place? Are there appropriate management goals, and is there evidence that management goals are being met? Do managers follow scientific advice? To achieve a highly effective rating, there must be appropriately defined management goals, precautionary policies that are based on scientific advice, and evidence that the measures in place have been successful at maintaining/rebuilding species.

**Maine; Hand Rake and Mussel Dredge**

Moderately Effective

Key relevant information:

In Maine, the Department of Marine Resources (MDMR) is responsible for the management of the blue mussel fishery. Regulations for blue mussels were first put in place in 1988 by MDMR and were implemented as an effort to protect the wild populations from the growing aquaculture industry (MDMR 2016a). There is current management in place to regulate the commercial and recreational fishing of blue mussels. A license is required to commercially fish for blue mussels, and fishers must tag mussels with the following information: fisher’s name, license number, date and time of catch, location of catch, and quantity of mussels. Landings of blue mussels cannot be combined with other shellfish (MDMR 2009a) (MDMR 2016a). Regulations restrict mussel drags to have a maximum width of 6.5 feet, and fishing is prohibited with any gear type between sunset and sunrise (MDMR 2009b) (MDMR 2016a). Wild mussels can be fished all year but the majority of fishing occurs in the winter when the meat quality is at its best (MDMR 2016a). There is currently no daily or annual catch limit for participants who fish by hand or with a drag (pers. comm., Pete Thayer 2016).

Management that is believed to be effective is in place, but there have been reported declines of blue mussels in Maine and further monitoring is needed. Management is therefore deemed “moderately effective.”

19
Detailed rationale:
In Maine, to reduce conflict between the wild mussel fishery and the growing aquaculture industry, the Maine Department of Marine Resources designated four “seed conservation areas” from which only seed-size mussels can be taken for growout (MDMR 2016a).

Massachusetts, Hand Rake and Mussel Dredge
Moderately Effective

Key relevant information:
In Massachusetts, a commercial shellfish permit is required to commercially fish for blue mussels, and permits cannot be transferred (MADMF 2016a). In Massachusetts, each town that borders coastal waters has the authority to control and regulate the taking of any kind of shellfish, including mussels (MSOA 2016). Town regulations may include but are not limited to daily limits, size limits, gear restrictions, and temporary and seasonal closures. The Massachusetts Division of Marine Fisheries (MADMF) does have the authority to regulate shellfish taken from contaminated areas (MADMF 2016b).

In Massachusetts, management effectiveness is uncertain due to the lack of monitoring of the blue mussel population, but there is no evidence of declines or overfishing. Management is deemed “moderately effective.”

New York; Hand Rake and Mussel Dredge
Moderately Effective

Key relevant information:
In New York, blue mussel fishing is managed by the New York Department of Environmental Conservation (NYSDEC). A state permit is required to catch blue mussels by hand (typically with a bull rake) and occasionally a town permit is needed as well, depending on the town (NY State Law 2016). A specific permit is required to catch blue mussels with a dredge/drag (pers. comm., Jennifer O’Dwyer 2016). For the commercial fishery, there is a daily limit of 15 bushels per person per day and 30 bushels per boat per day for blue mussels caught with a dredge, but no limit in place for mussels caught by hand (NY State Law 2016) (NYSDEC 2015a). For the recreational fishery, there is limit of one half bushel per day (NYSDEC 2015a). Shellfish are allowed to be fished year-round, but fishing is restricted to daylight hours and can only occur in designated shellfish areas (NYSDEC 2015a).

In New York, management effectiveness is uncertain due to the lack of monitoring of the blue mussel population, but there is no evidence of declines or overfishing. Management is deemed “moderately effective.”
Key relevant information:
In Rhode Island, blue mussel fishing is managed by the Rhode Island Department of Environmental Management (RIDEM) with advice from the Rhode Island Marine Fisheries Council (CRC 2014). Mussels are commercially fished with either hand gear (bull rake) or with a mussel drag (dredge). A specific permit is required to use a mussel drag, and only a small number of fishers currently use this gear type in Rhode Island. A comprehensive Shellfish Management Plan was developed in 2014 by state agencies, the fishing industry, and stakeholders (CRC 2014). This plan established a number of Shellfish Management Areas to help conserve and rebuild shellfish resources. These include the following: Greenwich Bay, Conimicut Point, Potowomut, High Banks, Bissel Cove/Fox Island, Mill Gut, Bristol Harbor, Kickemuit River, Jenny’s Creek, Sakonnet River, Pt. Judith Pond, Potter Pond, Ninigret (Charlestown) Pond, Quonochontaug Pond, and Winnapaug Pond (see map below) (RIDEM 2016d). For commercial blue mussel fishing, there is a limit of 3 bushels within Shellfish Management Areas (with the exception of a 12-bushel limit within Conimicut Point Management Area) and no limit outside of the management areas. For the recreational fishery, within shellfish management areas there is a 1 peck limit (4 pecks = 1 bushel) for RI residents and a half peck limit for nonresidents. Outside of shellfish management areas, there is a half bushel limit for RI residents and a 1 peck limit for non-residents (CRC 2014). Fishing is open year round in most Shellfish Management Areas, with the exception of Bissel Cove/Fox Island and Mill Gut, which are closed for blue mussel fishing from May–November (RIDEM 2016d).

In Rhode Island, management effectiveness is uncertain due to the lack of monitoring of the blue mussel population, but there is no evidence of declines or overfishing. Management is deemed “moderately effective.”
Detailed rationale (optional):

Figure 3. The red shaded areas represent the Shellfish Management Areas in Rhode Island, the yellow shaded areas represent quahog spawner sanctuaries, and the red-striped areas represent shellfish prohibited areas due to pollution issues (as of 2014) (Image from CRC 2014).

**Factor 3.2 Bycatch Strategy**

Considerations: What type of management strategy/measures are in place to reduce the impacts of the fishery on bycatch species and when applicable, to minimize ghost fishing? How successful are these management measures? To achieve a Highly Effective rating, the fishery must have no or low bycatch, or if there are bycatch or ghost fishing concerns, there must be effective measures in place to minimize impacts.

**Maine, Massachusetts, New York and Rhode Island; Hand Rake**

Highly Effective

Key relevant information:
In all regions, mussels form dense beds that allow fishers to selectively target mussels. Therefore, bycatch in blue mussel fisheries is generally low. When fishing with hand rakes, impacts to non-target species are considered negligible because any bycatch species can
typically be returned to the habitat unharmed. Because of negligible bycatch impacts in the hand rake fisheries, management of bycatch is deemed “highly effective.”

Key relevant information:
In all regions, mussels form dense beds that allow fishers to selectively target mussels. Mussel drags (dredges) are typically deployed directly on a mussel bed and then dragged to remove the mussels from the water in large quantities. Bycatch in mussel dredge fisheries is believed to be low, but some non-target invertebrates that live within the mussel beds are scooped up, and could be crushed by the gear or die due to handling disturbance (Mesher and Doidge 1995). In Rhode Island, when fishing for mussels, any scallops, oysters, and quahogs that are caught must be released (CRC 2014). Because bycatch is likely low in the mussel dredge fisheries but impacts to non-target species may not be negligible, management of bycatch is considered “moderately effective.”

**Factor 3.3 Scientific Research and Monitoring**

Considerations: How much and what types of data are collected to evaluate the fishery’s impact on the species? Is there adequate monitoring of bycatch? To achieve a Highly Effective rating, regular, robust population assessments must be conducted for target or retained species, and an adequate bycatch data collection program must be in place to ensure bycatch management goals are met.

Key relevant information:
In Maine, commercial catches of blue mussel are monitored, but there has been little effort to date by the management agency to assess the abundance of the blue mussel population. In Maine, the only full population assessment was completed in the late 1970s from the Damariscotta River Estuary to Jonesport (MARITEC 1978) (pers. comm., Pete Thayer 2016). In the 1980s and 1990s, there were some aerial photo surveys and field sampling conducted by the Maine Department of Marine Resources to assess the seed mussel conservation areas prior to permitting seed harvest each year. Most recently, there was an independent scientific study that compared recent blue mussel abundance estimates in the Gulf of Maine to historical estimates (Sorte et al. 2016). This study found declines at all studied sites, indicating that further monitoring is needed to ensure the health of the blue mussel population. Currently, the Department of Marine Resources (MDMR) is working to design a survey in the Jordan River in Frenchman’s Bay to sample the blue mussel population with drones, and there is some preliminary monitoring underway. These survey methods could potentially be used to conduct blue mussel population assessments in the future; however, the work is still in the preliminary stages (pers. comm., Pete Thayer 2016). Because only limited data on the blue mussel are currently collected but some efforts are underway to improve monitoring, this factor is deemed “moderately effective.”
**Massachusetts; Hand Rake and Mussel Dredge**  
Ineffective

Key relevant information:
In the state of Massachusetts, there are efforts currently underway to summarize the population status of blue mussels and the commercial fishery (pers. comm., Tom Shields 2016). But these studies have not yet been completed and at this time there is no available information on the blue mussel fishery or population in Massachusetts. Because no data are available at this time, an “ineffective” score is awarded.

**New York; Hand Rake and Mussel Dredge**  
Moderately Effective

Key relevant information:
In New York, there have been little to no efforts to track the population trends of blue mussel because of their assumed healthy distribution and low fishing effort (NYSDEC 2005). But commercial catches of blue mussel are monitored and some management is in place. Given the quite limited scientific monitoring but low fishing effort and management in place, research and monitoring is deemed “moderately effective.”

**Rhode Island; Hand Rake and Mussel Dredge**  
Moderately Effective

Key relevant information:
There have not been any efforts in Rhode Island to evaluate the blue mussel population, and at this time, the only reliable catch information available is in value rather than quantity. Because the fishery is considered to have quite low fishing effort, there has not been a demand or need for management to evaluate the population of blue mussels. Recent shellfish research efforts have been in regard to the growing aquaculture industry in Narragansett Bay, to evaluate shellfish disease and growing methods (CRC 2014). But there is some spatial management in place in Rhode Island to conserve wild blue mussels. Given the quite limited scientific monitoring but low fishing effort and management in place, research and monitoring is deemed “moderately effective.”

**Factor 3.4 Enforcement of Management Regulations**

Considerations: Do fishermen comply with regulations, and how is this monitored? To achieve a Highly Effective rating, there must be regular enforcement of regulations and verification of compliance.

**Maine, Massachusetts, New York and Rhode Island; Hand Rake and Mussel Dredge**  
Moderately Effective
**Key relevant information:**
In all states, there is enforcement at the state and town level to ensure that fishers comply with regulations. In Maine, enforcement of the commercial and recreational shellfish fishery is conducted by state officers, including Marine patrol and other law enforcement officers (pers. comm., Pete Thayer 2016). The Marine Patrol is the division of Maine Department of Marine Resources (MDMR) that is responsible for law enforcement on the state’s coastal waters (MDMR 2016d). In the state of Massachusetts, enforcement of commercial and recreational shellfish fishing is conducted by state officers from the Division of Marine Fisheries as well as town officers. In Massachusetts, each city or town that borders coastal waters has the authority to control and regulate the taking of any kind of shellfish, including mussels (MSOA 2016). In Rhode Island, the Division of Law Enforcement Marine Unit is responsible for providing patrol and enforcement of recreational and commercial fishing (RIDEM 2016c). In New York, the Department of Environmental Conservation is responsible for the enforcement of regulations (NYSDEC 2015e). In addition, local towns may require a town permit for shellfish fishing, and have town officers to enforce local and regional regulations (NYSDEC 2015a). Because there is regular enforcement of regulations but effectiveness and compliance are uncertain, enforcement is deemed “moderately effective.”

**Factor 3.5 Stakeholder Inclusion**
*Considerations: Are stakeholders involved/included in the decision-making process?*
*Stakeholders are individuals/groups/organizations that have an interest in the fishery or that may be affected by the management of the fishery (e.g., fishermen, conservation groups, etc.). A Highly Effective rating is given if the management process is transparent, if high participation by all stakeholders is encouraged, and if there a mechanism to effectively address user conflicts.*

**Maine; Hand Rake and Mussel Dredge**
**Highly Effective**

**Key relevant information:**
In Maine, the Shellfish Advisory Council includes 13 members who have various stakeholder interests in the shellfish fishery. The council consists of four commercial shellfish license holders, two aquaculture lease holders, one member from the wastewater treatment systems, two licensed seafood dealers, one public member, two shellfish wardens, and one member with a shellfish depuration certificate. The council meets at least once a year (typically three times) to discuss shellfish issues and make recommendations to managers as necessary (Maine Legislature 2016). The meetings are open to the public and allow for public input on the topics discussed. Stakeholder inclusion is considered “highly effective.”

**Massachusetts; Hand Rake and Mussel Dredge**
**Highly Effective**

**Key relevant information:**
In Massachusetts, shellfish management is through the local city and individual town shellfish constables (MSOA 2016). In general, there are Shellfish Committee Meetings held at various
times and locations (depending on the town). The shellfish meetings include various stakeholders in the industry and are also open to the public. Stakeholder inclusion is considered “highly effective.”

**New York; Hand Rake and Mussel Dredge**
**Highly Effective**

**Key relevant information:**
In New York, there is the Marine Resource Advisory Council (MRAC) that was established in 1987 to advise the Department of Environmental Conservation (NYSDEC) on marine resource issues, including commercial and recreational fishing regulations and protection (NYSDEC 2016d). The MRAC holds meetings to present information and answer questions regarding current marine resource issues, including shellfish (NYSDEC 2016d). The council is made up of 15 people including 7 commercial fishing representatives, 7 recreational fishing representatives, and the Director of the Marine Science Research Center from SUNY Stony Brook (NYSDEC 2016d). These meetings are also open to the public. There is also a Shellfish Advisory Committee that meets twice a year to discuss shellfish issues specifically and includes state and town representatives, baymen’s associations representatives, and members of nonprofit organizations (pers. comm., Jennifer O’Dwyer 2016). The Department of Environmental Conservation lists meetings open to the public and information about any proposed regulations on their website (NYSDEC 2016c). In addition, because shellfish are also managed at the town level, town meetings are occasionally held to present current regulations and issues. For example, the town of Southold, NY has an individual Shellfish Advisory Committee that represents members of the town before the state (Southold Town Hall 2016). Stakeholder inclusion is considered “highly effective.”

**Rhode Island; Hand Rake and Mussel Dredge**
**Highly Effective**

**Key relevant information:**
In Rhode Island, the Shellfish Advisory Panel is a division of the Rhode Island Marine Fisheries Council (RIMFC) and includes members with various stakeholder interests in the shellfish industry. All meetings by the RIMFC are open to the public and include a period for public comment. Prior to meetings, the RIDEM gives notice of intent to hold the hearing to provide the opportunity for public comment (RIDEM 2016a). Stakeholder inclusion is considered “highly effective.”
Criterion 4: Impacts on the Habitat and Ecosystem

This Criterion assesses the impact of the fishery on seafloor habitats, and increases that base score if there are measures in place to mitigate any impacts. The fishery’s overall impact on the ecosystem and food web and the use of ecosystem-based fisheries management (EBFM) principles is also evaluated. Ecosystem Based Fisheries Management aims to consider the interconnections among species and all natural and human stressors on the environment. The final score is the geometric mean of the impact of fishing gear on habitat score and the Ecosystem Based Fishery Management score. The Criterion 4 rating is determined as follows:

- Score >3.2=Green or Low Concern
- Score >2.2 and <=3.2=Yellow or Moderate Concern
- Score <=2.2=Red or High Concern

Criterion 4 Summary

<table>
<thead>
<tr>
<th>Fishery</th>
<th>Factor 4.1a Impact of Gear Type on Habitat/Substrate</th>
<th>Factor 4.1b Mitigation of Gear Impacts</th>
<th>Factor 4.2 Ecosystem Based Fisheries Management</th>
<th>Criterion 4 Score</th>
<th>Criterion 4 Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maine, Rake</td>
<td>3</td>
<td>0</td>
<td>Moderate Concern (3)</td>
<td>3</td>
<td>Yellow</td>
</tr>
<tr>
<td>Maine, Dredge</td>
<td>2</td>
<td>+0.5</td>
<td>Moderate Concern (3)</td>
<td>2.74</td>
<td>Yellow</td>
</tr>
<tr>
<td>Massachusetts, Rake</td>
<td>3</td>
<td>0</td>
<td>Moderate Concern (3)</td>
<td>3</td>
<td>Yellow</td>
</tr>
<tr>
<td>Massachusetts, Dredge</td>
<td>2</td>
<td>0</td>
<td>Moderate Concern (3)</td>
<td>2.45</td>
<td>Yellow</td>
</tr>
<tr>
<td>New York, Rake</td>
<td>3</td>
<td>0</td>
<td>Moderate Concern (3)</td>
<td>3</td>
<td>Yellow</td>
</tr>
<tr>
<td>New York, Dredge</td>
<td>2</td>
<td>+0.5</td>
<td>Moderate Concern (3)</td>
<td>2.74</td>
<td>Yellow</td>
</tr>
<tr>
<td>Rhode Island, Rake</td>
<td>3</td>
<td>0</td>
<td>Moderate Concern (3)</td>
<td>3</td>
<td>Yellow</td>
</tr>
<tr>
<td>Rhode Island, Dredge</td>
<td>2</td>
<td>+0.5</td>
<td>Moderate Concern (3)</td>
<td>2.74</td>
<td>Yellow</td>
</tr>
</tbody>
</table>
Criterion 4 Assessment

Factor 4.1a Physical Impact of Fishing Gear on the Habitat/Substrate

Scoring Guidelines

- 5 — Fishing gear does not contact the bottom
- 4 — Vertical line gear
- 3 — Gears that contacts the bottom, but is not dragged along the bottom (e.g. gillnet, bottom longline, trap) and is not fished on sensitive habitats. Or bottom seine on resilient mud/sand habitats. Or midwater trawl that is known to contact bottom occasionally. Or purse seine known to commonly contact the bottom.
- 2 — Bottom dragging gears (dredge, trawl) fished on resilient mud/sand habitats. Or gillnet, trap, or bottom longline fished on sensitive boulder or coral reef habitat. Or bottom seine except on mud/sand. Or there is known trampling of coral reef habitat.
- 1 — Hydraulic clam dredge. Or dredge or trawl gear fished on moderately sensitive habitats (e.g., cobble or boulder)
- 0 — Dredge or trawl fished on biogenic habitat, (e.g., deep-sea corals, eelgrass and maerl)

Note: When multiple habitat types are commonly encountered, and/or the habitat classification is uncertain, the score will be based on the most sensitive, plausible habitat type.

Maine, Massachusetts, New York and Rhode Island; Hand Rake

3

Key relevant information:
Blue mussels can be fished by hand with the use of a rake, and most commonly with a bull rake. A bull rake is a relatively heavy and robust rake weighing 8–11 kg with a metal basket at the end. The basket has a rectangular opening with teeth extending outward along the lower portion of the basket. Hand raking for blue mussels occurs in intertidal shallow zones. As the rake is pulled along the sediment, the mussels are forced into the basket, and when heavy, the rake is removed from the water (Peterson et al. 1983). There are no known studies on the effects of hand rakes on mussel beds, but there have been studies conducted on the effects of fishing with clam rakes and oyster tongs on oyster reefs (Lenihan and Micheli 2000), which produce similar habitats and substrate as mussel beds. One study reported that fishing with clam rakes and oyster tongs reduced the densities of living oysters by 50%–80% compared to densities of unfished oyster reefs (Lenihan and Micheli 2000). A subsequent study showed that the use of hand tongs (a fishing method similar to hand rakes) decreased the height of oyster reef habitats by 23% (Lenihan and Peterson 2004). Hand rake gear receives a score of “3” for this factor.
Key relevant information:
A mussel drag or dredge is a framed mouth with an attached bag to collect mussels. It is dragged by a boat along the ocean bottom (MDMR 2016a). Along the bottom of the framed mouth is a cutting bar or chain sweep to loosen mussels while the dredge is pulled across the bottom, and mussels are dislodged and accumulate in the bag (MDMR 2016a). Mussel dredges are small, restricted in size, and not hydraulic, so they have less of an impact on the bottom habitat and substrate compared to other dredging gear (Smolowitz 1998) (Sowles 2011). The majority of fishing for blue mussels with dredges occurs over intertidal and subtidal mudflats in nearshore bays, where the bottom sediment is mostly mud; however, some sediment also has sand and shells mixed within the mud. These portions of muddy nearshore bays may be adjacent to and interspersed with eelgrass (Moore and Atherton 2005) (Neckles et al. 2005).

Dredging can cause disturbances to bottom plants and animals, decreases in water quality, overfishing of adult mussels and seed mussels, and alterations to bay drainage, and can lead to a loss of food for birds and other organisms that depend on mussels (Arter 2007). Mussel dredges can be especially harmful to sensitive habitats, such as horseshoe crab wintering areas, kelp beds, eelgrass beds, aquaculture leases, and where there are intake or outflow pipes (Sowles 2011). In the past, because of the habitat overlap of blue mussels and eelgrass, dredging has caused damage to eelgrass beds in regions such as Maquoit Bay, Maine (Neckles et al. 2005). There was a growing concern about the impacts of dredging on eelgrass beds in Maquoit Bay, so a study was commenced in 2000 to identify these effects using aerial surveys, underwater video, and measurements of eelgrass. The study showed that dredging for blue mussels in Maquoit Bay, Maine in the 1990s left scars on eelgrass beds and did affect the eelgrass populations. It was found that mussel dredges can uproot eelgrass plants and that it would take 11–20 years for dragged areas to completely recover (USGS 2005) (Neckles et al. 2005). As a result, in 2007, the Maine Department of Marine Resources (MDMR) initiated research with the fishing industry to identify and protect habitat areas that are sensitive to the effects of mussel dredges (MDMR 2009a) (Sowles 2011).

Mussel dredge gear receives a score of “2” for this factor because most fishing today occurs over soft-bottom mud habitats.

Factor 4.1b Modifying factor: Mitigation of gear impacts

Scoring Guidelines
- +1 → >50% of the habitat is protected from fishing with the gear type. Or fishing intensity is very low/limited and for trawled fisheries, expansion of fishery’s footprint is prohibited. Or gear is specifically modified to reduce damage to seafloor and modifications have been shown to be effective at reducing damage. Or there is an effective combination of ‘moderate’ mitigation measures.
• +0.5 — At least 20% of all representative habitats are protected from fishing with the gear type and for trawl fisheries, expansion of the fishery’s footprint is prohibited. Or gear modification measures or other measures are in place to limit fishing effort, fishing intensity, and spatial footprint of damage caused from fishing that are expected to be effective.

• 0 — No effective measures are in place to limit gear impacts on habitats or not applicable because gear used is benign and received a score of 5 in 4.1

**Maine, Massachusetts, New York and Rhode Island; Hand Rake**

0

Key relevant information:
There are a few areas closed to any fishing of mussels, including with the use of hand gear. For instance, there are several permanent and temporary closures in place for sanitation reasons. In Rhode Island, some of the designated Shellfish Management Areas are closed to commercial fishing between May and November each year (CRC 2014). Because the areas closed to blue mussel hand rake fishing are unlikely to cover 20% of all representative blue mussel habitats, no mitigation points are awarded.

**Maine; Mussel Dredge**

+0.5

Key relevant information:
In Maine, there have been studies conducted on the effects of mussel dredges on the habitat; as a result, closures have been put in place to protect sensitive habitats such as eelgrass beds (MDMR 2009a). The 2007 study by the Maine Department of Marine Resources (MDMR) concluded that dragging is acceptable if the fishery is controlled to protect sensitive habitat areas and non-target resources and to allow for sustainable fishing of blue mussel (Sowles 2011). In Taunton Bay, Maine, there are multiple general shellfish closures in place, including areas closed to dredging for blue mussels. Additionally, in the Taunton Bay Management Area (TBMA), a dredge plan must be submitted and approved by the Commissioner prior to fishing for mussels (MDMR 2012). In TBMA, mussel dredging is prohibited in areas that are considered “sensitive areas,” which include but are not limited to horseshoe crab wintering areas, kelp beds, eelgrass beds, aquaculture leases, and intake or outflow pipes (MDMR 2012). See Figure 4 in the following “Detailed Rationale” for a map of no fishing areas in the TBMA. There are also other areas closed to any fishing of mussels (MDMR 2012). Additionally, because mussel dredges are small and restricted in size (MDMR 2016b), they have less of an impact on the bottom habitat and substrate compared to other dredging gear, such as a scallop dredge (Sowles 2011). Because of the protection of vulnerable habitats and characteristics of the gear, mitigation is considered moderate and “+0.5” point is awarded.
Figure 4. The no-fishing areas for mussel dragging in Taunton Bay Management Area. The eelgrass areas plotted are where persistent eelgrass beds are found (Map from MDMR 2012).

**Massachusetts; Mussel Dredge**

0

**Key relevant information:**

There is no available information on the intensity of mussel dredge fishing in Massachusetts. Therefore, no mitigation points are awarded.

**New York; Mussel Dredge**

+0.5

**Key relevant information:**

In New York, blue mussels can be taken with dredge gear in the following areas: in Long Island Sound east of a line from Herod Point on Long Island including the waters surrounding Fishers Island; the Atlantic Ocean easterly of a line south from the rock jetty on the east side of Shinecock Inlet; and in the bays east from the town of Riverbed to and including Block Island Sound (New York State Law 2016). In New York, fishing intensity with the use of mussel dredges is relatively low. During 2014–2016, only nine dredge permits were issued each year (pers. comm., Jennifer O’Dwyer 2016). In New York, mussel dredges are restricted in size and cannot exceed 36 inches in width (New York State Law 2016). Because of the low fishing effort and the area and size restrictions for dredge gear in New York, the mitigation is considered moderate and “+0.5” point is awarded.
Key relevant information:
In Rhode Island, a specific dredging permit is required to fish with a mussel drag. In certain areas, there are additional regulations in place to restrict the times when mussel dredges can be used. Some Shellfish Management Areas are designated to be open year-round, while some areas closed to commercial harvest between May and November each year and opened from December–April (CRC 2014). Specifically, in Bissel Cove/Fox Island, Mill Gut, and Bristol Harbor, blue mussel fishing with a dredge is only allowed from the second Wednesday of December to April 30th annually. Areas other than Shellfish Management Areas are open daily for blue mussel fishing unless specifically closed for pollution or other management purposes (RIDEM 2016d). Additionally, because mussel dredges are small, they have less of an impact on the bottom habitat and substrate compared to other dredging gear, such as a scallop dredge (Sowles 2011). Because of the characteristics of the gear, low fishing effort, and some seasonal closures, mitigation is considered moderate and “+0.5” point is awarded.

Factor 4.2 Ecosystem-based Fisheries Management

Scoring Guidelines

- 5 (Very Low Concern)—Policies that have been shown to be effective are in place to protect species’ ecological roles and ecosystem functioning (e.g. catch limits that ensure species’ abundance is maintained at sufficient levels to provide food to predators) and effective spatial management is used to protect spawning and foraging areas, and prevent localized depletion. Or it has been scientifically demonstrated that fishing practices do not have negative ecological effects.
- 4 (Low Concern)—Policies are in place to protect species’ ecological roles and ecosystem functioning that are believed to be effective but conclusive scientific evidence is not yet available and at least some spatial management is used.
- 3 (Moderate Concern) — Some policies (e.g. spatial management) are in place to protect species’ ecological roles and ecosystem functioning but further efforts are required. Or policies are not in place to protect species’ ecological roles and ecosystem functioning but detrimental food web impacts are not likely.
- 2 (High Concern)— Policies are not in place to protect species’ ecological roles and ecosystem functioning and the likelihood of detrimental food impacts are likely (e.g. trophic cascades, alternate stable states, etc.), but conclusive scientific evidence is not available for this fishery.
- 1 (Very High Concern)—Scientifically demonstrated trophic cascades, alternate stable states or other detrimental food web impact are resulting from this fishery.
**Key relevant information:**
Blue mussels are considered ecosystem engineers, because they form dense beds that act as shelter and substrate for a diversity of invertebrate species in the intertidal regions where they are found (Arribas et al. 2014). These beds provide settlement substrate for other marine species including hydroids, bryozoans, and sponges. They also provide a refuge from predation and physical stressors for many species (Altieri and Witman 2006) (Bertness 2007) (Borthagaray and Carranza 2007). In fact, blue mussel abundance has been found to be positively correlated to overall species richness (Borthagaray and Carranza 2007) (Sorte et al. 2016). Blue mussels are also an important food source for many bottom feeders (NEFMC 2011). A recent study showed that as blue mussels have declined at certain sites in the Gulf of Maine over the past 40 years, there have been other associated community level changes (Sorte et al. 2016). Specifically, the study found an increase in competitors of blue mussel (barnacle, *S. balanoides*) and decrease in predator species (whelk, *N. lapillus*) as the blue mussel has become less dominant in these areas (Sorte et al. 2016).

Further, the blue mussel’s function as a filter feeder is an ecologically important role in the ecosystem. As blue mussels filter out plankton from the seawater for food, this helps to clean bacteria and other organic matter from the water column (Bayne 1983). Mussel beds also provide shoreline protection by reducing wave strength and slowing shoreline erosion (CRC 2014).

Limited policies are in place to protect the ecological role of blue mussels, but in recent years states have been making some strides to evaluate and move toward ecosystem-based approaches. A study was recently completed by the Maine Department of Marine Resources (MDMR) in Taunton Bay to test an ecosystem-based management model and to potentially help inform future ecosystem approaches; as a result of this study, mussel dragging was prohibited in identified sensitive areas of Taunton Bay (Sowles 2011). Rhode Island has developed a comprehensive Shellfish Management Plan, which describes the ecological importance of shellfish species, including mussels, and designates Shellfish Management Areas to promote the conservation and restoration of shellfish populations. Shellfish Management Areas have reduced daily limits, and some areas have limited access (CRC 2014). New York and Massachusetts have developed Ocean Management Plans that seek to utilize an ecosystem-based approach to sustainably manage resources in their state waters (NYSEDEC 2015b) (MAEEA 2016).

Because the removal of blue mussels due to fishing is likely to affect food webs and the ecosystem as a whole, but some ecosystem/spatial management initiatives have been developed and fishing levels on blue mussels are low in most states, the overall impact is scored as “moderate” concern.
Acknowledgements

Scientific review does not constitute an endorsement of The Safina Center or Seafood Watch® programs, or its seafood recommendations, on the part of the reviewing scientists. The Safina Center and Seafood Watch® are solely responsible for the conclusions reached in this report.

We would like to thank Pete Thayer with Maine Department of Marine Resources, Cascade Sorte with University of California Irvine, Jennifer O’Dwyer with the New York Division of Marine Resources as well as one anonymous reviewer for graciously reviewing this report for scientific accuracy and clarity.
References


http://www.seagrant.umaine.edu/hosting/TB/07TBplan.pdf


https://www.researchgate.net/profile/Alvar_Carranza/publication/222422971_Mussels_as_ecosystem_engineers_their_contribution_to_species_richness_in_a_rocky_littoral_community._Acta_Oecol_/links/0912f50b37b0763df8000000.pdf


http://link.springer.com/article/10.1023%2FA%3A1014549026157


39


Schumann, S. 2015. Rhode Island’s Shellfish Heritage: An Ecological History. Coastal Resources Center and Rhode Island Sea Grant, Narragansett, RI. http://shellfishheritage.seagrant.gso.uri.edu/RI_Shellfish_Heritage_complete/


Thompson, R.J. 1979. Fecundity and reproductive effort in the blue mussel (Mytilus edulis), the sea urchin (Strongylocentrotus droebachiensis), and the snow crab (Chionoecetes opilio) from populations in Nova Scotia and Newfoundland. J. Fish. Res. Board Canada. 36:955-964.
