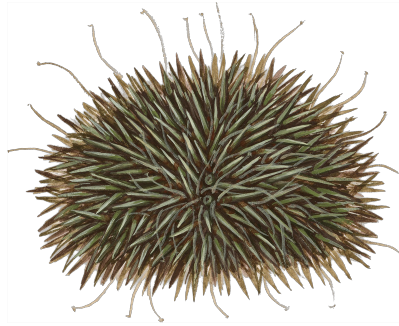




# Monterey Bay Aquarium Seafood Watch

## **Green Sea Urchin** *Strongylocentrotus droebachiensis*



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### **United States: Maine**

### **Diving, Hand Implements, Towed Dredges**

*Report ID 27935*

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Seafood Watch Standard used in this assessment: Fisheries Standard v3

#### **Disclaimer**

All Seafood Watch fishery assessments are reviewed for accuracy by external experts in ecology, fisheries science, and aquaculture. Scientific review does not constitute an endorsement of the Seafood Watch program or its ratings on the part of the reviewing scientists. Seafood Watch is solely responsible for the conclusions reached in this assessment.

## Table of Contents

Table of Contents	2
About Seafood Watch	3
Guiding Principles	4
Summary	5
Final Seafood Recommendations	6
Introduction	8
Criterion 1: Impacts on the species under assessment	12
Criterion 1 Summary	12
Criterion 1 Assessments	12
Criterion 2: Impacts on Other Species	18
Criterion 2 Summary	19
Criterion 2 Assessment	21
Criterion 3: Management Effectiveness	25
Criterion 3 Summary	25
Criterion 3 Assessment	26
Criterion 4: Impacts on the Habitat and Ecosystem	30
Criterion 4 Summary	30
Criterion 4 Assessment	31
Acknowledgements	34
References	35
Appendix A: Review Schedule	35
Appendix B: Report Update	36

## **About Seafood Watch**

Monterey Bay Aquarium's Seafood Watch program evaluates the environmental 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. 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.

Seafood Watch's science-based ratings are available at [www.SeafoodWatch.org](http://www.SeafoodWatch.org). Each rating is supported by a Seafood Watch assessment, in which the fishery or aquaculture operation is evaluated using the Seafood Watch standard.

Seafood Watch standards are built on our guiding principles, which outline the necessary environmental sustainability elements for fisheries and aquaculture operations. The guiding principles differ across standards, reflecting the different impacts of fisheries and aquaculture.

- Seafood rated Best Choice comes from sources that operate in a manner that's consistent with our guiding principles. The seafood is caught or farmed in ways that cause little or no harm to other wildlife or the environment.
- Seafood rated Good Alternative comes from sources that align with most of our guiding principles. However, one issue needs substantial improvement, or there's significant uncertainty about the impacts on wildlife or the environment.
- Seafood rated Avoid comes from sources that don't align with our guiding principles. The seafood is caught or farmed in ways that have a high risk of causing harm to wildlife or the environment. There's a critical conservation concern or many issues need substantial improvement.

Each assessment follows an eight-step process, which prioritizes rigor, impartiality, transparency and accessibility. They are conducted by Seafood Watch scientists, in collaboration with scientific, government, industry and conservation experts and are open for public comment prior to publication. Conditions in wild capture fisheries and aquaculture operations can change over time; as such assessments and ratings are updated regularly to reflect current practice.

More information on Seafood Watch guiding principles, standards, assessments and ratings are available at [www.SeafoodWatch.org](http://www.SeafoodWatch.org).

## Guiding Principles

Seafood Watch defines sustainable seafood as originating from sources, whether fished<sup>1</sup> or farmed, that can maintain or increase production in the long term without jeopardizing the structure or function of affected ecosystems.

The following guiding principles illustrate the qualities that fisheries must possess to be considered sustainable by the Seafood Watch program (these are explained further in the Seafood Watch Standard for Fisheries):

- Follow the principles of ecosystem-based fisheries management.
- Ensure all affected stocks are healthy and abundant.
- Fish all affected stocks at sustainable levels.
- Minimize bycatch.
- Have no more than a negligible impact on any threatened, endangered, or protected species.
- Managed to sustain the long-term productivity of all affected species.
- Avoid negative impacts on the structure, function, or associated biota of aquatic habitats where fishing occurs.
- Maintain the trophic role of all aquatic life.
- Do not result in harmful ecological changes such as reduction of dependent predator populations, trophic cascades, or phase shifts.
- Ensure that any enhancement activities and fishing activities on enhanced stocks do not negatively affect the diversity, abundance, productivity, or genetic integrity of wild stocks.

These guiding principles are operationalized in the four criteria in this standard. 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, Seafood Watch develops an overall recommendation. Criteria ratings and the overall recommendation are color coded to correspond to the categories on the Seafood Watch pocket guides and online guide:

**Best Choice/Green:** Buy first; they're well managed and caught or farmed responsibly.

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

**Avoid/Red:** Take a pass on these for now; they're caught or farmed in ways that harm other marine life or the environment.

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<sup>1</sup> "Fish" is used throughout this document to refer to finfish, shellfish and other invertebrates

## **Summary**

This report provides recommendations for the U.S. Atlantic fishery for green sea urchin (*Strongylocentrotus droebachiensis*). Green sea urchin is found in kelp forest and rocky reef habitats. U.S. fisheries for this species operate primarily in the coastal waters of New England. This report focuses on the Maine fishery, which accounts for 98% of U.S. landings.

### Criterion 1

Maine sea urchin stocks were severely overfished in the late 1980s to early 1990s, and current stocks are estimated to be less than 10% of virgin biomass. Historically, fisheries-induced ecosystem state changes have been documented in this fishery due to overfishing.

### Criterion 2

Fishery impacts on other species are low for all diver and hand collection fisheries, which are highly selective. By-catch in the drag fishery has not been explicitly studied, although the limited data do show catch of various species of benthic invertebrates. The Unknown Bycatch Matrix is used to supplement these data, indicating that corals and other biogenic habitats and finfish are also likely caught, with corals and other biogenic habitats as the driver for this criterion (lowest score).

### Criterion 3

Fishing mortality is controlled through a limited number of fishing days, combined with a daily landings limit. A stock assessment model using fishery-independent data was in place until 2013, when managers stopped using it due to concerns about poor fit to the data. Fishery-independent data are still collected and are currently used to make general management recommendations while the stock assessment model is being revised. Management effectiveness would be expected to improve with the re-implementation of a more robust stock assessment model. Stock abundances have shown an increasing trend since 2013, though stock monitoring over a longer time period is needed to determine if the stock is recovering. Appropriate measures are in place to verify compliance with regulations, and they involve stakeholders in the decision-making process. But overall, management has been ineffective at rebuilding the historically overfished urchin population.

### Criterion 4

The habitat impacts of the diver fisheries are minimal, because harvest is done by hand. The habitat impacts of urchin drags on rocky reef habitat are a higher concern, and there are no measures in place to mitigate these impacts. Urchin is also a key grazer in kelp ecosystems, and there is evidence that historical overfishing has led to ecosystem state changes. The pre-fishing ecosystem was already altered through the depletion of sea urchin predators; however, it is unclear whether the current alternate state is detrimental.

## Final Seafood Recommendations

SPECIES   FISHERY	CRITERION 1 TARGET SPECIES	CRITERION 2 OTHER SPECIES	CRITERION 3 MANAGEMENT	CRITERION 4 HABITAT	OVERALL RECOMMENDATION
Green sea urchin   Northwest Atlantic   Diving   United States   Maine	1.732	5.000	1.000	2.828	<b>Avoid (2.225)</b>
Green sea urchin   Northwest Atlantic   Hand implements   United States   Maine	1.732	5.000	1.000	2.828	<b>Avoid (2.225)</b>
Green sea urchin   Northwest Atlantic   Towed dredges   United States   Maine	1.732	0.750	1.000	1.414	<b>Avoid (1.164)</b>

### Summary

This report provides recommendations for green sea urchin (*Strongylocentrotus droebachiensis*) caught by diver, hand implements, and dredges in Maine. The report was updated in April 2022, but the overall recommendations for all fisheries remained unchanged.

Green sea urchin caught in Maine with all gears is rated as Avoid. The stock is overfished, and the management measures to control fishing levels have not yet been effective at rebuilding the urchin population. The removal of urchin has led to major changes in the ecosystem, but it is unclear if these changes should be considered damaging. There are no by-catch concerns, and habitat impacts are minimal for the diver and hand implement fisheries. There is limited information on by-catch in the dredge fishery, but many species are likely caught. In addition, observer data show high discard rates of undersized or poor-quality urchins, and it is unknown if these survive. Urchin dredges (called “drags”) can have considerable impacts on the seafloor, especially when towed over rocky ledges and boulder habitat.

## 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 no Red Criteria, and no Critical scores

**Good Alternative/Yellow** = Final score >2.2-3.2, and neither Harvest Strategy (Factor 3.1) nor Bycatch Management Strategy (Factor 3.2) are Very High Concern<sup>2</sup>, and no more than one Red Criterion, and no Critical scores

**Avoid/Red** = Final Score  $\leq$ 2.2, or either Harvest Strategy (Factor 3.1) or Bycatch Management Strategy (Factor 3.2) is Very High Concern or two or more Red Criteria, or one or more Critical scores.

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<sup>2</sup> Because effective management is an essential component of sustainable fisheries, Seafood Watch issues an Avoid recommendation for any fishery scored as a Very High Concern for either factor under Management (Criterion 3).

# Introduction

## Scope of the analysis and ensuing recommendation

This report provides recommendations for the U.S. Atlantic fishery for green sea urchin. Green sea urchin is found in kelp forest and rocky reef habitats. U.S. fisheries for this species operate primarily in the coastal waters of New England. Sea urchin is harvested by divers, rakers (i.e., “hand implements”), and vessel-towed urchin drags. This report focuses on the Maine fishery, which accounts for 98% of U.S. landings.

## Species Overview

Green sea urchin (*Strongylocentrotus droebachiensis*) has a large, circumpolar distribution. It is found in northern Europe, northern Japan, and along both coasts of North America. Its European distribution includes Russia, Scandinavia, and the British Isles. On the Atlantic coast of North America, it is found from the Arctic to Cape Cod, Massachusetts. On the Pacific coast, it ranges from Washington to Alaska. Green sea urchin is commercially harvested in Canada, the United States, Iceland, and Norway. The U.S. fisheries for green sea urchin operate along the New England coast. The Maine fishery constitutes over 98% of all landings, while Massachusetts, New Hampshire, and Rhode Island fisheries make up a tiny fraction of total landings. This report focuses on recommendations for the Maine green sea urchin fishery.

The Maine green sea urchin fishery is managed by the Maine State Legislature and the Maine Department of Marine Resources (DMR), with advice from the Maine Sea Urchin Zone Council, which consists of representatives from harvesters, buyers, processors, aquaculture, and researchers. The fishery is currently a closed-entry fishery with a limited number of licenses. There is a limited fishing season, and there are minimum and maximum size limits, and daily landings limits. There are two exclusive harvesting zones (Figure 1), which have different fishing seasons and landings limits. The fishery consists of hand-harvesting by scuba divers and low-tide “rakers,” and by the use of vessel-towed urchin drags. The diver and urchin dragger dominate this fishery; only one or two low-tide rakers currently operate, and their daily landings are much smaller than that of the divers and dragers.

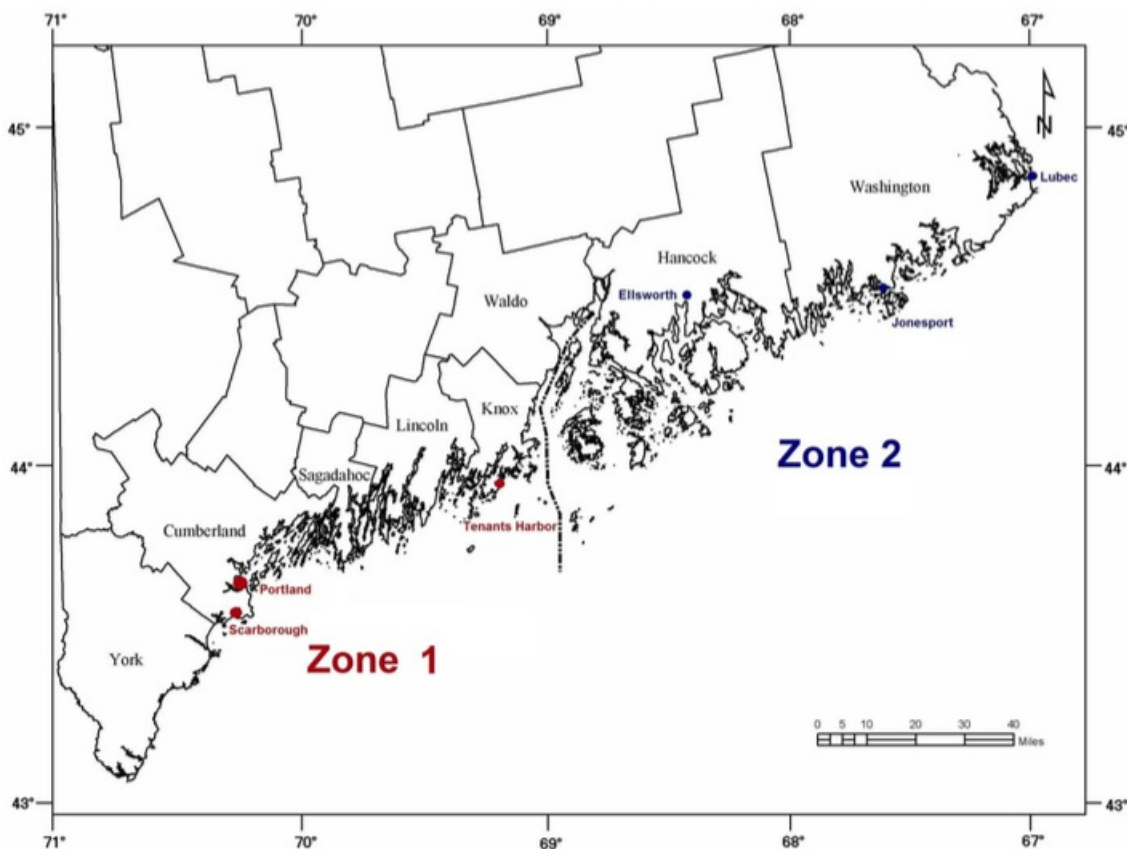


Figure 1. The two harvest zones for green sea urchin in Maine. Figure from (Hunter 2015).



## Production Statistics

Global production of sea urchins increased rapidly starting in the mid-1970s with the development and expansion of commercial urchin fisheries outside Japan, particularly in Chile and the United States. Global landings peaked in the mid-1990s (Figure 2).

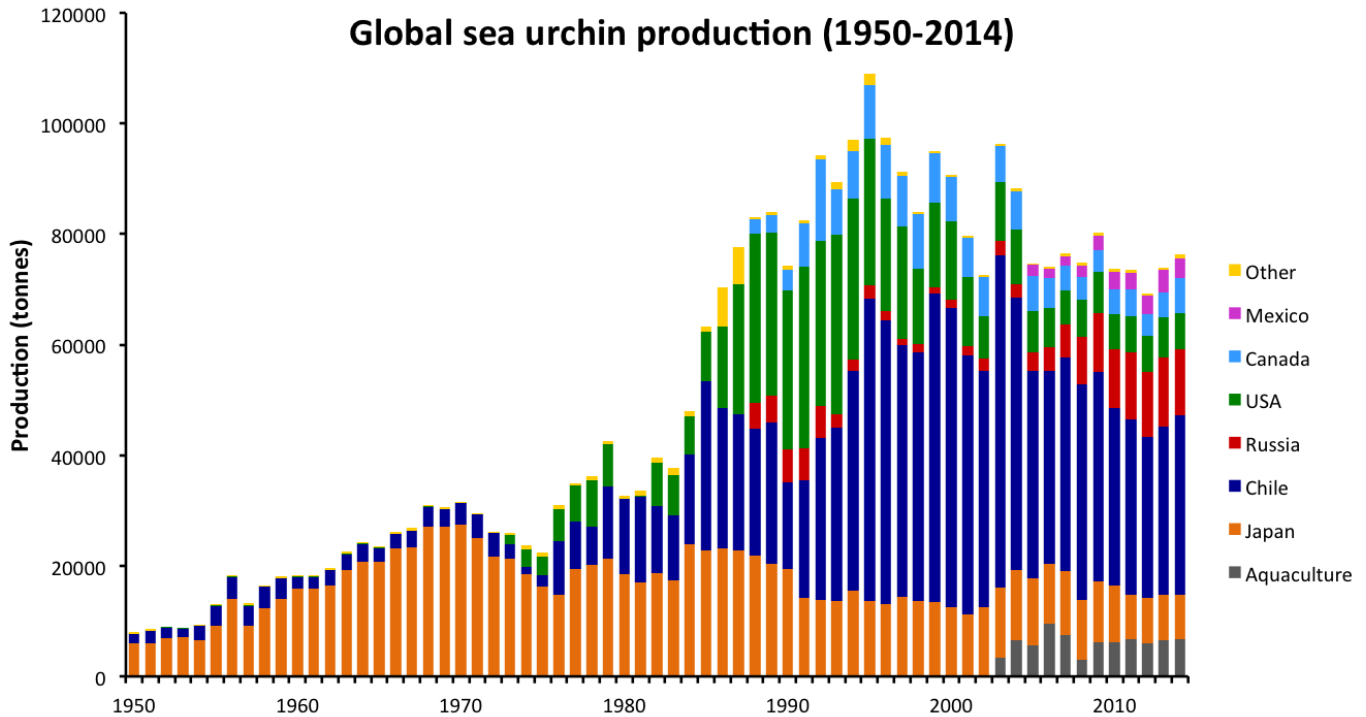


Figure 2. Global sea urchin production by country from 1950 to 2014. This includes multiple sea urchin species. Data from FishStat (2016).

The Chilean fishery dominates global production, and the Chilean sea urchin has made up over half of all landings in the past decade. U.S. sea urchin fisheries (for green and red sea urchins) represent 9% to 12% of global production in the past decade. Sea urchin commercial aquaculture is mostly limited to China, and represents about 10% of global production in the last decade.

In the United States, small fisheries for green sea urchin have existed since the 1930s. Small landings (<100 tons) were recorded annually until 1987, when the fishery expanded rapidly in line with global trends (Figure 3). Maine fisheries have dominated the U.S. production of green sea urchin since its commercialization, and they produce 98% of national landings. Other New England states (Massachusetts, New Hampshire, and Rhode Island) and the Pacific coast states of Alaska and Washington produce the rest. Aquaculture facilities for green sea urchin have existed in the United States since the 1990s, but none of these operations have yet become fully commercialized {Eddy et al. 2015}{Siikavuopio and Mortensen 2015}.

## U.S. landings of green sea urchin

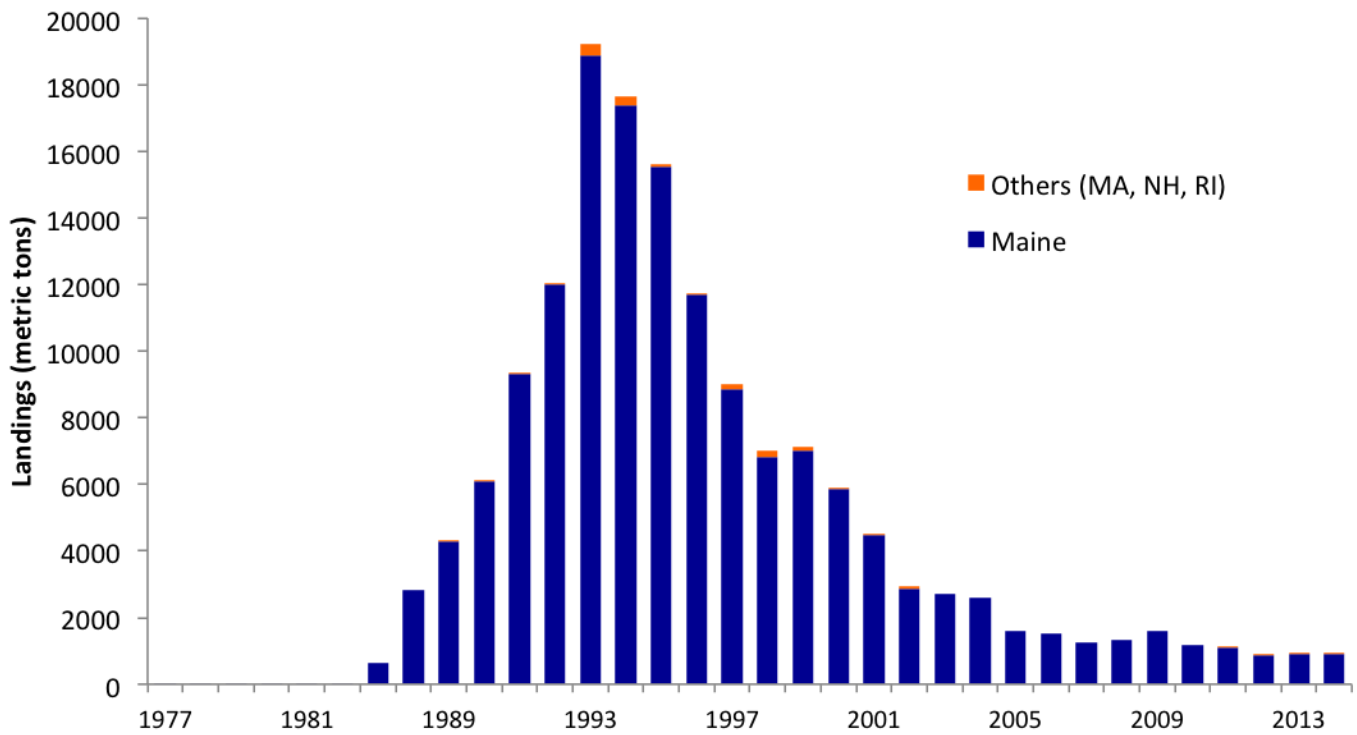


Figure 3. Landings of the green sea urchin (*S. droebachiensis*) from 1977 to 2014 in New England.

### Importance to the US/North American market.

Though most of the U.S. sea urchin production is exported to Japan and other East Asian markets, domestic consumption of sea urchin has grown in recent years (Figure 4). A fraction of sea urchin landings from Maine are processed locally and shipped to various U.S. cities (Sun and Chiang 2015). Sea urchin is also imported into the United States, primarily from Canada and Chile. This includes sea urchin from the nearby Canadian fisheries of New Brunswick and Newfoundland and Labrador, which are processed in Maine and may be re-exported {Pisces Consulting Ltd. 2014}(Sun and Chiang 2015).

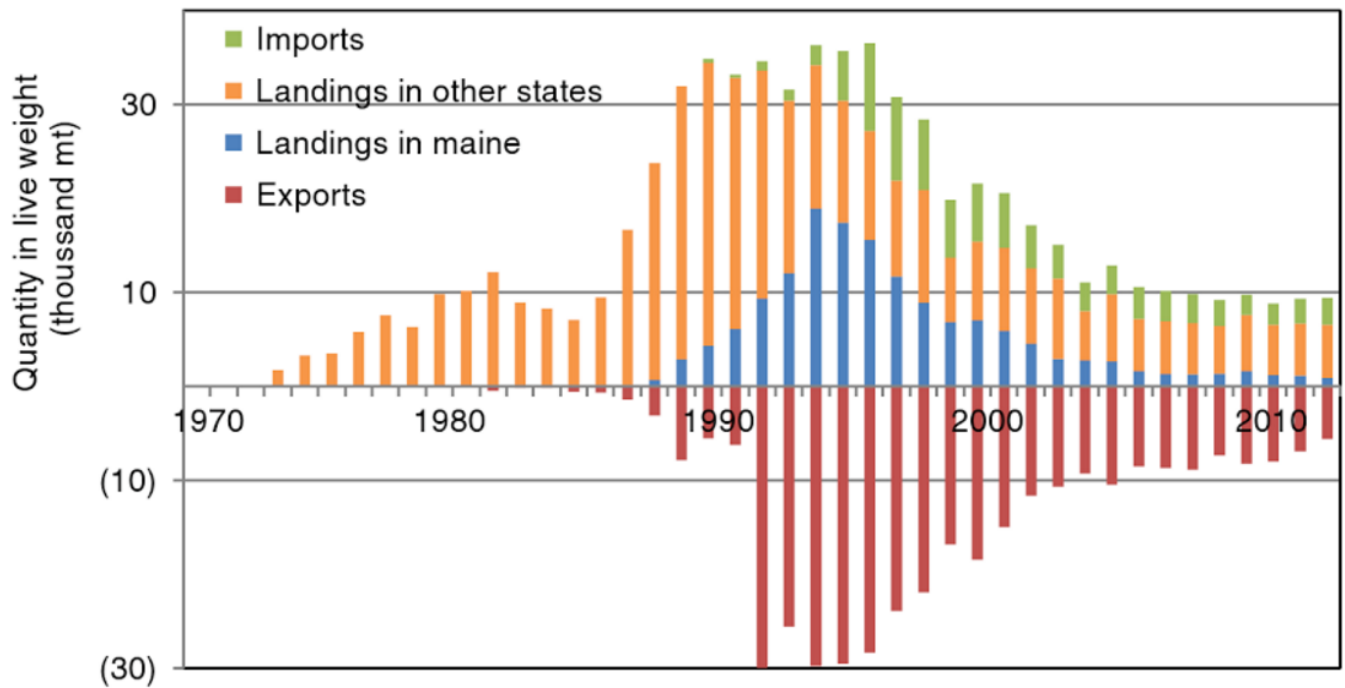


Figure 4. Landings and imports in comparison to exports of sea urchins in the United States, from 1970 to 2012 (Sun and Chiang 2015).

**Common and market names.**

*Strongylocentrotus droebachiensis* is commonly known as the green sea urchin and its roe is marketed as *uni*.

**Primary product forms**

Green sea urchin is harvested for its reproductive organs (gonads) or roe. Sea urchin is typically sold in the form of fresh roe (*uni*), where the test (shell) has been broken and the roe extracted for consumption. It may also be sold as a fresh or live whole animal, with the test and spines intact. A much smaller amount is frozen or preserved for consumption.

## Assessment

This section assesses the sustainability of the fishery(s) relative to the Seafood Watch Standard for Fisheries, available at [www.seafoodwatch.org](http://www.seafoodwatch.org). The specific standard used is referenced on the title page of all Seafood Watch assessments.

### Criterion 1: Impacts 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**

*Rating is Critical if Factor 1.3 (Fishing Mortality) is Critical.*

#### Guiding principles

- *Ensure all affected stocks are healthy and abundant.*
- *Fish all affected stocks at sustainable level*

## Criterion 1 Summary

GREEN SEA URCHIN			
REGION / METHOD	ABUNDANCE	FISHING MORTALITY	SCORE
Northwest Atlantic   Diving   United States   Maine	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Northwest Atlantic   Hand implements   United States   Maine	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Northwest Atlantic   Towed dredges   United States   Maine	1.000: High Concern	3.000: Moderate Concern	Red (1.732)

## Criterion 1 Assessments

### SCORING GUIDELINES

#### Factor 1.1 - Abundance

Goal: Stock abundance and size structure of native species is maintained at a level that does not impair recruitment or productivity.

- *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.*

#### Factor 1.2 - Fishing Mortality

Goal: Fishing mortality is appropriate for current state of the stock.

- *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.*

# Green sea urchin

## Factor 1.1 - Abundance

Northwest Atlantic | Diving | United States | Maine

Northwest Atlantic | Hand implements | United States | Maine

Northwest Atlantic | Towed dredges | United States | Maine

### High Concern

Fisheries-independent biomass surveys and a stock assessment model were used from 2001 to 2013, but the model has not been used since 2013 due to concerns about poor fit to the stock data. Model estimates from the 2013 stock model indicate that  $B_{2013} < \frac{1}{2} B_{MSY}$  for both zones; field biomass surveys show the same trend (Hunter 2015).

A more recent monitoring and assessment report from Maine Department of Marine Resources indicates that sea urchin biomass and abundance in Maine are at time-series lows (Hunter and Russell 2020). Therefore, it is probable that the stock is below the limit reference point, so abundance is scored a high concern.

### Justification:

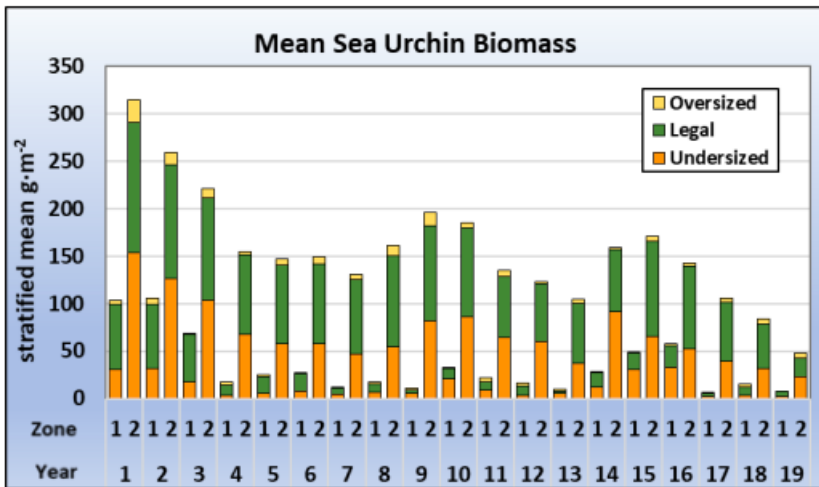
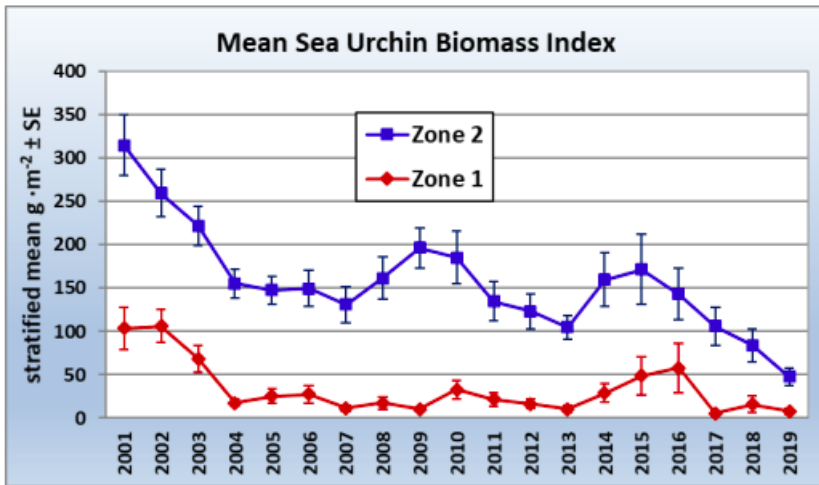


Figure 1: Mean sea urchin biomass (grams per square meter) from the spring dive survey by zone and year with standard errors (upper graph), and by zone, year, and size category (sub-legal or undersized, legal, and oversized) (lower graph) (Hunter and Russell 2020).

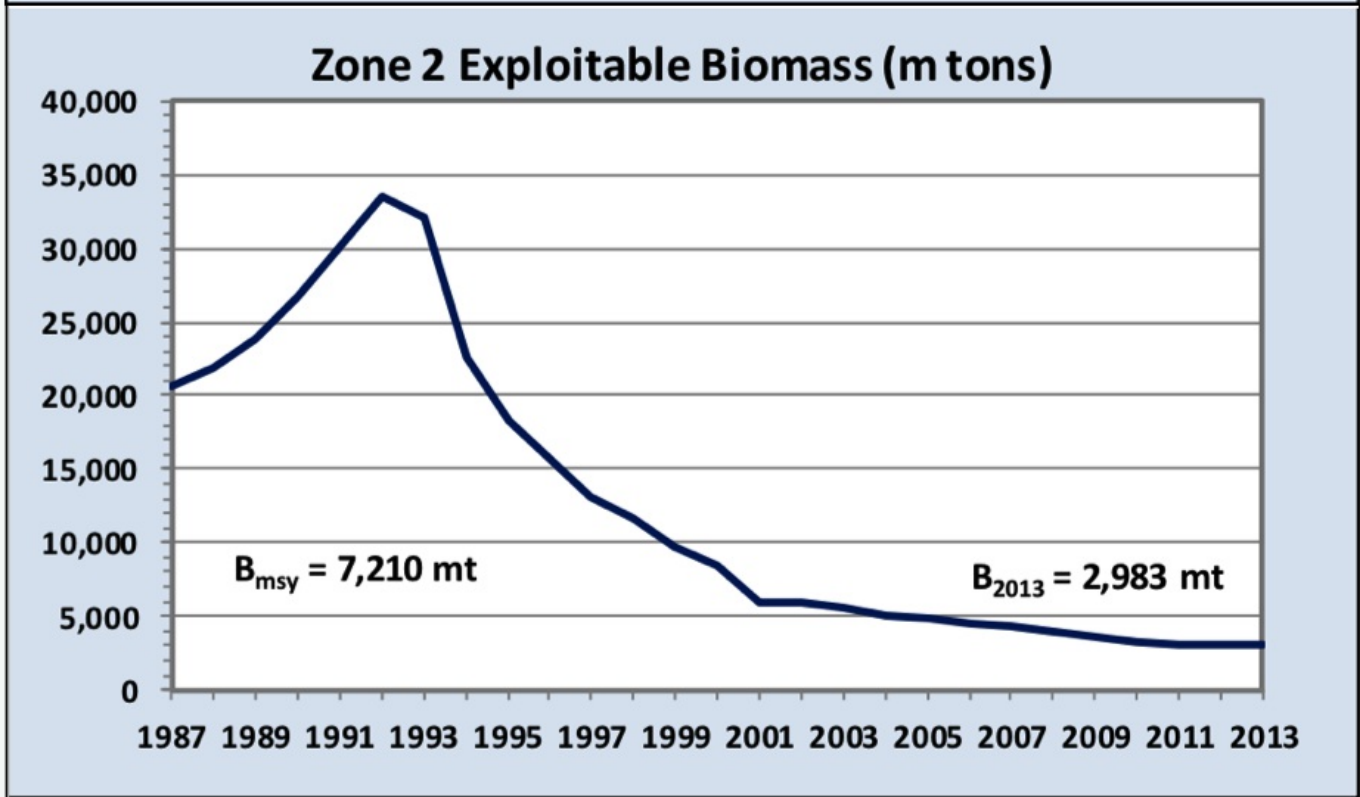
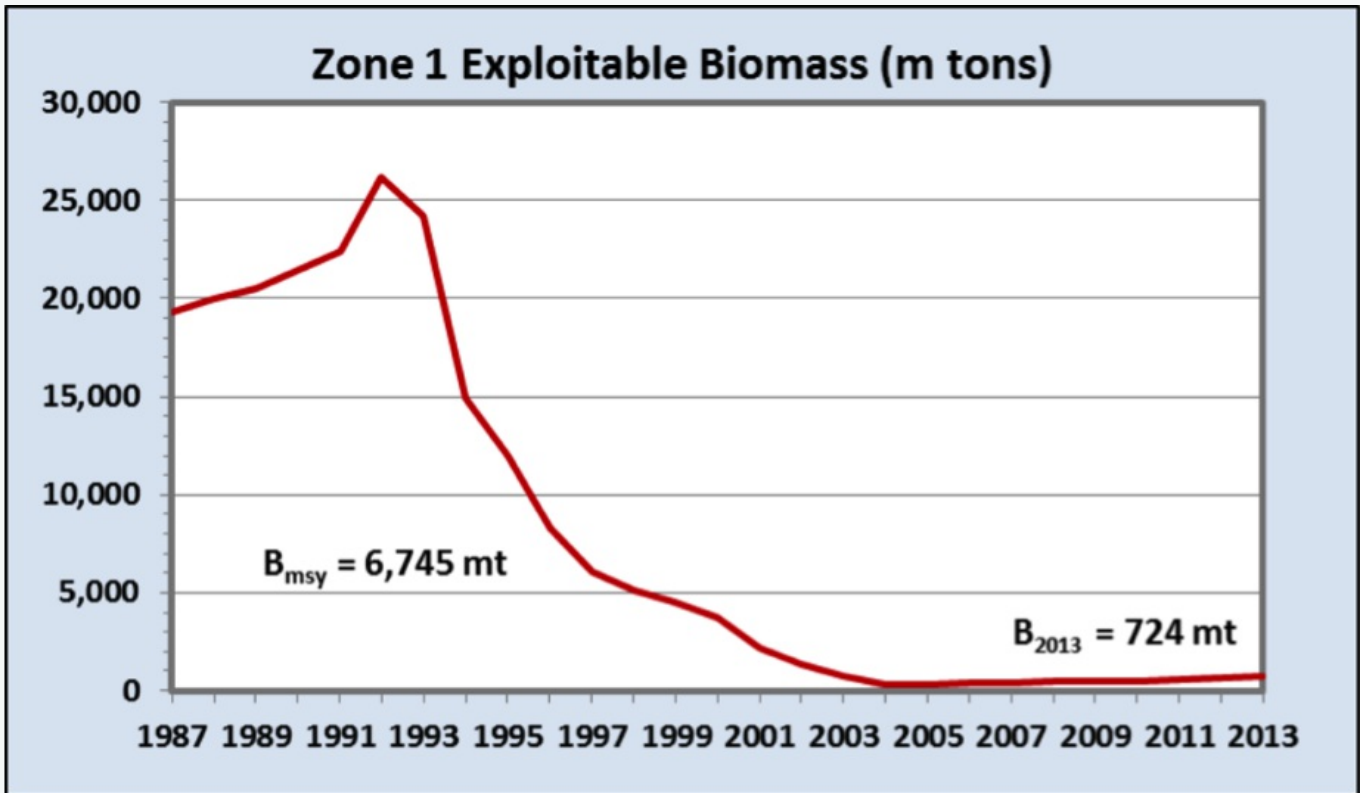


Figure 2: Exploitable biomass estimates for the two fishing zones, based on the 2013 stock assessment model (Hunter 2015).

**Northwest Atlantic | Diving | United States | Maine**

**Northwest Atlantic | Hand implements | United States | Maine**

**Northwest Atlantic | Towed dredges | United States | Maine**

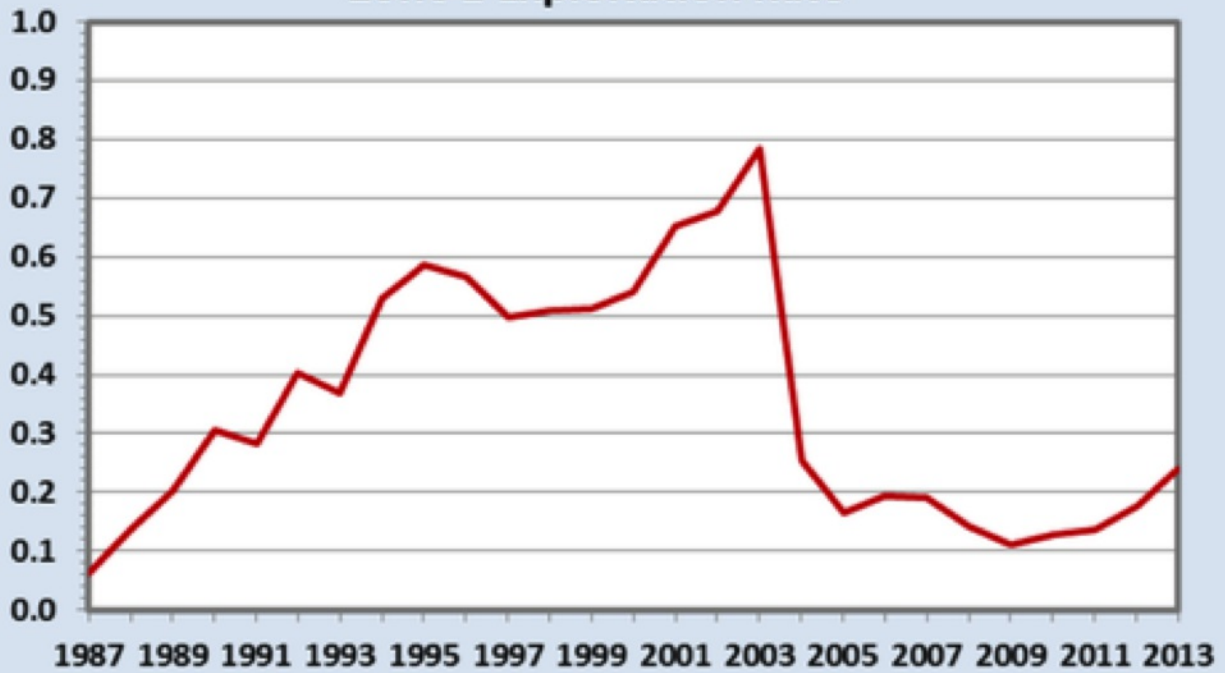
**Moderate Concern**

Fishing mortality in harvested areas in the past 5 years has been estimated at 10% to 25% in Zone 1 and 20% to 30% in Zone 2 (Hunter 2015), but reference points are not available for this fishery. Therefore, fishing mortality relative to a sustainable level is unknown, though it does not exceed Seafood Watch’s general recommendation for limit reference points. Fishing mortality is scored a moderate concern.

**Justification:**



### Zone 1 Exploitation Rate



### Zone 2 Exploitation Rate



Fisheries mortality rates (exploitation rates) of green sea urchin populations in the two fishing zones. Figures from (Hunter 2015).

## **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 ≤2.2 = Red or High Concern**

*Rating is Critical if Factor 2.3 (Fishing Mortality) is Critical*

### **Guiding principles**

- *Ensure all affected stocks are healthy and abundant.*
- *Fish all affected stocks at sustainable level.*
- *Minimize bycatch.*

## Criterion 2 Summary

### Criterion 2 score(s) overview

This table(s) provides an overview of the Criterion 2 subscore, discards+bait modifier, and final Criterion 2 score for each fishery. A separate table is provided for each species/stock that we want an overall rating for.

GREEN SEA URCHIN			
REGION / METHOD	SUB SCORE	DISCARD RATE/LANDINGS	SCORE
Northwest Atlantic   Diving   United States   Maine	5.000	1.000: < 100%	Green (5.000)
Northwest Atlantic   Hand implements   United States   Maine	5.000	1.000: < 100%	Green (5.000)
Northwest Atlantic   Towed dredges   United States   Maine	1.000	0.750: >= 100%	Red (0.750)

### Criterion 2 main assessed species/stocks table(s)

This table(s) provides a list of all species/stocks included in this assessment for each 'fishery' (as defined by a region/method combination). The text following this table(s) provides an explanation of the reasons the listed species were selected for inclusion in the assessment.

NORTHWEST ATLANTIC   DIVING   UNITED STATES   MAINE			
SUB SCORE: 5.000		DISCARD RATE: 1.000	SCORE: 5.000
SPECIES	ABUNDANCE	FISHING MORTALITY	SCORE
Green sea urchin	1.000: High Concern	3.000: Moderate Concern	Red (1.732)

NORTHWEST ATLANTIC   HAND IMPLEMENTS   UNITED STATES   MAINE			
SUB SCORE: 5.000		DISCARD RATE: 1.000	SCORE: 5.000
SPECIES	ABUNDANCE	FISHING MORTALITY	SCORE
Green sea urchin	1.000: High Concern	3.000: Moderate Concern	Red (1.732)

NORTHWEST ATLANTIC   TOWED DREDGES   UNITED STATES   MAINE			
SUB SCORE: 1.000		DISCARD RATE: 0.750	SCORE: 0.750
SPECIES	ABUNDANCE	FISHING MORTALITY	SCORE
Corals and other biogenic habitats	1.000: High Concern	1.000: High Concern	Red (1.000)
Benthic inverts	2.330: Moderate Concern	1.000: High Concern	Red (1.526)
Green sea urchin	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Finfish	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)

The diver and hand collection fisheries are selective and no other species are caught.

By-catch in the drag fishery has not been explicitly studied; however, mussels, sea stars, sea cucumbers, and juvenile lobster have been reported as part of by-catch (Creaser and Weeks 1998)(Wahle 1999). American lobster is the target of a major commercial fishery in New England, and the most recent stock assessment does not identify the urchin fishery as a source of mortality that should be included in stock assessments (ASMFC 2015). Combined with the knowledge that the statuses of the Gulf of Maine and Grand Banks stocks are not a conservation concern (see Seafood Watch assessment of U.S. American lobster), this means that lobster need not be assessed any further for the urchin fishery. Per the Seafood Watch assessment

on U.S. blue mussel, there are some indicators of stock status for blue mussel in some areas in New England, but overall stock status is unknown (because the conservation concern is less for blue mussel than other species in this assessment, it is not included any further in this assessment). There are no stock status indicators for sea stars (e.g., common and Forbes sea stars) or sea cucumbers (e.g., orange-footed sea cucumber) off New England.

Per the Seafood Watch Standard for Fisheries (v3.1), in instances where by-catch species are known but are data-limited, they are to be grouped by taxon and scored according to the Seafood Watch Unknown Bycatch Matrices. These matrices are used to determine the relative impact of a fishery on by-catch species of various taxa for fisheries where species and amounts of by-catch are not available or are incomplete. The matrices represent typical relative impacts of different fishing gear on various taxa, based on the best available science. Thus, cucumbers and sea stars have been grouped into "Benthic Invertebrates" for the purposes of this assessment. The Unknown Bycatch Matrices also identified sea turtles, finfish, and biogenic habitats as taxon groups that should be further investigated in Criterion 2, for a fishery using dredges in the Northwest Atlantic. But, the urchin fishery does not operate in the summer months when sea turtles may be found in the fished areas, so they are not assessed.

## Criterion 2 Assessment

### SCORING GUIDELINES

Factor 2.1 - Abundance  
(same as Factor 1.1 above)

Factor 2.2 - Fishing Mortality  
(same as Factor 1.2 above)

Factor 2.3 - Modifying Factor: Discards and Bait Use

Goal: Fishery optimizes the utilization of marine and freshwater resources by minimizing post-harvest loss. For fisheries that use bait, bait is used efficiently.

*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.*

Ratio of bait + discards/landings Factor 2.3 score	
<100%	1
>=100	0.75

## **Benthic inverts**

### **Factor 2.1 - Abundance**

**Northwest Atlantic | Towed dredges | United States | Maine**

#### **Moderate Concern**

Based on the Seafood Watch Standard for Fisheries (v3.1) Unknown Bycatch Matrices, benthic invertebrates are scored a moderate concern for abundance.

### **Factor 2.2 - Fishing Mortality**

**Northwest Atlantic | Towed dredges | United States | Maine**

#### **High Concern**

Based on the Seafood Watch Standard for Fisheries (v3.1) Unknown Bycatch Matrices, benthic invertebrates are scored a high concern for fishing mortality in dredge fisheries.

# Corals and other biogenic habitats

## Factor 2.1 - Abundance

**Northwest Atlantic | Towed dredges | United States | Maine**

### **High Concern**

Based on the Seafood Watch Standard for Fisheries (v3.1) Unknown Bycatch Matrices, corals and other biogenic habitats are scored a high concern for abundance.

## Factor 2.2 - Fishing Mortality

**Northwest Atlantic | Towed dredges | United States | Maine**

### **High Concern**

Based on the Seafood Watch Standard for Fisheries (v3.1) Unknown Bycatch Matrices, corals and other biogenic habitats are scored a high concern for fishing mortality in dredge fisheries.

# Finfish

## Factor 2.1 - Abundance

### Northwest Atlantic | Towed dredges | United States | Maine

#### **Moderate Concern**

Based on the Seafood Watch Standard for Fisheries (v3.1) Unknown Bycatch Matrices, finfish are scored a moderate concern for abundance.

## Factor 2.2 - Fishing Mortality

### Northwest Atlantic | Towed dredges | United States | Maine

#### **Moderate Concern**

Based on the Seafood Watch Standard for Fisheries (v3.1) Unknown Bycatch Matrices, finfish are scored a moderate concern for fishing mortality in dredge fisheries.

## Factor 2.3 - Discard Rate/Landings

### Northwest Atlantic | Diving | United States | Maine

#### **< 100%**

Divers are required to have a <20% discard rate from the boat. A higher proportion of sorting and discards may occur underwater, but this does not involve the removal of sea urchin from its habitat (Hunter 2015).

### Northwest Atlantic | Hand implements | United States | Maine

#### **< 100%**

No specific data on the discard rate are available for the small fraction of rakers in the fishery, but the discard rate is likely to be similar to that of divers (<20%), who use the same handheld tools (Hunter 2015).

### Northwest Atlantic | Towed dredges | United States | Maine

#### **>= 100%**

Available data indicate that the ratio of sub-legal to legal-sized sea urchins taken in standard urchin drags ranges between 0% and 78%. These sub-legal individuals are returned to the water alive, but survival rates after discard are not known {Hunter 2007}. There are no data on discarded by-catch species for the Maine drag fishery, but data from the neighboring New Brunswick drag fishery indicate that total discarded mass is >100% of landed legal-sized sea urchin mass (DFO 2010).



### Criterion 3: Management Effectiveness

Five factors are evaluated in Criterion 3: 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 a 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.

#### Guiding principle

- The fishery is managed to sustain the long-term productivity of all impacted species.

Five factors are evaluated in Criterion 3: 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:

### Criterion 3 Summary

FISHERY	MANAGEMENT STRATEGY	BYCATCH STRATEGY	RESEARCH AND MONITORING	ENFORCEMENT	INCLUSION	SCORE
Northwest Atlantic   Diving   United States   Maine	Ineffective	Highly effective	Moderately Effective	Highly effective	Highly effective	<b>Red (1.000)</b>
Northwest Atlantic   Hand implements   United States   Maine	Ineffective	Highly effective	Moderately Effective	Highly effective	Highly effective	<b>Red (1.000)</b>
Northwest Atlantic   Towed dredges   United States   Maine	Ineffective	Moderately Effective	Moderately Effective	Highly effective	Highly effective	<b>Red (1.000)</b>

This report was reviewed in April 2022 to determine if the overall rating is still accurate. Although no scoring changes were made during this update, some new information is provided below regarding management of the urchin fishery in Maine.

Fisheries managers and industry stakeholders initiated conservation closures in an effort to rebuild sea urchin populations through small-scale closures and urchin relocation (Ovitz and Johnson 2019). One such experiment in Cobscook Bay resulted in improved biomass of green sea urchin following a 3-year closure. But, following the reopening of the fishing area, commercial harvesters “decimated the resource within several days” (Ovitz and Johnson 2019). Likewise, urchin relocation efforts have been unsuccessful (Ovitz and Johnson 2019). Maine DMR continues to conduct fishery-independent surveys and collect fishery-dependent data, to inform management and monitor sea urchin biomass and abundance (Hunter and Russell 2020). As a result of declining sea urchin abundance and of input from stakeholders, Maine DMR reduced the daily limit in

Zone 2 from ≈640 lbs to 550 lbs (from 7 trays to 6) and in Zone 1 from ≈1,000 lbs to ≈750 lbs (from 12 trays to 9); also, it shortened the season in Zone 2 from 38 days to 30 days for the 2019–2020 season (Hunter and Russell 2020). These measures remain in place for the 2021–2022 season. The effectiveness of these measures is unknown, and it is likely that the fishery is having serious negative impacts on retained populations. Therefore, Factor 3.1 remains scored as “ineffective.”

## Criterion 3 Assessment

### SCORING GUIDELINES

#### 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.*

#### 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.*

#### 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.*

#### 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.*

#### 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.*

### Factor 3.1 - Management Strategy And Implementation

**Northwest Atlantic | Diving | United States | Maine**

**Northwest Atlantic | Hand implements | United States | Maine**

**Northwest Atlantic | Towed dredges | United States | Maine**

#### **Ineffective**

Measures to control fishing mortality are in place, including a limited number of fishing days and a daily landings limit. Reference points from stock assessment models were used in scientific advice to the fishery between 2002 and 2013, but these were discontinued due to concerns about poor data fit and continued declines in stock abundance that were not predicted from the model. Currently, scientific advice is based on the fisheries-independent monitoring data while work on the stock assessment model is ongoing (Hunter 2015) (pers. comm., Hunter 2015). Because management

measures have not been effective at rebuilding the historically overfished population, they are currently scored ineffective.

**Justification:**

Although Management Strategy and Implementation is scored ineffective for this fishery, it is well-managed in some regards, as explained below. But, this does not affect the Criterion 3: Management Effectiveness score, because of the overarching concerns detailed in the Explanation of Score above.

Scientific Research and Monitoring

In addition to fisheries-dependent data, DMR has collected fisheries-independent survey data on stock biomass, abundance, and population size structure since 2001. From 2001 to 2013, these data were used in a Bayesian stock assessment model to estimate fishable biomass and to set targets for the fishery {Kanaiwa et al. 2005}. But, the model has not been used for management since 2013 due to concerns about poor fit to the data. Although the model is being improved, general management recommendations have been made based on abundance trends. By-catch in the drag fishery is not monitored, though some observations of by-catch species have been reported (see Criterion 2).

Because the fishery collects and analyzes appropriate data to monitor stock abundance, but does not currently have a robust stock assessment, scientific research and monitoring would be scored moderately effective.

Enforcement

Logbook reporting is required for both harvesters and buyers of sea urchin, and these are verified against each other. There is also a port sampling (dockside monitoring) program in place, which has covered about 4.2% of landings over the past 5 years. The fishery recently introduced the use of swipe-card systems to track the transfer of landings from harvesters to buyers in real time, and for verification against harvester logs and port sampling data (Hunter 2015)(Hunter and Russell 2020).

Because there is regular enforcement and independent verification of management measures, the fishery's enforcement of management regulations would be scored highly effective.

Stakeholder Inclusion

Management decisions are made through consultative meetings between the Department of Marine Resources and the Maine Sea Urchin Zone Council. The council includes elected representatives from industry (harvesters, buyers, processors, boat tenders) and additional representatives from science, aquaculture, and other harvesters that are appointed by the commissioner (Hunter 2015). Meetings are open to the public, and meeting times are announced through a publicly available mailing list. Meeting summaries and minutes are posted publicly on the DMR website. Because the fishery's management process is transparent and includes stakeholder input, stakeholder inclusion would be scored highly effective.

**Factor 3.2 - Bycatch Strategy**

**Northwest Atlantic | Diving | United States | Maine**

**Northwest Atlantic | Hand implements | United States | Maine**

**Highly effective**

Harvest of sea urchin by divers and rakers is done by hand; it is highly selective and produces minimal or no by-catch of nontarget species. Because there is minimal by-catch in the fishery, by-catch strategy is scored highly effective.

**Northwest Atlantic | Towed dredges | United States | Maine**

**Moderately Effective**

There are no explicit strategies currently in place that reduce by-catch of nontarget species. In Zone 2, large-mesh escape panels are required on the drags to reduce the by-catch and discard rate of undersized or oversized sea urchins, but the effectiveness is uncertain. Drag gear impacts on some mobile benthic species (crabs and lobsters) may be reduced because the fishery operates during the fall/winter, when those species migrate to deeper waters. By-catch strategy is scored moderately effective, because a strategy is in place but effectiveness is not known.

**Factor 3.3 - Scientific Research And Monitoring**

**Northwest Atlantic | Diving | United States | Maine**

**Northwest Atlantic | Hand implements | United States | Maine**

**Northwest Atlantic | Towed dredges | United States | Maine**

**Moderately Effective**

In addition to fisheries-dependent data, DMR has collected fisheries-independent survey data on stock biomass, abundance, and population size structure since 2001. From 2001–2013, these data were used in a Bayesian stock assessment model to estimate fishable biomass and to set targets for the fishery {Kanaiwa et al. 2005}. But, the model has not been used for management since 2013 due to concerns about poor fit to the data. While the model is being improved, general management recommendations have been made based on abundance trends. By-catch in the drag fishery is not monitored, although some observations of by-catch species have been reported (see Criterion 2).

Because the fishery collects and analyzes appropriate data to monitor stock abundance but does not currently have a robust stock assessment, scientific research and monitoring is scored moderately effective.

**Factor 3.4 - Enforcement Of Management Regulations**

**Northwest Atlantic | Diving | United States | Maine**

**Northwest Atlantic | Hand implements | United States | Maine**

**Northwest Atlantic | Towed dredges | United States | Maine**

**Highly effective**

Logbook reporting is required for both harvesters and buyers of sea urchin, and these are verified against each other. There is also a port sampling (dockside monitoring) program in place, which has covered about 4.2% of landings over the past 5 years. The fishery has recently introduced the use of swipe-card systems to track the transfer of landings from harvesters to buyers in real time, and for verification against harvester logs and port sampling data (Hunter 2015).

Because there is regular enforcement and independent verification of management measures, the fishery's enforcement of management regulations is scored highly effective.

**Factor 3.5 - Stakeholder Inclusion**

**Northwest Atlantic | Diving | United States | Maine**

**Highly effective**

Management decisions are made through consultative meetings between the Department of Marine Resources and the Maine Sea Urchin Zone Council. The council includes elected representatives from industry (harvesters, buyers, processors, boat tenders) and additional representatives from science, aquaculture, and other harvesters that are appointed by the commissioner (Hunter 2015). Meetings are open to the public, and meeting times are announced through a publicly available mailing list. Meeting summaries and minutes are posted publicly on the DMR website. Because the fishery’s management process is transparent and includes stakeholder input, stakeholder inclusion is scored 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 (factor 4.1 + factor 4.2) 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**

### Guiding principles

- Avoid negative impacts on the structure, function or associated biota of marine habitats where fishing occurs.
- Maintain the trophic role of all aquatic life.
- Do not result in harmful ecological changes such as reduction of dependent predator populations, trophic cascades, or phase shifts.
- Ensure that any enhancement activities and fishing activities on enhanced stocks do not negatively affect the diversity, abundance, productivity, or genetic integrity of wild stocks.
- Follow the principles of ecosystem-based fisheries management.

Rating cannot be Critical for Criterion 4.

## Criterion 4 Summary

FISHERY	FISHING GEAR ON THE SUBSTRATE	MITIGATION OF GEAR IMPACTS	ECOSYSTEM-BASED FISHERIES MGMT	SCORE
Northwest Atlantic   Diving   United States   Maine	4	0	High Concern	<b>Yellow (2.828)</b>
Northwest Atlantic   Hand implements   United States   Maine	4	0	High Concern	<b>Yellow (2.828)</b>
Northwest Atlantic   Towed dredges   United States   Maine	1	0	High Concern	<b>Red (1.414)</b>

It is important to distinguish the ecological roles and the potential impacts of Canadian fisheries for sea urchin on the Pacific coast from those for the green sea urchin (*Strongylocentrotus droebachiensis*) on the Atlantic coast. Green sea urchin is the only herbivorous sea urchin in shallow coastal waters in Maine {Scheibling 1996}, is the only benthic grazer capable of controlling algal abundance in the western North Atlantic (Steneck et al. 2013), and largely determines the structure and dynamics of nearshore rocky ecosystems {Scheibling 1996}. Overfishing of this keystone species in Maine led to alternative stable states (Steneck et al. 2013).

Although red sea urchin is an important component of nearshore rocky ecosystems, high densities of purple sea urchin (*Strongylocentrotus purpuratus*) are largely responsible for overgrazing kelp forests and maintaining urchin barrens {Dudley et al. 2021}{Rogers-Bennett and Catton 2019}. In addition, fishing pressure on urchin predators (e.g., California spiny lobster and California sheephead) is thought to drive trophic cascades in southern California rock reef ecosystems, and decreasing fishing mortality on predators increases resilience of kelp forests {Dunn et al. 2017}. Declines in sea otter populations also resulted in urchin barrens {Estes and Palmisano 1974}. There are a number of factors that may cause kelp forests to convert to alternative stable states, but the likelihood of trophic cascades resulting from the red sea urchin fishery are low.

## Criterion 4 Assessment

### SCORING GUIDELINES

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

Goal: The fishery does not adversely impact the physical structure of the ocean habitat, seafloor or associated biological communities.

- 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.

#### Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts

Goal: Damage to the seafloor is mitigated through protection of sensitive or vulnerable seafloor habitats, and limits on the spatial footprint of fishing on fishing effort.

- +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 factor 4.1

#### Factor 4.3 - Ecosystem-Based Fisheries Management

Goal: All stocks are maintained at levels that allow them to fulfill their ecological role and to maintain a functioning ecosystem and food web. Fishing activities should not seriously reduce ecosystem services provided by any retained species or result in harmful changes such as trophic cascades, phase shifts or reduction of genetic diversity. Even non-native species should be considered with respect to ecosystem impacts. If a fishery is managed in order to eradicate a non-native, the potential impacts of that strategy on native species in the ecosystem should be considered and rated below.

- 5 — 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 — Policies are in place to protect species' ecological roles and ecosystem functioning but have not proven to be effective and at least some spatial management is used.
- 3 — Policies are not in place to protect species' ecological roles and ecosystem functioning but detrimental food web impacts are not likely or policies in place may not be sufficient to protect species' ecological roles and ecosystem functioning.
- 2 — 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 — *Scientifically demonstrated trophic cascades, alternate stable states or other detrimental food web impact are resulting from this fishery.*

#### **Factor 4.1 - Impact of Fishing Gear on the Habitat/Substrate**

##### **Northwest Atlantic | Diving | United States | Maine**

**4**

Diver harvest of green sea urchin is generally done with small, handheld rakes. Divers harvest in shallow water (3 to 6 m) (Hunter 2015). The rake tools used may make contact with benthic algae and invertebrates on rocky reefs, but they are not dragged along the bottom. No sensitive species such as corals or sponges are affected. The impacts of hand raking have not been formally assessed, but are expected to be very low or negligible (DFO 2016).

##### **Northwest Atlantic | Hand implements | United States | Maine**

**4**

Raker harvest of green sea urchin is generally done with small, handheld rakes. Rakers harvest from the shore at low tide (Hunter 2015). The rake tools used may make contact with benthic algae and invertebrates on rocky reefs, but they are not dragged along the bottom. No sensitive species such as corals or sponges are affected. The impacts of hand raking have not been formally assessed, but are expected to be very low or negligible (DFO 2016).

##### **Northwest Atlantic | Towed dredges | United States | Maine**

**1**

Urchin drags are similar to scallop dredges but are smaller and lighter. They are used similarly to scallop dredges, and are dragged over rocky ledge and cobble-boulder habitat, including areas with kelp beds and other macroalgae (Wahle 1999). Therefore, the dredge fishery receives a score of 1 for impacts to habitat/substrate.

#### **Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts**

##### **Northwest Atlantic | Diving | United States | Maine**

##### **Northwest Atlantic | Hand implements | United States | Maine**

##### **Northwest Atlantic | Towed dredges | United States | Maine**

**0**

The only area closure specific to the sea urchin fishery is the Cat Ledges Area (Maine DMR 2021). A substantial proportion of all representative habitats are not protected from all bottom contact, and this factor scores 0.

**Justification:**



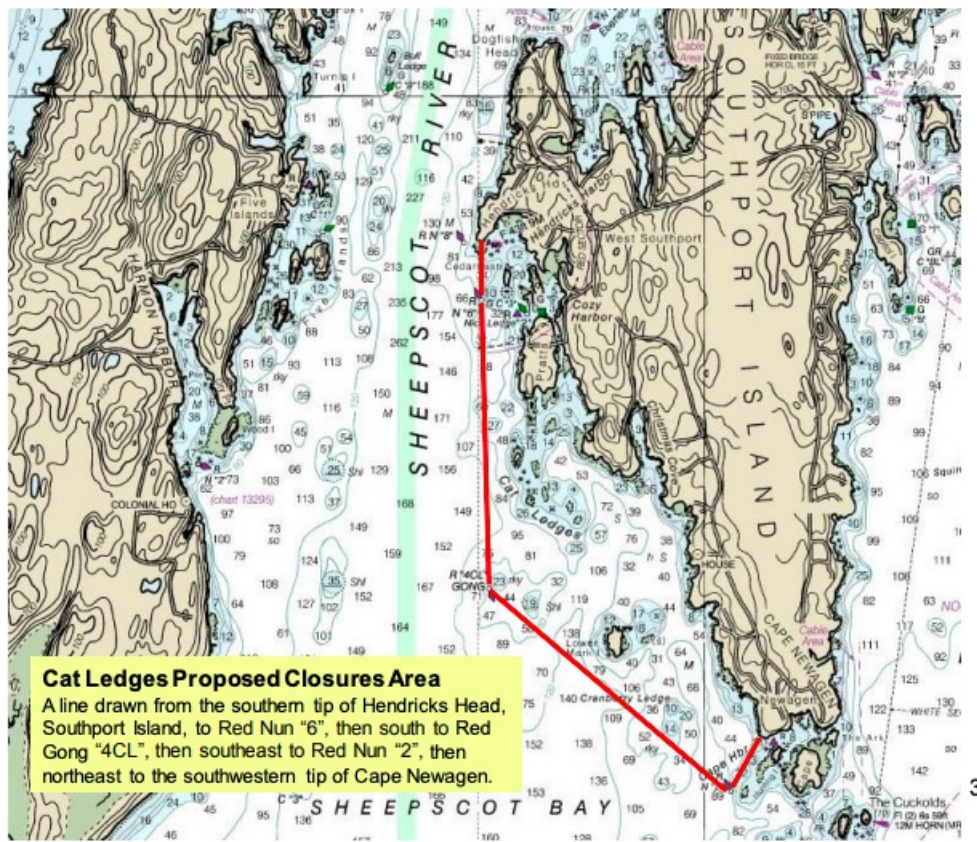


Figure 3: Cat Ledges Area targeted closure.

#### Factor 4.3 - Ecosystem-based Fisheries Management

**Northwest Atlantic | Diving | United States | Maine**

**Northwest Atlantic | Hand implements | United States | Maine**

**Northwest Atlantic | Towed dredges | United States | Maine**

##### High Concern

Overfishing of sea urchin has previously led to ecosystem state changes in the Maine fishery, particularly because this species is the only benthic grazer in the ecosystem. But, both current and pre-fishery ecosystems represent human-altered states due to the prior loss of sea urchin predators (Steneck et al. 2013), and lower sea urchin populations may represent a more productive ecosystem (Bernstein and Mann 1982). No management measures currently target the ecological roles of sea urchin, though management has begun to collect data on kelp and urchin predator abundances and to discuss the development of "ecosystem threshold"-based reference points for the fishery (Hunter 2015). Although the scientific documentation of "alternative stable states" would typically score a very high concern for this criterion, the extent to which they are detrimental is not clear. Thus, the fishery is scored a high concern.

## **Acknowledgements**

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

*Seafood Watch would like to thank Margaret Hunter and Robert Steneck for graciously reviewing this report for scientific accuracy.*

## **References**

- Atlantic States Marine Fisheries Commission (ASMFC) 2015. American Lobster Benchmark Stock Assessment and Peer Review Report.
- Bernstein BB and Mann KH. 1982. Changes in the Nearshore Ecosystem of the Atlantic Coast of Nova Scotia, 1968-81. NAFO Sci. Coun. Studies, 5: 101-105
- Creaser, E. and W. Weeks. 1998. Sea urchin drag study report. Maine Department of Marine Resources, W. Boothbay Harbor, Maine. 29p.
- DFO. 2010. Assessment of the Bay of Fundy Sea Urchin Fishery, Lobster Fishing Area 38. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2010/002.
- DFO. 2016. Pacific Region Integrated Fisheries Management Plan: Green Sea Urchin. September 1, 2016 to August 31, 2018
- Hunter M. 2015. Monitoring Maine's Sea Urchin Resource. Maine Department of Marine Resources.
- Hunter, M. and Russell, R. 2020. Monitoring and Assessment of Maine's Sea Urchin Resource July 1, 2014 – March 31, 2020. Maine Department of Marine Resources. 55 p.
- Maine DMR. 2021. Department of Marine Resources Regulations (13 188), Chapter 26 Sea Urchin.
- Ovitz, K.L. and Johnson, T.R., 2019. Seeking sustainability: Employing Ostrom's SESF to explore spatial fit in Maine's sea urchin fishery. *International Journal of the Commons*, 13(1), pp.276–302.
- Steneck R.S., Leland A., McNaught D.C., Vavrinec J. 2013. Ecosystem flips, locks, and feedbacks: the lasting effects of fisheries on Maine's kelp forest ecosystem. *Bull. Mar. Sci.* 89(1):31-55
- Sun J., Chiang F-S. 2015. Use and Exploitation of Sea Urchins. In: Brown N., Eddy S. (eds). *Echinoderm Aquaculture*. Wiley-Blackwell: New Jersey
- Wahle, R.A. 1999. An in situ study of the impact of sea urchin dragging on the benthos. Report to Maine DMR. 22p.

## **Appendix A: Review Schedule**

Beginning in the 2019–2020 season, Maine DMR reduced daily catch limits for both Zones 1 and 2, and shortened the season for Zone 3. Future monitoring and assessment reports may show the effectiveness of these measures. Sea urchin populations remain depleted, management effectiveness is unknown, and it is likely that the fishery is having serious negative impacts (thus, Criterion 1 is scored "Red").

## **Appendix B: Report Update**

Updates to the U.S. Atlantic Green Sea Urchin Report:

**Overall Recommendations for green sea urchin caught by divers, hand implements, and towed dredges** in Maine remain unchanged. Individual criterion updates are outlined below.

This report was reviewed in July 2022 for any significant stock status and management updates to the fishery. None was found that would indicate that the final rating is no longer accurate. But, information updates were added to Factor 1.1, Factor 4.2, and the Synthesis section of Criterion 3.