Jonah Crab
(*Cancer borealis*)

Current Status & Information Sources

In support of Fishery Pre-Assessment
Along Marine Stewardship Council (MSC) Standard
31 Principle Indicators

November 1, 2013

Prepared in Collaboration between
Gulf of Maine Research Institute and University of Maine

Table of Contents

Introduction

Statement of Purpose

The following compendium of information related to the current stock status has been presented as a fishery pre-assessment, along with the thirty-one Performance Indicators (PI) defined by the Marine Stewardship Council (MSC) standard. This report has been commissioned by the client group, which seeks to identify fishery improvement opportunities and maps existing information and materials gathered by the academic community along these PIs.

Jonah Crab Distribution and Life History

Geographic Distribution

The Jonah crab, *Cancer borealis*, is found in coastal and shelf waters along the Atlantic coast of North America, from Newfoundland as far south as Florida (Haefner 1977; Stehlik et al. 1991; Wenner et al. 1992; Williams 1984). However, the type-locality for *C. borealis* is from Nova Scotia to Cape Cod, Massachusetts.

Jonah crabs may have complex population structures, with migratory and non-migratory groups (Leland 2002). Several studies have suggested that the species undertakes inshore to offshore movements (Jeffries 1966; Haefner 1977; Carpenter 1978; Krouse 1980). Although the extent of their movement patterns is largely unknown, it is believed that females may move inshore to molt and spawn (Krouse 1980; Maher 1999). In the shelf waters off Chesapeake Bay, Virginia, for example, smaller females occupy depths less than 150 m whereas males occupy greater depths (FOC 2009). In the Mid Atlantic Bight, crab body size trends upward with depth and distance from shore, suggesting an offshore movement as crabs mature (Haefner 1977). Carpenter (1978) suggests that distinct size groups can be found at different depths depending on time of year. Spatial segregation by both size and sex, coupled with the possibility of fidelity to specific areas (e.g. feeding or spawning sites), may make male Jonah crabs particularly vulnerable to targeted fishing.

Environmental variables, such as depth, temperature, and habitat characteristics affect the abundance of Jonah crabs (Haefner 1977; Carpenter 1978; Krouse 1980; Stehlik et al. 1991). Jeffries (1966) found Jonah crabs on rocky areas in association with American lobster. Auster et al (1991) suggest Jonah crab prefer shell and biogenic depression microhabitats to sandier substrates, and also suggest seasonal variation of abundance within these microhabitats. Circadian patterns of abundance have also been observed. In near-shore rocky habitats down to 11m, active *Cancer* *borealis* were ten times more abundant during the day than at night. Significant depth by time-period interactions have been reported, with daytime densities higher in deeper waters and night time densities higher in shallow waters (Novak 2004).

Water temperatures also affect distributions. During 2003 and 2004, for example, there was a higher proportion of soft-shell Jonah crabs landed off Nova Scotia, which was interpreted to be the a result of colder than normal water temperatures (Petrie et al. 2005; DFO 2006; Robichaud and Frail 2006).

Growth and Reproduction

Growth of the two sexes is similar up to 30-40mm carapace width (CW), but does not exceed15mm during the first year. Thereafter females grow more slowly than males, attaining up to 100mm CW in 8 years with 14 molts whereas males grow up to 130mm CW after 13-14 molts in 6-7 years (Williams 1984). There is much variability surrounding the onset of sexual maturity in both sexes. Williams 1984 cites the onset of sexual maturity for both sexes around 30-40mm CW, although males often mature at a smaller size than females. However, some females have been found to mature at CW as low as 14-30mm (Williams 1984). Despite maturating at a smaller size than females, male crabs are considered functionally mature when they can engage in the copulatory embrace, and this may occur at a considerably larger size than physiological maturity. Moriyasu et al. (2002) estimated that the functional maturity of male Jonah crabs occurred at 128 mm CW. More information is needed surrounding age at maturity as it may be important in determining a minimum harvest size.

Information on the timing of the molt has been gleaned from commercial trawl samples in southern New England, stomach content analyses of predacious fishes and SCUBA observations also suggest seasonality of spawning and molting processes (Reilly and Saila 1978). The largest females molted in December and the largest males from January to March, with a smaller group of males, 40-60mm CW molting in May. A study of Dungeness crabs (*Cancer magister*), a close relative to Jonah crabs found in the Pacific Northwest, revealed increased mortality immediately following their molt (Zhang et al. 2004). If the same holds true for Jonah crabs, the species might benefit from protection during peak molting times.

Mating takes place after the female has molted and sperm can be stored for an indefinite period of time. Spawning consists of the extrusion of fertilized eggs beneath the abdomen where they are brooded for 5-6 months until larvae hatch (Reilly and Saila 1978, Elner 1985). Clutch size increases exponentially with carapace width: Reilly and Saila (1979) estimated ovigerous females of 21mm CW to carry 4430 eggs and 88mm CW females to carry 330,440 eggs. Once mature, female Jonah crabs probably spawn one clutch per year and about five times per lifetime (Cobb et al. 1997). The spawning season progresses from south to north along the coastal and shelf waters. In the Mid-Atlantic Bight, spawning takes place from late winter to early spring; in Rhode Island spawning begins in mid-July; and in Maine, it commences in August through September (FOC 2009). In southern New England Reilly and Saila (1978) found ovigerous females from March to June. Previous studies from the Mid-Atlantic Bight suggest that the timing of gonad development may be size-dependent, with crabs >100mm CW having mature gonads in June, whereas crabs <80mm CW were undeveloped or slightly developed and spawned in the fall and spring (Haefner 1977).

The Jonah Crab Fishery in the US

Jonah crabs are taken in crab pots and lobster traps (Wilson 2004, Robichaud and Frail 2006; Reardon 2006). The pots or traps are either deployed individually or attached to each other via a groundline along the seafloor, depending on the fishery. Jonah crab was originally known only as bycatch in nearshore lobster fisheries. In the late 1980s, as stocks of the more popular crabs became depleted, New England fishermen began to experiment with alternative fisheries, including Jonah crab and other edible crabs.

For historical perspective on harvest volumes, in 1990 Rhode Island landed 400.5 metric tons (mt) of Jonah crab, by far the largest share (NMFS 2004a) (Figure 1). Maine was in second place, with 183.2 metric tons. Maryland, New Jersey, and New York each landed less than 10 mt of Jonah crab in that year (NMFS 2004a). By 1994, Delaware, New Hampshire, and Massachusetts had joined the fishery. Maine's landings dropped below 25 mt and held steady around that figure for several years. Massachusetts has now taken the lead in Jonah crab landings (NMFS 2004a). In 2000, Massachusetts landed 612.2 mt, and New Hampshire landed 235 mt. Maine and Rhode Island each landed approximately 100 mt, New York approximately 25 mt, and Virginia, Connecticut, and New Jersey less than 10 mt each (NMFS 2004a). These figures indicate an emerging fishery for Jonah crab, based in the New England region but flexible as to landings sites. Total landings, while small, doubled in the decade from 1994 to 2004 (NMFS 2004a).

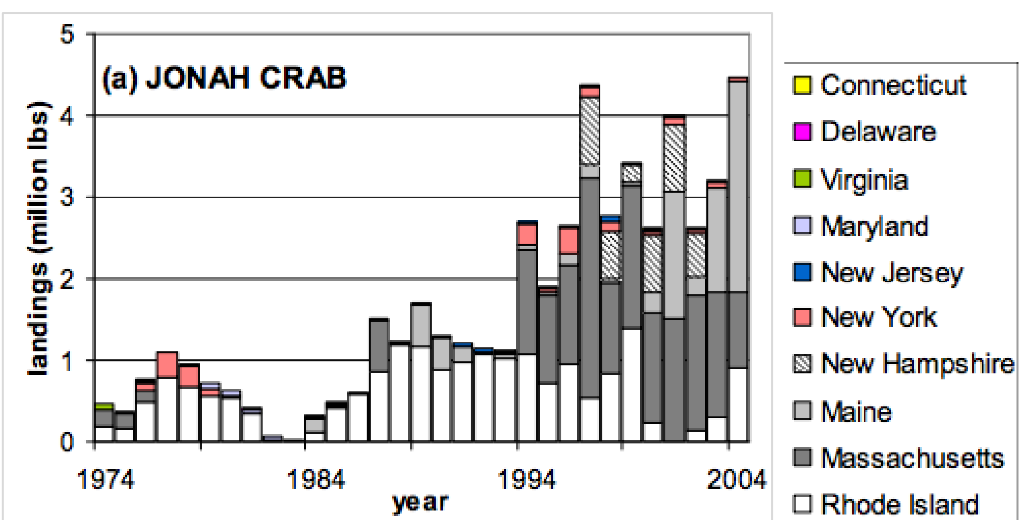

Figure 1. Source: Reardon Masters Thesis

More recently, Jonah crabs are landed in greater volume than rock crabs, and Jonah crab landings result in a significantly higher value. Massachusetts, followed by Rhode Island, has landed the greatest amount of Jonah crab in the region for the past eight years (Figures 2, 3). For example, in 2011, Massachusetts landed 2,440.30 mt of Jonah crab, Rhode Island landed 1,152.30 mt, Maine landed 497.10 mt, and Connecticut landed 0.1 mt (NMFS 2012). In 2011, 4,089.8 mt of Jonah crab was landed in New England with a total ex-vessel value of $5,530,388 (average $0.61/lb), while a total of 907.6 mt of rock crab was landed with an ex-vessel value of $895,587 (average $0.44/lb) (NMFS 2012, Figure 4).

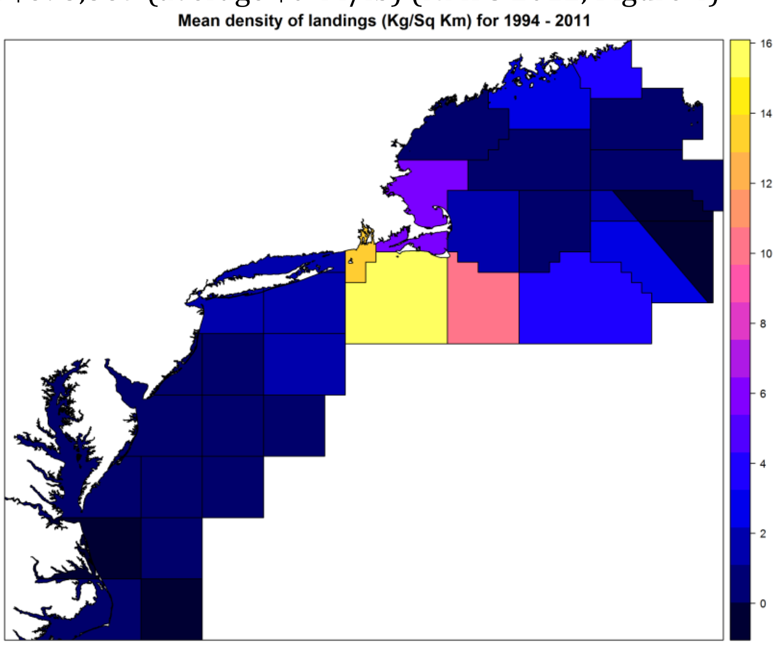

Figure 2. Source: Burton Shank, NOAA

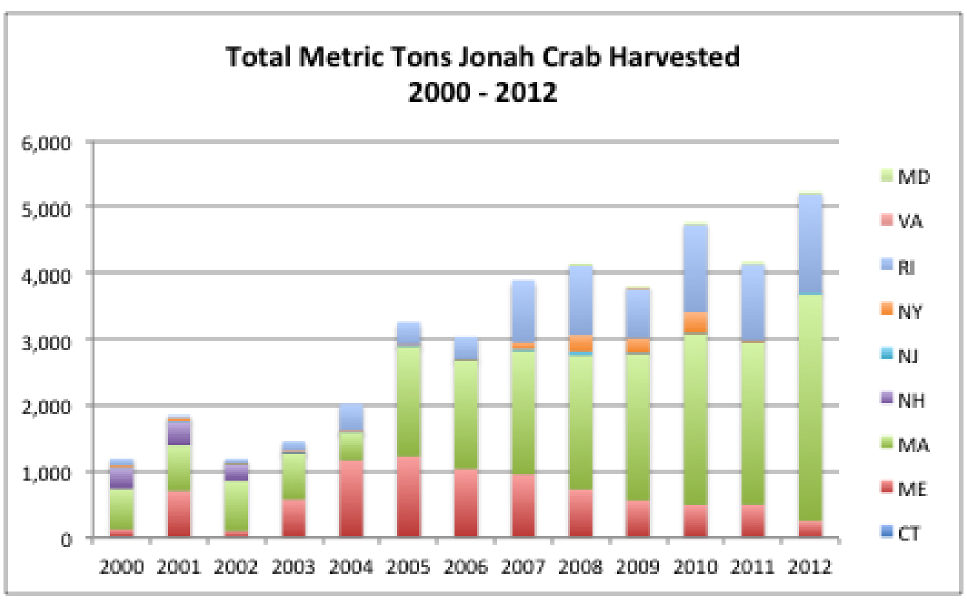

Figure 3. Source: NMFS

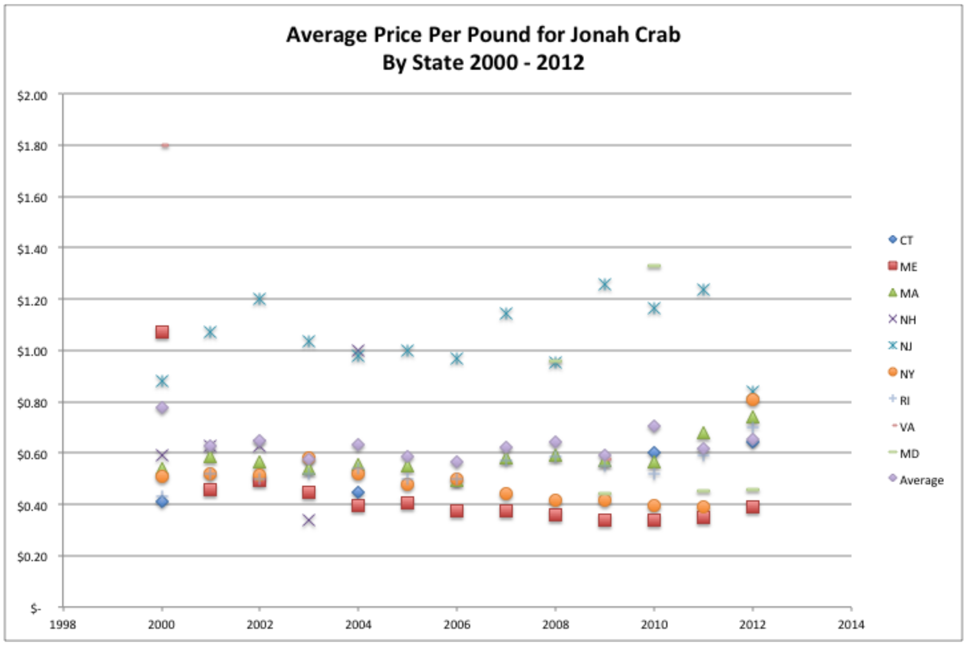

Figure 4. Source: NMFS

Jonah crabs have also been landed as bycatch in U.S. lobster fisheries for over 80 years (Krouse, 1980). Although the number of Jonah crabs taken in lobster fisheries is not fully known, data suggest that the number of Jonah crabs taken from at least some lobster fisheries may be far higher than the amount specifically targeted. In addition, lobster fishermen sometimes use Jonah crab bycatch as bait in their traps, and this could contain smaller individuals and females.

Pre-Assessment Report

Principle 1

Component: Outcome

1.1.1 Stock Status

Objective: The stock is at a level that maintains productivity and has a low probability of recruitment overfishing.

Summary of Findings:
- There is no stock assessment for Jonah crab, although some surveys and landings information might be useful to determine trends over time.
- State and federal data may be confounded as a result of misidentification of species or lumping crab species.
- Therefore this PI has not been met, but may be attainable with information currently available, at least for parts of the species range.

In the United States, crab stocks in federal waters have not been assessed, but assessments have been conducted in some state waters. See Appendix A for full detailed information regarding scientific data collection and sampling programs.

The University of Rhode Island and Rhode Island Department of Environmental Management conduct an annual survey of the abundance of *C. borealis* and *C. irroratus* (Jonah and rock crab, respectively), but the assessment is limited to Rhode Island state waters. Figure 5 below shows the URIGSO trawl survey time-series for the two *Cancer* crab species (Jonah and rock crabs combined). Recent (2006-2011) *Cancer* crab abundance is below the time-series mean.

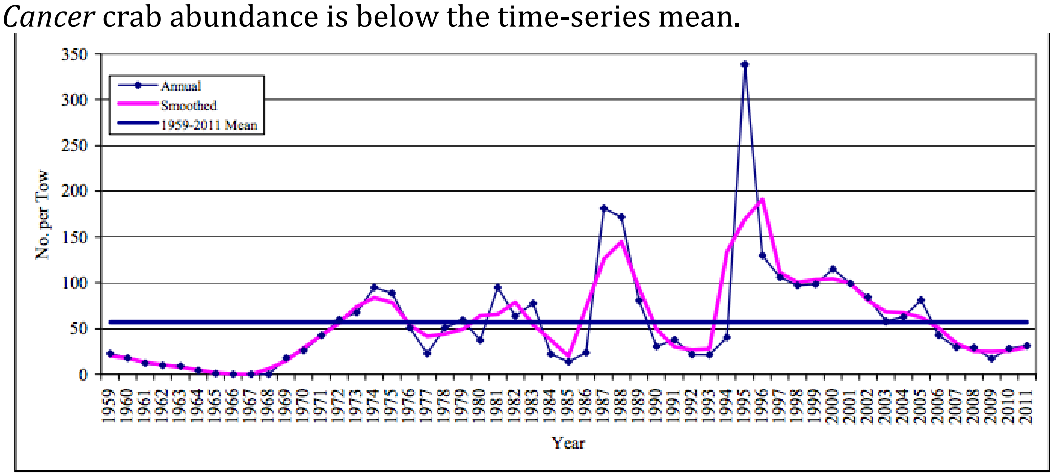

Figure 5. Source: URIGSO trawl survey.

When utilizing different sources of data to understand stocks, it is important to understand the limitations of different sampling programs. For example, Reardon 2006 points out an important consideration when using fishery dependent vs. fishery independent data in the abundance plots below (Figure 6a,b). Not surprisingly, the size/sex composition of the catch differs between sea sampling with commercial traps (which target larger males), and trawl survey (which want to catch a broader spectrum of sizes.)

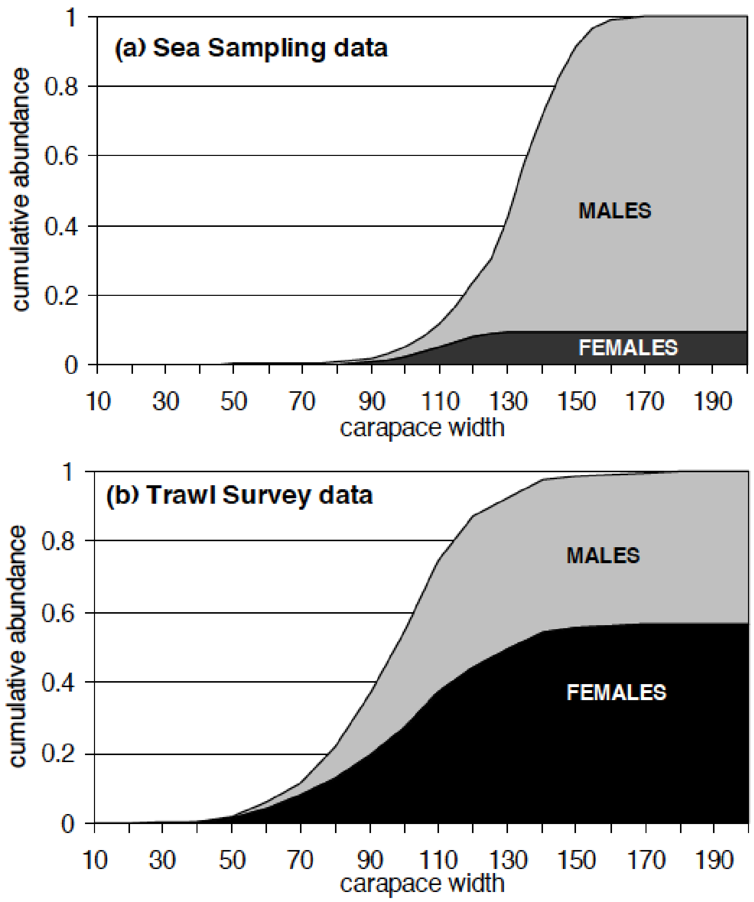

Figure 6a, b. Source: Reardon Masters Thesis 2006

1.1.2 Reference points

Objective: Limit and target reference points are appropriate for the stock.

Summary of Findings:

- Other than those found in Rhode Island, there are no limit and target reference points for the stock. Even in Rhode Island, the crab species are combined so the implications for Jonah crab alone are equivocal.
- Long-term information from other states and federal references is lacking.

Other than the reference points for the inshore fisheries found in Rhode Island, there are no limit and target reference points for the stock.

As additional background, Canada's Department of Fisheries and Oceans has conducted assessments on Jonah crab populations in Lobster Fishing Area 41 (LFA 41) or the northeast edge of Georges Bank, as well as on Scotian Shelf, but neither assessment was able to determine biological reference points or maximum sustainable yield for the commercial fisheries (DFO 2000, DFO 2009). The 2009 DFO assessment of LFA 41 indicated a decline in Jonah crab biomass, but the assessment was unable to determine production or recruitment rates for Jonah crab (DFO 2009). Although uncertain, the 2009 assessment suggests that a decrease in population is the result of fishing pressure in the area, and that the total allowable catch set in 1995 has not been sustainable (DFO 2009).

1.1.3 Stock Rebuilding

Objective: Where the stock is depleted, there is evidence of stock rebuilding within a specified timeframe.

Summary of Findings:

- In the absence of stock assessments or biological reference points, it is not possible to determine whether the stock is depleted.

Although U.S. and Canadian Jonah crab populations have not yet been fully assessed, some areas have demonstrated trends where they were abundant when initially fished, declined considerably, and then showed signs of recovery and renewed abundance. However, because these are in effect uncontrolled experiments, it is unclear whether the upward trend in landings is the result of changes in fishing effort or natural variability in recruitment. Given that comparatively low fishing effort (relative to most other fisheries) has led to quick declines in some areas (e.g. see Robichaud and Frail 2006), Jonah crab populations may be sensitive to even small fishing pressures (FOC 2009).

In 1990, Maine landed 183.2 metric tons of Jonah crab, but by 1994, catches had dropped to less than 25 metric tons (NMFS 2004). In 2002, however, catches in Maine had rebounded to about 101 metric tons (NMFS 2004).Declines in Jonah crab landings may be reflective of declines in fishing effort or declines in the populations. For example, in one of Canada's mid-shore Jonah crab fisheries, landings peaked in 2000 at 280 metric tons and decreased to 58 metric tons in 2004, while fishing effort peaked in 2001 at 59,955 trap hours, but declined by 73%, to 15,954 trap hours in 2004 (Robichaud and Frail 2006).

Very little biological data is collected in current surveys (see Appendix A). Some biological information is available from the experimental Jonah crab fishery project supported by the Maine Department of Marine Resources from 2002 to 2004 (Table 1).

	# of crabs	average carapace width (mm)
total crabs measured	6686	130.6
total male crabs	6049	132.9
soft	954 (16%)	139.8
hard	5095 (84%)	131.6
>127	4461 (74%)	139.9
>127mm and hard	3610 (60%)	139.1
total female crabs	637	108.7
berried female crabs	42	116.2

Table 1. Composition of Jonah crabs measured during at-sea observer trips from all sampled traps. Source: Reardon Masters Thesis 2006

Component: Management

See Appendix B for detailed information regarding state level management efforts.

1.2.1 Harvest Strategy

Objective: There is a robust and precautionary harvest strategy in place.

Summary of Findings:

- There is no harvest strategy specific to Jonah crab, as most crabs are harvested as bycatch in the lobster fishery.
- However, research assessing the use and efficiency of a modified crab trap has been explored.

There does not appear to be a harvest strategy associated with Jonah crab specifically. These crabs are primarily caught as a by-catch of lobster traps and in state exempted top entry traps.

From 2002 to 2005, Maine Department of Marine Resources undertook a project to develop a modified Jonah crab-specific trap designed to reduce or eliminate lobster bycatch (Wilson 2005). The design of the modified side entry trap worked using specific entrance and escape dimensions to maximize catch of large male crabs (>127 mm CW) and minimize the catch of legal size lobsters (>82.5 mm carapace length) (Reardon 2006). Lobster behavior with escape vents has shown a significant relationship of lobster CW size and the ability to escape or enter through rectangular openings (Nulk, 1978). Crab carapace width and depth limit entrance to or escape from a rectangular opening, while lobster carapace width and length limit entrance to and escape from circular openings. Using body dimensions of both lobsters and Jonah crabs, DMR determined that a 63.5 mm (2.5”) entrance head and 82.55 mm (3.25”) circular escape vent would attain the goal of maximizing large crabs and minimizing legal size lobsters as compared to a standard lobster trap (Reardon 2006, Figure 7). That trap is not currently in use and no further development has been initiated.

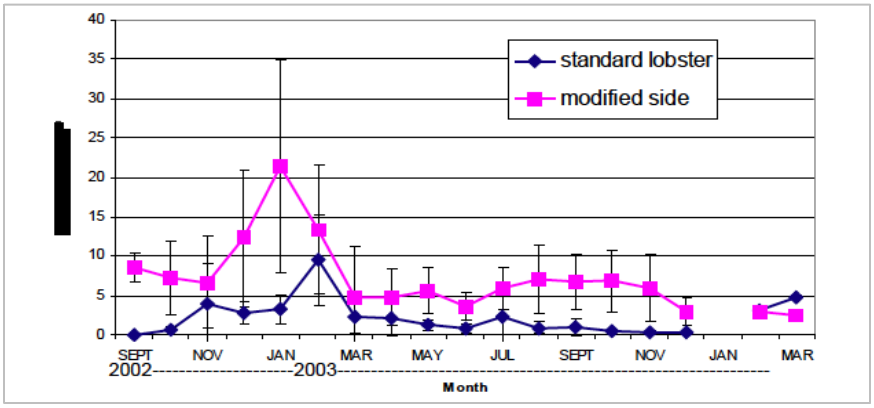

Figure 7. Source: Reardon Master’s Thesis 2006

1.2.2 Harvest Control Rules and Tools

Objective: There are well-defined and effective harvest control rules in place.

Summary of Findings:

- There are no federal harvest control rules in place and regulations are inconsistent from state to state.
- State management efforts utilize combination lobster/crab permits or lump Jonah crabs with “other edible crabs” under blue crab regulations.

In the U.S., Jonah crab populations are managed by individual states as opposed to federally, although catch reporting is processed by the National Marine Fisheries Service. There are no regulations regarding Jonah crabs in Federal waters (Wilson 2005). Management measures for Jonah crabs appear to be non-specific, although many states have specific harvest regulations for other commercially viable crab species such as blue crab and horseshoe crab, which include minimum size limits, sex restrictions, seasonal and area closures, as well as limits on trap size, configuration, and trap numbers (see Appendix B) (Reardon 2006; FOC 2010). Some states (e.g. Maine, Connecticut, and Massachusetts) require joint lobster and crab permits for the harvest of crabs in state waters and do not have separate crab permits. Other states (e.g. Maryland) cover Jonah crabs under a crustacean permit (Reardon 2006). Most states require a license for commercial harvest and transport of crabs, which are stated generally enough to include Jonah crabs.

Overall, we did not find Jonah crab-specific directed fisheries regulations in any of the New England states, although crab fishery regulations were found specific to other species in Southern New England and Mid-Atlantic states, such as blue crab in particular. There are currently no size limits for recreational harvest of Jonah crab in ME, NH, MA, RI, CT, NY or NJ (reference the state regulation table in Appendix B), although regulations related to other crabs such as blue crab often do have restrictions on harvest size. The two states with highest reported landings – Massachusetts and Rhode Island – do not adequately describe management frameworks specific to Jonah crab, but rather include the harvest of Jonah crab within lobster regulations (see Appendix B).

Commercial harvest limits for Jonah crabs specifically do not appear to be established in most states. Maine does have a daily commercial maximum of 200 lbs. for general harvest of crabs (See Maine Laws & Regs p.15) . Recreational landings and alternate harvest methods, such as scuba and hand harvest, are described in the regulatory frameworks for blue crabs (e.g. Massachusetts and Connecticut), and often are broadly written to include Jonah crabs as an edible crab.

Maryland, with a large blue crab fishery, has provided for the most detailed regulatory framework, which could be a model for Jonah crab, but currently does not include Jonah crab specifically.

As background information, we see that in Canada Jonah crabs have been taken in near-shore lobster fisheries since the 1960s (Elner 1986; Robichaud and Frail 2006). When populations of more popular crabs became depleted, fishermen began targeting Jonah crabs. During the late 1980s and early 1990s, exploratory directed Jonah crab fisheries commenced along the northeast Atlantic coast (Robichaud et al. 2000a,b). Regulations were put in place to manage Jonah crab fisheries, with management efforts intended to protect the reproductive capacity of Jonah crab populations (Robichaud and Frail 2006). Additional management measures include limited entry access, bycatch provisions, logbooks and at-sea observers, third-party catch verification, and a total allowable catch (TAC) (FOC 2010). Directed offshore fisheries commenced in 1995 and from 1999 to 2002 an experimental offshore Jonah crab fishery was developed. However, landings declined sharply in less than a decade and the offshore fishery is no longer active (FOC 2009). It appears that the TAC of 720 metric tons set in 1995 was not sustainable.

1.2.3 Information and Monitoring

Objective: Relevant information is collected to support the harvest strategy.

Summary of Findings:

- Landings data, mostly from the near shore lobster fisheries, are available.
- State sea sampling programs do not collect information on the Jonah crab catch.
- Some biological information does exist, however, from federal and state fishery dependent and independent surveys.
- State and federal trawl surveys may provide relevant information to support a harvest strategy.

The reporting of commercial harvest of crabs in general does appear to be required by most States, and would include Jonah crab among other edible crabs although Jonah crab is not specifically cited in these reporting requirements. The National Marine Fisheries Service data reporting portal does have a category for Jonah crab specifically, which suggests that reporting is occurring and landings data in the U.S. are available. However, Jonah crabs can be easily confused with rock crab, so confusion around species identification might create false landings data.

As well, to date a fair amount of biological data about Jonah crabs have been gathered from bottom trawl surveys, and also through inshore surveys performed by various state agencies and can provide an indicator of relative changes in spatial and temporal abundances (See Appendix A). However, trawls cannot sample certain habitats and Jonah crab may learn to avoid them (Reardon 2006). State and federal trawl surveys may provide relevant important historical and current fishery-independent information to support the harvest strategy, but they have not been examined for this purpose.

Catch levels may be an index for Jonah crab population abundance. However, these may also be skewed by changes in effort as determined by market forces, regulations, availability of other fisheries, etc. As well, species identification remains an issue, where Joan crab is often confused with rock crab and this is likely to confound the existing data.

As noted earlier, the number of Jonah crabs taken in lobster fisheries is not fully known, and anecdotal reports suggest that the number of Jonah crabs taken from at least some lobster fisheries may be far higher than the amount specifically targeted. In addition, lobster fishermen sometimes use Jonah crab bycatch as bait in their traps, and this could contain smaller individuals and females.

1.2.4 Assessment of Stock Status

Objective: There is an adequate assessment of stock status.

Summary of Findings:
- There is no assessment of stock status or evaluation of all the relevant data with the goal of determining whether the resource is overfished.
- In the case of RI, the two Cancer species seem to have been combined, and results therefore are very equivocal.

To date no comprehensive stock assessment has been undertaken at the U.S. federal level, and information to undertake such an assessment has data gaps (refer to Appendix A.)

The 2012 Rhode Island state assessment indicated that the fishing mortality rate in the state *Cancer* crab fishery (both Jonah and rock crabs) exceeded F_{msy}, but the biomass had not fallen below B_{msy} and therefore was not considered overfished

(RIDEM 2012). According to the report, fishing mortality for *Cancer* crab species has recently exceeded the F_{msy} level (Figure 8) and should be monitored in the future. Biomass, however, was above the B_{msy} level, so the Jonah and rock crab resource was not considered over-fished at this time (see Figure 9 below).

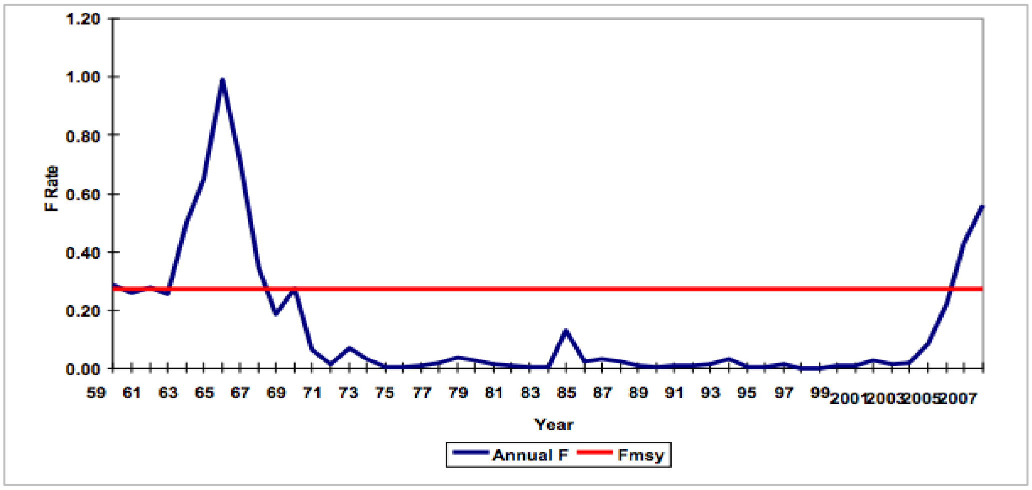

Figure 8. Source: RIDEM

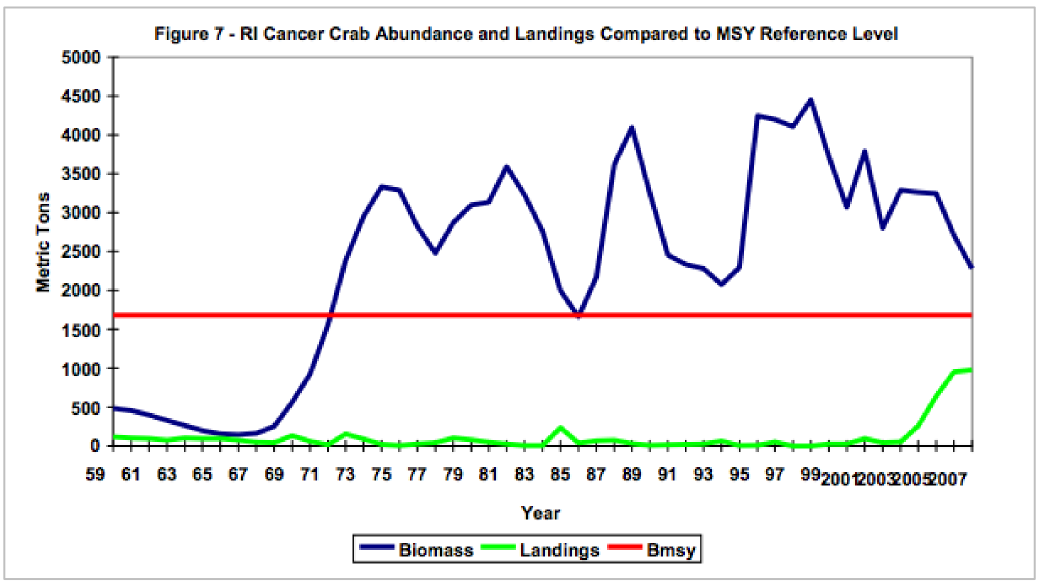

Figure 9. Source: RIDEM

As previously noted, Jonah crab appears to be landed primarily in American lobster fisheries and as a component of other edible crab fisheries. The take in lobster fisheries is hard to assess because fishermen sometimes use Jonah crab as lobster bait or do not report their catch (Reardon 2006). Until the levels of Jonah crab catch in lobster fisheries are fully understood, and lobster fishermen report all of their Jonah crab catch (whether it is used directly as bait or sold commercially), accurate assessments of the fisheries that land Jonah crab will be difficult (Robichaud and Frail 2006; Reardon 2006).

Principle 2

Component: Retained Species

2.1.1 Outcome

Objective: The fishery does not pose a risk of serious or irreversible harm to the retained species and does not hinder recovery of depleted retained species.

Summary of Findings:

- Not enough information is available to determine the risks to the retained species.
- Expansion of biological sampling in fishery dependent and independent surveys could increase our understanding of this issue.

Information to understand the impact of removals on the retained species abundance and recovery in the case of decline does not appear to be available. The biological sampling data gathered (see Appendix A) could however yield some insights.

In fisheries that target large males, such as the Jonah crab fishery, the fishery will likely modify the size distribution of males in the population (Jamieson et al. 1998). The concern here is whether removal of large reproductive males affects the stock performance and yield of the population. There may also be concerns about removing claws as a harvesting strategy, and discarding the carapace. This has prompted regulations in Maryland that specify that no more claws may be found on board than twice the number of carapaces.

2.1.2 Management

Objective: There is a strategy in place for managing retained species that is designed to ensure the fishery does not pose a risk of serious or irreversible harm to the retained species and does not hinder recovery of depleted retained species.

Summary of Findings:

- Not enough information is available at this time.
- States have different regulations for Jonah crab harvest.

There is no federal management plan for Jonah crab stocks, but crab species are harvested in the federal lobster fishery, and the federal regulatory framework for lobsters includes restrictions on trap limits, size, and configurations that applies to crab harvested in that fishery (ASFMC 1997). As previously noted, individual states manage Jonah and rock crab through joint licenses that allow fishermen to harvest lobster as well as crab, or under the blue crab regulations, and therefore the lobster regulatory frameworks provide much of the current protections. Massachusetts has implemented a closed crab season for edible crabs in general from January 1 to April 30 (MA DMF 2012), while Maine utilizes seasonal closures in specific harvest areas for lobster and crab combined (ME DMR 2012). Other states have provided for seasonal closures in their blue crab and other edible crab fisheries, but these do not necessarily target the reproductive cycles of Jonah crab specifically.

2.1.3 Information

Objective: Information on the nature and extent of retained species is adequate to determine the risk posed by the fishery and the effectiveness of the strategy to manage retained species.

Summary of Findings:

- The majority of information results from findings from the lobster fishery.
- Reardon's (2006) and Wilson's (2005) experimental fishery and modified trap project could provide some insight.

Commercial harvest volumes of Jonah crab are reported to the National Marine Fisheries Service, and deemed to be accurate, barring the previously mentioned misidentification issue between rock crab and Jonah crab. However, biological sampling data have not been tied back to these removals to provide a comprehensive understanding of the impact of fishing mortality on the population. Although there are several fishery independent surveys that could provide information useful in assessing the impact of fishing (See Appendix B), comprehensive stock-wide analyses have yet to be done. We therefore don't know if the information available is adequate to determine the risks posed by the fishery and the effectiveness of any management plan.

Component: Bycatch Species

2.2.1 Outcome

Objective: The fishery does not pose a risk of serious or irreversible harm to the bycatch species or species groups and does not hinder recovery of depleted bycatch species or species groups.

Summary of Findings:

- Because there are no directed Jonah crab fisheries in the U.S., much of the information available is from American lobster bycatch information.
- Atlantic cod, white hake, and cusk were identified as main species caught as bycatch in the lobster fishery.
- Additional bycatch data specific to modified Jonah crab traps are available.

The Jonah crab harvest in the U.S. has itself been largely seen as a bycatch in the lobster fishery and therefore many of the bycatch discussions are confounded by this nuance, and assessment of the impact of any directed Jonah crab fishery is difficult. In the Gulf of Maine, Reardon (2006) reported very low bycatch rates of non-target species when asked about Jonah crab harvest specifically,all at less than 1% of the total catch. For discussion, we see that in Canada, bycatch of lobsters in directed Jonah Crab fisheries appears to be negligible (0.4 lobster per trap haul) (Robichaud and Frail 2006). For this section, we will therefore focus attention on the findings of the lobster fishery, which may offer applicable parallels.

If bycatch in the Maine lobster fishery is any indication of what might be expected in a directed Jonah crab fishery, according to the American Lobster Marine Stewardship Council Certification report, at least 10 finfish species are recorded as discarded bycatch (data provided by C. Wilson, Maine DMR).

The species found to be most abundant in the bycatch analysis of the lobster fishery (longhorn sculpin) made up 0.5% of the lobster catch over the three years sampled, and all other species were well below this level. Total numbers of individuals taken and discarded can be estimated based on an estimate of 260,000 trips made in 2008 (the first year for which such an estimate is available). Discard survival rate is unknown but probably greater than zero, since the fishery operates in relatively shallow waters.

Species that comprise less than 5% of the total catch by weight may normally be considered minor species (not “main”), unless they are of high volume or particular vulnerability. Using this guidance it was concluded that three species are considered to be main bycatch species owing to their vulnerability:

- The Gulf of Maine Atlantic cod, which are overfished (that is, they are below a chosen abundance reference point) and overfishing is occurring (that is, fishing mortality is higher than the chosen reference point) (NEFSC 2011).
- White hake, which are overfished and overfishing is occurring. (NEFSC 2012)
- Cusk, which has been identified as a "species of concern" following a steep decline in trawl survey indices and a Canadian assessment of the shared population indicating an "at-risk" status.

According to Reardon (2006), reported non-targeted species catch was very low during the reporting period. Sublegal lobsters had the highest catch rate, Atlantic redfish, hake, and legal size lobsters followed sublegal lobsters in catch rate. Lobsters, redfish, and hake were the only regulated species bycatch observed during DMR observer trips.

2.2.2 Management

Objective: There is a strategy in place for managing bycatch that is designed to ensure the fishery does not pose a risk of serious or irreversible harm to bycatch populations

Summary of Findings:

- Some requirements on harvest strategy decrease risks of harm to bycatch populations.
- The main bycatch species of concern also have management strategies to ensure their sustainability.

In U.S. trap and pot fisheries, all pots are mandated to contain devices that allow sub-legal lobsters and crabs to escape, and fishermen have developed modified Jonah crab traps that are highly successful at reducing lobster and other non-targeted species bycatch (Reardon 2006). In addition, pots are required to use biodegradable webbing in the event that pots are lost (FOC 2009, 2010). In the Maryland crab fisheries, turtle bycatch reduction devices similar to escape vents in lobster traps, are required.

For discussion, based on data from the last decade, the number of sub-legal male (< 130 mm CW; < 2.5 crabs per trap haul) and female Jonah crabs per trap haul (< 7 females per trap haul) in Canadian fisheries has remained low, indicating that trap escape vents were effective in limiting the amount of females that were taken (Robichaud and Frail 2006).

Additional concerns arise from traps which are no longer retrievable, often called 'Ghost gear." No records of amount of gear lost are available. Fishermen advise that they make every effort not to lose gear, and to retrieve gear which is lost, because of the high cost of gear (approximately $100 per trap); GPS systems are now widely available and facilitate retrieval of lost gear. By regulation, traps must include a biodegradable escape panel. No studies of length of time for these to degrade are available, but they are usually replaced annually (C. Wilson, pers. comm.).

Diving experience shows wide prevalence of ghost gear on the bottom in shallow water within SCUBA depths (C. Wilson, pers. comm.). In November of 2009, The Gulf of Maine Lobster Foundation initiated the two-year National Fish and Wildlife Foundation-funded *Derelict Lobster Gear Retrieval, Salvage and Disposal* project. The project employs lobstermen from each of Maine's seven lobster management zones to remove derelict lobster gear. Although the project will continue into early 2012, an interim report from October 2011 indicated that of the 3037 traps retrieved during the first two years of the project, the majority held a State tag to indicate the last year fished. Of these, the majority of recently lost traps had closed escape panels while the majority of older traps had open panels. For example, the 2011 report indicated that of those traps recovered with 2010 tags, 223 had closed panels while 66 had open panels. Of those traps recovered with 2009 tags, 38 had closed panels while 72 had open panels (Ludwig 2011).

2.2.3 Information

Objective: Information on the nature and amount of bycatch is adequate to determine the risk posed by the fishery and the effectiveness of the strategy to manage bycatch.

Summary of Findings:

- The majority of bycatch information comes from the lobster fishery.
- Bycatch of cod and white hake species is not considered in their assessments, apparently because the levels are so low.

We refer again to the lobster fishery findings. Information on discarded bycatch in the lobster fishery has been collected on sea sampling trips in 2006, 2007, and 2008 (Table 2). The sea sampling program targets 3 trips per month in each of the 7 fishery management zones; although the target is not always met, sampling covers areas and seasons well. A total of 542 trips were sampled for bycatch in the three years for which data are available (varying from 171-186 per year), for a total of 123,269 traps sampled (varying from 40,482-41,782 per year). Of the 542 trips sampled, 465 (with 103,439 traps) had observed bycatch. Finfish bycatch relative to lobster catch, per trip and per trap is very low in this fishery (Table 2 below).

Species	Individuals taken on 465 sampling trips (3yrs)	Individuals per trip	Total individuals taken in 2008 fishery
Lobster	322,356		
Sculpin longhorn	1,765	3.80	986,882
Sea raven	996	2.14	556,903
Sculpin shorthorn	745	1.60	416,559
Cunner	414	0.89	231,484
Cod	**317**	0.68	177,247
Redfish Acadian	**302**	0.65	168,860
Cusk	**201**	0.43	112,387
Sculpins	140	0.30	78,280
Spiny dogfish	**129**	0.28	72,800
Hake unclassified	**96**	0.21	54,600
Flatfishes unclassified	**77**	0.17	44,200
Mackerel Atlantic	**67**	0.14	37,462
Pollock	**27**	0.06	15,097
Lumpfish	18	0.04	10,065
Horseshoe crab	**16**	0.03	8,946

Note: species in bold are managed species. Total individuals taken is an estimate based on individuals taken per trip from observer program and an estimate of 260,000 trips made for 2008.

Table 2. Source: Lobster MSC certification document.

Estimated catches of cod and white hake are very low compared to other sources of mortality. In other words, assuming an average weight of 1 kg per individual (based on the size of cod likely to be able to enter a trap), 177 tons of Atlantic cod were discarded in 2008 in the lobster fishery, compared to total landings of Atlantic cod of 3,989 tons in 2007 and similar levels in preceding years; there are also recreational catches and discards (NEFSC 2008). Based on the same assumptions, discards of white hake in the lobster fishery (55 t/yr) were low compared to reported landings (1,600 t in 2007, higher in preceding years) (NEFSC 2008). Bycatch of these species is not considered in their assessments, apparently because the levels are so low.

Cusk taken as bycatch in the Maine lobster fishery are part of a stock shared with Canada, with the center of abundance on the Scotian Shelf (Harris and Hanke 2010). Cusk is not considered a commercial species in either Canada or the U.S. (although bycatches from groundfisheries may be landed) but has been identified as a “species of concern” for possible listing under the US Endangered Species Act (ESA) (NMFS 2009). “Species of Concern” are those species about which NMFS has some concerns regarding status and threats, but for which insufficient information is available to indicate a need to list the species under the ESA. "Species of concern" status does not carry any procedural or substantive protections under the ESA.

Total removals of Cusk include fishery landings of the order of 100 tons/yr in the U.S. (O’Brien 2006), 800 tons/yr from fisheries in Canada and 200 tons/yr lobster bycatch in Canada (DFO 2008). Annual Maine lobster fishery bycatch would be around 112 tons/yr from the table above. A recent population assessment (Harris and Hanke 2010) indicates that survey abundance catch rates have been stable since the late 1990s; commercial catch rates have declined but this may be due to management restrictions on the fisheries in which cusk are taken as bycatch. DMR received a federal grant to evaluate the extent and degree of Cusk bycatch in the trap and longline fisheries. This project began in Spring 2011 and measure the condition and survival of cusk caught in non-directed fisheries. These data will be used in stock assessments and future management of this resource (DMR 2011).

Component: ETP Species

2.3.1 Outcome

Objective: The fishery meets national and international requirements for protection of ETP species. The fishery does not pose a risk of serious or irreversible harm to ETP species and does not hinder recovery of ETP species.

Summary of Findings:

- Measures are taken in the lobster fishery to maximize protection of ETP species.
- This is cited as a challenge to the use of a modified trap design since it would allow an additional 200 traps into waters (Wilson 2005).

Fixed gear trap and pot fisheries have been criticized for critically endangering North Atlantic right whales (*Eubalaena glacialis*), which sometimes become entangled in the lines that connect the traps or pots together (Johnson et al. 2005). Entanglements appear to be relatively common, as opposed to isolated events. For example, scar studies of right whales revealed that 72% of the population has been entangled in fishing lines at least once and entanglement appears to be increasing (Knowlton and Kraus 2001; Knowlton et al. 2003). In addition, a scar study of humpback whales in the Gulf of Maine indicated that more than half of the population had been entangled in fishing lines, with 8 – 25% of individuals receiving new injuries each year (Robbins and Mattila 2004). Johnson et al. (2005) found that 80% of North Atlantic Right Whale entanglements and 56% of humpback whale entanglements occurred in Lobster pot gear despite management efforts that included a minimum number of pots allowed per vessel and limited entry into the fishery. The researchers reported that right whale entanglements occurred in pot gear 71% of the time, with the next most frequent gear type (gillnets) substantially lower at 14% (Johnson et al. 2005).

2.3.2 Management

Objective: The fishery has in place precautionary management strategies designed to:

- Meet national and international requirements;
- Ensure the fishery does not pose a risk of serious or irreversible harm to ETP species;
- Ensure the fishery does not hinder recovery of ETP species; and
- Minimize mortality of ETP species.

There is a strategy in place for managing ETP species that is designed to ensure the fishery does not hinder the recovery of ETP species.

Summary of Findings:

- The Jonah crab fishery does not specifically have any management strategies in place, precautionary or otherwise.
- There is information to the extent that there is information from the lobster fishery, which appears to be applicable.

In U.S. waters, North Atlantic Right Whales are currently managed under the Atlantic Large Whale Take Reduction Plan (ALWTRP), with several measures in place to reduce entanglement in fishing gear such as pots and traps (NMFS 2010). Specific management strategies include the following:

- Fishing gear modifications (e.g. the use of sinking or neutrally buoyant line and weak links between lines and traps/buoys; Johnson et al. 2005; Kraus et al. 2005),
- Seasonal area management zones (e.g. no fishing in high-use areas during spring and summer), and
- Dynamic area management zones (e.g. no fishing when aggregations are located) to regulate fishing efforts, a disentanglement network, and a sighting advisory system (NMFS 2010).

Although the population remains critically low, recent data indicate it appears to be slowly increasing (NARWC 2010), which suggests that these measures may be working.

2.3.3 Information

Objective: Relevant information is collected to support the management of fishery impacts on ETP species, including:

- Information for the development of the management strategy;
- Information to assess the effectiveness of the management strategy; and
- Information to determine the outcome status of ETP species.

Summary of Findings:

- There is no information specific to Jonah crab.
- There is information from the lobster fishery, which appears to be applicable.

NMFS (2010) published a biological opinion on whether impacts of the American lobster fishery would be likely to appreciably reduce the likelihood of survival or recovery of endangered, threatened and protected species. The species considered, for which there are documented interactions with the American lobster fishery, were:

- North Atlantic right whale
- Humpback whale
- Fin and Sei whales
- Loggerhead turtle
- Leatherback turtle

All of the whale species are listed under the ESA as endangered. The ESA describes a "distinct population segment" of loggerhead turtle as "threatened" and the leatherback turtle as endangered.

Three minke whales were reported entangled in lobster gear in the Maine fishery in 2010, so this species must also be considered. Minke whales are not listed under the ESA but are protected under the U.S. Marine Mammal Protection Act, and are listed on Appendix I of CITES, as are all of the above listed species.

The following sections review information available to the assessment on these species and concludes with a summary of the results of NMFS (2010) on the potential impacts of the fishery on them. Further detail on the NMFS (2010) analysis as it affects scoring is found in the scoring table.

The population of right whales is one of the most critically endangered marine species and is known to interact with the Maine lobster fishery.
Current population size of right whales is estimated at somewhere between 300 and 400 individuals. Annual calf production, and estimated population trend (decreasing, stable, or increasing) have been highly variable over the past two decades, with calf production low in the early 2000s and a production of nearly 40 calves in 2008. The most recent population assessment concluded that the population had been increasing in the period 1990-2005 (NMFS 2010a).

Component: Habitats

2.4.1 Outcome

Objective: The fishery does not cause serious or irreversible harm to habitat structure, considered on a regional or bioregional basis, and function.

Summary of Findings:
- Information is available on the impact of lobster pots on habitats.
- Lobster pots impact an area approximately two to three times larger than their actual footprint due to dragging when the pots are set and retrieved.
- Overall, the effect of fishing practices in the American lobster fishery, and therefore in the Jonah crab fishery, rates as a moderate conservation concern.

Jonah crabs are harvested from both sensitive (e.g. rocky) and resilient (e.g. sandy or silty) benthic habitats. Jonah crab can be found at depths ranging from 1 to 800m. Their habitat preferences vary from shallow to deep water and from rocky to sandy bottoms. In Narragansett Bay (Jeffries 1966) and Maine (Krouse 1980), they are found along rocky bottoms, whereas in the deep water of the continental slope they are found on silt and clay (Musick and McEachran 1972; Wenner et al. 1992; Robichaud and Frail 2006). Habitat preferences also vary seasonally. For example, in Rhode Island, Jonah crab occupy inshore areas during the spring and move to deeper, warmer waters during the winter (FOC 2009). These benthic habitats are likely sufficiently robust to support Jonah crab.

As previously noted, Jonah crabs are taken in crab pots and lobster traps (Wilson 2004, Robichaud and Frail 2006; Reardon 2006). The pots or traps are either deployed individually or attached to each other via a groundline along the seafloor, depending on the fishery. Traps used in the American lobster fishery are reported to affect an area two to three times the footprint of the trap (Table 3; Northeast Region Essential Fish Habitat Steering Committee 2002). The overall impact from pots and traps will vary between benthic habitats. Although the impact of an individual pot may be seem minimal, the cumulative impact of more than four million lobster pots may be cause for concern (NREFHSC 2002). The Essential Fish Habitat Steering Committee concluded, however, that the resilience of the bottom habitat is considered moderate to high, depending on the bottom habitat.

Gear type	Effect of fishing gear on habitats	Habitat resilience to disturbance	Geographic extent of fishery effects	Evidence of food web disruption	Evidence of ecosystem changes	Sources
Lobster traps/ pots	Moderate	Moderate	Moderate	None	None	Northeast Region Essential Fish Habitat Steering Committee 2002

Table 3: Habitat effects of gear used to catch American lobster. Source: American Lobster MSC certification document.

2.4.2 Management

Objective: There is a strategy in place that is designed to ensure the fishery does not pose a risk of serious or irreversible harm to habitat types.

Summary of Findings:

- There is information from the lobster fishery, which appears to be applicable.

Although pots and traps are required to use biodegradable webbing in the event that they become lost at sea (FOC 2009, 2010), no known efforts are currently in place to mitigate damage to sensitive seafloor habitats (e.g. rocky bottoms, deep corals).

2.4.3 Information

Objective: Information is adequate to determine the risk posed to habitat types by the fishery and the effectiveness of the strategy to manage impacts on habitat types.

Summary of Findings:

- The recent high abundance of lobster in Maine area suggests that impacts of the fishery on lobster habitat, at least, are not substantial.
- However impacts of dragging ground ropes over the bottom were greater than those of traps alone.

(The below reference material provided as excerpts from the 2013 Maine Lobster MSC report.)

According to the Maine lobster MSC findings, the inner continental shelf off the Maine coast has been mapped using sidescan sonar and related data (Barnhardt et al 1998; Maine Geological Survey n.d.). Surficial geology in this area is extremely complex, a mosaic of rock, gravel, and mud habitats often changing over short distances (Barnhardt et al 1998). Fishermen report that fishing areas for Jonah crab are primarily on rocky and muddy bottoms which are the predominant bottom types in the area within 3 miles where the fishery is concentrated (Maine Geological Survey data provided by the MLA). Natural disturbance from storms and currents (including strong tidal currents) is high down to 30 m depths (Witman 1998), so one would not expect to see development of the complex, long-lived erect fauna which are particularly sensitive to fishery impacts, including trap fishery impacts. A variety of invertebrate and algal assemblages are associated invertebrate species

(Ojeda and Dearborn 1989; Witman 1987). More complex, emergent fauna might be expected to occur at greater depths and lower-energy environments; fishing does occur at depths beyond 30 m where natural disturbances would be less pronounced.

The impact of trap gear on bottom habitats has generally been considered to be much lower than that of towed gear, although information on trap impacts is very limited. Several studies have provided observations of trap impacts on benthic habitats. Eno et al (2001) studied impacts of trap fishing on emergent fauna (sponges, bryozoans, ascidians, soft corals, and tube worms) at three sites off the British Isles, and concluded that impacts were generally low. Soft, erect fauna (sea pens) tended to bend as traps descended, and although some were uprooted, recovery was relatively rapid. Impacts on other emergent fauna were limited. However impacts of dragging ground ropes over the bottom were greater than those of traps alone. Further, the authors noted that the study did not assess the impacts of long periods of repeated fishing which could have been more significant. Recent studies, including Adey (2007) (*Nephrops* creel impact on soft-bodied emergent fauna, Scotland), Stone (2006) (crab pot impact on corals, Alaska) and Troffe et al (2005) (prawn trap impacts on sea pens), all concluded that traps can damage emergent fauna, but did not provide assessments of the degree of damage. Troffe et al (2005) observed that prawn traps caused more damage to emergent fauna (sea whips) than beam trawls, while Stone (2006) observed less damage from crab pots to corals than longlines and trawls.

A workshop on effects of fishing gear on marine habitats in the Northeastern U.S. (NEFMC 2002) concluded that the degree of impact caused by pots and traps to biological and physical structure and to benthic species in mud, sand, and gravel habitats was low. Impacts were expected to be greater in rocky habitats where emergent epifauna or biogenic structures are present. Impacts from dragging a trap along the bottom, or from ground ropes linking several traps, could increase the impact over that of a single trap. The general conclusion that trap gear is likely to have lower impacts on bottom habitats than towed gear was confirmed by the detailed review of NEFMC (2011a). Stevenson et al (2004) reviewed impacts of fishing gear on bottom habitats off the Northeastern U.S., citing Eno et al (2001) as the only available study of trap impacts on bottom habitats at that time. The recent requirement to use sinking ground ropes in parts of the Maine lobster fishery area to reduce potential for whale entanglements could potentially contribute to increasing damage to bottom habitats, since dragging ground ropes increase the risk of trap fishery damage to habitats.

The collective footprint of the Maine lobster trap fishery, in terms of distribution of trap hauls, is not well known, although studies have provided improved information on this. Trap fishing effort appears to be extremely intensive, with high trap densities throughout state waters (at least in the summer) and relatively frequent hauling of gear. In total ,Maine DMR issues over 3 million trap tags annually, but not all of these are used. A study of vertical line distribution and abundance, based on information from a survey of all federal permit holders in Maine (Smith 2006), provided estimates of numbers of vertical lines in the water by season and by fishing area along the coast of Maine, along with information on trap fishing configurations (singles, pairs, trawls, etc.), which could be used to estimate the number of trap contacts with the bottom. Generally, trap densities are much greater within state waters, lower in the nearshore area (3-12 mile zone) and lower still offshore (outside 12 miles); densities are greatest in summer months, peaking in July and August, in state waters but greatest in the fall beyond 12 miles. Pairs and singles are the dominant fishing configuration inside 12 miles, while trawls of 10 to 20 traps (which have the potential to cause more damage to benthic fauna than pairs and singles) are much more important outside 12 miles. Information on distribution of fishing compiled by the Maine Lobsterman's Association (MLA), based on logbook information, shows fishing to be strongly concentrated in the state waters peaking at over 100 traps per km2 in July-September. Traps are hauled several times per week during summer when weather is favorable, less frequently in spring and fall when storms may impede fishing operations.

Component: Ecosystem

2.5.1 Outcome

Objective: The fishery does not cause serious or irreversible harm to the key elements of ecosystem structure and function.

Summary of Findings:

- There is potential to cause harm to the ecosystem, to the extent that the fishery targets a key mid-level consumer in the benthic ecosystem and may also impact the habitat and other species as bycatch.
- As a consumer, Jonah crab has the potential to initiate a trophic cascade by direct and indirect controls of urchin abundance, which in turn could have important positive effects on the structure of macroalgal communities.

Jonah crab co-exists with rock crab and the American lobster (*Homarus americanus* (Williams 1984). In Narragansett Bay, Jeffries (1966) reported the rock crab and Jonah crab partition the estuary into sandy and rocky habitat respectively. He found the difference in metabolic rates could explain the differential speed of movement and habitat choice. The difference in pace allows rock crab to escape predation by moving away rapidly while the slower Jonah crab must find shelter in complex habitat. In Narragansett Bay, Jonah crab likely exclude rock crab from the preferred shelter rich habitat (Fogarty 1976), but in more northern latitudes, like in the Gulf of Maine, juvenile rock crab are found in rocky substrate (Krouse 1980). Lobster, especially at smaller sizes, is also known to live in rocky habitat for shelter (Wahle and Steneck 1991). Richards and Cobb (1986) found in lab experiments that Jonah crab and lobster utilize similar habitat, but if competing for limited shelter, Jonah crab will often be displaced by lobster.

Atlantic cod (*Gadus morhua*) and other groundfish are important predators of Jonah crab. NMFS trawl data showed a 4-fold increase in Jonah crab abundance in 2000 and 2001 in the Gulf of Maine, which may be related to a continuing decline in Gulf-wide fish predator populations. It is therefore speculated that highly mobile Jonah crabs at high densities may have replaced groundfish as apex predators since their release from predatory control by groundfish (e.g. cod) in some shallow subtidal zones of the Gulf of Maine. Additionally, predation by gulls may directly influence distribution and abundance of invertebrates into intertidal zones, possibly limiting their upper distributions (Good 1992). Cascading effects of predation are well-known in ecological communities, and such interactions may be important in rocky intertidal zones. The impact of avian predators on lower trophic levels remains unknown, and future work requires experiments which can separate the effects of invertebrate, fish, and bird predators.

Adult Jonah crabs prey on small invertebrates on the seafloor. In turn, Jonah crabs are preyed upon by a variety of fishes and American lobsters (Ojeda and Dearborn 1991). With population decreases of large predatory fishes (e.g. Atlantic Cod) during the past half-century, Jonah crabs have become apex predators on sea urchins in some areas (Leland 2002; Steneck et al. 2004). Current levels of Jonah crab likely remain high enough to maintain their increasingly important roles in the marine ecosystem. Therefore there is potential to cause harm to the ecosystem, to the extent that the fishery targets a key mid-level consumer in the benthic ecosystem and may also impact the habitat and other species as bycatch.

Jonah crab are a voracious generalist predator in the subtidal zone of the Gulf of Maine, consuming mussels, polychaetes, sea urchins, and crab and fish remains (Ojeda and Dearborn 1991). In turn, small Jonah and rock crabs were found to be the most common prey of cunner, sculpin, and lobsters. In deeper waters, Jonah and rock crab are reported to be the preferred prey of large predatory groundfish, including cod , that once dominated the Gulf of Maine ecosystem (Link and Garrison 2002). Leland (2002) and Steneck et al. (2004) provide evidence that the Jonah crab has become an “apex” predator, especially on urchins, since the populations of large predatory finfish decreased in the past half-century.

In August and September, predation by migratory populations of large Jonah crabs decimated relocated urchin populations and restored fleshy-algal dominance at these locations (Leland 2002). Laboratory experiments confirmed that sea urchin grazing decreases algal biomass and that Jonah crabs are stronger sea urchin predators than rock crabs.

In laboratory experiments, the presence of Jonah crabs significantly decreased sea urchin grazing rates on kelp (McKay and Heck 2008). The results suggest Jonah crabs could have important positive effects on kelp abundance through their direct or indirect effects on urchins.

Urchin mortality was significantly lower in the mussel habitat than in habitats dominated by the macro algae *Codium fragile* or urchin barrens (Siddon and Witman

2004). Crab diet was determined by prey availability. It was dominated by mussel prey in mussel beds and sea urchins in urchin barrens. In the barrens, crab predation on urchins indirectly increased the abundance of the introduced ascidian, *Diplosoma* sp., whereas *Codium* density did not change among treatments. A significant risk reduction for urchins occurred in *Codium* and barren habitats, but not in mussel habitats when crabs and lobsters were combined. Lobsters also produced a positive indirect effect on mussels by reducing crab predation. Thus, lobsters modify crab behavior and dampen changes in community structure.

To date there has been no assessment of whether the removal of American lobster, or Jonah crab, has substantially disrupted the foodweb. There is evidence, however, that the addition of bait from lobster traps may have measureable trophic impact by enhancing lobster growth rates (Grabowski et al. 2010), and there is reason to believe this would also be true for Jonah crabs. Overall, the effect of fishing practices in the American lobster fishery, and therefore in the Jonah crab fishery, rates as a moderate conservation concern.

2.5.2 Management

Goal: There are measures in place to ensure the fishery does not pose a risk of serious or irreversible harm to ecosystem structure and function

Summary of Findings:

- There do not appear to be measures in place to ensure the fishery does not pose a risk to the ecosystem, associated with Jonah crab specifically.
- Measures mentioned in above sections could help reduce ecosystem impacts, but no measures are in place to specifically address this question.

2.5.3 Information

Objective: There is adequate knowledge of the impacts of the fishery on the ecosystem

Summary of Findings:

- There does not appear to be adequate information to inform the knowledge of impacts of the fishery on the ecosystem, associated with Jonah crab specifically.

Principle 3

Component: Governance and Policy

3.1.1 Legal and Customary Framework

Objective: The management system exists within an appropriate and effective legal and/or customary framework, which ensures that it:

- Is capable of delivering sustainable fisheries in accordance with MSC Principles 1 and 2, and
- Observes the legal rights created explicitly or established by custom of people dependent on fishing for food or livelihood; and
- Incorporates an appropriate dispute resolution framework.

Summary of Findings:

- There does not appear to be a legal and customary framework associated with Jonah crab specifically.

3.1.2 Consultation, roles and responsibilities

Objective: The management system has effective consultation processes that are open to interested and affected parties. The roles and responsibilities of organizations and individuals who are involved in the management process are clear and understood by all relevant parties.

Summary of Findings:

- There do not appear to be Management Consultation, roles and responsibilities associated with Jonah crab specifically.

3.1.3 Long term objectives

Objective: The management policy has clear long-term objectives to guide decision-making that are consistent with MSC Principles and Criteria, and incorporates the precautionary approach.

Summary of Findings:

- There do not appear to be long-term management objectives associated with Jonah crab specifically.

3.1.4 Incentives for Sustainable fishing

Objective: The management system provides economic and social incentives for sustainable fishing and does not operate with subsidies that contribute to unsustainable fishing.

Summary of Findings:

- There do not appear to be incentives for sustainable fishing associated with Jonah crab specifically.

Component: Fishery Management System

3.2.1 Fishery Specific Objectives

Objective: The fishery has clear, specific objectives designed to achieve the outcomes expressed in MSC's principles 1 and 2.

Summary of Findings:

- There do not appear to be Fishery specific objectives associated with Jonah crab specifically.

3.2.2 Decision making processes

Objective: The fishery-specific management system includes effective decision-making processes that result in measures and strategies to achieve the objectives and has an appropriate approach to actual disputes in the fishery under assessment.

Summary of Findings:

- There does not appear to be a decision making process associated with Jonah crab specifically.

3.2.3 Compliance and Enforcement

Objective: Monitoring, control and surveillance mechanisms ensure the fishery's management measures are enforced and complied with.

Summary of Findings:

- There does not appear to be a Jonah crab specific enforcement plan, nor do there appear to be regulations specific to Jonah crab which require enforcement.
- There is information from the lobster fishery, which appears to be applicable to Jonah crab.

Enforcement of any federal regulations is coordinated through the National Oceanic and Atmospheric Administration's Office of Law Enforcement (OLE). OLE Special Agents and Enforcement conduct criminal and civil investigations, board vessels fishing at sea, inspect processing plants, and conduct patrols on land, in the air and at sea. In addition to this enforcement work, the OLE administers the Cooperative Enforcement Program (CEP), which authorizes certain coastal state and territorial marine conservation law enforcement agencies to enforce federal laws and regulations in the Exclusive Economic Zone (EEZ). OLE also partners with the U.S. Coast Guard (USCG) and various other federal agencies, fishery management councils, and non-governmental organizations. Federal and state law enforcement agents

3.2.4 Research Plan

Objective: The fishery has a research plan that addresses the information needs of management.

Summary of Findings:

- To date there is no formal research plan.
- However, the first steps in gathering information to inform the design of such a plan have been undertaken by the Jonah crab FIP.

The FIP team has compiled a literature review, a list of fishery-dependent and –independent surveys, and focused studies to identify key monitoring programs that could contribute to a stock assessment. This effort has already identified information gaps in current surveys that could be filled by gathering additional data on Jonah crab. Literature and monitoring of other *Cancer* species in the in the North Atlantic, Northeast and Southeast Pacific may also prove useful in the absence of specific information on Jonah crab.

3.2.5 Management performance evaluation

Objective: There is a system for monitoring and evaluating the performance of the fishery-specific management system against its objectives. There is effective and timely review of the fishery-specific management system

Summary of Findings:

- There does not appear to be a Management performance evaluation associated with Jonah crab specifically.

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Appendix A: Summary of Biological Sampling Efforts

See attached.

Federal Waters

Sampling Program	Data collected: species ID	count	weight	carapace width	sex	eggs	Source	Geographic Coverage	Depth Range (fathoms)	No. Sites	Sampling Method	Sampling Frequency	Length of Time Series	Proprietary Issues	Limitation	Contact Person	Contact Info	Link to Reports/Data
NEFSC Bottom Trawl- Spring	x	x		x			NEFSC	Cape Lookout to Scotian Shelf	10-100+	370	Otter trawl/ Stratified	Annual- spring	1963- present			Burton Shank	burton.shank@noaa.gov	
NEFSC Bottom Trawl- Fall	x	x		x			NEFSC	Cape Lookout to Scotian Shelf	10-100+	370	Otter trawl/ Stratified Random	Annual - fall	1968- present			Burton Shank	burton.shank@noaa.gov	
NEFSC Bottom Trawl- Winter	x	x		x			NEFSC	Cape Hatteras to Georges Bank	10-100+	105-160	Otter trawl/ Stratified Random stratified	Annual - winter	1992-2007			Burton Shank	burton.shank@noaa.gov	
NEFSC Winter Flatfish	x	x		x			NEFSC				Otter trawl/ Stratified	Annual - winter			Does not include	Burton Shank	burton.shank@noaa.gov	
NEFSC/ ME DMR GOM Shrimp	x		x	x			NEFSC	Gulf of Maine	0-100	84	Trawl/ Random Stratified	Annual - Summer	2000- present		daylight hours only	Russell Brown	Russell.Brown@noaa.gov	http://www.nefsc.noaa.gov/femad/ecosurvey/mainpage/s
NEFSC Clam Dredge	x	x		x			NEFSC	S. VA to Georges Bank		453	"Pre-selected stations"	Every 3 years	Since 2008			Burton Shank	burton.shank@noaa.gov	
NEFSC Scallop Dredge Survey	x	x	x				NEFSC	MAB-BG	13-83	307	Scallop dredge, random	Annual - Early	2000- present			Burton Shank	burton.shank@noaa.gov	
Sea Sampling	x	x		x			NEFSC	Fed waters					1995- present		limited coverage/ total of 65	Burton Shank	burton.shank@noaa.gov	
Port Sampling	x		x				NEFSC						2007- present		75 observed trips/ 2157 crabs	Burton Shank	burton.shank@noaa.gov	
Dealer Reports/ Landings		x					NEFSC								from Federally permited vessels	Burton Shank	burton.shank@noaa.gov	
NEAMAP Trawl survey	x			x	x		NEAMAP	state/fed waters NC to s. MA	3-20	150	Otter trawl/ stratified	Annual - spring/fall	2007- present					http://www.vims.edu/research/departments/fisheries/programs/multispecies_fisherie
HABCAM							NEFSC	Georges Bank, mid-Atlantic Bight			Towed sled, Hi-Res still image transects		2007-2009 scallop survey, other surveys		limited spatial coverage	Scott Gallager	sgallager@whoi.edu	http://habcam.whoi.edu/category_table.pl
SMAST Scallop Drop Camera Survey	x	x					SMAST/ UMass	Fed waters Mid-Atlatnic shelf to Georges Bank			Drop camera random grid	Annual summer				Kevin Stokesbury	kstokesbury@umassd.edu	

Sampling Program	Data collected: species ID	count	weight	carapace width	sex	eggs	Source	Geographic Coverage	Depth Range (fathoms)	No. Sites	Sampling Method	Sampling Frequency	Length of Time Series	Proprietary Issues	Limitation	Contact Person	Contact Info	Link to Reports/Data
NH																		
ME-NH Inshore trawl survey	x	x		x			ME DMR	NH-ME state waters	5-50+	120	Fixed & random stratified combo	Spring/Fall annually	2000-present		Large catches were subsampled to 100, weight and length	Sally Sherman (ME DMR)	Sally.Sherman@maine.gov	http://www.maine.gov/dmr/rm/trawl/index.htm
Seabrook Monitoring Program	x	x		x			Normandeau Assoc./NextEra	Coastal NH		7	Ventless lobster Traps	3x weekly, June-Nov	1975-current			Paul Geoghegan	pgeoghegan@normandeau.com	
American Lobster Settlement Index	x	x		x			NH DF&G	NH state waters	2-10	3	Suction sampling of fixed sites	annually	1995-1997, 2008-current			Joshua Carloni	Joshua.Carloni@wildlife.nh.gov	
ME																		
ME/NH Inshore Trawl Survey	x	x		x			ME DMR	NH-ME state waters	5-50+	120	Fixed & random stratified combo	Spring/Fall annually	2000-present		Large catches were subsampled to 100, weight and length	Sally Sherman	Sally.Sherman@maine.gov	http://www.maine.gov/dmr/rm/trawl/index.htm
ME DMR Urchin Survey	x	x		x	x		ME DMR	ME state waters	0-8	162	Diver quadrat/ drop camera Fixed, Not stratified, combined per site		2002-present			Robert Russell	Robert.Russell@maine.gov	http://www.maine.gov/dmr/rm/seaurchin/research.htm
American Lobster Settlement Index	x	x		x			ME DMR	ME state waters	2-10	36	Suction sampling/ Fix sites	Annual Sep-Oct	1989-present			Carl Wilson	carl.wilson@maine.gov	
ME DMR Lobster Sea Sampling							ME DMR	ME state waters			commercial lobster traps				no bycatch data collected	Carl Wilson	carl.wilson@maine.gov	
ME DMR Ventless trap survey							ME DMR	ME state waters		138	unvented commercial lobster traps		2006-present		no bycatch data collected	Carl Wilson	carl.wilson@maine.gov	
ME DMR Crab Trap Report	x	x		x	x		ME DMR	ME state waters	100	39	Random stratified (camera)	1 year	2004		Difficult to ID to species from images	Carl Wilson	carl.wilson@maine.gov	
ME DMR Port Sampling							ME DMR	ME state waters							no bycatch data collected	Carl Wilson	carl.wilson@maine.gov	
Dealer Reports	x		x				ME DMR	ME state waters					2008-present		Reporting not mandatory until 2008; Jonah & Rock crab often reported	Heidi Bray	Heidi.Bray@maine.gov	

Sampling Program	Data collected: species ID	count	weight	carapace width	sex	eggs	Source	Geographic Coverage	Depth Range (fathoms)	No. Sites	Sampling Method	Sampling Frequency	Length of Time Series	Proprietary Issues	Limitation	Contact Person	Contact Info	Link to Reports/Data
RI																		
RIDEM Inshore Trawl Survey	?						RIDEM	RI state waters	~10-30	40+	Random stratified	spring & fall annually	1978-present		No Jonah in database, but possibly in the field logs.	Jason McNamee	jason.mcnamee@dem.ri.gov	
URIGSO Trawl	x	x		x			URI	Narragansett Bay	5-15	2	Fixed sites	weekly	1959-present		Not identified to species.	Jeremy Collie	jcollie@gso.uri.edu	
American Lobster Settlement Index	x	x		x			RIDEM	RI state waters	2-5	6	Suction sampling/ Fix sites	annual - late-Aug/Sep	1990-present			Scott Olszewski	Scott.Olszewski@DEM.RI.GOV	http://www.umaine.edu/marine/people/sites/rwahle/ALSIPage.htm
Ventless Trap	x	x		?			RIDEM	RI state waters			Ventless lobster Traps		2006-current		Need to fill in the blanks here. Unable to find via internet search.	Jason McNamee	jason.mcnamee@dem.ri.gov	
Sea Sampling	x	x		?			RIDEM	RI state waters			commercial lobster traps		1990-current		Need to fill in the blanks here. Unable to find via internet search.	Jason McNamee	jason.mcnamee@dem.ri.gov	
Port Sampling	x	x		?			RIDEM	RI state waters					2006-current			Jason McNamee	jason.mcnamee@dem.ri.gov	
Logbook catch and effort, VTR, Dealer reports	x		x				RIDEM	state waters					2005-current		Possible confounding of species issues	Jason McNamee	jason.mcnamee@dem.ri.gov	
MA																		
MA DMF Inshore Trawl Survey	x	x		x	x		MADMF	MAstate waters	0-30	100	Random stratified	Spring (May)/Fall (Sept.) Annually	1978-present			Derek Perry	derek.perry@state.ma.us	http://www.mass.gov/dfwele/dmf/publications/tr_38.pdf
Industry-based Survey for GOM cod	x	x	x				MADMF	ME, NH, MA	10-79 (9 strata)	1125	Random stratified	5 cruises /year	2003-2007				marine.fish@state.ma.us	http://www.mass.gov/dfwele/dmf/programsandprojects/ibs_final_report.htm
American Lobster Settlement Index	x	x		x			MADMF	MA state waters	to 10	22	Suction sampling/ Fix sites	August-October	1995-present			Bob Glenn	Robert.Glenn@state.ma.us	
MA Sea Sampling							MADMF	MA state waters							no bycatch data collected			
MA Ventless Trap Survey	x	x					MADMF	MA state waters	<30	Variable	Ventless lobster Traps	Spring/Fall annually	2005-2012			Derek Perry	derek.perry@state.ma.us	
MA Dealer Reports	x		x				MADMF	All state landings				Year round	2005-present			Derek Perry	derek.perry@state.ma.us	
MA Vessel Landings Reports	x		x				MADMF	All state landings				Year round	1995-present		suggested that only 2006-present be used due to various issues	Derek Perry	derek.perry@state.ma.us	
MA Port sampling							MADMF	All state landings				Year round			no bycatch data collected	Derek Perry	derek.perry@state.ma.us	

Sampling Program	Data collected: species ID	count	weight	carapace width	sex	eggs	Source	Geographic Coverage	Depth Range (fathoms)	No. Sites	Sampling Method	Sampling Frequency	Length of Time Series	Proprietary Issues	Limitation	Contact Person	Contact Info	Link to Reports/Data
CT																		
Long Island Sound Trawl Survey	x	x	x				CT DEP	Long Island Sound	<20		Otter trawl/ Random Stratified	spring (May)/Fall (Sept.)	1978-present		No Jonah crab found, but included as a source for other species?	Penny Howell	Penny.Howell@ct.gov	http://www.ct.gov/deep/lib/deep/fishing/fisheries_management/2011_long_island_sound_trawl_survey.pdf
Millstone Power Station Monitoring Survey	x	x		x			Millstone Power Station	Niantic River, CT	<10	3	Triplicate bottom tows	Every other week	?	Millstone Power Plant project, not accessible from website.	No weights or lengths			
NY																		
NY Ocean trawl survey	x	x					NY DEP	NY state waters		?	Otter trawl/ Random Stratified	?			no Jonah crabs in the data set	Kim McKown	kamckown@gw.dec.state.ny.us	
Peconic Bay trawl survey	x	x	?				NY DEP	Peconic Bay NY		?	Otter trawl	?				Kim McKown	kamckown@gw.dec.state.ny.us	
Sea Sampling	x	x					NY DEP									Kim McKown	kamckown@gw.dec.state.ny.us	
Ventless Trap Survey	x	x					NY DEP						2006-2009			Kim McKown	kamckown@gw.dec.state.ny.us	
Dealer Reports	x	x					NY DEP									Kim McKown	kamckown@gw.dec.state.ny.us	

Appendix B: Summary of State Regulations

Summary of Existing and Potential U.S. Federal and State Regulatory Frameworks for Jonah Crab

Compiled in the context of a FIP directed at the Jonah Crab Fishery

	Limit on Trap Qty	Gear Restrictions	Limit on Trap Size	Commercial License required Y/N	Minimum landing Size	Maximum Landing Size	Sex Restrictions	Closed seasons	Source(s)
New Jersey	N	biodegradable panel	Y	Y	3" - 4.5" varies by hardness	N	No egg bearers	Y ?	http://www.state.nj.us/dep/fgw/njregs.htm
New York	N	escape panel	Y	N	3" - 4.5" varies by hardness	N	No egg-bearers	N	http://www.dec.ny.gov/outdoor/7894.html; http://www.dec.ny.gov/outdoor/fishing.html
Massachusetts	Y -Lobster limit	Y - Lobster traps	Y-lobster traps	Y	N	N	No egg bearers	Yes; closed Jan 1 - Apr 30	http://www.mass.gov/eea/agencies/dfg/dmf/laws-and-regulations/recreational-regulations/; http://www.mass.gov/eea/agencies/dfg/dmf/laws-and-regulations/commercial-regulations/
Maine	Y -Lobster limit 500/800	Y - Lobster traps	Y-lobster traps	Y	N	N	None indicated	Dec 30 - Apr 1 in rivers	http://www.maine.gov/ifw/fishing/regulations_seasons/index.htm; http://www.maine.gov/dmr/lawsandregs/regs/25.pdf
Rhode Island	N	N	N	Y	N	N	No egg-bearers	N	Scott Olszewski; <Scott.Olszewski@DEM.RI.GOV>
New Hampshire	Y - lobster limit 1200	Y - Lobster traps	Y-lobster traps	Y	N	N	None indicated	N	http://www.wildlife.state.nh.us/Fishing/fishing.htm; http://www.wildlife.state.nh.us/pubs/digests/SW_2011.pdf
Connecticut	?	Y - lobster trap	Y-lobster traps	Y	3.5" - 5" varies by hardness	N	No egg bearers	Y; Rec Open May 1 - Nov 30; commercial closed Dec 1 - Apr 30	http://www.ct.gov/dep/cwp/view.asp?a=2696&q=322740&depNAV_GID=1647; Matt Gates
Maryland	N	Turtle BRD (juvenile), escape vent	Y	N	3.25" - 5/25" varies by season, hardness	N	Commercial no females at certain times, Rec no females at all	Y, opens Apri 1 - Dec 15	http://www.dnr.state.md.us/fisheries/regulations
Virginia									http://www.dgif.virginia.gov/fishing/

Continued:

	Closed Areas	Commercial Catch Reporting	Harvest Limits Commercial	Harvest Limits Recreational	Recreational License required Y/N	Recreational Limit on Trap Qty	Notes	Jonah Specific Regs	Source(s)
New Jersey	Y	Y	N	One bushel per day	Y	Y	Blue Crab Regs	N	http://www.state.nj.us/dep/fgw/njregs.htm
New York	Y	Y	50/day	50/day	N	N	Blue Crab Regs	N	http://www.dec.ny.gov/outdoor/7894.html; http://www.dec.ny.gov/outdoor/fishing.html
Massachusetts	Y	Y	50/Day personal use no traps; unlimited commercial	25/day	N for hand harvest; Y if trap or SCUBA	10 traps	Rec: Blue Crab Regs, applied to other species; Commercial: lobster regs	N	http://www.mass.gov/eea/agencies/dfg/dmf/laws-and-regulations/recreational-regulations/; http://www.mass.gov/eea/agencies/dfg/dmf/laws-and-regulations/commercial-regulations/
Maine	Y	Y	200 lbs./day or 500 lbs./trip	N	N/Y	license for hand harvest	Lobster Regs	Y	http://www.maine.gov/ifw/fishing/regulations_seasons/index.htm; http://www.maine.gov/dmr/lawsandregs/regs/25.pdf
Rhode Island	N	Y	N	N	Y	N	Limited findings	N	Scott Olszewski; <Scott.Olszewski@DEM.RI.GOV>
New Hampshire	N	Y	N	N	Y if more than 12 crabs taken	?		N	http://www.wildlife.state.nh.us/Fishing/fishing.htm; http://www.wildlife.state.nh.us/pubs/digests/SW_2011.pdf
Connecticut	N	Y	N	N	Y	10 traps hauled per day	Blue Crab regs; Lobster Regs incl other crab	Y	http://www.ct.gov/dep/cwp/view.asp?a=2696&q=322740&depNAV_GID=1647; Matt Gates
Maryland	Y	Y	25 bushels per vessel/day	Y, varies 1 bushel hard crabs, 2 doz soft	N/Y	N, limited harvest qty	Blue Crab Regs	N	http://www.dnr.state.md.us/fisheries/regulations
Virginia		Y							http://www.dgif.virginia.gov/fishing/