

# Monterey Bay Aquarium Seafood Watch®

## Blue crab

*Callinectes sapidus*



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## United States

## Pots and Trotline

*May 06, 2019*

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### Disclaimer

Seafood Watch® strives to have all Seafood Reports reviewed for accuracy and completeness by external scientists with expertise in ecology, fisheries science and aquaculture. Scientific review, however, does not constitute an endorsement of the Seafood Watch program or its recommendations on the part of the reviewing scientists. Seafood Watch is solely responsible for the conclusions reached in this report.

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## **About Seafood Watch**

Monterey Bay Aquarium's Seafood Watch program evaluates the ecological sustainability of wild-caught and farmed seafood commonly found in the United States marketplace. Seafood Watch defines sustainable seafood as originating from sources, whether wild-caught or farmed, which can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems. Seafood Watch makes its science-based recommendations available to the public in the form of regional pocket guides that can be downloaded from [www.seafoodwatch.org](http://www.seafoodwatch.org). The program's goals are to raise awareness of important ocean conservation issues and empower seafood consumers and businesses to make choices for healthy oceans.

Each sustainability recommendation on the regional pocket guides is supported by a Seafood Watch Assessment. Each assessment synthesizes and analyzes the most current ecological, fisheries and ecosystem science on a species, then evaluates this information against the program's conservation ethic to arrive at a recommendation of "Best Choices," "Good Alternatives" or "Avoid." This ethic is operationalized in the Seafood Watch standards, available on our website here. In producing the assessments, Seafood Watch seeks out research published in academic, peer-reviewed journals whenever possible. Other sources of information include government technical publications, fishery management plans and supporting documents, and other scientific reviews of ecological sustainability. Seafood Watch Research Analysts also communicate regularly with ecologists, fisheries and aquaculture scientists, and members of industry and conservation organizations when evaluating fisheries and aquaculture practices. Capture fisheries and aquaculture practices are highly dynamic; as the scientific information on each species changes, Seafood Watch's sustainability recommendations and the underlying assessments will be updated to reflect these changes.

Parties interested in capture fisheries, aquaculture practices and the sustainability of ocean ecosystems are welcome to use Seafood Watch assessments in any way they find useful.

## **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, we develop an overall recommendation. Criteria ratings and the overall recommendation are color coded to correspond to the categories on the Seafood Watch pocket guide and online guide:

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

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

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

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

## **Summary**

The following assessment focuses on the US domestic blue crab pot and trotline fisheries. These fisheries occur in Chesapeake Bay and Delaware Bay (Virginia, Maryland, Delaware, New Jersey), and the US Atlantic, including North and South Carolina, Georgia, Florida, and the Gulf of Mexico (Alabama, Mississippi, Louisiana, Texas, Florida). There has also been a historic winter dredge fishery in Virginia, which is currently (but not necessarily permanently) closed, and therefore not included in this report.

The blue crab stock in Chesapeake Bay, Delaware Bay, and the Gulf of Mexico is abundant, but in the Atlantic, blue crab appears to be varying over time without any trends. As one of the most ecologically and economically significant species in the country, there has been increasing attention given to more effective management of these stocks. Maryland, Virginia, and the Potomac River Fisheries Commission are working closely to sustain healthy fisheries in Chesapeake Bay. North Carolina has adopted an innovative stock assessment method (based on Georgia's threshold management approach), and Gulf Coast states have been collaborating with the Gulf States Marine Fisheries Commission (GSMFC) to develop a new fishery management plan (FMP) and an updated stock assessment to help ensure that blue crab populations are healthy.

Blue crab management is working sufficiently in all states. Blue crab populations naturally fluctuate both spatially and temporally, and in order to manage them effectively, adequate data needs to be gathered and shared, and management targets established. In some states, fishery-independent data that informs management decisions are lacking, as is information about the environment. Both anthropogenic and natural processes such as harvesting, habitat quality/quantity, water quality, and recruitment strength greatly affect blue crab population dynamics. Thus, more effective management depends on increased data collection and analysis so the relative effects of these threats can be determined.

Blue crabs are primarily caught using crab pots with bait. There is also a small trotline fishery in Chesapeake Bay. Trotlines, unlike traditional longlines, do not operate with hooks; the bait is tied to a line and the crabs grasp the bait and are subsequently hauled onto the boat. Trotline gear catches individual crabs and produces no bycatch. However, blue crab pot fisheries have the potential to catch non-targeted species, and are known to have some impact on endangered, threatened, and protected (ETP) species. Crab pot bycatch primarily consists of sublegal blue crabs, as well as small amounts of non-targeted finfish (mostly released alive), and diamondback terrapins (*Malaclemys terrapin*). The most significant bycatch impact from the crab pot fishery is on diamondback terrapins, mainly because they are air-breathers; while they constitute only a small fraction of catch the impact on their populations can be significant. Diamondback terrapins are listed as "endangered" in Rhode Island, "threatened" in Massachusetts, a "species of concern" in North Carolina and Virginia, and a "rare" species in Georgia. Under the Natural Heritage Program State Wildlife Action Plans and NatureServe, terrapins are identified as "critically imperiled" in Alabama, "imperiled" in Mississippi, and "vulnerable" in Louisiana, Georgia, North Carolina, New Jersey, and Texas, while Florida terrapins are categorized as "apparently secure."

Bycatch management to reduce interactions with diamondback terrapins needs significant improvement, as terrapin bycatch affects the scoring of all crab pot fisheries from Virginia southward. New Jersey requires that terrapin bycatch reduction devices (BRDs) be used in the commercial fishery, while Delaware and Maryland, in the Chesapeake Bay and Delaware Bay region have very strict spatial regulations regarding pot placement (only in the main stem of the bays, not in tidal creeks) and only require terrapin BRDs in the recreational fishery. These regulations somewhat mitigate the bycatch of terrapins, but there is still insufficient protection for immature terrapins, as well as low compliance rates. Virginia, however, does not have any mandatory bycatch mitigation measures for terrapins in the commercial fishery, but recently introduced a reduction in licensing fees for recreational crabbers that use BRDs. The Atlantic states do not currently have any terrapin bycatch mitigation regulations, and bycatch management is ranked as "ineffective." There is ongoing research regarding the most effective way to minimize bycatch, whether it is through using excluder devices or by minimizing fishing in areas of high terrapin abundance. However, until mandatory management measures are in place,

terrapins are still at risk. All five of the Gulf states are conducting ongoing research on the blue crab fishery's interaction with terrapins, and share their individual research through the GSMFC Blue Crab Subcommittee. Of the 13 locations where terrapin populations were identified, seven of those sites prohibit crab pots completely (within Rockefeller Wildlife Refuge and Marsh Island Wildlife Refuge) and one site prohibits commercial crabbing (Sabine NWR). Additionally, there are several derelict pot cleanup programs in the Gulf states, since ghost fishing from derelict pots is also a source of mortality for diamondback terrapins. These programs have removed large amounts of derelict pots; however, the actual number of such pots is unknown, and estimates indicate that ghost fishing is still a problem. Closed areas to fishing account for only a small percentage of potential terrapin habitat, and BRDs are not required; therefore, bycatch management in the Gulf is ineffective except in Alabama where spatial closures have been implemented similar to those in Chesapeake Bay.

Crab pots are a passively fished gear type, but they impact the substrate because the wire structures rest on the bottom. Trotlines, similar to bottom longlines (but without hooks), rest along the benthos and are held in place at each end with anchors and chains. Trotlines are set primarily in sand and silt. Both the blue crab pot and trotline fisheries in this report have minimal mitigation of gear impacts.

Blue crabs play an important role as a potential keystone predator in all regions covered in this report. Each of the FMPs address the need for evaluating impacts of ecosystem variables on blue crab population dynamics, as well as the need for conducting further research for a future ecosystem-based assessment model. However, there are currently no plans in any region to implement ecosystem-based management measures.

## Final Seafood Recommendations

SPECIES/FISHERY	CRITERION 1: IMPACTS ON THE SPECIES	CRITERION 2: IMPACTS ON OTHER SPECIES	CRITERION 3: MANAGEMENT EFFECTIVENESS	CRITERION 4: HABITAT AND ECOSYSTEM	OVERALL RECOMMENDATION
Blue crab Georgia Western Central Atlantic, Pots, United States of America	Yellow (2.644)	Red (1.000)	Red (1.000)	Yellow (3.000)	<b>Avoid (1.678)</b>
Blue crab South Carolina Western Central Atlantic, Pots, United States of America	Yellow (2.644)	Red (1.000)	Red (1.000)	Yellow (3.000)	<b>Avoid (1.678)</b>
Blue crab Florida Western Central Atlantic, Pots, United States of America	Yellow (2.644)	Red (1.000)	Red (1.000)	Yellow (3.000)	<b>Avoid (1.678)</b>
Blue crab Maryland Chesapeake Bay, Trotline, United States of America	Green (3.410)	Green (5.000)	Green (4.000)	Yellow (3.000)	<b>Best Choice (3.782)</b>
Blue crab Virginia Chesapeake Bay, Pots, United States of America	Green (3.413)	Red (1.000)	Red (1.000)	Yellow (3.000)	<b>Avoid (1.788)</b>
Blue crab North Carolina Northwest Atlantic, Pots, United States of America	Yellow (2.644)	Red (1.000)	Red (1.000)	Yellow (3.000)	<b>Avoid (1.678)</b>
Blue crab Florida Gulf of Mexico, Pots, United States of America	Green (3.413)	Red (1.000)	Red (1.000)	Yellow (3.000)	<b>Avoid (1.788)</b>
Blue crab Alabama Gulf of Mexico, Pots, United States of America	Green (3.413)	Red (1.000)	Yellow (3.000)	Yellow (3.000)	<b>Good Alternative (2.354)</b>
Blue crab Mississippi Gulf of Mexico, Pots, United States of America	Green (3.413)	Red (1.000)	Red (1.000)	Yellow (3.000)	<b>Avoid (1.788)</b>

Blue crab Louisiana Gulf of Mexico, Pots, United States of America	Green (3.413)	Red (1.000)	Red (1.000)	Yellow (3.000)	<b>Avoid (1.788)</b>
Blue crab Texas Gulf of Mexico, Pots, United States of America	Green (3.413)	Red (1.000)	Red (1.000)	Yellow (3.000)	<b>Avoid (1.788)</b>
Blue crab Maryland Chesapeake Bay, Pots, United States of America	Green (3.413)	Red (1.000)	Green (4.000)	Yellow (3.000)	<b>Good Alternative (2.529)</b>
Blue crab New Jersey Delaware Bay, Pots, United States of America	Green (3.413)	Red (1.000)	Green (4.000)	Yellow (3.000)	<b>Good Alternative (2.529)</b>
Blue crab Delaware Northwest Atlantic, Pots, United States of America	Green (3.413)	Red (1.000)	Green (4.000)	Yellow (3.000)	<b>Good Alternative (2.529)</b>

## 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 ≤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.

<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**

The following analysis focuses on the US domestic blue crab pot and trotline fisheries in the Chesapeake Bay, Delaware Bay, and Gulf of Mexico as well as the US eastern Atlantic:

- Blue crab, Chesapeake Bay, and Delaware Bay (New Jersey, Delaware, Maryland, and Virginia), crab pot
- Blue crab, Maryland, trotline
- Blue crab, Gulf of Mexico (Florida, Alabama, Mississippi, Louisiana, and Texas), crab pot
- Blue crab, Atlantic (North Carolina, South Carolina, Georgia, and Florida), crab pot

## **Species Overview**

The blue crab, *Callinectes sapidus*, is a member of the swimming crab family, Portunidae, which inhabits estuarine and coastal waters. This species is both ecologically and economically significant. Blue crabs contribute to the ecological processes in estuarine and coastal food web dynamics as both prey and predator to several other species. Economically, the fisheries also represent a great resource; blue crab is one of the most significant domestic commercial fisheries nationally, as well as for many individual states, in terms of weight and monetary value (NMFS 2016a).

Management of blue crab fisheries is governed by many federal policies, but direct management responsibilities fall upon the states in which the fisheries are located (Guillory et al. 2001). State natural resource departments are generally responsible for managing blue crab fisheries under the direction of their respective regulatory commissions (ibid). Regional Fishery Management Councils established by the Magnuson-Stevens Fishery Conservation and Management Act do not have a direct hand in management because almost all US landings are in state waters. The primary influence of federal law on blue crab fisheries is the regulation of coastal water quality, habitat protection, and pollution control (ibid).

Chesapeake Bay and Delaware Bay present slightly unique situations where there is jurisdiction overlap in the estuarine waters. Although Maryland, Virginia, and the Potomac River Fisheries Commission each have their own regulations within Chesapeake Bay, and the same exists for Delaware and New Jersey in Delaware Bay, there is some coordination in information-gathering and sharing, as well as in management efforts. Maryland, Virginia, and the Potomac River Fisheries Commission share the management of blue crab fisheries in Chesapeake Bay and are coordinated as signatories to the Chesapeake Bay Blue Crab FMP (CBP 1997). The first FMP in 1989 recognized the importance of the blue crab resource, identified areas of concern, and recommended strategies to stabilize fishing effort across the three jurisdictions (CBP 1989). A second FMP in 1997 focused on conserving the stock in the bay to maintain the ecological value and long-term use of the resource (CBP 1997). The Delaware Bay Blue Crab FMP was prepared by the State of Delaware, in cooperation with the State of New Jersey, as a result of decreased bay-wide landings in 1996 (DDFW 2009). Bay jurisdictions also share a common stock, and the biology, including the life cycle and migratory patterns of crabs, mandates coordination (E. Schwaab, personal communication 2017).

Blue crab landings from Chesapeake Bay accounted for over 50% of all US crab landings from the 1970s to the early 1990s (CBP 1997). Landings increased with rising effort through the latter part of the century and peaked in the mid-1990s, as gear became more efficient (ibid). In 1996, both Maryland and Virginia limited effort in the blue crab pot fishery by implementing limited access programs and capping the number of licenses available (ibid). In 2008, Virginia also closed its winter dredge fishery, which targeted overwintering mature female crabs (VMRC 2008). New Jersey and Delaware landings peaked in the late 1980s to mid-1990s, but declined in the early 2000s (Sartwell 2009). Although there was a spike in landings in 2012, landings in 2014 were one of the lowest on record (R. Wong, personal communication 2016). North Carolina landings increased in 1999 as a

result of flooding from three consecutive hurricanes, but dropped significantly from 2000 to 2002, and again from 2005 to 2007 (NCDENR 2014). Recent landings in South Carolina have been above the long-term, 10-year average (SCDNR 2018c), whereas Georgia landings decreased in the late 2000s, but have increased slightly since 2010 (GADNR 2017a). Landings in Florida have decreased since the late 1990s (FWC and FWRI 2015).

Blue crab management in the Gulf of Mexico (GOM) is regulated by the respective states where crabs are caught, but there is also a collaborative management effort through the Gulf States Marine Fisheries Commission (GSMFC). Evaluation and modification of management efforts in any Gulf state must consider the activities of the neighboring states. The GSMFC can make management recommendations to a state, but ultimately, the state remains responsible for management of the species (Guillory et al. 2001).

## Production Statistics

US blue crab fisheries are the greatest in volume of all the domestic crab fisheries (NMFS 2016c), ranging from approximately 200 million lb caught in 2000 to approximately 150 million lb caught in 2015 (see figure; blue crab landings in 2010 made the fishery the eighth largest fishery in the nation). At least 75% of reported blue crab landings during this period were from four states: Louisiana, Maryland, North Carolina, and Virginia.

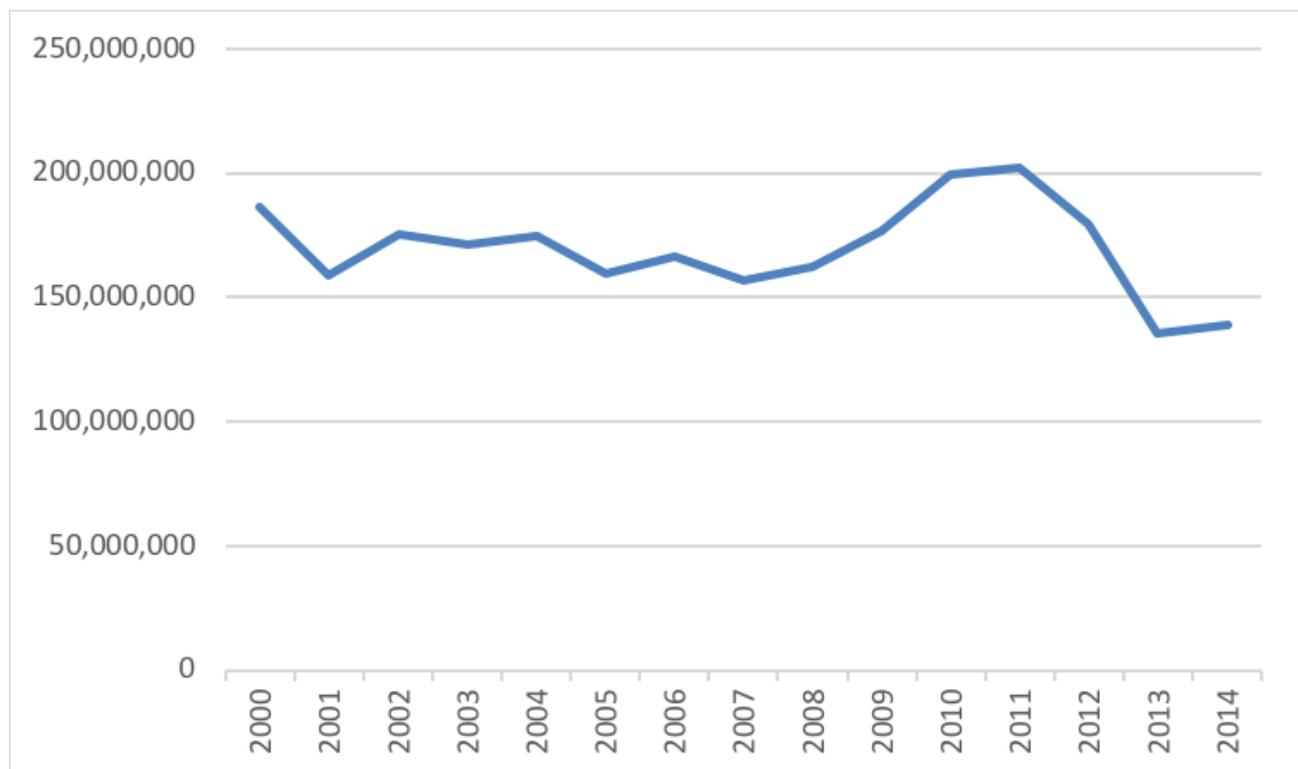


Figure 1 U.S. Blue Crab Landings (lbs) in the Atlantic and Gulf of Mexico, from 2000-2014 (NMFS 2016a).

## Importance to the US/North American market.

The National Marine Fisheries Service reports imports of crabs from the Family Portunidae and Genus *Callinectes* (swimming crabs). Imports of frozen and preserved "swimming crab" meat totaled over 24 million kg (~53,000 lb) in 2015 (see figures) (NMFS 2016b).

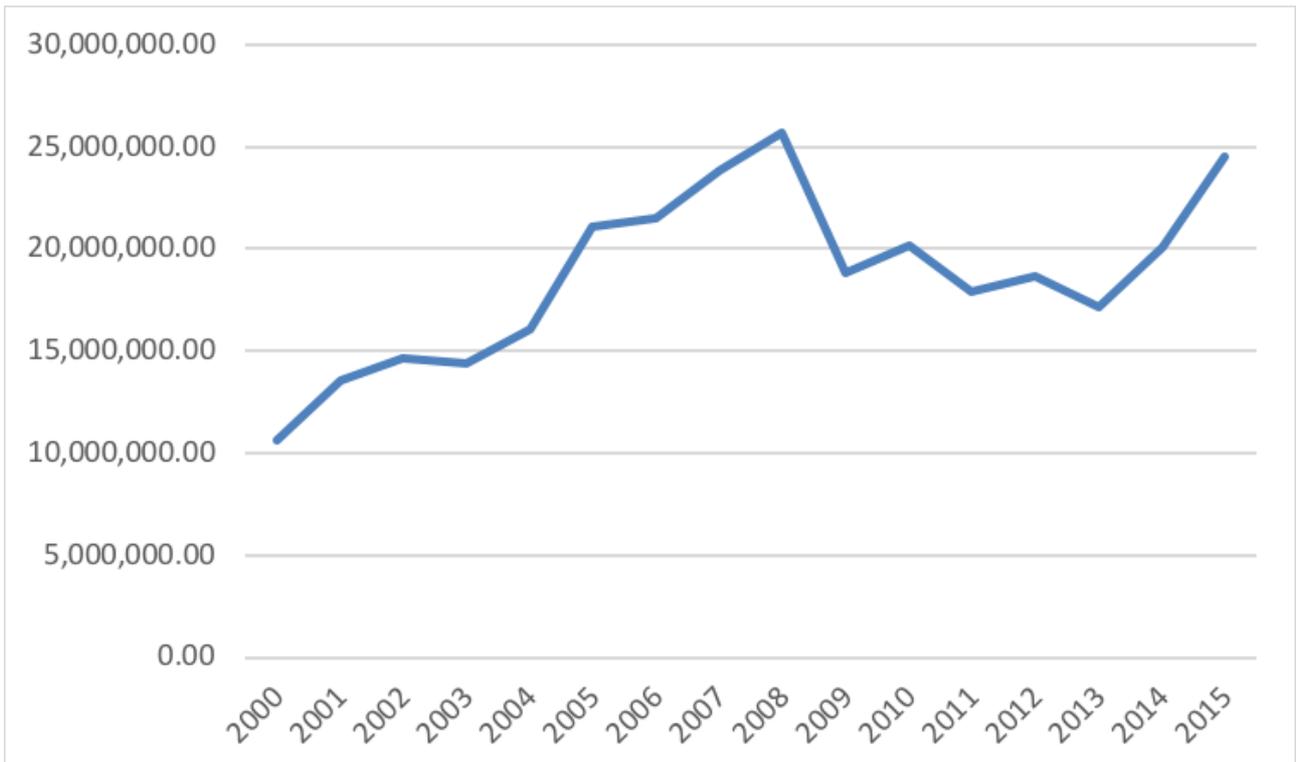


Figure 2 Imports of swimming crab (Portunidae and Callinectes) into the U.S. (kilos), from 2000 to 2015 (NMFS 2016b).

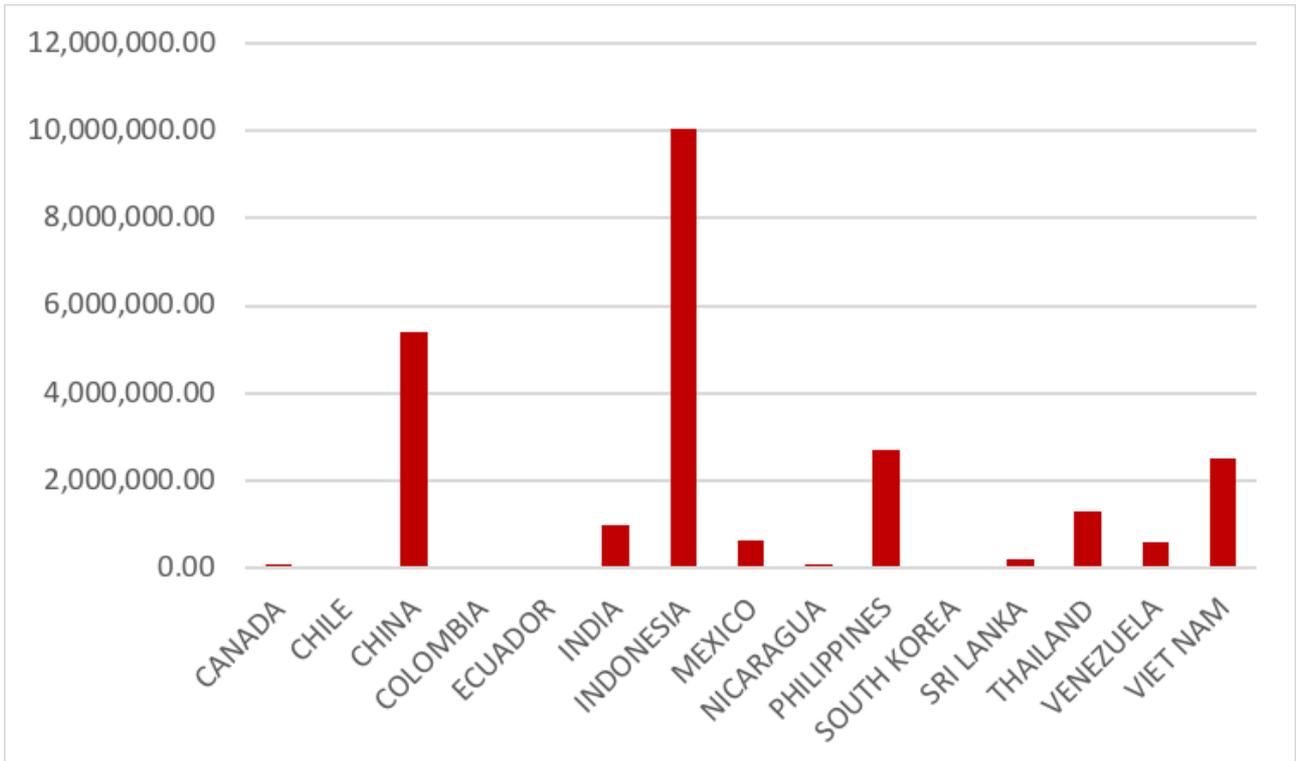


Figure 3 Imports of swimming crab into the U.S. by country (kilos) in 2015 (NMFS 2016b).

**Common and market names.**

Blue crabs are also known as hardshell crab and softshell crab (FDA Seafood List 2016). Within the industry,

crabs have specific names based on sex and maturity (Zinkski 2006). These are: 1) *Jimmy*—a male blue crab; 2) *Sally* or *She-crab*—an immature female; 3) *Sook*—a mature female; and 4) *Sponge Crab*—an ovigerous (egg-bearing) female crab, named for the appearance of her egg mass (“sponge”). Egg-bearing females are also referred to as *spawn crabs*, *blooming female crabs*, and *mother crabs* (PRFC 2009).

Crabs are categorized as hard, soft, or peeler crabs based on their stage of molting. *Softie* is another name for a soft-shell crab, and *bust crab*, *buster*, or *busted crab* describes a crab that is in the process of shedding its exoskeleton (Sea Grant Virginia 2006).

### **Primary product forms**

Blue crabs are harvested as hard shell crabs, peeler crabs (crabs just prior to molting), and soft shell crabs (crabs that have just molted) (CBP 1997). Most blue crab crabmeat is sold fresh, but some is frozen or pasteurized (Guillory et al. 2001).

## 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

BLUE CRAB			
Region   Method	Abundance	Fishing Mortality	Score
Georgia/Western Central Atlantic   Pots   United States of America	2.33: Moderate Concern	3.00: Moderate Concern	Yellow (2.644)
South Carolina/Western Central Atlantic   Pots   United States of America	2.33: Moderate Concern	3.00: Moderate Concern	Yellow (2.644)
Florida/Western Central Atlantic   Pots   United States of America	2.33: Moderate Concern	3.00: Moderate Concern	Yellow (2.644)
Maryland/Chesapeake Bay   Trotline   United States of America	2.33: Moderate Concern	5.00: Low Concern	Green (3.410)
Virginia/Chesapeake Bay   Pots   United States of America	2.33: Moderate Concern	5.00: Low Concern	Green (3.413)
North Carolina/Northwest Atlantic   Pots   United States of America	2.33: Moderate Concern	3.00: Moderate Concern	Yellow (2.644)

Florida/Gulf of Mexico   Pots   United States of America	2.33: Moderate Concern	5.00: Low Concern	Green (3.413)
Alabama/Gulf of Mexico   Pots   United States of America	2.33: Moderate Concern	5.00: Low Concern	Green (3.413)
Mississippi/Gulf of Mexico   Pots   United States of America	2.33: Moderate Concern	5.00: Low Concern	Green (3.413)
Louisiana/Gulf of Mexico   Pots   United States of America	2.33: Moderate Concern	5.00: Low Concern	Green (3.413)
Texas/Gulf of Mexico   Pots   United States of America	2.33: Moderate Concern	5.00: Low Concern	Green (3.413)
Maryland/Chesapeake Bay   Pots   United States of America	2.33: Moderate Concern	5.00: Low Concern	Green (3.413)
New Jersey/Delaware Bay   Pots   United States of America	2.33: Moderate Concern	5.00: Low Concern	Green (3.413)
Delaware/Northwest Atlantic   Pots   United States of America	2.33: Moderate Concern	5.00: Low Concern	Green (3.413)

## Criterion 1 Assessment

### 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.*

### BLUE CRAB

#### Factor 1.1 - Abundance

GEORGIA/WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA

##### **Moderate Concern**

In 2003, NMFS declared a fishery failure for Georgia blue crab in response to declining abundance levels from five consecutive years of extreme drought (GADNR 2008a). Four tropical storms in the fall of 2004 officially ended the drought and produced one of the highest spawner year classes in the history of the survey (since 1976), in the spring of 2005 (ibid). The 2008 FMP implemented the use of a threshold management system that establishes thresholds for spawning stock from surveys and commercial catch-per-unit-effort (CPUE) estimates (ibid).

There are three thresholds, which are based on the confidence interval around the grand mean CPUE (for the history of the fishery), and include the lower 95% confidence interval, and upper and lower 81% confidence intervals (see figures (GADNR 2015a). If the average CPUE based on trip tickets and the monthly surveys for a six-month period exceed the confidence interval thresholds, then there are several specific management measures that will be implemented for a minimum of three consecutive months (ibid).

The management measures vary in severity based on the threshold level that is exceeded, and include: 1) seasonal restrictions on female harvest; and 2) a prohibition on all female harvest, or a complete harvest moratorium (GADNR 2008a). Abundance levels have never fully recovered from the period of low rainfall, and since 2011, there have been many months where CPUE and survey estimates have been below the lower 81% confidence interval (see figures). However, both the fishery-independent trawl data and commercial catch and effort data need to agree for a management action to be undertaken. This has not happened since the drought of the early 2000s (P. Geer, personal communication 2017). There is no clear evidence as to whether the Georgia blue crab stock is overfished or not, based on the limited data available, and in combination with medium vulnerability, abundance results in a score of "moderate" concern.

**Justification:**

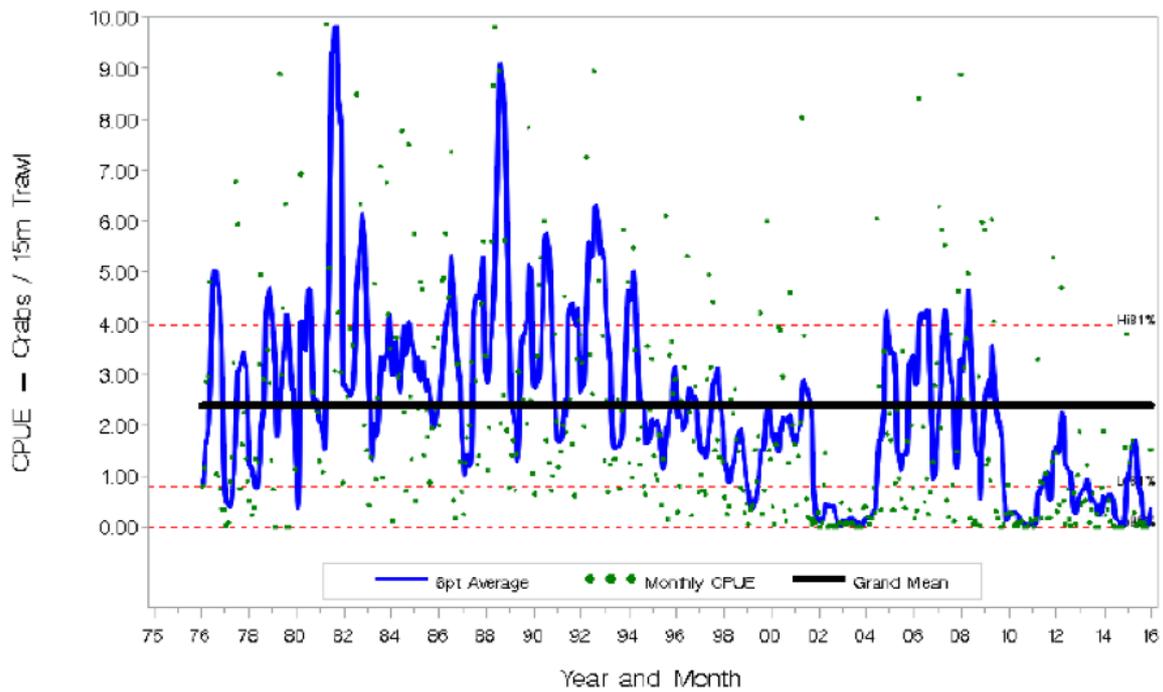


Figure 4 Catch-per-unit-effort (crabs per trawl) of female blue crabs (*Callinectes sapidus*) caught in monthly trawl surveys (GADNR 2015a).

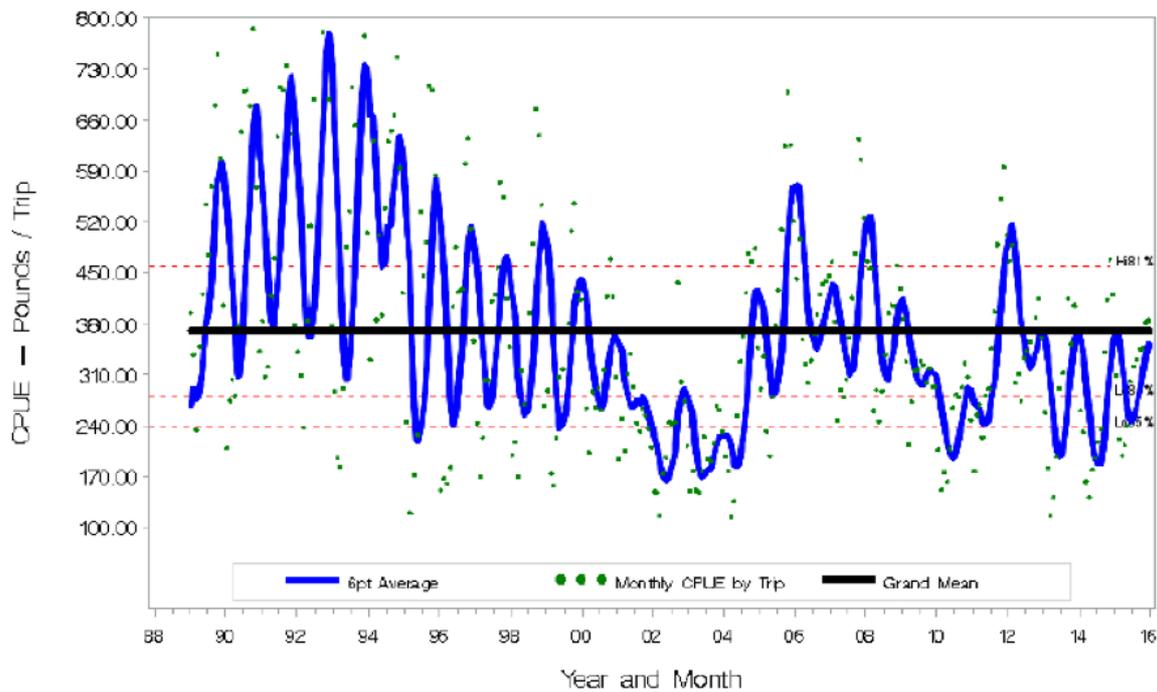


Figure 5 Catch-per-unit effort (lbs per pot) of commercially harvested blue crab in Georgia. Shown are monthly CPUE (green dots), six-month running average CPUE (blue line), grand mean (black line), and management thresholds of upper and lower 81% CI and lower 95% CI (red dashed lines) (GADNR 2015a).

**Moderate Concern**

The South Carolina (SC) Department of Natural Resources (SCDNR) has conducted fishery-independent surveys of blue crab using crab pots since 1988 (SCDNR 2016f). The SC blue crab stock has fluctuated in abundance over time, but has never fully recovered from a decline after periods of low rainfall between 1998 and 2002 (see figure) (DeLancey 2015) (SCDNR 2016b). Sampling is conducted in six sound systems with samples stratified by small creek, sound proper, and coastal ocean waters (SCDNR 2016b). At each of the 42 sites presently sampled, total number of crabs, total weight, maturity, sex, ecdysis stage, and egg stage are recorded from all specimens (ibid). However, the information on if and how these metrics have changed over time is not publicly available. There are no reliable estimates of abundance compared to reference points; therefore, data-limited indicators are used to estimate stock status. Catch-per-unit-effort in scientific surveys has been increasing since 2015 (following a period of decline) (figure 3), and blue crabs have a medium inherent vulnerability (PSA = 3.13; see PSA below for detailed scoring). As a result, SFW scores the SC blue crab stock as a "moderate" concern (a minimum of two data-limited indicators are needed to show a positive outcome for a score of "low" concern to be achieved for species of medium vulnerability [as determined by the PSA]).

**Justification:****Productivity-Susceptibility Analysis – All stocks:***Scoring Guidelines*

1.) Productivity score ( $P$ ) = average of the productivity attribute scores ( $p_1, p_2, p_3, p_4$  (finfish only),  $p_5$  (finfish only),  $p_6, p_7$ , and  $p_8$  (invertebrates only))

2.) Susceptibility score ( $S$ ) = product of the susceptibility attribute scores ( $s_1, s_2, s_3, s_4$ ), rescaled as follows:  $S = [(s_1 * s_2 * s_3 * s_4) - 1/40] + 1$ .

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

Productivity Attribute	Relevant Information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Average age at maturity	1-1.25 years (Van Engel 1958) (Perry 1975)	1
Average maximum age	3 years	1
Fecundity	3,200,000 eggs/year (Graham et al. 2012)	2
Average maximum size (fish only)	N/A	-
Average size at maturity (fish only)	N/A	-
Reproductive strategy	Demersal egg layer (GSMFC 2015)	2

Trophic level	3.2 (Christian and Luczkovich 1999)	2
Density dependence (invertebrates only)	Compensatory (Wahle 2003)	1

<b>Susceptibility Attribute</b>	<b>Relevant Information</b>	<b>Score (1 = low risk, 2 = medium risk, 3 = high risk)</b>
<b>Areal overlap</b> (Considers all fisheries)	Crab pots are only fished in shallow bays and estuarine waters, and are not fishable in deep waters (Gandy, R.L. personal communication 2016); however, the amount of blue crab populated area that is unfished is unknown.	3
<b>Vertical overlap</b> (Considers all fisheries)	Fishing for blue crab with crab pots and trotlines occurs exclusively on the bottom, where blue crabs are found.	3
<b>Selectivity of fishery</b> (Specific to fishery under assessment)	In LA, FL, MS, and TX, blue crab pots are required to have a minimum of two escape rings to allow for the exit of undersized crabs from the pots (GSMFC 2015). NC requires the use of 3 escape rings in all crab pots (NCDMF 2013).	2
<b>Post-capture mortality</b> (Specific to fishery under assessment)	In most states, blue crab is retained unless they are under-sized or are egg bearing females. However, there is no evidence that over 33% of species caught in the blue crab fishery are released.	3

Vulnerability Score (V):

$$V = \sqrt{P^2 + S^2}$$

$$V = \sqrt{1.5^2 + 2.75^2}$$

$$V = \sqrt{9.81}$$

$$V = 3.13$$

Blue crabs are considered to have medium inherent vulnerability

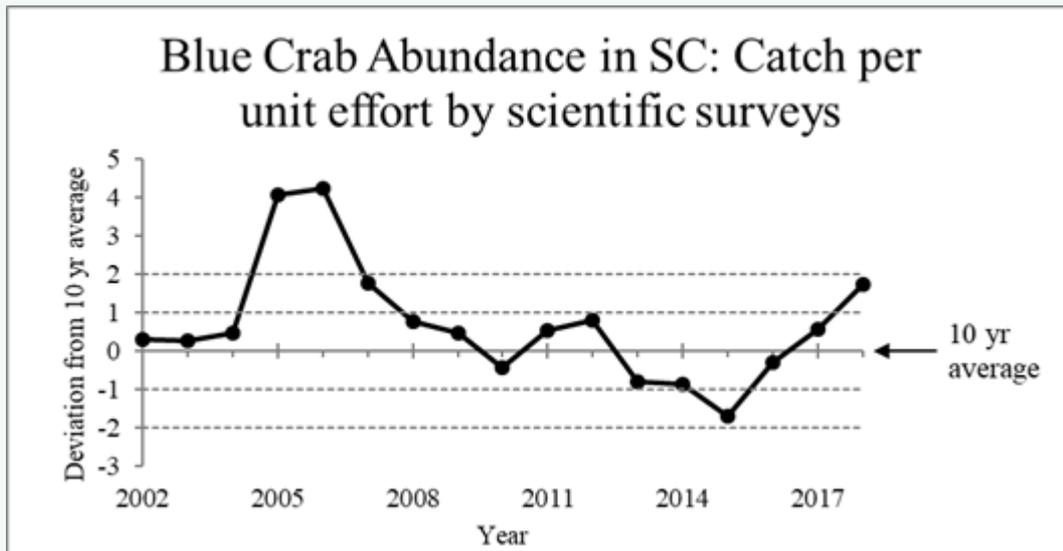


Figure 6 Estimates of relative blue crab abundance from 2002 to 2018 based on catch per unit effort in scientific surveys conducted in South Carolina (pers comm. SCDNR, 2019)

FLORIDA/WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA

**Moderate Concern**

In Florida, the Atlantic coast and Gulf coast stocks are assessed separately. The Florida Gulf coast stock is assessed as a part of the Gulf States Fisheries Commission blue crab assessment, and is considered below. The 2015 assessment estimated MSY at 12 million crabs for the Atlantic coast (FWC and FWRI 2015). Although estimates of current abundance are not available, the assessments have estimated indices for young-of-the-year (the current measure of abundance for Florida blue crabs), which show that Florida blue crabs were at near-historic lows in 2014 (see figure; *ibid*). However, the stock is not currently considered overfished. Young-of-the-year abundance has varied cyclically over time based on freshwater inflow, so even though abundance is low, there is not yet concern over the condition of the stock (*ibid*). Since fishery managers classify crab stock abundance as low, but not overfished, Florida blue crab is ranked as "moderate" concern.

**Justification:**

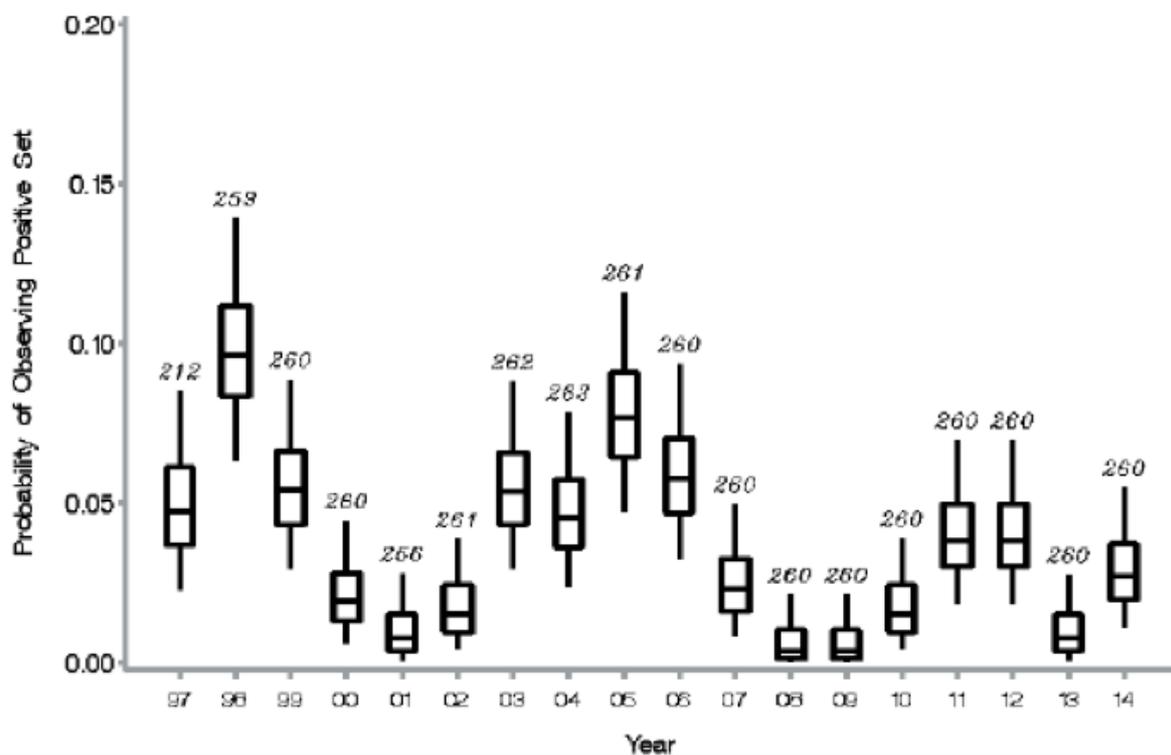


Figure 7 Proportion of fishery-independent monitoring sets that captured Florida Atlantic coast young-of-the-year blue crab, from 1997-2014 (FWC and FWRI 2015).

MARYLAND/CHESAPEAKE BAY, TROTLINE, UNITED STATES OF AMERICA  
VIRGINIA/CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
MARYLAND/CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
NEW JERSEY/DELAWARE BAY, POTS, UNITED STATES OF AMERICA  
DELAWARE/NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA

**Moderate Concern**

The Chesapeake Bay blue crab population is not overfished (CBSAC 2015). Recent crab survey results found that crab abundance has significantly increased, and the crab stock is healthy (VMRC 2016a). In 2008, the U.S. Department of Commerce declared a failure of the blue crab fishery in Chesapeake Bay after a dramatic downturn in the softshell and peeler segments of the fishery (CBP 2008). By 2016, there were 194 million crabs, which is below the target of 215 million crabs, but above the threshold of 70 million crabs (see figure) (CBSAC 2016). The female-specific, age 1+ abundance target and threshold were set accordingly at abundance levels associated with 75%  $N_{MSY}$  (target) and 50%  $N_{MSY}$  (threshold; *ibid*). The 2016 blue crab winter dredge survey, which also monitors the number of female age 1+ crabs in comparison to female-specific abundance points, found that the population of blue crabs in the Chesapeake Bay has increased by 35%, to a total of 553 million crabs (CBSAC 2016). The number of female age 1+ crabs nearly doubled to 194 million, and the male stock more than doubled, from 44 to 91 million crabs (VMRC 2016a). Due to the uncertainty of the reference points, as they are based only on survey abundance and not on modeled biomass levels, abundance is ranked as "moderate" concern.

**Justification:**

The number of blue crabs over time in the winter dredge survey is shown below in the figure. Reference points were modified in 2011 to be maximum sustainable yield (MSY)-based thresholds and targets based on

the abundance of female age 1+ crabs, which is a more appropriate measure of the blue crab spawning stock biomass (CBSAC 2015). The overfished abundance threshold is 70 million crabs, which is based on 50% of female biomass of age 1+ crabs (135 million). The overfished abundance target is 215 million crabs, which is based on 75% of female biomass of age 1+ crabs.

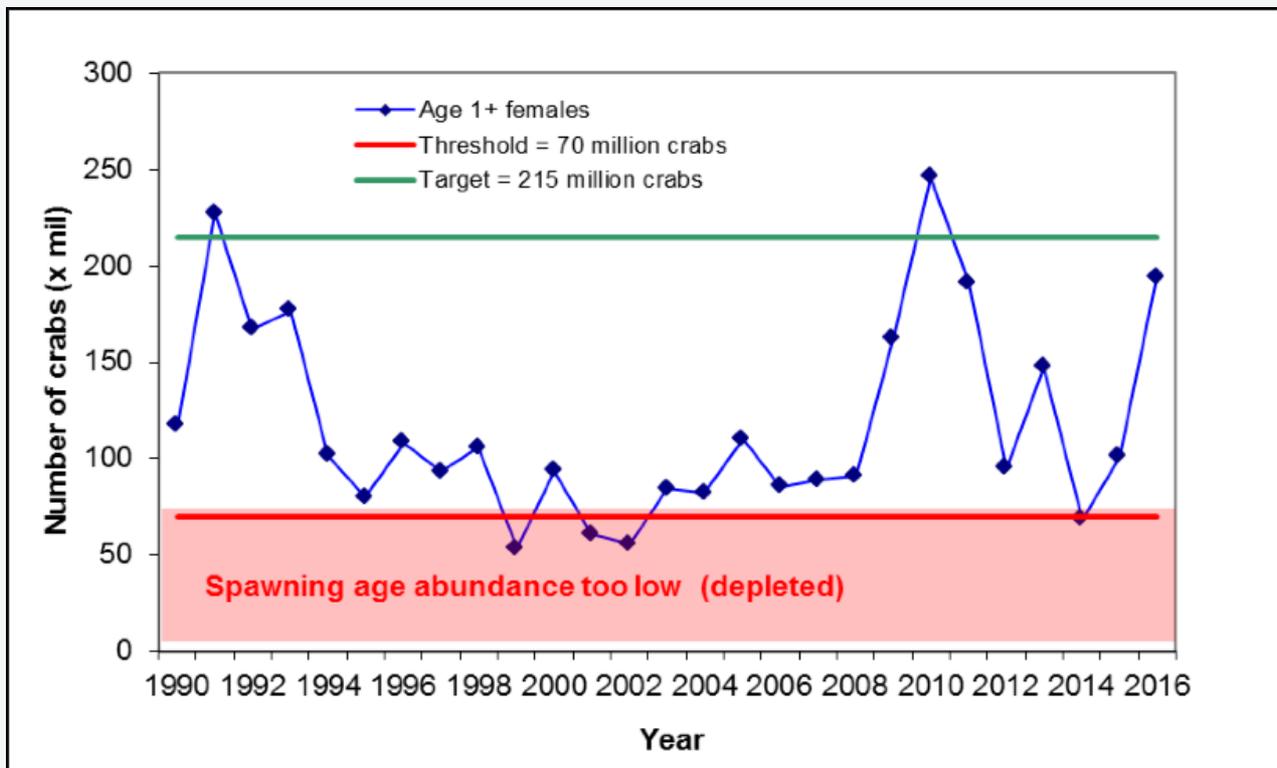


Figure 8 Winter dredge survey estimate of abundance of female blue crabs age one year and older (age 1+) with female-specific reference points, from 1990-2016. These are female crabs measuring greater than 60 mm across the carapace and are considered the 'exploitable stock' that could spawn within this year (CBSAC 2016).

NORTH CAROLINA/NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA

**Moderate Concern**

The North Carolina blue crab population has been in decline, and management actions are currently being taken to improve stock condition (NCMFC 2016a). The stock is considered moderately vulnerable based on the Productivity-Susceptibility Analysis (PSA) below, which uses proxy information that considers the species' life-history and characteristics of the fishery. There are also concerns that the stock is approaching an unfavorable state based on North Carolina's Traffic Light Assessment System (described below) (ibid). North Carolina's blue crab population has declined since record-high commercial landings from 1996 to 1999, and significant reductions in commercial landings were experienced from 2000 to 2002, and from 2005 to 2007 (NCDMF 2013). However, blue crab abundance increased between 2014 and 2015 (NCMFC 2016a). Blue crab harvest from Pamlico Sound and Core Sound are traditionally the lowest. Landings from Albemarle Sound make up the majority of landings in the state, with over half of the state's commercial harvest in 2009 (NCDMF 2013). The abundance characteristics for 2015 estimated that survey abundance is below the historical average, and the 2015 stock assessment found that adult abundance and recruit characteristics had declined for three consecutive years (additional explanation in the "justification" section below, and in the figure).

Management actions have been put into place to minimize the decline in adult and recruit abundance (NCMFC

2016a). The management measures included: 1) adding one additional cull ring to crab pots; 2) eliminating the harvest of v-apron immature female hard crabs (excluding peeler crabs), and that v-apron immature hard crab females be included in the culling tolerance (currently only includes sublegal male and immature female hard crabs); 3) prohibiting harvest of dark sponge crabs (brown and black) from April 1 to April 30, and including dark sponge crabs in the cull tolerance; 4) lowering the cull tolerance to 5% for all crabs, except mature females; and 5) prohibiting crab harvest with dredges, except incidental to lawful oyster dredging (NCMFC 2016b). Although abundance, recruitment, and production characteristics were below the average historical level in 2014 and 2015, indices have improved since, indicating that the stock may be rebuilding (NCMFC 2016). As blue crab is a short-lived species, and since the fishery varies greatly from year to year, it is too soon to tell if the stock is moving back towards historical levels. Since there is uncertainty over the current stock status relative to a sustainable level, and blue crabs are considered to have a medium vulnerability to fishing pressure (according to the PSA), abundance in North Carolina is scored as a "moderate" conservation concern.

### **Justification:**

The most recent blue crab FMP, published in 2013, found that data was lacking for a traditional surplus production model and catch survey analysis (NCDMF 2013). As a result, North Carolina decided to use an index-based assessment called the Traffic Light Method (based on Georgia's threshold management approach), which combines a variety of information to provide a qualitative description of stock condition (ibid). The Traffic Light Assessment uses data from three surveys to create four different indices, in order to assess the status of the stock (ibid). The abundance characteristic is based on adult abundance in three different surveys throughout state waters, and the production characteristic is based on trends over time in carapace width, spawning stock biomass, frequency of mature females, and length at 50% maturity throughout different regions of North Carolina state waters (ibid). Based on the results, green is indicative of a favorable stock condition, yellow of an uncertain or transitioning stock, and red of an unfavorable stock condition (ibid). The adult abundance indicator is a composite of all the individual adult abundance survey indices. Each year, each survey index is evaluated based on the relationship of that value to the historical mean for that survey. If an index value is above the 95% confidence interval of the base year mean, it is 100% green; if it is below the 95% confidence interval, it is 100% red. If the index value is within the 95% confidence interval, it is assigned a percentage of green and yellow, or yellow and red, depending on how far above or below the mean it is. Once this is done for each adult abundance index, the percentage of green, yellow, and red are multiplied by a weighting factor (weighting factor is based on area and is determined by the region the survey index is from) and combined into one indicator. Therefore, the adult abundance indicator is representing the weighted percentage of green, yellow, and red from all the adult abundance surveys combined. Amendment 2 to the FMP considers the blue crab stock to be in an overfished condition when the proportion of red in the production characteristic of the Traffic Light Method is greater than or equal to the third quartile ( $\geq 75\%$  red) for three consecutive years. Although the North Carolina blue crab stock is not overfished, it is currently below the historical average.



Figure 9 Traffic Light Assessment for adult abundance, recruit abundance, and production characteristics, from 1987-2015 (NCMFC 2016).

FLORIDA/GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
 ALABAMA/GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
 MISSISSIPPI/GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
 TEXAS/GULF OF MEXICO, POTS, UNITED STATES OF AMERICA

**Moderate Concern**

The GOM blue crab stocks in each state are assessed together as a part of the GSMFC blue crab stock assessment. According to the most recent GSMFC stock assessment, the GOM blue crab population is not overfished (GDAR 2013). GOM blue crab landings have gradually decreased over the past two decades, along with juvenile abundance, while adult abundance has fluctuated (ibid). Blue crab in the GOM was last assessed in 2013, using a catch-survey analysis and a surplus production model from both fishery-dependent (logbook) and -independent (survey) data for the Western and Eastern GOM stocks, separately (Perry and VanderKooy 2015). The population estimates in both stocks are currently close to the estimated abundance for maximum sustainable yield (MSY), though the Western GOM stock has showed a slight decline in the past few years (GDAR 2013). For the Western GOM stock,  $N/N_{MSY} = 0.95$  (90% CI: 0.21 to 1.29; Figure 10) and  $N/N_{MSY} = 3.13$  (90% CI: 1.41 to 19.45) for the Eastern GOM stock (see figure; ibid);  $N > N_{limit}$  in both the Western and Eastern stocks. Both stocks are currently not overfished, although the Western stock is in a depressed state and approaching an overfished limit. Due to the above, a score of "moderate" concern is given.

Justification:

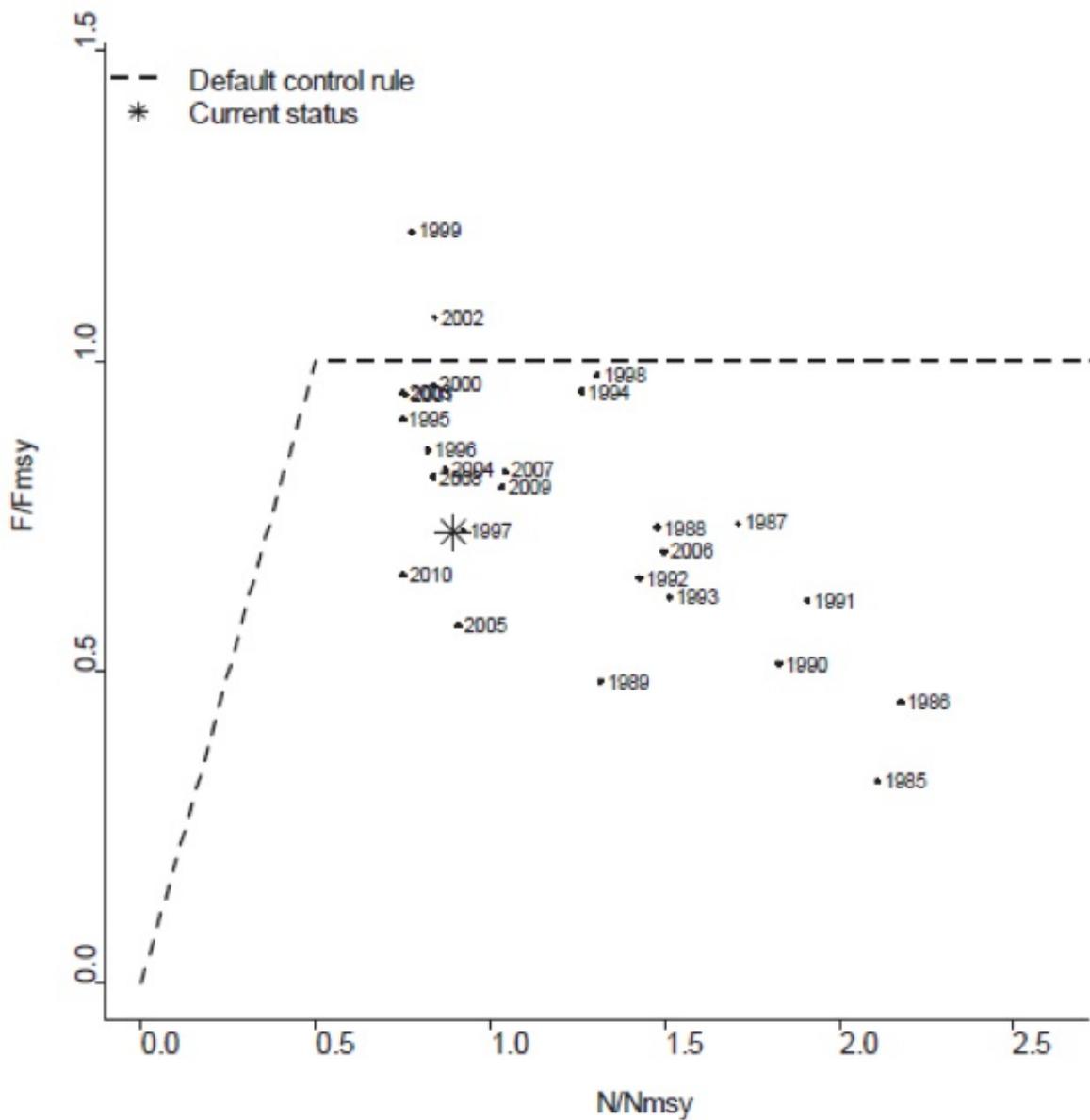


Figure 10 Western GOM stock status relative to proposed control rule. All points below the control rule line are not overfished or undergoing overfishing relative to the default limits proposed in the 2013 assessment (GSMFC 2015).

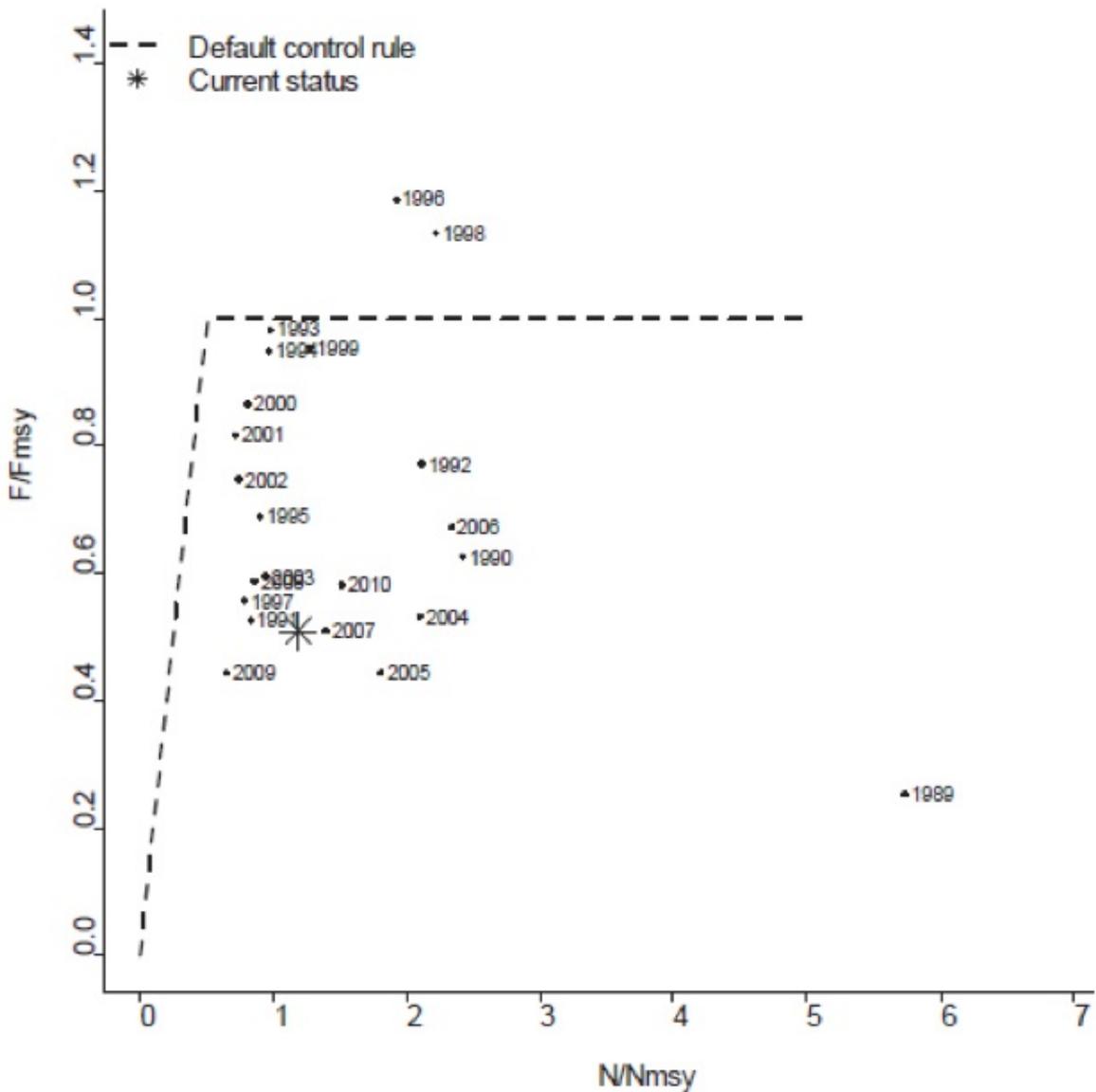


Figure 11 Eastern GOM stock status relative to proposed control rule. All points below the control rule line are not overfished or undergoing overfishing relative to the default limits proposed in the 2013 assessment (GSMFC 2015).

LOUISIANA/GULF OF MEXICO, POTS, UNITED STATES OF AMERICA

**Moderate Concern**

The 2017 estimate for Louisiana blue crab is  $SSB/SSB_{limit} = 1.36$  or 25 million lb, which is below the target of 27.4 million lb, but above the  $SSB_{limit}$  of 18.2 million lb (West et al. 2018), suggesting that the stock is currently not overfished, and above 75% of the target. Louisiana blue crab is not overfished, but is a part of the wider GOM western stock, and is therefore included in the GOM blue crab stock assessment. The Western stock, as a whole, is in a depressed state and approaching an overfished limit; therefore, abundance is scored as "moderate" concern.

**Justification:**

Blue crab landings from the northern Gulf of Mexico (GOM) are primarily of Louisiana (LA) origin (part of the Western GOM blue crab stock in the inclusive GOM stock assessment). For purposes of the LA stock assessment, the blue crab unit stock is defined as those crabs occurring in LA waters (ibid).

In the previous assessment update (LDFW 2016), the Louisiana blue crab stock was considered overfished. The state of Louisiana has a control rule that ensures management actions will be taken if the stock is defined as overfished. Therefore, based on that status, the Louisiana Legislature and the Wildlife and Fisheries Commission took actions to reduce harvest. These management actions included: 1) legislation to modify escape rings and to expand crab trap cleanup abilities; 2) commission rule to provisionally ban harvest of immature females from 2017 to 2019; 3) allowing seasonal closures of all crab harvest in 2017; and 4) allowing seasonal closure of female crab harvest in 2018 and 2019 (ibid). The current assessment (2018) is the first measure of the effectiveness of those management actions enacted prior to 2018 (ibid).

Auditors of the LA blue crab fishery MSC re-assessment noted that there were significant increases in blue crab SSB after Hurricanes Katrina and Rita (due to reduced fishing effort), and that the LA blue crab stock is capable of recovering from the current low SSB with the potential to rebuild to the biomass TRP in about 3 years (Scott and Tremblay 2018). The initial closure and subsequent measures to protect female blue crabs are expected to decrease landings by 5% each year (LDWF 2016), which will increase the percentage of crabs that reproduce, and increase yield per recruit (ibid). It is therefore believed that it is highly likely that reducing F as a rebuilding strategy will ensure rebuilding of the stocks within five years (ibid).

**Factor 1.2 - Fishing Mortality**

GEORGIA/WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA

**Moderate Concern**

Georgia landings decreased in the late 2000s, but have increased slightly since 2010 (see Figure 12). Some of the decline in landings is because of reduced effort, closure of all the blue crab picking houses, and an industry-led reduction of latent effort by reducing available licenses from 159 to 100 (P. Geer, personal communication 2016). Although fishing mortality is not calculated directly, there is no indication that overfishing is occurring, and a score of "moderate" concern is given.

**Justification:**

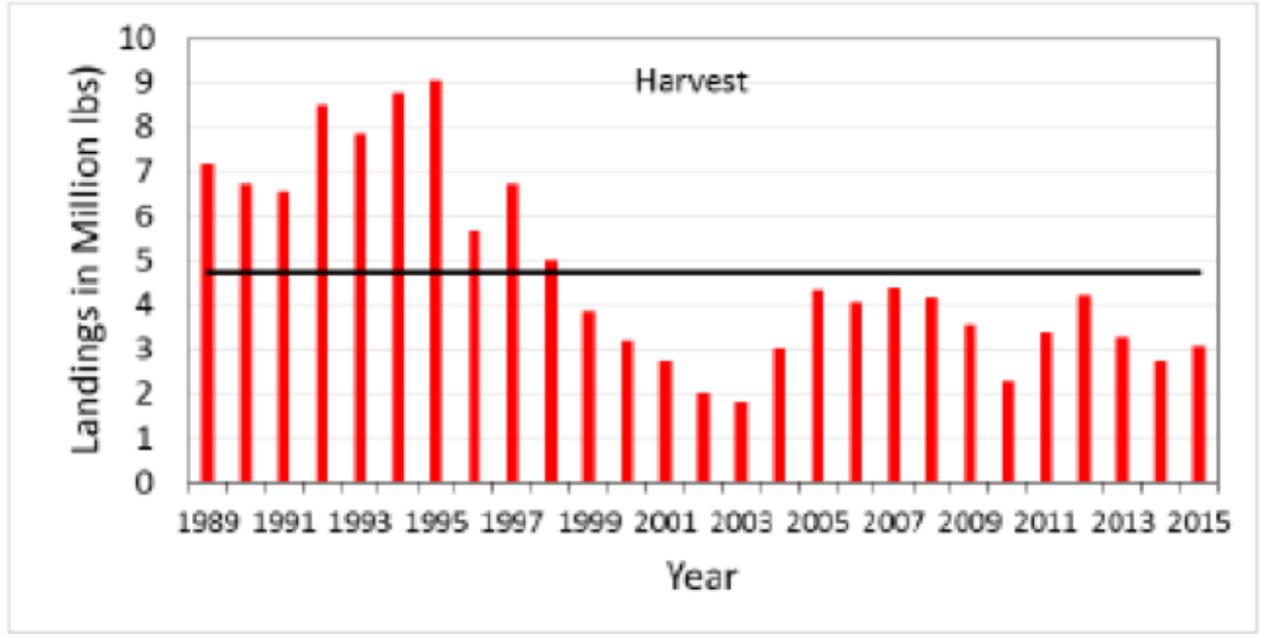


Figure 12 Georgia hard crab landings, from 1989-2015 (GADNR 2016).

SOUTH CAROLINA/WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA

**Moderate Concern**

South Carolina blue crab landings have been above the long-term, 10-year average, although lack of a formal assessment of fishing mortality means that the overfishing status of the stock is unknown (see figure) (SDNR 2016c), or of "moderate" concern.

**Justification:**

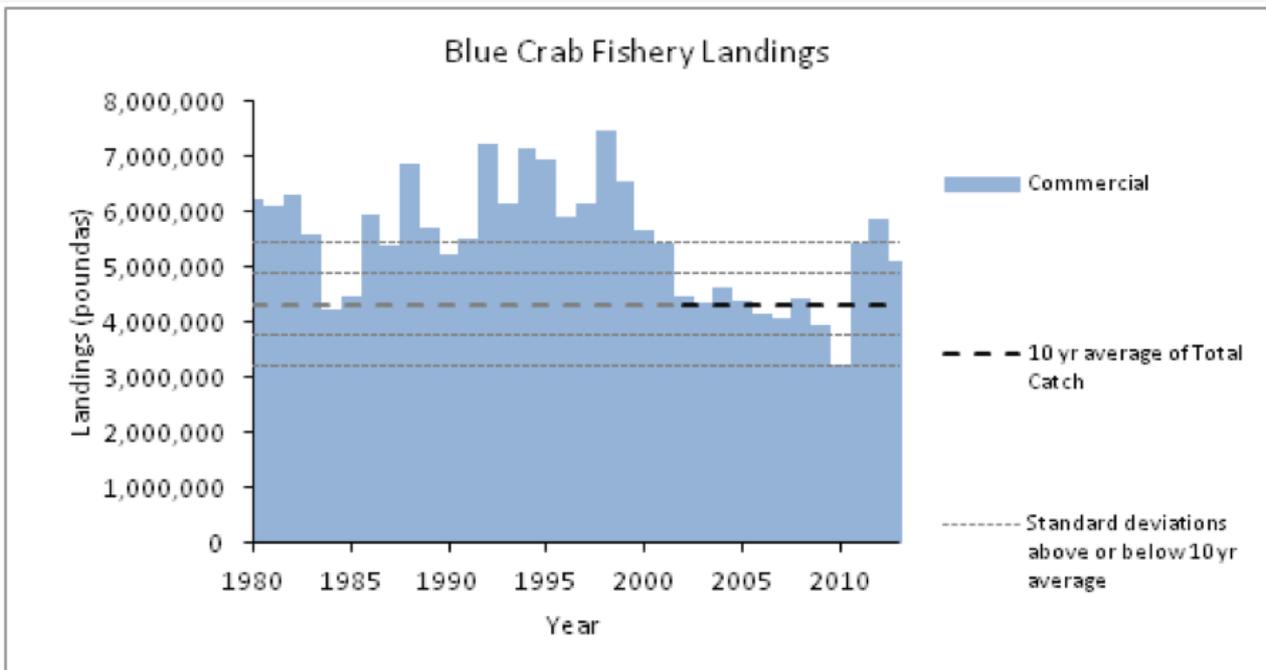


Figure 13 Commercial catch of blue crab (lbs) in South Carolina compared to the 10-year average (SDNR 2016c).

FLORIDA/WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA

**Moderate Concern**

Florida blue crabs are also not experiencing overfishing, and fishing mortality has decreased since the late 1990s (see figure) (FWC and FWRI 2015). Due to the lack of sufficient information from all states in the Atlantic, but considering that overfishing does not appear to be occurring, fishing mortality is ranked as "moderate" concern.

**Justification:**

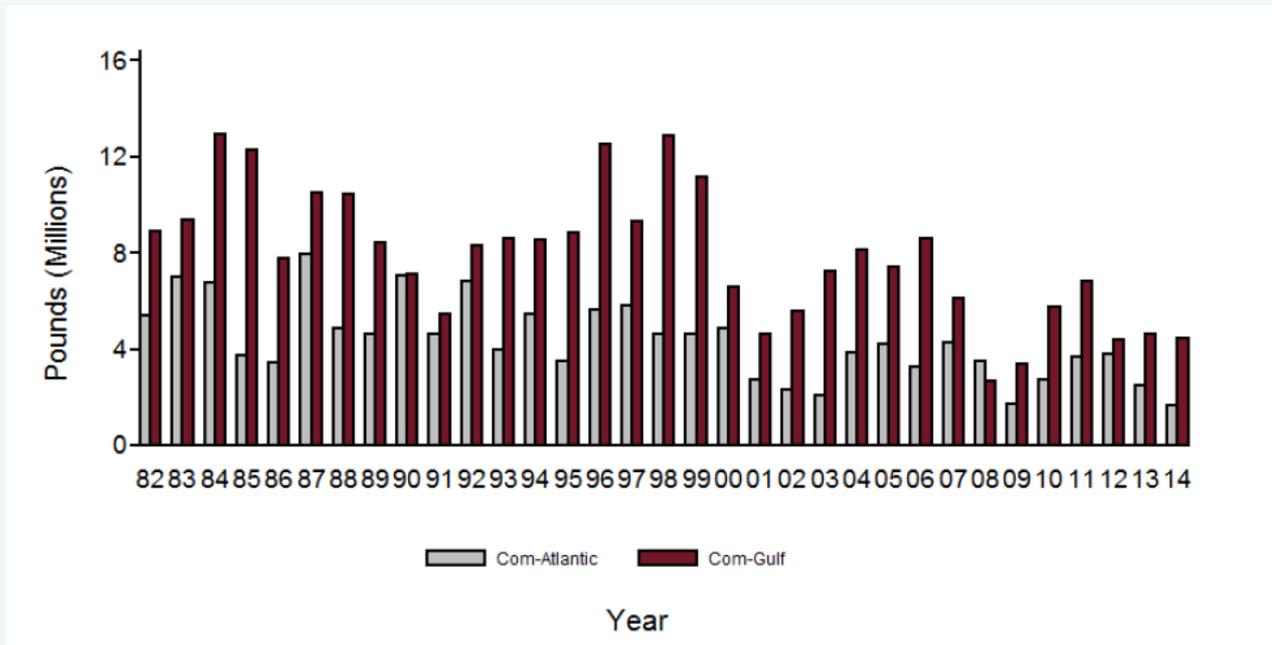


Figure 14 Total annual landings (lbs) of blue crab on the Atlantic and Gulf coasts of Florida, from 1982-2014 (FWC and FWRI 2015).

MARYLAND/CHESAPEAKE BAY, TROTLINE, UNITED STATES OF AMERICA  
 VIRGINIA/CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
 MARYLAND/CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
 NEW JERSEY/DELAWARE BAY, POTS, UNITED STATES OF AMERICA  
 DELAWARE/NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA

**Low Concern**

Although there is no formal estimate of fishing mortality, the blue crab stock in Chesapeake Bay does not appear to be experiencing overfishing. Estimates of fishing mortality are calculated using an exploitation fraction, which is the annual harvest of female crabs in one year divided by the total number of female crabs at age 0+ (CBSAC 2017). The most recently estimated abundance of female crabs removed by fishing is 16%, which is below the target of 25.5%, and the threshold of 34%, for the ninth consecutive year (see first figure). In addition, the exploitation rate on male crabs has been below the conservation trigger since 2005 (see second figure; *ibid*). For this reason, blue crab fishing mortality is deemed as "low" concern. The Delaware Bay (DE and NJ) blue crab stock does not have a separate assessment and is managed in conjunction with the Chesapeake Bay stock. Blue crab catch in DE and NJ has decreased in the last decade, but has increased slightly in recent years (see third figure) (NMFS 2016a). Fishing mortality is deemed a "low" concern for

Delaware Bay as well.

**Justification:**

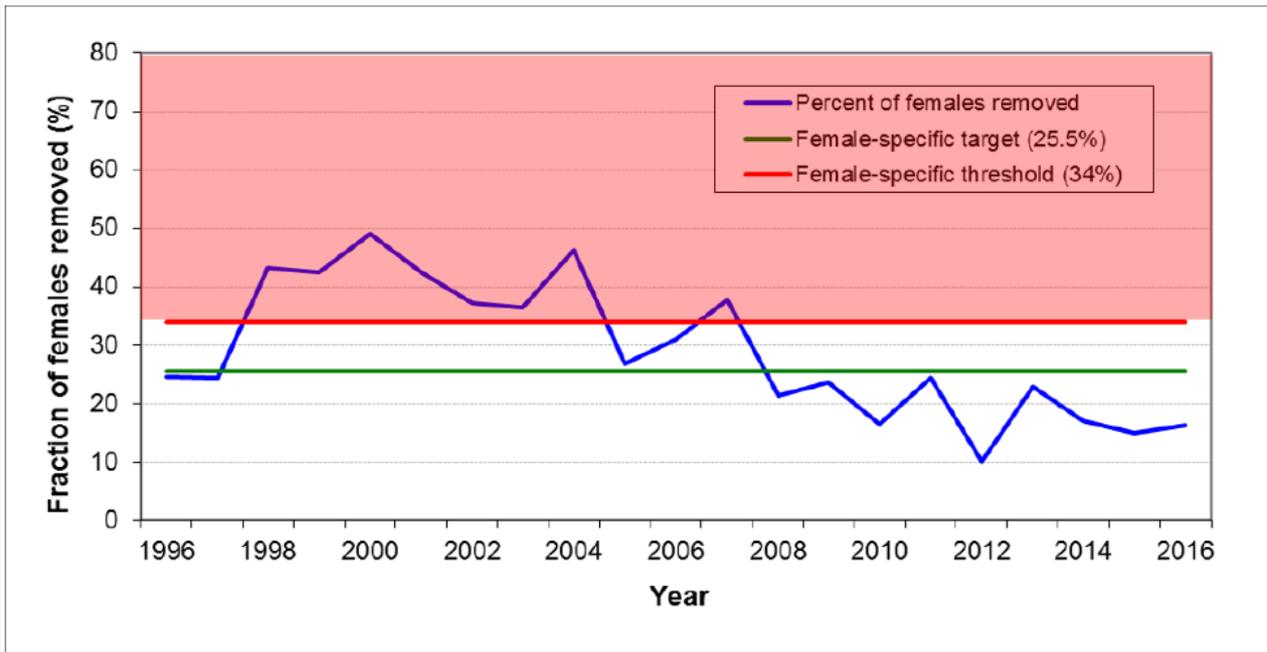


Figure 15 The percentage of female crabs removed from the population each year by fishing, relative to the female specific target (25.5%) and threshold (34%) exploitation rates, from 1996-2016. Exploitation rate (% removed) is the number of crabs harvested within a year, divided by the population of all crabs estimated at the beginning of the year (CBSAC 2017).

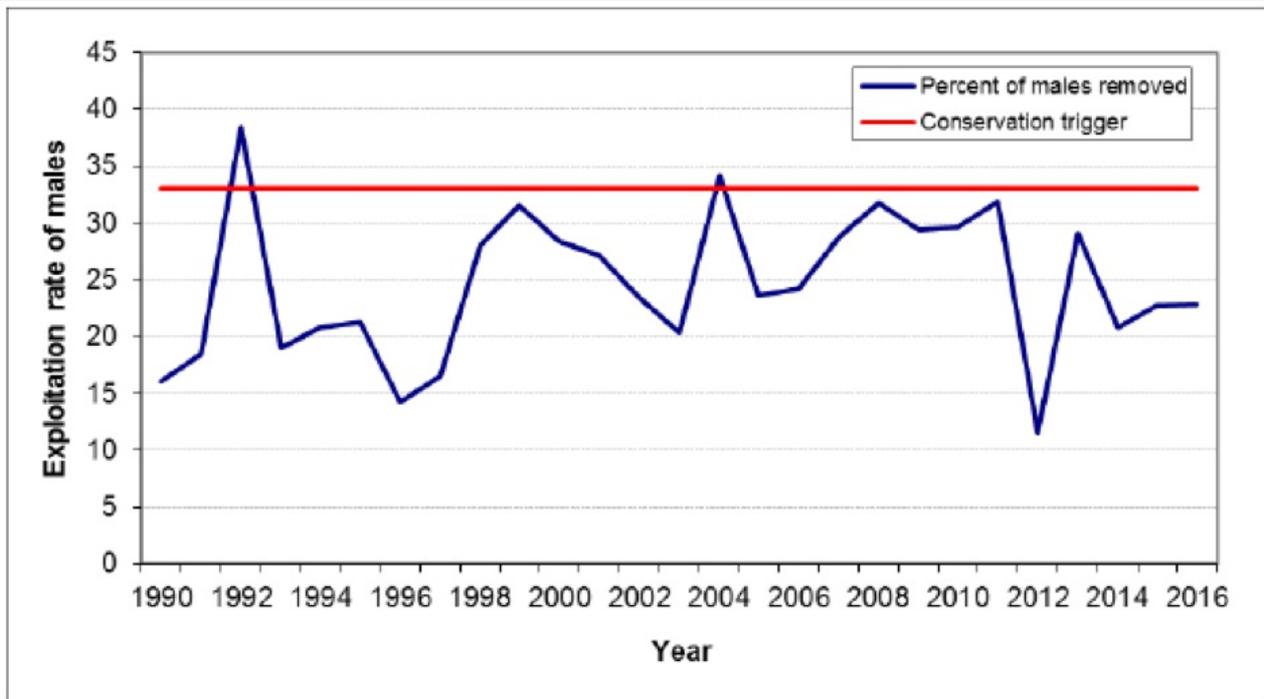


Figure 16 The percentage of male crabs removed from the population each year by fishing, from 1990-2016. Exploitation rate (% removed) is the number of male crabs harvested within a year, divided by the male population estimate (age 0 and age 1+) at the beginning of the year (CBSAC 2017).

## NJ and DE Commercial Blue Crab Landings 1973-2015

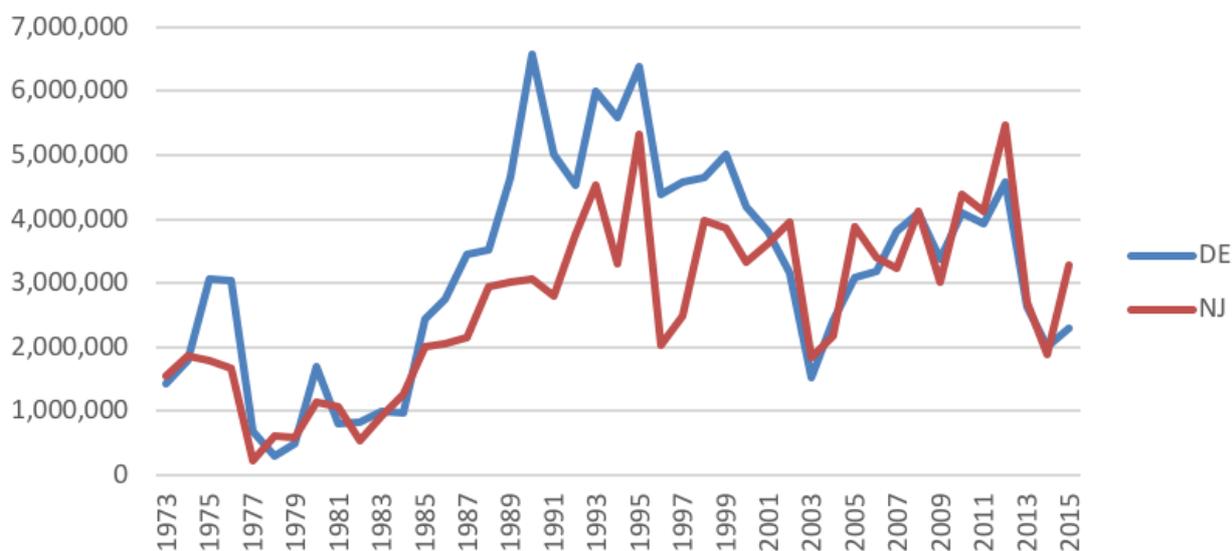


Figure 17 New Jersey (NJ) and Delaware (DE) commercial blue crab landings by state, from 1973-2015 (NMFS 2016a). Landings from 2015 are projected landings and have not yet been finalized (Richard Wong, personal communication, 2016).

### NORTH CAROLINA/NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA

#### Moderate Concern

North Carolina uses carapace width, spawning stock, frequency of mature females, pre-recruit abundance, and length at 50% maturity to assess the status of blue crab under the Traffic Light Method. Due to the lack of a quantitative assessment, the overfishing status of blue crab in North Carolina cannot be estimated. Although landings were low in 2013, they have increased in both 2014 and 2015 (see figure). Due to the condition of adult and recruit abundance characteristics, management actions were taken that affect fishing mortality. These included: 1) adding one additional cull ring to crab pots; 2) eliminating the harvest of v-apron immature female hard crabs (excluding peeler crabs), and that v-apron immature hard crab females be included in the culling tolerance (currently only includes sublegal male and immature female hard crabs); 3) prohibiting harvest of dark sponge crabs (brown and black) from April 1 to April 30, and including dark sponge crabs in the cull tolerance; 4) lowering the cull tolerance to 5% for all crabs, except mature females; and 5) prohibiting crab harvest with dredges except incidental to lawful oyster dredging (NMFC 2016b). Since there is no quantitative stock assessment, but overfishing is not likely to be occurring based on recent landings data, a score of "moderate" concern is awarded.

## Justification:

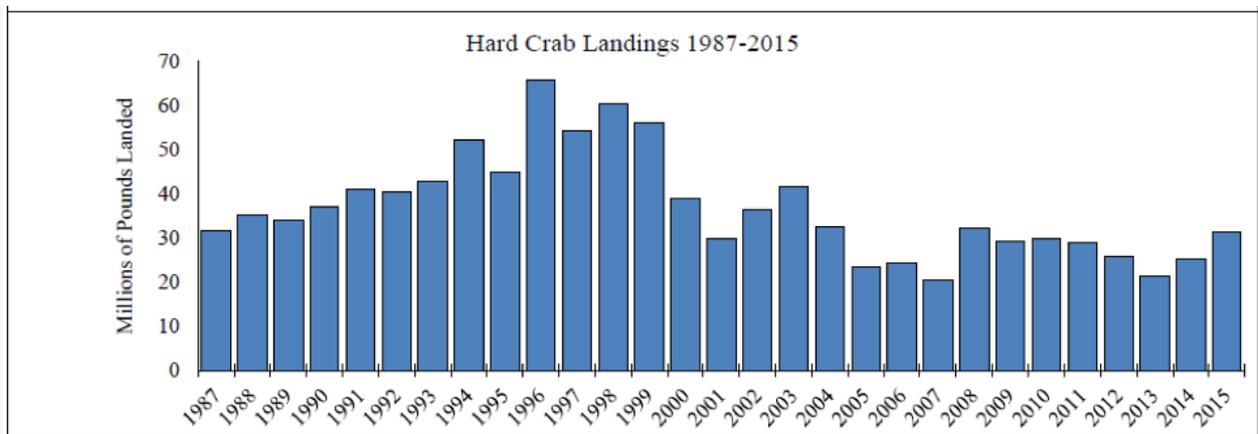


Figure 18 Commercial hard crab landings in North Carolina waters, from 1987-2015 (millions of lbs) (NMFC 2016b).

FLORIDA/GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
ALABAMA/GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
MISSISSIPPI/GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
TEXAS/GULF OF MEXICO, POTS, UNITED STATES OF AMERICA

### Low Concern

In both the Eastern and Western GOM stocks,  $F/F_{MSY}$  was less than 1.0 (0.72 for the Western stock and 0.51 for the Eastern stock) (GSMFC 2013); therefore, overfishing is not occurring. To prevent overfishing, the following management measures were implemented: 1) a ban on the take of immature females (went into effect in January 2017); 2) seasonal crab closures (the first was held from February 20 to March 22, 2017); 3) a rule implementing a minimum of three escape rings, and an increase in escape ring size to 2 3/8 in (which took effect in November 2017; and 4) the removal of an exemption of escape rings in Lake Pontchartrain) (LDWF 2017a) (LDWF 2017b). Since blue crab fishing mortality is variable from year to year, and is dependent on environmental conditions (and management actions are being implemented), it is likely that overfishing will be prevented and harvest will be controlled. Louisiana is the only state in the GOM that has conducted their own recent assessment. Therefore, until the next Gulf-wide assessment, the GOM blue crab fishery is ranked as "low" concern.

LOUISIANA/GULF OF MEXICO, POTS, UNITED STATES OF AMERICA

### Low Concern

The 2016 estimate ( $F$  was not estimated by the model for the most recent year, 2017) for Louisiana blue crab is  $F/F_{limit} = 0.82$ , suggesting that the stock is not currently experiencing overfishing (West et al. 2018). Yet, the 2014, 2015, and 2016 fishing mortality rate estimates were past their target and the 2014 value was very close to the overfishing threshold (ibid). Because the stock is not undergoing overfishing, fishing mortality is considered a "low" concern.

### Justification:

These estimates should be considered from a precautionary viewpoint given the upward trend in fishing mortality, combined with the decrease in exploitable biomass observed in the most recent decade (ibid). The overfishing reference point estimate in this assessment ( $F_{limit}$ ) is calculated assuming equilibrium conditions and potentially overestimated given the below-average recruitment observed in the past 20 years. Estimates of fishing mortality are not available for 2017 (ibid).

## 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

Only the lowest scoring main species is/are listed in the table and text in this Criterion 2 section; a full list and assessment of the main species can be found in Appendix A.

BLUE CRAB - ALABAMA/GULF OF MEXICO - POTS - UNITED STATES OF AMERICA					
Subscore:	1.000	Discard Rate:	1.00	C2 Rate:	1.000
Species	Abundance	Fishing Mortality	Subscore		
Diamondback terrapins (unspecified)	1.00:High Concern	1.00:High Concern	Red (1.000)		
West Indian manatee	1.00:High Concern	5.00:Low Concern	Yellow (2.236)		

BLUE CRAB - DELAWARE/NORTHWEST ATLANTIC - POTS - UNITED STATES OF AMERICA					
Subscore:	1.000	Discard Rate:	1.00	C2 Rate:	1.000
Species	Abundance	Fishing Mortality	Subscore		
Diamondback terrapins (unspecified)	1.00:High Concern	1.00:High Concern	Red (1.000)		
Bottlenose dolphin	1.00:High Concern	3.00:Moderate Concern	Red (1.732)		

BLUE CRAB - FLORIDA/GULF OF MEXICO - POTS - UNITED STATES OF AMERICA					
<b>Subscore:</b>	<b>1.000</b>	<b>Discard Rate:</b>	<b>1.00</b>	<b>C2 Rate:</b>	<b>1.000</b>
Species	Abundance	Fishing Mortality	Subscore		
Diamondback terrapins (unspecified)	1.00:High Concern	1.00:High Concern	Red (1.000)		
West Indian manatee	1.00:High Concern	5.00:Low Concern	Yellow (2.236)		

BLUE CRAB - FLORIDA/WESTERN CENTRAL ATLANTIC - POTS - UNITED STATES OF AMERICA					
<b>Subscore:</b>	<b>1.000</b>	<b>Discard Rate:</b>	<b>1.00</b>	<b>C2 Rate:</b>	<b>1.000</b>
Species	Abundance	Fishing Mortality	Subscore		
Diamondback terrapins (unspecified)	1.00:High Concern	1.00:High Concern	Red (1.000)		
Bottlenose dolphin	1.00:High Concern	3.00:Moderate Concern	Red (1.732)		
West Indian manatee	1.00:High Concern	5.00:Low Concern	Yellow (2.236)		

BLUE CRAB - GEORGIA/WESTERN CENTRAL ATLANTIC - POTS - UNITED STATES OF AMERICA					
<b>Subscore:</b>	<b>1.000</b>	<b>Discard Rate:</b>	<b>1.00</b>	<b>C2 Rate:</b>	<b>1.000</b>
Species	Abundance	Fishing Mortality	Subscore		
Diamondback terrapins (unspecified)	1.00:High Concern	1.00:High Concern	Red (1.000)		
Bottlenose dolphin	1.00:High Concern	3.00:Moderate Concern	Red (1.732)		
West Indian manatee	1.00:High Concern	5.00:Low Concern	Yellow (2.236)		

BLUE CRAB - LOUISIANA/GULF OF MEXICO - POTS - UNITED STATES OF AMERICA					
<b>Subscore:</b>	<b>1.000</b>	<b>Discard Rate:</b>	<b>1.00</b>	<b>C2 Rate:</b>	<b>1.000</b>
Species	Abundance	Fishing Mortality	Subscore		
Diamondback terrapins (unspecified)	1.00:High Concern	1.00:High Concern	Red (1.000)		
West Indian manatee	1.00:High Concern	5.00:Low Concern	Yellow (2.236)		

BLUE CRAB - MARYLAND/CHESAPEAKE BAY - POTS - UNITED STATES OF AMERICA					
<b>Subscore:</b>	<b>1.000</b>	<b>Discard Rate:</b>	<b>1.00</b>	<b>C2 Rate:</b>	<b>1.000</b>
Species	Abundance	Fishing Mortality	Subscore		
Diamondback terrapins (unspecified)	1.00:High Concern	1.00:High Concern	Red (1.000)		
Bottlenose dolphin	1.00:High Concern	3.00:Moderate Concern	Red (1.732)		

BLUE CRAB - MARYLAND/CHESAPEAKE BAY - TROTLINE - UNITED STATES OF AMERICA					
<b>Subscore:</b>	<b>5.000</b>	<b>Discard Rate:</b>	<b>1.00</b>	<b>C2 Rate:</b>	<b>5.000</b>
Species	Abundance	Fishing Mortality	Subscore		
No other main species caught					

BLUE CRAB - MISSISSIPPI/GULF OF MEXICO - POTS - UNITED STATES OF AMERICA					
<b>Subscore:</b>	<b>1.000</b>	<b>Discard Rate:</b>	<b>1.00</b>	<b>C2 Rate:</b>	<b>1.000</b>
Species	Abundance	Fishing Mortality	Subscore		
Diamondback terrapins (unspecified)	1.00:High Concern	1.00:High Concern	Red (1.000)		
West Indian manatee	1.00:High Concern	5.00:Low Concern	Yellow (2.236)		

BLUE CRAB - NEW JERSEY/DELAWARE BAY - POTS - UNITED STATES OF AMERICA					
<b>Subscore:</b>	<b>1.000</b>	<b>Discard Rate:</b>	<b>1.00</b>	<b>C2 Rate:</b>	<b>1.000</b>
Species	Abundance	Fishing Mortality	Subscore		
Diamondback terrapins (unspecified)	1.00:High Concern	1.00:High Concern	Red (1.000)		
Bottlenose dolphin	1.00:High Concern	3.00:Moderate Concern	Red (1.732)		

BLUE CRAB - NORTH CAROLINA/NORTHWEST ATLANTIC - POTS - UNITED STATES OF AMERICA					
<b>Subscore:</b>	<b>1.000</b>	<b>Discard Rate:</b>	<b>1.00</b>	<b>C2 Rate:</b>	<b>1.000</b>
Species	Abundance	Fishing Mortality	Subscore		
Diamondback terrapins (unspecified)	1.00:High Concern	1.00:High Concern	Red (1.000)		
Bottlenose dolphin	1.00:High Concern	3.00:Moderate Concern	Red (1.732)		
West Indian manatee	1.00:High Concern	5.00:Low Concern	Yellow (2.236)		

BLUE CRAB - SOUTH CAROLINA/WESTERN CENTRAL ATLANTIC - POTS - UNITED STATES OF AMERICA					
<b>Subscore:</b>	<b>1.000</b>	<b>Discard Rate:</b>	<b>1.00</b>	<b>C2 Rate:</b>	<b>1.000</b>
Species	Abundance	Fishing Mortality	Subscore		
Diamondback terrapins (unspecified)	1.00:High Concern	1.00:High Concern	Red (1.000)		
Bottlenose dolphin	1.00:High Concern	3.00:Moderate Concern	Red (1.732)		
West Indian manatee	1.00:High Concern	5.00:Low Concern	Yellow (2.236)		

BLUE CRAB - TEXAS/GULF OF MEXICO - POTS - UNITED STATES OF AMERICA					
<b>Subscore:</b>	<b>1.000</b>	<b>Discard Rate:</b>	<b>1.00</b>	<b>C2 Rate:</b>	<b>1.000</b>
Species	Abundance	Fishing Mortality	Subscore		
Diamondback terrapins (unspecified)	1.00:High Concern	1.00:High Concern	Red (1.000)		
West Indian manatee	1.00:High Concern	5.00:Low Concern	Yellow (2.236)		

BLUE CRAB - VIRGINIA/CHESAPEAKE BAY - POTS - UNITED STATES OF AMERICA					
<b>Subscore:</b>	<b>1.000</b>	<b>Discard Rate:</b>	<b>1.00</b>	<b>C2 Rate:</b>	<b>1.000</b>
Species	Abundance	Fishing Mortality	Subscore		
Diamondback terrapins (unspecified)	1.00:High Concern	1.00:High Concern	Red (1.000)		
Bottlenose dolphin	1.00:High Concern	3.00:Moderate Concern	Red (1.732)		

Gear used in the blue crab fishery has the potential to catch non-targeted species, and as a result, crab fishing has had some impacts on endangered, threatened, and protected (ETP) species. Bycatch in the blue crab fishery is minimal and consists primarily of invertebrates and small numbers of non-targeted finfish (Guillory et al. 2012) (Page et al. 2013). There has been some concern over marine mammal and sea turtle interactions with crab pots due to entanglement in the float lines, but these interactions are thought to be very rare (NMFS 2017). The Atlantic blue crab pot fishery is listed as a Category II fishery and the GOM blue crab fishery is listed as a Category III fishery under the NMFS list of fisheries (NMFS 2017), which means there are occasional or rare interactions with marine mammals, respectively. The Atlantic blue crab fishery is listed as a Category II fishery due to interactions with Atlantic bottlenose dolphins and manatees (ibid). Interactions with manatees are minimal, and fishing mortality is ranked as "low" concern. Bottlenose dolphin populations, on the other hand, are of unknown abundance, and it is not possible to identify a sustainable level of impact, or Potential Biological Removal (PBR), in many cases (Waring et al. 2016). As a result, the impact of blue crab fisheries on Atlantic bottlenose dolphins is unknown, or a "moderate" conservation concern, according to Seafood Watch.

Literature on bycatch in blue crab pots has shown that the pot fisheries do not have a significant impact on finfish or invertebrate bycatch, but that diamondback terrapins (*Malaclemys terrapin*) can become caught in pots (Page et al. 2013) and cannot escape to breathe at the surface. Diamondback terrapin abundance is known to decrease significantly as fishing effort increases (Grosse et al. 2011). Although diamondback terrapin populations are threatened due to mortality in crab pots (both active and derelict), there is only a threat where terrapin habitat and blue crab fishing overlaps. The main threat to terrapins is nest depredation and habitat reduction/modification (Seigel and Gibbons 1995) (Pearson and Wiebe 2018a) (S. Vanderkooy, personal communication 2018). Terrapins play a very important role in maintaining coastal saltwater marsh ecosystems by aiding in seed dispersal, and controlling insects and snails that prey on seagrass (USFWS 2016). For all blue crab pot fisheries, terrapin bycatch limits the score for Criterion 2 due to gear interactions and their importance as potential keystone predators in estuarine ecosystems (Rook et al. 2010).

## 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)

### DIAMONDBACK TERRAPINS (UNSPECIFIED)

#### Factor 2.1 - Abundance

NEW JERSEY / DELAWARE BAY, POTS, UNITED STATES OF AMERICA  
DELAWARE / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA  
MARYLAND / CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
VIRGINIA / CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
NORTH CAROLINA / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA  
SOUTH CAROLINA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
GEORGIA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
FLORIDA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
FLORIDA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
LOUISIANA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
ALABAMA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
MISSISSIPPI / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
TEXAS / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA

#### High Concern

Diamondback terrapins are highly inherently vulnerable, primarily because of their minimal reproductive output, but also because they are a long-lived species (Roosenburg 1991). In the early 20<sup>th</sup> century, terrapins were hunted (as food) nearly to extinction, but the population is thought to have recovered to some extent once the demand for them waned (Maerz and Grosse 2010). Two recent genetic studies of terrapins across Louisiana's coast found low genetic diversity and potential bottlenecks in recent history, which is evidence of the overharvest of terrapins in Louisiana (Drabek et al. 2014) (Petre et al. 2015).

However, there are still many sources of mortality for diamondback terrapins, including habitat degradation, pollution, predation by raccoons, feral hogs, foxes, coyotes, birds, otters, skunks, bald eagles, ants, stone, ghost and blue crabs Seigel and Gibbons 1995} (Butler et al. 2006) (Rook et al. 2010) (Munscher et al. 2012) (Drabek et al. 2014) (Pearson and Wiebe 2018a), and being caught as bycatch in commercial and recreational blue crab pots, both active and derelict (Gibbons et al. 2001) (Anderson and Alford 2015) (Pearson and Wiebe 2018a). More than 90% of terrapin nests are destroyed by predators such as raccoons (*Procyon lotor*), who predate on both terrapin eggs and adults (Mohrman and Tappa 2014) (Munscher et al. 2012). As a result, only a few diamondback terrapins survive to adulthood, and thus, impacts on the species from any of the above-mentioned sources could have serious consequences.

Considering the unknown population status of diamondback terrapins, the various listings in different states, the considerable number of threats they face, and the fact that they are a keystone species (Silliman and Bertness 2002), diamondback terrapins are highly vulnerable to fishing and are therefore ranked as a "high" conservation concern.

#### Justification:

Diamondback terrapins live along the US Atlantic Coast from Cape Cod to Galveston Bay. In the GOM (Roosenburg 1991) and throughout their range, the population sizes in the states are primarily unknown or declining, and few are considered stable (Butler et al. 2006) (Seigel and Gibbons 1995). There are seven distinct subspecies that are managed as different units. Moving south along the coast, population sizes tend to decrease so that those in Cape Cod and Chesapeake Bay are the highest, and those in the GOM and south of Chesapeake Bay are low, and of concern (Butler et al. 2006) (Seigel and Gibbons 1995). The Tortoise &

Freshwater Turtle Specialist Group of the IUCN and the Endangered Species List have classified this species as "Near Threatened" (Tortoise & Freshwater Turtle Specialist Group 1996). Terrapins are listed as endangered in Rhode Island and threatened in Massachusetts. Under the Natural Heritage Program, terrapins are identified as critically imperiled in Alabama, imperiled in Mississippi, vulnerable in North Carolina, Louisiana, and Texas, and "apparently secure" in Maryland, Georgia, and Florida (see table) (Hackney 2010) (Selman et al. 2014).

<b>State</b>	<b>Status</b>	<b>Reference</b>
New Jersey	Special Concern	(NJDEP 2008)
Delaware	Rare to Uncommon (Tier II)	(DDNREC 2015)
Maryland	Apparently Secure (S4)	(MDDNR 2016)
Virginia	Very High Conservation Need (Tier II)	(VDGIF 2015)
North Carolina	Vulnerable (S3)	(NCWRC 2015)
South Carolina	High Priority	(SCDNR 2014)
Georgia	Apparently Secure (S4)	(GADNR 2015b)
Florida	Apparently Secure (S4)	(FWC 2012)
Alabama	Critically Imperiled (S2 P1)	(ADCNR 2015)
Mississippi	Imperiled (S2)	(MMNS 2015)
Louisiana	Vulnerable (S3)	(LDFW 2015)
Texas	Vulnerable (S3)	(Natureserve 2016)

The total abundance of diamondback terrapins in US waters is unknown as there have been very few population surveys, and those conducted recently found that terrapin populations tend to be localized throughout creeks and brackish water wetlands (USFWS 2016). Therefore, obtaining accurate population counts along the US east coast and in the GOM is difficult. A recent study in Georgia found that 88% of creeks were populated with terrapins, and estimated the population to be approximately 92,000 individuals, one of the largest populations recorded (Maerz and Grosse 2010). In Georgia, Kiawah island has the largest historical terrapin population; however, there has been a 75% decline over the past two decades, which is likely attributable to increased development on the island, among other things (Dorcas et al. 2007). In 2014, a terrapin survey in Louisiana found terrapins in nearly all their historical localities, as well as in 12 new localities; some areas were even considered locally abundant (Selman et al. 2014). Pearson and Wiebe (2018b) also found patchy distribution with local areas of abundance in Louisiana's Deltaic marshes, similar to those described in the Chenier Plain (Selman et al. 2014). In Pontchartrain and Terrebonne basins, the authors found that highest CPUE sites were within remote locations, whereas the site with the highest CPUE in Barataria Basin was in relative proximity to anthropogenic development (boat launch, fishing communities, etc.), but where trapping for blue crab is prohibited (Pearson and Wiebe 2018b). Higher CPUE at these sites could be attributed to a number of things: improved habitat quality (higher salinity near the Gulf of Mexico), proximity to nesting habitats, or reduced pressure from fisheries in/around these sites (ibid). Further research is needed to determine the drivers of terrapin abundance.

Nonetheless, terrapin abundance appeared to be the lowest in areas associated with crab pots, smaller marsh

areas, and channels that no longer have a permanent connection to the Gulf of Mexico (ibid). In other words, this study identifies crab pots as a possible cause for low terrapin abundance (not as a major source of mortality), but ultimately identifies a need for more research on terrapin abundance throughout Louisiana and the GOM.

## Factor 2.2 - Fishing Mortality

NEW JERSEY / DELAWARE BAY, POTS, UNITED STATES OF AMERICA  
DELAWARE / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA  
MARYLAND / CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA

### High Concern

Mortality of diamondback terrapins is the result of a variety of factors (as described above). Since direct harvest of terrapins has been prohibited in this region, fishing mortality of diamondback terrapins occurs only as bycatch in crab pots in the blue crab fishery. Crab pots are considered to be one of the threats to diamondback terrapin populations, along with habitat degradation and nest predation (Roosenburg 1991) (Seigel and Gibbons 1995) (Pearson and Wiebe 2018a). Bycatch in crab pots can range from 0.0 to 0.49 terrapins/day/pot depending on the area fished and the water depth. Mortality rates range from 10 to 78% depending on the time of year and the size of the individual (Roosenburg 2004) (Hart and Crowder 2011). If a terrapin enters a crab pot, it can be trapped inside, and because pots are not monitored frequently (enough) to allow for the release of any bycatch, the terrapin is likely to drown (Harden and Willard 2012). In addition, terrapins can get caught in ghost (or derelict) pots that are abandoned by fishers, which increases fishing mortality (Roosenburg 1991).

It is complicated to assess the extent of terrapin bycatch in blue crab pots, as terrapins are only caught as bycatch where their habitat overlaps with the blue crab fisheries (often small, shallow tributaries in estuarine systems) (R. Gandy, personal communication 2016). While crab pots are set throughout bays and offshore, terrapins are found in localized populations, primarily in tributaries and intertidal regions. In a Florida study, no terrapins were caught in pots other than in the intertidal regions, where 10 shallow pots set in intertidal zones (at the marsh edge) to simulate derelict pots, caught 65 terrapins over the course of 33 days (Gandy and Turner 2014). Traps that were deployed from 30.5 m to 305 m from shore captured no terrapins over a 31-day period (in the Fall of 2012), and only two terrapins over 57 days the following Spring/Summer (ibid). These results further support that proximity to the shoreline is the biggest contributor to pot interactions in areas that have suitable habitat for terrapins. Deep water traps, actively fished or derelict, are not likely posing a threat to terrapins (C. Blankenship, personal communication 2017).

The use of BRDs has been shown to reduce terrapin bycatch, while preserving blue crab catch (Hart and Crowder 2011)(McKee et al. 2015). Although Maryland only requires BRDs in the recreational blue crab fishery, they do not allow the commercial blue crab fishery to set crab pots in tributaries or waters less than 4 ft deep in the main stream (B. Davis, personal communication 2016). This minimizes the number of terrapins caught as bycatch. However, studies have shown that BRDs are only effective where terrapin and blue crab habitats overlap, and so implementation of BRDs throughout the entire fishery in a particular state may not be necessary. Some states (in the management section below) are exploring implementation of BRD requirements in areas where terrapins and blue crabs overlap, or during sensitive times of the year when terrapin bycatch is high; however, no such regulations have been implemented yet.

Since the current impact of fishing mortality on terrapin populations is unknown, but they are a highly inherently vulnerable species, fishing mortality on diamondback terrapins in New Jersey, Delaware, and Maryland is ranked as "high" concern.

VIRGINIA / CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
NORTH CAROLINA / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA  
SOUTH CAROLINA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
GEORGIA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
FLORIDA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
FLORIDA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
LOUISIANA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
ALABAMA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
MISSISSIPPI / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
TEXAS / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA

### **High Concern**

Many states have distributed BRDs to commercial and recreational blue crab fishers, but use is voluntary (R. Burriss (MDMR) and P. Geer (GADNR), personal communication 2016).

### **Florida, Virginia**

There are no existing regulations in Florida or Virginia that require BRDs to reduce terrapin bycatch (D. Ellinor, personal communication 2016) (NCDMF 2013).

### **North and South Carolina**

North and South Carolina have been working on finding a BRD that will minimize terrapin bycatch while maintaining blue crab catch levels (Chavez and Willard 2017) (SCCR 2017). They are currently working to determine critical conservation areas, and the most effective excluder device (C. Flora, personal communication 2016). Arendt et al (2018) used morphometric measurements to model the effectiveness of BRDs at excluding terrapin catch while retaining legal-sized crab (Arendt et al 2018). They found that a BRD that measures 5.1 to 6.4 cm (height) by 7.3 cm (width) improves exclusion of terrapins relative to other tested BRDs, and that extending the width of this BRD would result in a 99% capture probability of legal-sized crab (Arendt et al 2018). It is important to note that this study is based on morphometric measurements of terrapin and crab in South Carolina and similar studies would need to be conducted with state-specific measurements to ensure effectiveness in other states (Arendt et al 2018).

### **Georgia**

In Georgia, a study of terrapins in tidal creeks found that a decrease in terrapin abundance was correlated with an increase in the number of crab pots (Grosse et al. 2011). In addition, a separate study suggested that terrapin excluder devices would likely be effective at reducing terrapin bycatch, while effective at maintaining larger crab catches (Belcher et al. 2007). Georgia has promoted the use of BRDs to all recreational and commercial crabbers in creeks less than 100 ft wide (VCCRM 2017). They have purchased over 2000 BRDs and have distributed them free of charge (P. Geer, personal communication 2016). Georgia promoted this voluntary use of excluder devices in the recreational fishery, which is believed to have higher terrapin catch per pot than the commercial fishery, due to proximity of the docks in the recreational fishery to the marsh edge (P. Geer, personal communication 2017). However, it is unknown how many commercial crabbers are currently using these BRDs, since there are no regulations requiring them.

### **Louisiana**

The Louisiana blue crab fishery has been conducting bycatch surveys in the Gulf of Mexico since 2012, as part of its Marine Stewardship Council (MSC) re-certification. Preliminary results from the most extensive bycatch

study of blue crab pots in Louisiana waters to date (results through January 2015 are presented), found that only six diamondback terrapins were caught as bycatch out of a total of 7,062 pots set; one in the Lake Pontchartrain Basin, two in the Terrebonne Basin and three in the Vermilion/Teche River Basins (Audubon Nature Institute 2016).

From 2012 to 2013, a derelict crab pot bycatch study was conducted using the general public as citizen scientists during the derelict pot cleanups/rodeos from Louisiana (Anderson and Alford 2014). In Cocodrie, one of the four sampling locations, 70% of the bycatch recorded were diamondback terrapins. In the other three sites, terrapin bycatch was 2% (Delacroix), 0% (Pointe a la Hache) and 35% (Hopedale) (ibid). The few traps that did have terrapins had several, which included old shells, suggesting that the pot had been there for a long period of time (C. Blankenship (and Anderson), personal communication 2017). Based on communications with the author, the Delacroix site had the most accurate data collection and is likely more representative of coast-wide derelict pots in Louisiana (L. Picariello, personal communication 2017). Between 2004 and Spring of 2016, Louisiana Sea Grant and LDWF have removed over 27,000 pots (Audubon Nature Institute 2016). Overall, the varied results demonstrate that the impact of blue crab pots on terrapins is not uniform across the fishery. Certain areas are likely to encounter higher rates of interaction with terrapins, and identifying these areas should be a priority.

### **Summary**

Although both total bycatch numbers and terrapin populations are unknown, it is believed that the blue crab fishery is a substantial contributor to declines in terrapin populations, and is potentially impeding their recovery (Roosenburg 2004)(Bilkovic et al. 2012) (Pearson and Wiebe 2018). Although bycatch in blue crab pots may not be the primary source of mortality for terrapins (nesting predation has a very high impact on populations, as discussed above), there is evidence that crab pots (both active and derelict) are a known source of mortality. As noted above in the New Jersey, Delaware, and Maryland section, studies have shown that BRDs are only effective where terrapin and blue crab habitats overlap, and so implementation of BRDs throughout the entire fishery in a particular state may not be necessary (Gandy and Turner 2014). Some states (see the management section) are exploring implementation of BRD requirements in areas where terrapins and blue crabs overlap, or during sensitive times of the year when terrapin bycatch is high. However, no such regulations have been implemented yet.

Since the impact of fishing mortality on terrapins is unknown, and there are currently no implemented BRD regulations, fishing mortality for diamondback terrapins in Virginia, the Atlantic, and the GOM is ranked as "high" concern.

### **Justification:**

Direct harvest of diamondback terrapins is either prohibited or severely limited throughout the Atlantic and the GOM. Mississippi allows possession of no more than four terrapins per person with a valid Small Game Hunting/Freshwater Fishing license (MDWFP 2018). In Louisiana, diamondback terrapins may not be taken in pots of any kind, and may not be taken at all between 15 April and 15 June (LDWF 2018b). Commercial and recreational possession, with the required license, is limited to terrapins measuring over six inches; there is no bag limit (ibid). Florida allows a recreational possession of two terrapins per individual per day. Alabama and Texas strictly prohibit any harvest of terrapins from their waters (FWC 2016).

Bycatch of terrapins in blue crab pots remains a source of mortality, however. Virginia, North and South Carolina, Georgia, Florida, and the GOM do not have any mandatory BRD requirements in place to reduce terrapin bycatch (NCDMF 2013). Though mandatory BRD requirements do not exist, some of these states have closure areas (as a mitigation measure) that protect terrapin habitat by preventing commercial crabbing and/or prohibiting all pots.

### 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

NEW JERSEY / DELAWARE BAY, POTS, UNITED STATES OF AMERICA  
DELAWARE / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA  
MARYLAND / CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
VIRGINIA / CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
NORTH CAROLINA / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA  
SOUTH CAROLINA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
GEORGIA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
FLORIDA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
FLORIDA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
LOUISIANA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
ALABAMA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
MISSISSIPPI / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
TEXAS / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA

#### < 100%

The overall ratio of bait + discards/landings in the blue crab fisheries is less than 100% (see table). Pots are designed to trap crabs, but occasionally turtles, sublegal blue crabs, and finfish enter pots. Most states that have an active blue crab fishery require cull rings, which allow most sublegal blue crabs to escape (VCCRM 2008). The amount of terrapin bycatch is unknown, but is thought to be a small portion of the blue crab landing weight. However, given that terrapins are highly vulnerable, the impact can be notable. Ghost pots contribute most significantly to unintended mortality from the blue crab fishery, but total mortality due to derelict gear is low (Bilkovic et al. 2012). A two-year survey of derelict fishing gear in Chesapeake Bay found that blue crabs comprised just under 80% of the catch, while oyster toadfish, whelk, black seabass and Atlantic croaker made up approximately 20% of the catch (ibid).

Gulf and Atlantic menhaden (*Brevoortia patronus* and *B. tyrannus*, respectively) and striped mullet (*Mugil cephalus*) are the main species used for bait in the GOM blue crab fishery (Perry and VanderKooy 2015), where approximately 0.6 lb of bait are used per pot, for a total of 19 million lb annually (SCS 2012). Forty to 55% of blue crab catch by weight is caught using either Atlantic or Gulf menhaden (ibid). The traditional bait for most crab fishermen in the Gulf was Atlantic menhaden; however, this bait supply has diminished over the last decade as Atlantic menhaden populations have been afforded more protection (Anderson 2014). In addition, the Gulf menhaden bait industry in the Gulf declined (C. Blankenship, personal communication 2017). To address the needs of the crab fishery, efforts are underway to rebuild a Gulf bait industry in Louisiana and Florida (Schueller 2016).

Although Atlantic menhaden were in decline, the latest assessment indicated an increase in population biomass and spawning stock biomass (compared to the 2013 assessment); hence, the stock is neither

overfished nor undergoing overfishing (Schueller 2016). The ratio of bait use to catch is considered similar to the impact of discarded bycatch. Thus, overall discards and bait use is ranked as 40% to 60%, or <100%.

**Table 1:** 2014 Landings in blue crab pot gear (percentage by weight) (NMFS 2016a).

Species landed in blue crab pots	Percentage of landings by weight (lb)
Blue crab	99.22%
Black drum	0.01%
American eel	0.01%
Southern flounder	0.01%
Striped mullet	0.01%
Shellfish (general)	0.02%
Sheepshead	0.01%
Snails (conch)	0.02%
Toadfish	0.01%
Channeled whelk	0.01%

## **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.

### **Criterion 3 Summary**

<b>Fishery</b>	<b>Management Strategy</b>	<b>Bycatch Strategy</b>	<b>Research and Monitoring</b>	<b>Enforcement</b>	<b>Stakeholder Inclusion</b>	<b>Score</b>
Fishery 1: Maryland / Chesapeake Bay   Pots   United States of America	Highly Effective	Moderately Effective	Moderately Effective	Highly Effective	Highly Effective	Green (4.000)
Fishery 2: Maryland / Chesapeake Bay   Trotline   United States of America	Highly Effective	Highly Effective	Moderately Effective	Highly Effective	Highly Effective	Green (4.000)
Fishery 3: Virginia / Chesapeake Bay   Pots   United States of America	Highly Effective	Ineffective				Red (1.000)
Fishery 4: New Jersey / Delaware Bay   Pots   United States of America	Highly Effective	Moderately Effective	Moderately Effective	Highly Effective	Highly Effective	Green (4.000)

Fishery 5: Alabama / Gulf of Mexico   Pots   United States of America	Moderately Effective	Moderately Effective	Moderately Effective	Highly Effective	Highly Effective	Yellow (3.000)
Fishery 6: Florida / Gulf of Mexico   Pots   United States of America	Moderately Effective	Ineffective				Red (1.000)
Fishery 7: Louisiana / Gulf of Mexico   Pots   United States of America	Highly Effective	Ineffective	NA	NA	NA	Red (1.000)
Fishery 8: Mississippi / Gulf of Mexico   Pots   United States of America	Moderately Effective	Ineffective				Red (1.000)
Fishery 9: Texas / Gulf of Mexico   Pots   United States of America	Moderately Effective	Ineffective				Red (1.000)
Fishery 10: Delaware / Northwest Atlantic   Pots   United States of America	Highly Effective	Moderately Effective	Moderately Effective	Highly Effective	Highly Effective	Green (4.000)
Fishery 11: North Carolina / Northwest Atlantic   Pots   United States of America	Highly Effective	Ineffective				Red (1.000)
Fishery 12: Florida / Western Central Atlantic   Pots   United States of America	Moderately Effective	Ineffective	NA			Red (1.000)
Fishery 13: Georgia / Western Central Atlantic   Pots   United States of America	Moderately Effective	Ineffective				Red (1.000)
Fishery 14: South Carolina / Western Central Atlantic   Pots   United States of America	Moderately Effective	Ineffective				Red (1.000)

### Criterion 3 Assessment

#### Factor 3.1 - Management Strategy and Implementation

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

MARYLAND / CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
MARYLAND / CHESAPEAKE BAY, TROTLINE, UNITED STATES OF AMERICA  
VIRGINIA / CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
NEW JERSEY / DELAWARE BAY, POTS, UNITED STATES OF AMERICA  
DELAWARE / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA

### **Highly Effective**

The original Chesapeake Bay FMP was adopted in 1989 and recognized the importance of the blue crab resource, identified areas of concern, and recommended strategies to stabilize fishing effort (CBP 1989). The 1997 revision has the same overall goal of managing blue crabs to conserve the baywide stock, protect its ecological value, and optimize long-term use of the resource (CBP 1997). Management is aimed at reducing exploitation fractions and focuses on conserving female crabs. From previous management recommendations, female-specific exploitation rate and female-specific abundance reference points were established and followed, resulting in a favorable response by the population (CBSAC 2015). The FMP process has been iterative to recommend management options, test them, and update management, as a result.

A baywide stock assessment committee was established to evaluate fisheries and identify data needed for stock assessment models in Chesapeake Bay. Recommendations suggest improvements in collecting catch, effort, and biological data from landings, and surveys for estimating abundances. Biomass and exploitation thresholds, and exploitation target reference points, were established in 2001 (NOAA 2010). Nearly-annual stock assessments, based on both fishery-dependent and -independent data are conducted, (most recently in 2015), and the status of the stock is determined relative to those reference points (CBSAC 2015). Managers have been responsive to the assessment results and implemented management measures as appropriate, to preserve the stock status (B. Goldsborough, personal communication 2016). Bushel limits set by scientific assessments are routinely followed by fishers in each state (B. Davis, personal communication 2012). Bycatch management programs have been in place for over 10 years in some states and have proven effective at reducing bycatch of undersized blue crabs during this time. Bycatch of undersized blue crabs is minimized by the use of excluder rings in crab pots throughout the region (CBSAC 2015). Due, in part, to management efforts, blue crab stocks in Chesapeake Bay have increased since their very low abundance in the 1990s; therefore, management strategy and implementation is deemed "highly effective."

ALABAMA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
FLORIDA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
MISSISSIPPI / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
TEXAS / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA

### **Moderately Effective**

The 2001 FMP for the GOM provided basic management considerations and recommendations, as well as research needs for management of blue crabs in the GOM (Guillory et al. 2001). A new stock assessment was conducted in 2013, and the FMP was updated in 2015, which addressed research needs more so than management recommendations. The 2013 stock assessment defined reference points and found that blue crab stocks in the Western and Eastern GOM are not overfished or experiencing overfishing (GDAR 2013). Although each state is ultimately responsible for implementing its own regulations, and accountability is at the state level, the FMP recommended a regional approach to management to be implemented in coming years (Perry and VanderKooy 2015). Fishery-independent monitoring is conducted in every Gulf state, and data from each state program are included in the GSMFC stock assessment (ibid). Additionally, and for the past few years, Mississippi (in partnership with the Gulf Coast Research Lab) and Alabama (ADCNR Marine Resources Division) have been placing biologists on commercial vessels to conduct observations/collect data (since 2007 in MI and 2015 in AL).

Bycatch of undersized blue crabs has been minimized by the requirement to have circular escape rings in crab pots in Florida, Louisiana, Mississippi, and Texas (ibid). The Blue Crab Task Force associated with the assessment found that the current management measures are adequate to maintain the current level of abundance; however, there is a lack of accountability to any of the states if the stock were to decrease below an acceptable level (ibid). Most states do not have individual stock assessments, other than Louisiana, which was required to complete an assessment in order to obtain Marine Stewardship Council certification (West et al. 2011). Since the 2011 Louisiana stock assessment, Louisiana has established control rules that ensure management actions are put into place if the stock appears to be overfished, and if overfishing is occurring (LDWF 2016).

Management of the blue crab fishery by the GSMFC and the individual Gulf state marine agencies has led to maintenance of the stock thus far; however, there is a clear need for defined accountability measures (in addition to Louisiana's), as well as increased precaution. Therefore, management strategy and implementation for the GOM is deemed "moderately effective."

### **Justification:**

#### **Texas**

Texas implemented a Blue Crab FMP in 1992 (Cody et al. 1992), as referenced in the 2007 Texas blue crab stock assessment (Sutton and Wagner 2007). The recommendations in the FMP served as the basis for regulations developed in subsequent years to ensure the sustainability of the blue crab fishery. Those regulations are as follows:

- 1993: implementation of escape vent requirements in crab pots to reduce bycatch of sublegal crabs and other species; regulation limiting crab harvesting activity to daylight hours
- 1994: further reduction of pot numbers to 200 maximum per fisher
- 1997: Crab License Management Program (implemented in 1998)
- 1998: degradable panel requirement to reduce ghost fishing by lost or abandoned pots
- 2002: implementation of the Abandoned Crab Trap Removal Program

The Crab License Management Program was instituted in 1998. Its purpose was to "stabilize fishing effort and support a healthy fisheries stock" and "to conserve commercially important crab resources" (TPWD 2018). This program included a license buyback system, which resulted in a 28% reduction in licenses between 1998 and 2005 (GDAR 2013).

The 2007 Texas blue crab stock assessment was designed to provide "recommendations of future management measures and research needs to promote sustainable long-term yields of blue crabs in Texas" including determination of both maximum sustainable yield (MSY) and  $E_{MSY}$  (optimal effort level) (Sutton and Wagner 2007). Based on this assessment, it was determined that another 15% reduction in effort was necessary for the long-term sustainability of the blue crab population. Continuation of the Blue Crab License Buyback Program to reduce effort resulted in another 14% effort reduction between 2005 and 2011 (GDAR 2013).

## **LOUISIANA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA**

### **Highly Effective**

Louisiana (LA) has an FMP, with clear fishery objectives, management measures, a harvest control rule, and actions implemented in response to that rule (LDWF 2017b). In addition, as of 15 November 2014, to obtain a commercial crab pot gear license, a fisher must either possess a valid commercial crab pot license during any two license years between 2011 and 2014, or enroll in, and complete a professionalism program established

by the Commission. Among other elements, the program includes education on the proper placement of, tending to, and maintenance of crab pots, regulatory requirements, and best practices for handling and quality.

Reference points are estimated and are appropriate for the stock. Measures initiated prior to the 2016 stock assessment (where LA blue crabs were considered overfished) are part of the rebuilding strategy: 1) to reduce the number of active fishers (fishing effort) via the professionalization program (above); and 2) an increase in the number of escape rings in the traps and their size (applicable from November 2017) (Scott and Tremblay 2018). The harvest strategy (HS) consists of a number of elements: 1) a HCR with LRPs and TRPs; 2) a suite of measures that control various aspects of the fishery, including regulations on minimum size, the protection of females, discards; 3) gear type and characteristics; 4) seasonal closures; 5) periodic stock assessments using fishery independent surveys to obtain estimates of juvenile and adult crab abundance to feed into the Collie-Sissenwine model; 6) fishery monitoring (e.g., trip tickets); 7) effective off-shore and on-shore enforcement activities; 8) the removal of derelict traps; 9) direct stakeholder involvement in the decision making process through the blue crab task force (BCTF) (see PI 3.2.2); and 10) collaboration in habitat protection projects that support the recruitment process for blue crabs (ibid). A comprehensive range of information (on stock structure, stock productivity, fleet composition, stock abundance, fishery removals and other information such as environmental information), including some that may not directly relate to the current harvest strategy, is available (ibid). Fishery-independent and -dependent monitoring is in place.

LDWF is also working with the blue crab industry to provide management options that will both reduce annual landings and minimize negative impact on the industry (ibid). As such, there has been a change to Louisiana blue crab commercial harvest regulations for 2019. The 30-day full closure and the 60-day restriction on commercial harvest of female blue crab (LDWF 2018a) have been lifted and replaced by a thirty-five day closure period from 9 September to 13 October 2019 (LDWF 2018e). In addition, LWFC has authorized crab trap closures in 2019 for the removal of derelict crab traps (ibid). Five defined areas were designated for closure with up to 14 days for any one area (LDWF 2018f).

The blue crab fishery in LA has a highly appropriate strategy and goals, and there is evidence that the strategy is being implemented successfully; therefore, management strategy for LA is ranked as "highly effective."

## NORTH CAROLINA / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA

### **Highly Effective**

The North Carolina FMP was adopted in 1998, with amendments and revisions made in 2004, 2013, and 2016 (NCMFC 2016a). The stated FMP objectives include: 1) maintaining the stock at a level that maximizes reproductive potential; 2) promoting harvesting practices that minimize waste; 3) protecting and restoring the habitat; 4) distinguishing between conservation goals and allocation issues; 5) providing resource utilization for all users; 6) minimizing conflict; 7) identifying and promoting biological, social, and economic research; 8) maintaining the blue crab fisheries as a major source of income for commercial fishermen; and 9) promoting education (NCDMF 2004).

In 2013, Amendment 2 to the North Carolina FMP set up a Traffic Light Assessment System, which assesses the status of the stock on an annual basis. Under this system, if certain biological triggers are met, protective management measures must be implemented. If adult abundance or production is at or above the 50% red threshold level for three consecutive years, then moderate management actions are triggered. If either is at or above 75% of the red threshold level for two of those years, then the more restrictive elevated management actions are triggered. The moderate and elevated management actions were implemented as part of Amendment 2 to the FMP (NCDMF 2016a). Examples of potential moderate and corresponding elevated management actions include the following:

<b>Moderate management actions:</b>	<b>Elevated management actions:</b>
Increase in minimum size limit	Closure of the fishery (season and/or gear)
Reduction in tolerance of sub-legal size blue crabs (to a minimum of 5%)	Reduction in tolerance of sub-legal size blue crabs (to a minimum of 1%)
Closure of the crab spawning sanctuaries from 1 September to 28 February	Closure of the fishery year-round
Restriction of trip-level sponge crab harvest	Prohibition of sponge crab harvest and/or requirement of sponge crab excluders in pots for specific areas
Establishment of a seasonal size limit on peeler crabs	Reduction of peeler harvest (no white line peelers and/or peeler size limit)

The adult abundance trigger was met in 2015, and the moderate management measures were put into place (ibid). Additionally, recruit abundance, which can augment management once a trigger is achieved, had moderate and elevated management measures put into place (ibid). These new management measures are expected to be effective at increasing abundance, since they directly target the cause of the stock decline.

Furthermore, North Carolina has closures to the fishery for season, area, and gear. Five locations are designated as crab spawning sanctuaries, which are closed from 1 March through 31 August (NCDMF 2013). These areas were created to protect mature female crabs prior to and during sponge stage. Additionally, lower Broad Creek is closed to crab pots from 1 June through 30 November (ibid). This area closure is to reduce conflict between crab pot fishermen and shrimp trawlers. Finally, North Carolina has an annual pot cleanup period, which is a statewide closure between 15 January and 7 February. This closure was enacted to allow for removal of lost, derelict, or abandoned pots.

The North Carolina blue crab fishery has a highly appropriate strategy and goals and there is evidence that the strategy is being implemented successfully; therefore, management strategy for North Carolina is ranked as "highly effective."

FLORIDA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
 GEORGIA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
 SOUTH CAROLINA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA

**Moderately Effective**

**Georgia**

Georgia has had limited entry in the blue crab fishery since 1998, which was capped at 159 licenses, with a maximum of 200 pots each (GADNR 2008b). The number of licenses has been reduced by attrition and voluntary relinquishment to 122, and recent legislation will reduce it to 100 commercial licenses (P. Geer, personal communication 2016). In addition, a sponge crab moratorium has been in place since 2002 (GADNR 2008a). Abundance levels are updated annually and are presented to the Georgia DNR Board and the Blue Crab Advisory Panel, which is a network of commercial and recreational crabbers, dealers, and academics (see the FMP for more details: <http://coastalgadnr.org/sites/uploads/crd/pdf/FMPs/BlueCrabFMP.pdf>).

**South Carolina**

In South Carolina, there are no mandatory management measures other than size limits, prohibitions on berried crabs, and crab seasons (SCDNR 2018a). In addition, there are currently no accountability measures in place for when the stock shows signs of decline (A. Fowler, personal communication 2016).

### **Florida**

The Florida blue crab fishery is a limited entry fishery managed under a Blue Crab Effort Management Plan (BCEMP) and pot limits are in place for each endorsement type (F.A.C. 68B–45.007). The crab license moratorium, and subsequent BCEMP have reduced endorsements down from over 6,000 endorsements in 1995, to 950 endorsements as of 2011 (GDAR 2013).

Gear requirements include escape rings and degradable panels (F.A.C. 68B–45). Florida also conducts its own stock assessments for both the Atlantic and Gulf (2001, 2007, and 2013). Nevertheless, there are currently no accountability measures in place for when the stock shows signs of decline (A. Fowler, personal communication 2016).

Due to the above, management strategy and implementation for these Atlantic states is ranked as "moderately effective."

## **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.*

MARYLAND / CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
NEW JERSEY / DELAWARE BAY, POTS, UNITED STATES OF AMERICA  
DELAWARE / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA

### **Moderately Effective**

Bycatch of blue crabs, finfish, and invertebrates is managed in MD, NJ, and DE using BRDs, pot spatial restrictions, and/or derelict pot removal programs. Some pots from the commercial fishery and the majority of pots from the recreational fishery pose a serious threat to terrapins because the pots are set in shallow-water habitats (shallow embayments and tidal marsh creeks) where terrapins are more common (Grubbs et al. 2018). Additionally, in the recreational fishery, pots are checked less frequently (Hoyle and Gibbons 2000). The placement of pots in these locations, and the resulting bycatch mortality of diamondback terrapins have been shown to affect terrapin population size and demographics (Roosenburg et al. 1997) (Wood 1997) (Grosse et al. 2009) (Wolak et al. 2010), as well as pose a threat to their conservation (Roosenburg 2004).

Because the regulations in MD, NJ, and DE focus on limiting terrapin bycatch in these shallow waters where interactions are of greatest concern, either by prohibiting fishing in those areas entirely or by requiring BRDs when fishing in those areas, the regulations are expected to be "moderately effective" at reducing terrapin bycatch.

### **New Jersey (NJ)**

New Jersey requires BRDs (measuring 5.1 × 15.3 cm) in commercial crab pots that are in tributaries less than 150 ft wide, or within 23 m of shore, to help reduce terrapin bycatch (Grubbs et al. 2018).

## **Delaware (DE)**

In Delaware, all recreational crab pots, regardless of where they are set, must be equipped with a BRD (usually measuring 4.5 × 12.1 cm), as described in 7 DE Admin Code 3721. Commercial crabbing in the Delaware River and Bay is not authorized in any of the tidal creeks (7 Del. C. §2304; see "Justification" section for more detail; *ibid*). There is one short tidal creek that drains into a coastal bay shared with Maryland where commercial crabbing is authorized—Roy Creek—however, there is no commercial blue crab fishery operating there at present (S. Michels, personal communication 2018).

## **Maryland (MD)**

Maryland has very strict spatial restrictions on crab pots (see (COMAR 2018) for details), which help minimize terrapin bycatch. Since these restrictions are very specific, the general "rule of thumb" is that crab pots cannot be set in most rivers/tributaries, but can be set in the main stem (in water > 4 ft deep) of the Chesapeake Bay. Due to the habitat preferences of many turtles, only having pots set in the main stem of Chesapeake Bay should reduce turtle encounters with this gear (G. McClair, personal communication 2018). BRDs (usually measuring 4.5 × 12.1 cm) are only required in the recreational crab pot fishery, where private landowners in Maryland are allowed to set up to two crab pots from their private dock or property (Grubbs et al. 2018) (MFG 2018). There have been long-term studies on public compliance with BRD use in the recreational pot fishery, and compliance was 50% in the 2016 sample (S. Smith via G. McClair, personal communication, 23 July 2018). In addition, as per Maryland Department of Natural Resources population monitoring, it appears that, in areas with good habitat, terrapin populations are rebounding since the commercial harvest of terrapins was banned in 2017; in areas where shoreline hardening has occurred extensively, terrapins are not doing well (especially the western shore; *ibid*).

## **Summary**

Ghost fishing is a real concern for all bycatch species, and particularly for diamondback terrapins (because they are air-breathers). In 2005, the NOAA Chesapeake Bay Office established the Derelict Fishing Gear Program (DFGP) to research the effects of derelict crab pots and implement a pot removal program (Giordano et al. 2011).

Although the exact impact of blue crab fisheries on terrapin populations is unknown, the strict spatial restrictions of crab pots in Delaware and Maryland, the use of BRDs in the commercial pot fishery in New Jersey, and in the recreational pot fisheries in Delaware and Maryland are likely reducing the number of terrapins that are caught in blue crab pots. Although the effectiveness of the strict spatial restrictions and the BRDs is uncertain, overall concern about terrapin bycatch in those states is lower than it was in the past (B. Goldsborough and R. Wong, personal communication 2016).

## **Justification:**

### **Delaware:**

3721 Non-commercial Crab Pot Design; Bycatch Reduction Device (Penalty Section 7 Del.C. §1912) 1.0: It shall be unlawful for the owner of any non-commercial crab pot to place said crab pot in the tidal waters of this State unless said crab pot has a by-catch reduction device securely attached in each entrance such that each crab entering said crab pot must pass through the bycatch reduction device. A bycatch reduction device shall mean a metal or plastic rigid rectangle that measures on the inside no more than 1.75 inches by 4.75 inches in width. A bycatch reduction device made of metal wire shall be no less than 11-gauge rigid wire.

§ 2304 Area permitted for commercial crabbing.

It shall be unlawful for any commercial crabber to catch or take, or attempt to catch or take, for commercial purposes any hard-shell, soft-shell or peeler crabs from any waters of the rivers and bays of this State and the tributaries thereof or sell, offer for sale or buy any hard-shell crabs taken from said waters, except the Delaware Bay and the Delaware River and that area of Roy's Creek which lies south of Fenwick Island Ditch (7 Del. C. 1953, §§ 2303, 2304; 51 Del. Laws, c. 151, § 1; 57 Del. Laws, c. 587, §§ 1, 2; 60 Del. Laws, c. 513, § 2; 61 Del. Laws, c. 352, § 1).

#### MARYLAND / CHESAPEAKE BAY, TROTLINE, UNITED STATES OF AMERICA

##### **Highly Effective**

Trotlines are not known to catch any bycatch other than undersized crabs (Seachoice 2016), which can be returned alive and in good condition. Therefore, bycatch strategy is ranked as "highly effective."

#### VIRGINIA / CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA

##### **Ineffective**

Virginia recently implemented BRD regulations for the recreational fishery, where fishers can purchase a license for \$36 if they use terrapin excluder devices in their pots, or for \$46 if their pots do not have excluders (VMRC 2016c). There are many locations where pots with BRDs are being sold throughout the state, but it is unknown yet how many will end up being used (R. O'Reilly, personal communication 2016). There are currently no BRD regulations in the commercial fishery, although some fishers use them voluntarily (VCCRM 2017). Even though the commercial fishery tends to operate in deeper waters most of the year, where there are lower numbers of terrapins (R. O'Reilly, personal communication 2016), there are no enforceable management measures controlling terrapin bycatch. Ghost fishing is also a problem in Virginia, where crab pot losses were estimated to be 30% in the lower York River (Voss et al. 2015). Because of the sheer number of ghost pots found in the Chesapeake Bay, VIMS scientists are investigating the properties of PHA, plastics that are made and eaten by bacteria, for use in crab pots, as a way to disarm ghost traps (William and Mary 2015). However, due to the lack of management measures on terrapin bycatch in Virginia, bycatch management is ranked as "ineffective."

#### ALABAMA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA

##### **Moderately Effective**

Bycatch in crab pots is reduced by the use of escape rings (cull rings) and escape panels in crab pots; hence, the concern over bycatch, aside from diamondback terrapins, is minimal (GSMFC 1999). However, there are currently no regulations for the use of BRDs in the GOM, even though bycatch of diamondback terrapins is known to be minimized by their use (e.g., the use of BRDs in an Alabama salt marsh led to a 90% reduction in terrapin bycatch (Coleman et al. 2011)).

All of the Gulf States have closure areas, such as Wildlife Management Areas or Refuges, along the coast that prohibit commercial fishing and/or use of crab traps in marshes and shallow water areas. These areas are designed to protect wetlands, marshes, and estuarine areas, and in many cases overlap with potential or known terrapin habitats providing protection to terrapin populations (Audubon Institute, personal communication 2017).

Ghost fishing is a real concern for diamondback terrapins, as is bycatch in active fishing pots. In the GOM, the loss of crab pots is greater than 25% (Voss et al. 2015), and it has been estimated that 12 million harvestable

blue crabs could be lost to ghost fishing every year, which was 10% of the annual landings in Louisiana in 2012 (Anderson and Alford 2014).

## **Alabama**

ADCNR created an area closure (Heron Bay closure west of Highway 193) in 2012 based on the above study on causes for terrapin decline, which indicated that Cedar Point Marsh is a primary nesting area for diamondback terrapins. The area closure prevents the use of pots within the marsh area to reduce interactions between terrapins and crab pots ((ADCNR 2012) code r. 220-3.31 Crabs, #10). Additionally, Alabama prohibits crab pots north of I-10 or Hwy 90 (whichever is southernmost) protecting the upper Mobile delta area, and in several rivers, creeks, bayous, bays, canals, or their tributaries, as listed in the Alabama Blue Crab Laws and Regulations (ADCNR 2013).

Pot removal programs are reported to have been highly successful in Alabama and Mississippi, and they also now operate removal programs on an as-needed basis, between coordinated cleanups (Perry and Vanderkoooy 2015). From 2002 to 2007, the Derelict Crab Trap Retrieval Program successfully removed over 2,400 pots from Alabama waters (GSMFC 2008). Alabama has also recently received a grant from the NOAA Marine Debris Program to conduct crab pot cleanups for the next three years; the first event was held in 2017 (NOAA 2017). In addition to these measures, Alabama has observers on boats monitoring incidence of high terrapin catch in blue crab pots (LDWF 2014).

Because Alabama has closures to prevent crabbing in the upper Mobile delta area, and also identified a high-risk area for terrapins and subsequently closed this area, bycatch strategy for this state is scored as "moderately effective."

### **Justification:**

The GSMFC held a symposium at their Annual Meeting on the topic of terrapins and their interactions with the blue crab fishery (S. Vanderkoooy, personal communication 2018). Members of the blue crab management community and the terrapin research world came together to share information and discuss working together on these issues in the region. In addition, the MS Department of Marine Resources has developed and implemented a reporting application for commercial trap fishermen to help the GSMFC better identify "hot spots" in state waters where terrapin habitat and blue crab fishing overlap; this will target outreach and potentially reduce bycatch of terrapins (S. Vanderkoooy, personal communication 2018).

## **FLORIDA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA**

### **Ineffective**

Bycatch in crab pots is reduced by the use of escape rings (cull rings) and escape panels in crab pots; hence, the concern over bycatch, aside from diamondback terrapins, is minimal (GSMFC 1999). However, there are currently no regulations for the use of BRDs in the GOM, even though bycatch of diamondback terrapins is known to be minimized by their use (e.g., the use of BRDs in an Alabama salt marsh led to a 90% reduction in terrapin bycatch (Coleman et al. 2011)).

All of the Gulf States have closure areas, such as Wildlife Management Areas or Refuges, along the coast that prohibit commercial fishing and/or use of crab traps in marshes and shallow water areas. These areas are designed to protect wetlands, marshes, and estuarine areas, and in many cases overlap with potential or known terrapin habitats providing protection to terrapin populations (Audubon Nature Institute, personal communication, 2017).

Ghost fishing is a real concern for diamondback terrapins, as is bycatch in active fishing pots. In the GOM, the

loss of crab pots is greater than 25% (Voss et al. 2015), and it has been estimated that 12 million harvestable blue crabs could be lost to ghost fishing every year, which was 10% of the annual landings in Louisiana in 2012 (Anderson and Alford 2014).

## **Florida**

In Florida, a terrapin hot spot mapping project is being used to determine the next step forward in implementing localized terrapin conservation projects (S. VanderKooy, personal communication 2016).

In addition to using biodegradable materials, Florida has two types of pot removal programs: a volunteer program, as well as an FWC coordinated cleanup where fishermen are contracted to remove pots during closure periods (FWC 2017). Florida has dedicated zones that close annually for cleanup activities (three zones in even years, three zones in odd years) covering the entire coastline (ibid). Commercial pots are required to have FWC-issued pot tags and, as part of the FWC Spiny Lobster, Stone Crab and Blue Crab Trap Retrieval Program, fishermen are also charged \$10/pot for their pots if they are retrieved as derelict pots during the closure period (ibid).

Florida prohibits crabbing in the Everglades National Park, Arthur R. Marshall Loxahatchee, J.N. Ding Darling, and Hobe Sound NWR (NPS 2012) (USFWS 2017a) (USFWS 2017b) (USFWS 2018).

Overall, the Gulf States are making headway in reducing the number of diamondback terrapins that are incidentally caught in blue crab pots through closures, derelict pot removal programs, and the use of biodegradable materials in pots. However, there are no mandatory regulations to minimize bycatch, such as the use of BRDs. Because there are no mandatory regulations to minimize terrapin bycatch in Florida, and closed areas likely account for only a small portion of terrapin habitat, bycatch strategy for this state is ranked as "ineffective."

### **Justification:**

The GSMFC held a symposium at their Annual Meeting on the topic of terrapins and their interactions with the blue crab fishery (S. Vanderkooy, personal communication 2018). Members of the blue crab management community and the terrapin research world came together to share information and discuss working together on these issues in the region. In addition, the MS Department of Marine Resources has developed and implemented a reporting application for commercial trap fishermen to help the GSMFC better identify "hot spots" in state waters where terrapin habitat and blue crab fishing overlap; this will target outreach and potentially reduce bycatch of terrapins (S. Vanderkooy, personal communication 2018).

## **LOUISIANA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA**

### **Ineffective**

Bycatch in crab pots is reduced by the use of escape rings (cull rings) and escape panels in crab pots; hence, the concern over bycatch, aside from diamondback terrapins, is minimal (GSMFC 1999). However, there are currently no regulations for the use of BRDs in the GOM, even though bycatch of diamondback terrapins is known to be minimized by their use (e.g., the use of BRDs in an Alabama salt marsh led to a 90% reduction in terrapin bycatch (Coleman et al. 2011)).

All of the Gulf States have closure areas, such as Wildlife Management Areas or Refuges, along the coast that prohibit commercial fishing and/or use of crab pots in marshes and shallow water areas. These areas are designed to protect wetlands, marshes, and estuarine areas, and in many cases overlap with potential or

known terrapin habitats, providing protection to terrapin populations. Roughly 8% of LA state waters, including freshwater, are closed to crabbing (see "Justification" section below for details; Audubon Nature Institute, personal communication 2017). Of the 13 locations with terrapin populations identified by (Selman et al. 2014), 7 of those sites already prohibit crab traps completely (Rockefeller Wildlife Refuge and Marsh Island Wildlife Refuge) and one site already prohibits commercial crabbing (Sabine NWR).

Ghost fishing is a real concern for diamondback terrapins, as is bycatch in active fishing pots. In the GOM, the loss of crab pots is greater than 25% (Voss et al. 2015), and it has been estimated that 12 million harvestable blue crabs could be lost to ghost fishing every year, which was 10% of the annual landings in Louisiana in 2012 (Anderson and Alford 2014).

## **Louisiana**

In 2004, the Louisiana (LA) Department of Wildlife and Fisheries (LDWF) implemented a voluntary derelict pot removal program during a 10-day fishing closure each year (LDWF 2014). Since the program's inception, volunteers have assisted in removing over 37,000 pots (LDWF 2018). In 2017, a 30-day statewide closure period allowed LA to expand derelict pot cleanup efforts, which will continue through 2019 (KNOE 8 News 2017). Louisiana is also conducting identification and removal of submerged derelict pots using side scan sonar, through a grant awarded by the NOAA Marine Debris Program (see page 22 of (Scott and Addison 2016)). Finally, LA conducted a multi-year survey of terrapin nest locations and depredation rates (LDWF 2014) (Pearson and Wiebe 2018a).

There is limited area of potential interaction between the fishery and terrapins, and LDWF biologists are researching their distribution and abundance throughout coastal LA. This study includes: 1) trapping adult and sub-adult terrapin in small bayous and appropriate shoreline habitats (Pearson and Wiebe 2018b); and 2) surveying and monitoring terrapin nesting efforts (including reproductive productivity) along coastal beaches (Scott and Tremblay 2018) (Pearson and Wiebe 2018a). Terrapins cannot be legally taken by any pots and cannot be taken between 15 April and 15 June; there is an ongoing bycatch study to identify the risk to terrapins from the blue crab pot fishery; and there is a closed season that will reduce the potential to catch terrapins in active traps, while the removal of derelict traps during the closure will also reduce the risk of bycatch (ibid).

Overall, the Gulf States are making headway in reducing the number of diamondback terrapins that are incidentally caught in blue crab pots through closures, derelict pot removal programs, and the use of biodegradable materials in pots. A study is underway to evaluate the impact of the blue crab fishery on terrapins in LA, but the results are not yet known, and it is also unclear as to whether there will be any mandatory mitigation measures implemented following publication of the report. Because bycatch management measures are insufficient given the potential impacts of the fishery, bycatch strategy for this state is ranked as "ineffective."

## **Justification:**

The GSMFC held a symposium at their Annual Meeting on the topic of terrapins and their interactions with the blue crab fishery (S. Vanderkooy, personal communication 2018). Members of the blue crab management community and the terrapin research world came together to share information and discuss working together on these issues in the region. In addition, the MS Department of Marine Resources has developed and implemented a reporting application for commercial trap fishers to help the GSMFC better identify "hot spots" in state waters where terrapin habitat and blue crab fishing overlap; this will target outreach and potentially reduce bycatch of terrapins (S. Vanderkooy, personal communication 2018).

The following areas all prohibit commercial crabbing (only recreational allowed and must be attended at all times) and refuges (in bold) are areas that completely prohibit crab pots (Audubon Institute, personal

communication 2017): 1) Bayou Sauvage National Wildlife Refuge (23,000 acres) (USFWS 2018b); 2) Big Branch Marsh NWR (15,000 acres) (USFWS 2018c); 3) Breton National Wildlife Refuge (6,100 acres) (USFWS 2006); 4) Delta National Wildlife Refuge (48,800 acres) (USFWS 2018d); 5) Elmer's Island Wildlife Refuge (1,145 acres) (LDWF 2018c), 6) **Marsh Island Wildlife Refuge (76,664 acres)—pots prohibited** (ibid), 7) **Rockefeller Wildlife Refuge (76,042 acres)—pots prohibited** (ibid); 8) Salvador Wildlife Management Area (34,520 acres) (LDWF 2018d); 9) Southeast Louisiana NWR Complex (4 refuges: Carmon Prairie, Lacassaine, Sabine and Shell Keys) (total of 185,338 acres) (ibid); 10) **State Wildlife Refuge (13,000 acres)—pots prohibited** (LDWF 2018c). These closures were enacted to protect salt marsh resources, which include terrapin habitat (J. Lively, personal communication, 6 Sept. 2018).

## MISSISSIPPI / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA

### Ineffective

Bycatch in crab pots is reduced by the use of escape rings (cull rings) and escape panels in crab pots; hence, the concern over bycatch, aside from diamondback terrapins, is minimal (GSMFC 1999). However, there are currently no regulations for the use of BRDs in the GOM, even though bycatch of diamondback terrapins is known to be minimized by their use (e.g., the use of BRDs in an Alabama salt marsh led to a 90% reduction in terrapin bycatch (Coleman et al. 2011)).

All of the Gulf States have closure areas, such as Wildlife Management Areas or Refuges, along the coast that prohibit commercial fishing and/or use of crab traps in marshes and shallow water areas. These areas are designed to protect wetlands, marshes, and estuarine areas, and in many cases overlap with potential or known terrapin habitats providing protection to terrapin populations (Audubon Nature Institute, personal communication 2017).

Ghost fishing is a real concern for diamondback terrapins, as is bycatch in active fishing pots. In the GOM, the loss of crab pots is greater than 25% (Voss et al. 2015), and it has been estimated that 12 million harvestable blue crabs could be lost to ghost fishing every year, which was 10% of the annual landings in Louisiana in 2012 (Anderson and Alford 2014).

### Mississippi

The Mississippi Crab Trap Bycatch Reduction Device/TED Program has distributed over 20,000 BRDs to both commercial and recreational blue crab fishers, although the use of such BRDs is voluntary, and the rate of actual use is unknown (R. Burriss, personal communication 2018). In Mississippi, the Nature Conservancy and the National Park Service are working together to document ghost pot locations and areas where terrapins are commonly caught in commercial blue crab pots (Guillory et al. 2001). Work is also being done with commercial crab fishermen to pilot a Diamondback Terrapin Reporting System, which has been providing useful geospatially referenced data on terrapin locations in state waters (R. Burriss, personal communication 2018).

Mississippi Department of Marine Resources (MDMR) initially collaborated with the Gulf Coast Research Lab (GCRL) in 1999 on pot removals, and then added volunteer-based retrieval programs in 2003 and 2004 (GSMFC 2008). In 2007, commercial crab fishers were hired, utilizing Katrina recovery funds, to conduct cleanups during a week-long closure (ibid). Commercial fishers were hired again in 2016, utilizing disaster relief funds from the Bonne Carre Spillway opening, to conduct pot removals during a 10-day closure (MDMR 2016a). Since 1999, the MS Derelict Crab Trap Removal Program has removed 21,546 derelict pots from Mississippi waters (MDMR 2016b), although it is unknown how many pots are lost annually. Fishers have also started to incorporate the use of biodegradable materials in pots, such as untreated steel wire, jute, and sisal twine that will decompose within 28 to 77 days (Bilkovich et al. 2012). These panels are currently mandated by law in Florida and Texas (Perry and VanderKooy 2015).

Mississippi prohibits commercial crabbing north of the CSX bridge in the 3 coastal counties of MS and recreational crabbing north of I-10 (includes Bay St. Louis, Back Bay and Pascagoula) (MDMR 2016). There is also no commercial fishing or crabbing within one mile of shore around Petit Bois, Horn, and Ship Islands (Gulf Islands National Seashore) (NPS 2018).

Overall, the Gulf States are making headway in reducing the number of diamondback terrapins that are incidentally caught in blue crab pots through closures, derelict pot removal programs, and the use of biodegradable materials in pots. However, there are no mandatory regulations to minimize bycatch, such as the use of BRDs. Because there are no mandatory regulations to minimize terrapin bycatch in MS, and closed areas likely account for only a small portion of terrapin habitat, bycatch strategy for this state is ranked as "ineffective."

**Justification:**

The GSMFC held a symposium at their Annual Meeting on the topic of terrapins and their interactions with the blue crab fishery (S. Vanderkooy, personal communication 2018). Members of the blue crab management community and the terrapin research world came together to share information and discuss working together on these issues in the region. In addition, the MS Department of Marine Resources has developed and implemented a reporting application for commercial trap fishers to help the GSMFC better identify "hot spots" in state waters where terrapin habitat and blue crab fishing overlap; this will target outreach and potentially reduce bycatch of terrapins (S. Vanderkooy, personal communication 2018).

**TEXAS / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA**

**Ineffective**

Bycatch in crab pots is reduced by the use of escape rings (cull rings) and escape panels in crab pots; hence, the concern over bycatch, aside from diamondback terrapins, is minimal (GSMFC 1999). However, there are currently no regulations for the use of BRDs in the GOM, even though bycatch of diamondback terrapins is known to be minimized by their use (e.g., the use of BRDs in an Alabama salt marsh led to a 90% reduction in terrapin bycatch (Coleman et al. 2011)).

All of the Gulf States have closure areas, such as Wildlife Management Areas or Refuges, along the coast that prohibit commercial fishing and/or use of crab traps in marshes and shallow water areas. These areas are designed to protect wetlands, marshes, and estuarine areas, and in many cases overlap with potential or known terrapin habitats providing protection to terrapin populations (Audubon Nature Institute, personal communication 2017). Roughly 1% of Texas (TX) state waters, including freshwater, are closed to crabbing (ibid).

Ghost fishing is a real concern for diamondback terrapins, as is bycatch in active fishing pots. In the GOM, the loss of crab pots is greater than 25% (Voss et al. 2015), and it has been estimated that 12 million harvestable blue crabs could be lost to ghost fishing every year, which was 10% of the annual landings in Louisiana in 2012 (Anderson and Alford 2014).

**Texas**

Texas is continuing to conduct their terrapin monitoring program, and state employees are working with academic researchers to test the effectiveness of BRDs in a TX estuary (S. Vanderkooy, personal communication 2016).

Texas Parks and Wildlife Department (TPWD) has also been conducting abandoned trap removals for over 15 years. There is a 10-day closure every February for derelict pot removal (TPWD 2017). Prior to the 2017 removal, TX had removed over 32,000 pots through this program (ibid).

Texas prohibits commercial crab pots in Aransas Bay National Wildlife Refuge (114,657 acres) and J.D. Murphree Wildlife Management Area (WMA; 24,498 acres of coastal marsh) prohibits commercial fishing in most areas of the WMA except within Keith Lake (TPWD 2017) (TPWD 2018b).

Overall, the Gulf States are making headway in reducing the number of diamondback terrapins incidentally caught in blue crab pots through closures, derelict pot removal programs, and the use of biodegradable materials in pots. However, there are no mandatory regulations to minimize bycatch, such as the use of BRDs. Because there are no mandatory regulations to minimize terrapin bycatch in TX, and roughly only 1% of areas are closed to fishing, bycatch strategy for this state is ranked as "ineffective."

#### **Justification:**

The GSMFC held a symposium at their Annual Meeting on the topic of terrapins and their interactions with the blue crab fishery (S. Vanderkooy, personal communication 2018). Members of the blue crab management community and the terrapin research world came together to share information and discuss working together on these issues in the region. In addition, the MS Department of Marine Resources has developed and implemented a reporting application for commercial trap fishers to help the GSMFC better identify "hot spots" in state waters where terrapin habitat and blue crab fishing overlap; this will target outreach and potentially reduce bycatch of terrapins (S. Vanderkooy, personal communication 2018).

### **NORTH CAROLINA / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA**

#### **Ineffective**

North Carolina requires the use of two unobstructed cull rings that are at least 2 5/16 inches in diameter (NCDMF 2014). However, cull rings are not large enough to allow diamondback terrapins to escape, and studies in North Carolina and Georgia have shown that both active and derelict crab pots can have a significant impact on terrapin populations (Grosse et al. 2011) (Harden and Willard 2012) (Voss et al. 2015).

There have been several studies on the effectiveness of BRDs for reducing terrapin bycatch while maintaining crab catch (Rook et al. 2010) (McKee et al. 2015), but there is not one specific device that ensures crab catch is maintained at a level relative to crab pots without BRDs. To this end, there are currently several ongoing research projects to find the optimal BRD (M. Arendt, personal communication 2017). North Carolina is also currently working on determining the areas critical for diamondback terrapin conservation (and where excluder devices will be required in the future). The paper will also determine the most effective terrapin bycatch excluder device, with the goal of developing and implementing terrapin bycatch regulations in the blue crab fishery once the study is completed (C. Flora, personal communication 2016). North Carolina has a regulation in place that allows the Fisheries Director to require the use of terrapin excluder devices, as well as implement area and time restrictions on the use of excluder devices, or crabbing in general (NCDMF 2014).

Ghost fishing is a real concern for all bycatch species, and particularly for diamondback terrapins. In North Carolina, it is estimated that crab pot loss ranged from 12% to 17% in some years (NCDMF 2013). In North Carolina, 45 different species were found in ghost pots, the most abundant of which were blue crabs and Florida stone crabs, and the most concerning of which was the capture of five diamondback terrapins (Voss et al. 2015). States in the Chesapeake Bay and Atlantic regions with a blue crab fishery also now have a derelict pot reduction program to address this issue (Roosenburg 2004). North Carolina's crab pot removal program began in 2003, and from 2003 to 2011, North Carolina Division of Marine Fisheries removed a total of 22,430 pots out of the 170,000 pots lost annually (only 1.4%) from coastal waters (Voss et al. 2015). Currently, active

crab pots must be removed from North Carolina waters between 15 January and 7 February each year to allow for the marine patrol's annual statewide derelict pot removal program (NCDMF 2013). In addition, North Carolina law states that all blue crab pots must be marked with the owners identification, and if they do not have any markings, they are considered ghost pots and can be removed from the water by anyone at any time (ibid). This allows volunteers to remove any pots that have no identification.

Because these regulations have not yet been implemented, Seafood Watch considers North Carolina's current bycatch management to be "ineffective."

**Justification:**

Amendment 2 established the proclamation authority for requiring terrapin excluder devices in crab pots. It also established a framework for developing criteria and excluder specifications to be used in such proclamations. These criteria and specifications were in the process of being developed when the North Carolina Marine Fisheries Commission requested moving up the timeline for a new blue crab FMP; therefore, criteria and specifications will be addressed in Amendment 3 to the plan (C. Flora, personal communication 2017). Mandating use of reduction devices is dependent on these criteria and specifications; hence, there are currently no required BRDs.

FLORIDA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA

**Ineffective**

Bycatch in crab pots is reduced by the use of escape rings (cull rings) and escape panels in crab pots; hence, the concern over bycatch, aside from diamondback terrapins, is minimal (GSMFC 1999). However, there are currently no regulations for the use of BRDs in the GOM, even though bycatch of diamondback terrapins is known to be minimized by their use (e.g., the use of BRDs in an Alabama salt marsh led to a 90% reduction in terrapin bycatch (Coleman et al. 2011)).

All of the Gulf States have closure areas, such as Wildlife Management Areas or Refuges, along the coast that prohibit commercial fishing and/or use of crab traps in marshes and shallow water areas. These areas are designed to protect wetlands, marshes, and estuarine areas, and in many cases overlap with potential or known terrapin habitats providing protection to terrapin populations (Audubon Institute, personal communication 2017). Florida has closures to crabbing in Everglades National Park, Arthur R. Marshall Loxahatchee, J.N. Ding Darling, and Hobe Sound NWR (NPS 2012) (USFWS 2017c) (USFWS 2017d) (USFWS 2018).

Ghost fishing is a real concern for diamondback terrapins, as is bycatch in active fishing pots. In the GOM, the loss of crab pots is greater than 25% (Voss et al. 2015), and it has been estimated that 12 million harvestable blue crabs could be lost to ghost fishing every year, which was 10% of the annual landings in Louisiana in 2012 (Anderson and Alford 2014).

**Florida**

In Florida, three cull rings at least 2 3/8 inches in diameter, as well as a degradable panel larger than 3 x 6 inches, are required per crab trap (FWC 2016). Florida does not currently have any ongoing regulations requiring terrapin excluder devices, nor are there any closed areas associated with terrapins (D. Ellinor and R. Gandy, personal communication 2016; 2017).

Florida has yet to implement any regulations requiring BRDs, or any temporal or spatial restrictions associated with diamondback terrapins. Although there are some ongoing studies on terrapin bycatch, regulations limiting bycatch of terrapins are not imminent. Therefore, bycatch strategy in Florida is ranked as "ineffective."

## GEORGIA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA

### **Ineffective**

Georgia requires two cull rings that are at least 2 3/8 inches in diameter to allow small, unwanted bycatch to escape from crab pots (GADNR 2017b), but does not currently have any ongoing regulations requiring terrapin excluder devices (M. Dodd (GA) and D. Ellinor (FL), personal communication 2016). However, there was a study on the effectiveness of five BRDs in crab pots, with the objective of providing support and direction for management recommendations, to reduce terrapin mortality rates in Georgia's commercial and recreational blue crab fisheries (Belcher et al. 2007). A state-wide survey was also conducted in 2008 to assess Georgia's terrapin population (Page et al. 2013). The study showed that terrapins are relatively abundant in Georgia, but that the commercial crab pot fishery is, in fact, impacting their population. Finally, a study of terrapin bycatch in crab pots in Georgia suggested that limiting the number of crab pots in shallow water tidal creeks during the months of April, May, and June, may have an impact on the number of terrapins caught as bycatch (Grosse et al. 2011). Terrapin bycatch may also be limited by shortening crab pot soak time to under 24 hours. When crab pots are checked daily, the mortality rate is only 10%, but when they are soaked for one to two days, mortality increases to 40%, and over two days, mortality is 100% (Grosse et al. 2011) (Hart and Crowder 2011). Other than these exploratory studies, there have been no serious efforts to protect diamondback terrapin populations from crab pot mortality in Georgia.

Georgia has yet to implement any regulations requiring BRDs, or any temporal or spatial restrictions associated with diamondback terrapins. Although there are some ongoing studies on terrapin bycatch, regulations limiting bycatch of terrapins are not imminent. Therefore, bycatch strategy in Georgia is ranked as "ineffective."

## SOUTH CAROLINA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA

### **Ineffective**

South Carolina requires two cull rings that are at least 2 3/8 inches in diameter to allow small, unwanted bycatch to escape from crab pots. Cull rings are effective at letting undersized crabs escape, although the placement of the rings within the pot panels can have an impact on their effectiveness (Havens et al. 2009). However, like in North Carolina, these cull rings are not effective at allowing larger bycatch, such as diamondback terrapins, to escape.

South Carolina recently launched a volunteer terrapin reporting form to understand more about their terrapin populations (SCDNR 2016g). A number of studies have been conducted to test the effectiveness of bycatch reduction devices (BRDs) (SDNR 2016d) (SCDNR 2016e) (Grubbs et al. 2017) (Arendt et al 2018). Most recently Arendt et al (2018) modeled the effectiveness of different BRDs at excluding terrapins from traps while maintaining harvest levels of legal-sized blue crab in South Carolina. This novel approach to testing BRDs determined that a BRD of 5.1 to 6.4 cm (height) by 7.3 cm (width) was >30% more effective at excluding terrapins, and that by increasing the width of the BRD, 99% of legal-sized crab could be retained (Arendt et al 2018). Research such as this points to possible solutions to the problem of terrapin bycatch; similar studies in other states (using local morphometric data) may help identify possible solutions for other states.

South Carolina, has yet to implement any regulations requiring BRDs, or any temporal or spatial restrictions associated with diamondback terrapins. Although there are some ongoing studies on terrapin bycatch, regulations limiting bycatch of terrapins are not imminent. Therefore, bycatch strategy in South Carolina is ranked as "ineffective."

### 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.*

MARYLAND / CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
MARYLAND / CHESAPEAKE BAY, TROTLINE, UNITED STATES OF AMERICA  
NEW JERSEY / DELAWARE BAY, POTS, UNITED STATES OF AMERICA  
DELAWARE / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA

#### Moderately Effective

Blue crab stock assessments in Chesapeake Bay provide detailed scientific advice for management based on very quantitative measures of the population. The Maryland Department of Natural Resources and the Virginia Institute of Marine Sciences monitor crab populations with a winter survey during the crabs' dormant period each year (CBF 2016). However, very little is known about the nature of the blue crab fishery's impact on diamondback terrapins and how effective the regulations in New Jersey, Maryland, and Delaware have been on minimizing bycatch. Therefore, scientific research and monitoring is ranked as "moderately effective."

ALABAMA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA

#### Moderately Effective

The assessment of blue crabs in Louisiana is based on catch/survey analyses, which incorporate abundance indices, harvest estimates and natural mortality (stock/production models). Estimates of exploitable biomass and recruitment, as well as fishing mortality, are produced from these models. Indices of abundance are derived from the LDWF fishery-independent trawl survey (LDWF 2016). A stock assessment was completed in 2015 for the entire GOM fishery, which includes fishery reference points (*ibid*). An additional stock assessment was recently completed by the state of Louisiana for their blue crab population. Although a study is being conducted on terrapin bycatch in Louisiana, and the most effective method for minimizing bycatch, the results are not yet available. Since the GOM blue crab fishery is being assessed regularly, especially the Louisiana population, but is not sufficient to meet a score of highly effective, scientific research and monitoring in the GOM is ranked as moderately effective.

### Factor 3.4 - Enforcement of Management Regulations

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

MARYLAND / CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
MARYLAND / CHESAPEAKE BAY, TROTLINE, UNITED STATES OF AMERICA  
NEW JERSEY / DELAWARE BAY, POTS, UNITED STATES OF AMERICA  
DELAWARE / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA

#### Highly Effective

Regulation of the commercial blue crab fishery is set by the number of licenses, which limits the number of pots. Trotline gear in the recreational fishery may not exceed 1,200 ft in length for the baited portion; there is no limit on the length of trotline that can be used in the commercial fishery (MDDNR 2016a). When a reduction in blue crab take is necessary, fishing effort (number of pots) is reduced; however, there are potential future

issues of overcapacity, with over 5,000 licenses issued in Maryland (*ibid*). Although not all of the licenses are in use, there is a significant amount of latent effort, which could result in overcapacity. In attempt to minimize this risk, there is an effort to buy back unused licenses; so far, there has been a reduction of 1,000 female harvest licenses and some additional male-only licenses (Davis, personal communication 2016). Enforcement in the commercial fishery is based on a point system, where points are applied to a fishing license if an individual is found guilty of violating a fishing regulation, or for individuals fishing without a commercial license (MDDNR 2016b). A certain number of points can result in a suspension of licenses, which has made a large impact on improving regulation compliance. The Virginia fishery is monitored by the Virginia Marine Police, which monitors for compliance (VAMRC 2016). The Delaware Department of Fish and Wildlife Natural Resources police officers monitor Delaware waters for compliance; in only one week in April 2016, five citations were issued for unlicensed fishing (DDFW 2016). Since there is sufficient enforcement of regulations in each state, enforcement is ranked as "highly effective."

#### ALABAMA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA

##### **Highly Effective**

Regulation of the commercial blue crab fishery is set by the number of licenses, and hence, the number of pots, for each state (Perry and VanderKoooy 2015). When a reduction in blue crab take is necessary, fishing effort is reduced through a reduction in issued licenses (*ibid*). Management is enforced and information is verified through trip ticket programs where dealers and fishermen report a variety of information about their catch, including, but not limited to, gear; area fished; and species landed (*ibid*). The trip ticket program is used to verify catch. Compliance officers manage enforcement of regulations in each state (*ibid*). A 2013 survey on enforcement, sent out to recreational blue crab anglers, found that less than a quarter of anglers were concerned about enforcement (*ibid*). Therefore, enforcement is ranked as highly effective.

### **Factor 3.5 - Stakeholder Inclusion**

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

MARYLAND / CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
MARYLAND / CHESAPEAKE BAY, TROTLINE, UNITED STATES OF AMERICA  
NEW JERSEY / DELAWARE BAY, POTS, UNITED STATES OF AMERICA  
DELAWARE / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA

##### **Highly Effective**

In an effort to improve industry leadership and coordination, as well as to increase co-management among managers and industry, a stakeholder group (by region, interest and gear) was formed by the industry to review, evaluate, and propose new blue crab management options (MBCIDT 2012). The Blue Crab Industry Design Team is a volunteer, industry-led group charged with assessing and thinking long-term about the future of the Chesapeake Bay commercial crab fishery (*ibid*). In addition, there are Blue Crab Management Advisory Committee meetings, in which members of the industry and public can share input on the assessment and any management measures proposed (*ibid*). This transparent process of management with a variety of stakeholder involvement is ranked as "highly effective" for stakeholder inclusion.

**Highly Effective**

Stakeholders can participate in the evaluation and recommended management of blue crabs in their home state. In Louisiana, participation is through the Louisiana Crab Task Force. In addition, the GSMFC has a Crab Subcommittee for public participation in the management process (GSMFC 2015). During the development of the FMP, a survey was conducted in the entire crab fishing community, and included all licensed commercial crab fishermen in the GOM fishery; the same survey was repeated in 1998 (Perry and VanderKooy 2015). The GSMFC allows for public review of all management plans and assessments before they are published (GSMFC 2015). Therefore, stakeholder inclusion is highly effective in the Gulf of Mexico.

## **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**

<b>Region / Method</b>	<b>Gear Type and Substrate</b>	<b>Mitigation of Gear Impacts</b>	<b>EBFM</b>	<b>Score</b>
Alabama / Gulf of Mexico / Pots / United States of America	3	0	Moderate Concern	Yellow (3.000)
Delaware / Northwest Atlantic / Pots / United States of America	3	0	Moderate Concern	Yellow (3.000)
Florida / Gulf of Mexico / Pots / United States of America	3	0	Moderate Concern	Yellow (3.000)
Florida / Western Central Atlantic / Pots / United States of America	3	0	Moderate Concern	Yellow (3.000)
Georgia / Western Central Atlantic / Pots / United States of America	3	0	Moderate Concern	Yellow (3.000)
Louisiana / Gulf of Mexico / Pots / United States of America	3	0	Moderate Concern	Yellow (3.000)
Maryland / Chesapeake Bay / Pots / United States of America	3	0	Moderate Concern	Yellow (3.000)

Maryland / Chesapeake Bay / Trotline / United States of America	3	0	Moderate Concern	Yellow (3.000)
Mississippi / Gulf of Mexico / Pots / United States of America	3	0	Moderate Concern	Yellow (3.000)
New Jersey / Delaware Bay / Pots / United States of America	3	0	Moderate Concern	Yellow (3.000)
North Carolina / Northwest Atlantic / Pots / United States of America	3	0	Moderate Concern	Yellow (3.000)
South Carolina / Western Central Atlantic / Pots / United States of America	3	0	Moderate Concern	Yellow (3.000)
Texas / Gulf of Mexico / Pots / United States of America	3	0	Moderate Concern	Yellow (3.000)
Virginia / Chesapeake Bay / Pots / United States of America	3	0	Moderate Concern	Yellow (3.000)

Crab pots are a passively fished gear type that have a light impact on benthic habitats. The primary threat comes from lost or abandoned pots, which can be naturally swept across the habitat during a large storm or tropical system. Derelict gear is also referred to as “ghost fishing” because abandoned pots often continue to trap a variety of species, both blue crab and non-target species. Unmaintained, they can contribute to unnecessary mortality with the potential to alter ecosystem or food web dynamics. Trotlines, similar to bottom longlines (but without hooks), rest along the benthos and are anchored at both ends with anchors and chains. Trotlines are set primarily in sand and silt habitats.

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

MARYLAND / CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
VIRGINIA / CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
NEW JERSEY / DELAWARE BAY, POTS, UNITED STATES OF AMERICA  
ALABAMA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
FLORIDA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
LOUISIANA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
MISSISSIPPI / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
TEXAS / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
DELAWARE / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA  
NORTH CAROLINA / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA  
FLORIDA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
GEORGIA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
SOUTH CAROLINA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA

**3**

Pots are less damaging than highly mobile gears, such as trawls or dredges. Although pots contact the benthos, they are not very mobile and have contact with a substantially smaller area of the seafloor than do other types of gear. Relative to blue crab habitat, pots are less likely to cause damage on sandy or muddy substrates, as opposed to submerged aquatic vegetation or live bottom substrate (Barnette 2001). However, pots can affect the benthic habitat because they do not always remain entirely stable on the seafloor (Chuenpagdee et al. 2003). Therefore, Seafood Watch scores pots a 3 out of 5 for impacts on the habitat.

MARYLAND / CHESAPEAKE BAY, TROTLINE, UNITED STATES OF AMERICA

**3**

Trotlines, similar to bottom longlines (without hooks), rest along the benthos and are anchored at both ends. Along the mainline, there are a series of baits attached at intervals of two to six feet. The baits are attached to the main line by slipknots or by shorter lines called dropper lines (also known as trots or snoods). At each end of the line is an anchor with a line that goes to a float, and then another line that goes to a section of about 10 links of chain for stability. Trotlines are set primarily in sand and silt habitats. Therefore, trotlines score 3 out of 5 for impacts on the habitat.

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

MARYLAND / CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
VIRGINIA / CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
NEW JERSEY / DELAWARE BAY, POTS, UNITED STATES OF AMERICA  
ALABAMA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
FLORIDA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
LOUISIANA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
MISSISSIPPI / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
TEXAS / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
DELAWARE / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA  
NORTH CAROLINA / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA  
FLORIDA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
GEORGIA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
SOUTH CAROLINA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA

**0**

Most states have had or currently have established derelict pot removal programs (Anderson and Alford 2014) (Giordano et al. 2011) (Guillory et al. 2012). Since 2004, the LDWF has carried out voluntary derelict pot removal programs during 10-day fishing closures each year. In 2012, there were 2,704 pots removed, and in 2013 a total of 903 pots were removed (Anderson and Alford 2014). Pot removal programs have been highly successful, and Alabama and Mississippi now operate removal programs on an as-needed basis, in addition to annually (Perry and VanderKooy 2015). Furthermore, fishers have incorporated the use of biodegradable materials into pots, such as untreated steel wire, jute, and sisal twine that decompose within 28 to 77 days. These panels are currently mandated by law in Florida and Texas (ibid). Quantifying and identifying the location of ghost pots for their eventual removal can be considered mitigation, but since ghost pots are still an issue that can affect bottom habitats, Seafood Watch considers the blue crab pot fishery to have no mitigation.

MARYLAND / CHESAPEAKE BAY, TROTLINE, UNITED STATES OF AMERICA

0

There is no mitigation of habitat impacts in the trotline fishery.

### Factor 4.3 - Ecosystem-Based Fisheries Management

MARYLAND / CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
MARYLAND / CHESAPEAKE BAY, TROTLINE, UNITED STATES OF AMERICA  
VIRGINIA / CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
NEW JERSEY / DELAWARE BAY, POTS, UNITED STATES OF AMERICA  
ALABAMA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
FLORIDA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
LOUISIANA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
MISSISSIPPI / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
TEXAS / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
DELAWARE / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA  
NORTH CAROLINA / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA  
FLORIDA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
GEORGIA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
SOUTH CAROLINA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA

#### Moderate Concern

Blue crabs play an important role as potential keystone predators in the Chesapeake Bay, South Atlantic, and GOM ecosystems (Perry and VanderKooy 2015). Therefore, their protection is important to maintain ecosystem function. Limits on blue crab fishing throughout all regions, as well as accountability measures for potential decreases in abundance and increases in fishing, will allow blue crab populations to remain healthy. Although more work needs to be done in all regions to develop assessments with appropriate reference points, blue crab populations are being adequately protected to allow for healthy ecosystem function. In addition to recommendations to maintain regulations enacted by the states—limiting access to the fishery, preventing exploitation, and improving research and monitoring—the 1997 Chesapeake Bay Blue Crab FMP incorporates an enhanced habitat section recommending protection and restoration of bay grasses and water quality (Chesapeake Bay Program 1997). These concerns are very important in Chesapeake Bay because it is such a large and very productive estuary. In this system, which is more closed than many coastal environments, the ecosystem and food web dynamics are crucial.

Outside of the Chesapeake, there are numerous restoration activities, but the efforts tend not to be specifically

coordinated as part of blue crab population management. Efforts to restore habitats are underway to support a variety of species for the health of the entire ecosystem. In the GOM, some of the current management plan's objectives are to evaluate impacts of ecosystem variables on blue crab population dynamics, as well as to conduct further research on blue crab diets and predation in order to develop an ecosystem-based assessment model in the future (Perry and VanderKooy 2015). In Louisiana, crab pots are prohibited in wildlife management areas and refuges, and in many states, commercial fishing is restricted to upper bays, rivers, and streams (LDWF 2018b). Although the overall percentage restricted to fishing is low, there is some conservation effort to protect spawning and juvenile crabs, such as escape ring regulations and a minimum size limit (5 in) (GSMFC, unpublished data). Additionally, prohibition of berried females (and immature females in Louisiana) protects spawning crabs. Due to these efforts, management of the ecosystem and food web impacts of the fishery is deemed as "moderate" 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 the consulting researcher and author of this report, Rachel Simon, as well as Chris Blankenship of the Alabama Department of Conservation and Natural Resources and several anonymous reviewers for graciously reviewing this report for scientific accuracy.*

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## **Appendix A: Extra By Catch Species**

### **BOTTLENOSE DOLPHIN**

#### **Factor 2.1 - Abundance**

MARYLAND / CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
NEW JERSEY / DELAWARE BAY, POTS, UNITED STATES OF AMERICA  
DELAWARE / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA  
VIRGINIA / CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
NORTH CAROLINA / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA  
FLORIDA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
GEORGIA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
SOUTH CAROLINA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA

#### **High Concern**

There are several populations of Atlantic bottlenose dolphins, *Tursiops truncatus*, that may interact with blue crab pot fisheries in the Atlantic. The 2017 List of Fisheries states that it is not possible to determine the exact population from which a stranded dolphin originates (NMFS 2017), therefore we consider these populations together.

Of the several populations that may be encountered by blue crab fisheries in the Atlantic, some are listed as depleted under the Marine Mammal Protection Act (MMPA), namely: 1) Central Florida Coastal; 2) Northern Florida Coastal; 3) Northern Migratory Coastal; 4) South Carolina and Georgia Coastal; and 5) Southern Migratory Coastal (Waring et al. 2016). Due to the depleted status of these bottlenose dolphin populations, Seafood Watch considers abundance to be of "high" concern.

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

MARYLAND / CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
NEW JERSEY / DELAWARE BAY, POTS, UNITED STATES OF AMERICA  
DELAWARE / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA  
VIRGINIA / CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
NORTH CAROLINA / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA  
FLORIDA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
GEORGIA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
SOUTH CAROLINA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA

#### **Moderate Concern**

There is no systematic observer program for the blue crab fishery, which makes it difficult to estimate the impact of the blue crab fishery on Atlantic bottlenose dolphin populations. However, there is evidence that dolphins do interact with crab pots. For example, between 2009 and 2013 there were three known interactions in the Indian River Lagoon region (Waring et al. 2016). These dolphins were released without serious injury; however, stranded dolphins are found bearing evidence of interactions with crab pots and associated lines. Between 2009 and 2013, seven stranded dolphins were found in the Jacksonville Estuarine region that showed signs of having interacted with pots (ibid).

As many of the populations have an unknown abundance, it is also impossible to identify a sustainable level of impact, or Potential Biological Removal (PBR), in many cases (ibid). As a result, the impact of blue crab fisheries on Atlantic bottlenose dolphins is unknown, or a "moderate" conservation concern.

## Factor 2.3 - Discard Rate

MARYLAND / CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
 NEW JERSEY / DELAWARE BAY, POTS, UNITED STATES OF AMERICA  
 DELAWARE / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA  
 VIRGINIA / CHESAPEAKE BAY, POTS, UNITED STATES OF AMERICA  
 NORTH CAROLINA / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA  
 FLORIDA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
 GEORGIA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
 SOUTH CAROLINA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA

### < 100%

The overall ratio of bait + discards/landings in the blue crab fisheries is less than 100% (see table). Pots are designed to trap crabs, but occasionally turtles, sublegal blue crabs, and finfish enter pots. Most states that have an active blue crab fishery require cull rings, which allow most sublegal blue crabs to escape (VCCRM 2008). The amount of terrapin bycatch is unknown, but is thought to be a small portion of the blue crab landing weight. However, given that terrapins are highly vulnerable, the impact can be notable. Ghost pots contribute most significantly to unintended mortality from the blue crab fishery, but total mortality due to derelict gear is low (Bilkovic et al. 2012). A two-year survey of derelict fishing gear in Chesapeake Bay found that blue crabs comprised just under 80% of the catch, while oyster toadfish, whelk, black seabass and Atlantic croaker made up approximately 20% of the catch (ibid).

Gulf and Atlantic menhaden (*Brevoortia patronus* and *B. tyrannus*, respectively) and striped mullet (*Mugil cephalus*) are the main species used for bait in the GOM blue crab fishery (Perry and VanderKooy 2015), where approximately 0.6 lb of bait are used per pot, for a total of 19 million lb annually (SCS 2012). Forty to 55% of blue crab catch by weight is caught using either Atlantic or Gulf menhaden (ibid). The traditional bait for most crab fishermen in the Gulf was Atlantic menhaden; however, this bait supply has diminished over the last decade as Atlantic menhaden populations have been afforded more protection (Anderson 2014). In addition, the Gulf menhaden bait industry in the Gulf declined (C. Blankenship, personal communication 2017). To address the needs of the crab fishery, efforts are underway to rebuild a Gulf bait industry in Louisiana and Florida (Schueller 2016).

Although Atlantic menhaden were in decline, the latest assessment indicated an increase in population biomass and spawning stock biomass (compared to the 2013 assessment); hence, the stock is neither overfished nor undergoing overfishing (Schueller 2016). The ratio of bait use to catch is considered similar to the impact of discarded bycatch. Thus, overall discards and bait use is ranked as 40% to 60%, or <100%.

**Table 1:** 2014 Landings in blue crab pot gear (percentage by weight) (NMFS 2016a).

Species landed in blue crab pots	Percentage of landings by weight (lb)
Blue crab	99.22%
Black drum	0.01%
American eel	0.01%
Southern flounder	0.01%
Striped mullet	0.01%
Shellfish (general)	0.02%

Sheepshead	0.01%
Snails (conch)	0.02%
Toadfish	0.01%
Channeled whelk	0.01%

## WEST INDIAN MANATEE

### **Factor 2.1 - Abundance**

NORTH CAROLINA / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA  
 FLORIDA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
 GEORGIA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
 SOUTH CAROLINA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
 FLORIDA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
 LOUISIANA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
 ALABAMA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
 MISSISSIPPI / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
 TEXAS / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA

#### **High Concern**

The West Indian manatee, *Trichechus manatus*, is found in the coastal waters of North, Central, and South America. There are two known sub-species, the Antillean manatee (*Trichechus manatus manatus*) and the Florida manatee (*Trichechus manatus latirostris*). Here we discuss the Florida manatee and the potential interactions with the US blue crab fishery.

The Florida manatee is found in waters of Texas, Louisiana, Mississippi, Alabama, Florida, Georgia, and the Carolinas (USFWS 2017b). The Florida manatee is listed as Endangered under the ESA; however, it is currently being considered for reclassification as "threatened" (USFWS 2017a). Seafood Watch considers all threatened and endangered species a "high" concern.

#### **Justification:**

The most recent stock assessment for the Florida manatee considers data from 2008 to 2012 (USFWS 2014). There is no statistically robust estimate of population size; however, a count of 4,834 individuals was recorded in January 2011. Demographic studies suggest that the population is stable or increasing (ibid), leading to calls for reclassification under the ESA.

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

NORTH CAROLINA / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA  
 FLORIDA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
 GEORGIA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
 SOUTH CAROLINA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
 FLORIDA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
 LOUISIANA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
 ALABAMA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
 MISSISSIPPI / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
 TEXAS / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA

## Low Concern

Human threats to the Florida manatee include collisions with watercrafts, water control structures, and interactions with recreational and commercial fishing gear. The US blue crab pot fishery is considered a Category II fishery by the National Marine Fisheries Service due to potential interactions with manatees, as well as bottlenose dolphins (NMFS 2017). Most mortalities and serious injuries are caused by collisions with watercrafts (FWC 2018a). Blue crab fisheries were known to cause injury to one manatee in the Gulf of Mexico (Pinellas County in 2008; FWC/FWRI Marine Mammals Pathobiology Laboratory, personal communication 2017) and two manatees in the Atlantic between 2008 and 2012 (USFWS 2014). Each of these manatees was successfully treated and returned to the wild. As such, total impact from the blue crab fishery, and commercial fisheries as a whole, is considered insignificant and approaching zero (ibid). Thus, Seafood Watch considers fishing mortality to be "low" concern.

## Factor 2.3 - Discard Rate

NORTH CAROLINA / NORTHWEST ATLANTIC, POTS, UNITED STATES OF AMERICA  
FLORIDA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
GEORGIA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
SOUTH CAROLINA / WESTERN CENTRAL ATLANTIC, POTS, UNITED STATES OF AMERICA  
FLORIDA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
LOUISIANA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
ALABAMA / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
MISSISSIPPI / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA  
TEXAS / GULF OF MEXICO, POTS, UNITED STATES OF AMERICA

### < 100%

The overall ratio of bait + discards/landings in the blue crab fisheries is less than 100% (see table). Pots are designed to trap crabs, but occasionally turtles, sublegal blue crabs, and finfish enter pots. Most states that have an active blue crab fishery require cull rings, which allow most sublegal blue crabs to escape (VCCRM 2008). The amount of terrapin bycatch is unknown, but is thought to be a small portion of the blue crab landing weight. However, given that terrapins are highly vulnerable, the impact can be notable. Ghost pots contribute most significantly to unintended mortality from the blue crab fishery, but total mortality due to derelict gear is low (Bilkovic et al. 2012). A two-year survey of derelict fishing gear in Chesapeake Bay found that blue crabs comprised just under 80% of the catch, while oyster toadfish, whelk, black seabass and Atlantic croaker made up approximately 20% of the catch (ibid).

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Although Atlantic menhaden were in decline, the latest assessment indicated an increase in population biomass and spawning stock biomass (compared to the 2013 assessment); hence, the stock is neither overfished nor undergoing overfishing (Schueller 2016). The ratio of bait use to catch is considered similar to the impact of discarded bycatch. Thus, overall discards and bait use is ranked as 40% to 60%, or <100%.

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Sheepshead	0.01%
Snails (conch)	0.02%
Toadfish	0.01%
Channeled whelk	0.01%

## **Appendix B: Management Factors for Ineffective States**

### **Factor 3.3 Scientific Research and Monitoring**

#### **Blue crab: Chesapeake Bay and Delaware Bay (Virginia), crab pot**

##### **Moderately effective**

###### Key relevant information:

Blue crab stock assessments in Chesapeake Bay provide detailed scientific advice for management based on quantitative measures of the population. The Maryland Department of Natural Resources and the Virginia Institute of Marine Sciences monitor crab populations with a winter survey during the crabs' dormant period each year (CBF 2016). However, very little is known about the nature of the blue crab fishery's impact on diamondback terrapins and how effective the regulations in New Jersey, Maryland, and Delaware have been on minimizing bycatch. Therefore, scientific research and monitoring is ranked as "moderately effective."

#### **Blue crab: Atlantic (North Carolina, South Carolina, Georgia and Florida), crab pot**

##### **Moderately effective**

###### Key relevant information:

The Pamlico Sound Survey and other North Carolina Division of Marine Fisheries surveys are used to collect fishery-independent and fishery-dependent data through the trip ticket program, and by sampling catches at offloading sites (NCDENR 2018c). The stock has been characterized by a Traffic Light Stock Assessment Method, which synthesizes a variety of information about the stock (NCMFC 2016a). South Carolina crab abundance levels are measured by an annual survey conducted by the South Carolina Department of Natural Resources (SCDNR 2016c). Georgia has a monthly blue crab survey program and results are monitored constantly to detect any decrease in blue crab survey abundance, as well as any changes in CPUE results (GADNR 2015a). Florida conducts a state-wide blue crab survey approximately every three years, which is used to measure abundance and fishing effort (D. Ellison, personal communication 2016). Management efforts can be improved with the collection and use of more fishery-independent data, and the development of a stock assessment methodology with reference points for all Atlantic states. Although a study is being conducted on terrapin bycatch and the most effective method for minimizing bycatch in the Atlantic region, the results are not yet available. Scientific research and monitoring is therefore ranked as "moderately effective."

#### **Blue crab: GOM (Mississippi, Louisiana and Texas, crab pot)**

##### **Moderately effective**

The assessment of blue crabs in Louisiana is based on catch-survey analyses, which incorporate abundance indices, harvest estimates, and natural mortality (stock-production models). Estimates of exploitable biomass and recruitment, as well as fishing mortality, are produced from these models. Indices of abundance are derived from the LDWF fishery-independent trawl survey (LDWF 2016). A stock assessment was completed in 2015 for the entire GOM fishery, which includes fishery reference points (ibid). An additional stock assessment was recently completed by the state of Louisiana for their blue crab population. Although a study is being conducted on terrapin bycatch in Louisiana, and the most effective method for minimizing bycatch, the results are not yet available. Since the GOM blue crab fishery is being assessed regularly, especially the Louisiana population, but is not sufficient to meet a score of "highly effective," scientific research and monitoring in the GOM is ranked as "moderately effective."

### **Factor 3.4 Enforcement of Management Regulations**

## **Blue crab: Chesapeake Bay and Delaware Bay (Virginia), crab pot**

### **Highly effective**

#### Key relevant information:

Regulation of the commercial blue crab fishery is set by the number of licenses, which limits the number of pots. Trotline gear used from the boat may not exceed 1,200 ft in length for the baited portion (MDDNR 2016a). When a reduction in blue crab take is necessary, fishing effort (number of pots) is reduced; however, there are potential future issues of overcapacity, with over 5,000 licenses issued in Maryland (ibid). Although not all of the licenses are in use, there is a significant amount of latent effort, which could result in overcapacity. In an attempt to minimize this risk, there is an effort to buy back unused licenses; so far, there has been a reduction of 1,000 female harvest licenses and some additional male-only licenses (Davis, personal communication 2016). Enforcement in the commercial fishery is based on a point system, where points are applied to a fishing license if an individual is found guilty of violating a fishing regulation, or for individuals fishing without a commercial license (MDDNR 2016b). A certain number of points can result in a suspension of licenses, which has made a large impact on improving regulation compliance. The Virginia fishery is monitored by the Virginia Marine Police, which monitors for compliance (VAMRC 2016). The Delaware Department of Fish and Wildlife Natural Resources police officers monitor Delaware waters for compliance; in only one week in April 2016, five citations were issued for unlicensed fishing (DDFW 2016). Since there is sufficient enforcement of regulations in each state, enforcement is ranked as "highly effective."

## **Blue crab: Atlantic (North Carolina, South Carolina, Georgia and Florida), crab pot**

### **Highly effective**

#### Key relevant information:

Regulation of the commercial blue crab fishery in North Carolina is set by the number of licenses, which limits the number of pots. When a reduction in blue crab fishing is triggered through the Traffic Light Assessment System, possible management measures include: 1) restricting harvest of sponge crabs; 2) setting a size limit for mature females; 3) closing crab spawning sanctuaries; 4) prohibiting harvest of sponge crabs; 5) expanding the crab sanctuaries; or 6) closing the entire fishery (NCMFC 2016a). There are enforcement agents throughout the state that monitor compliance with fisheries regulations, both on the water and at the dock, by issuing citations for infractions (C. Flora, personal communication 2016). In South Carolina, enforcement is handled by the South Carolina Department of Natural Resources Division of Law Enforcement, which is responsible for ensuring commercial fishers abide by the rules and regulations (SCDNR 2016a). Enforcement is managed by a points system where each violation is assessed and assigned a number of points against one's record. After one full year without receiving any additional points, those points are reduced by half. If one accumulates more than 18 points, that person is no longer allowed to fish within South Carolina's coastal waters (SCDNR 2016a). The Law Enforcement Division of Georgia's Department of Natural Resources is responsible for enforcing Georgia's commercial fishing regulations. Law enforcement implements a three-strike system where, if a fisher is convicted of three violations, they lose their license permanently (GADNR 2016). Enforcement in Florida is handled through the Fish and Wildlife Commission's Law Enforcement Division. All states have adequate enforcement divisions, and therefore, enforcement is ranked as "highly effective."

## **Blue crab: GOM (Alabama, Mississippi, Louisiana and Texas), crab pot**

### **Highly effective**

#### Key relevant information:

Regulation of the commercial blue crab fishery is set by the number of licenses, and hence, the number of pots,

for each state (Perry and VanderKooy 2015). When a reduction in blue crab take is necessary, fishing effort is reduced through a reduction in issued licenses (ibid). Management is enforced and information is verified through trip ticket programs where dealers and fishers report a variety of information about their catch, including, but not limited to: gear, area fished, and species landed (ibid). The trip ticket program is used to verify catch. Compliance officers manage enforcement of regulations in each state (ibid). A 2013 survey on enforcement, sent out to recreational blue crab anglers, found that less than a quarter of anglers were concerned about enforcement (ibid). Therefore, enforcement is ranked as "highly effective."

### **Blue crab: Chesapeake Bay and Delaware Bay (New Jersey, Delaware, Maryland and Virginia), crab pot**

#### **Highly effective**

##### Key relevant information:

In an effort to improve industry leadership and coordination, as well as to increase co-management among managers and industry, a stakeholder group (by region, interest, and gear) was formed by the industry to review, evaluate, and propose new blue crab management options (MBCIDT 2012). The Blue Crab Industry Design Team is a volunteer, industry-led group charged with assessing and thinking long-term about the future of the Chesapeake Bay commercial crab fishery (ibid). In addition, there are Blue Crab Management Advisory Committee meetings, in which members of the industry and public can share input on the assessment and any management measures being proposed (ibid). This transparent process of management with a variety of stakeholder involvement is ranked as "highly effective" for stakeholder inclusion.

### **Blue crab: Atlantic (North Carolina, South Carolina, Georgia and Florida), crab pot**

#### **Highly effective**

##### Key relevant information:

All meetings of the North Carolina Marine Fisheries Commission and Advisory Committee are streamed live (online) for the public (NCDENR 2018a). In addition, stakeholders can participate in the evaluation and recommended management of blue crabs through the North Carolina Marine Fisheries Commission Regional Stakeholder Advisory Committee system (NCDENR 2018b). South Carolina also has a Marine Advisory Committee, which is made up of stakeholders and citizens interested in the management of marine fisheries (SCDNR 2018b). Advisory meetings are open to the public, and the time and place of the meeting is published in local newspapers (SCDNR 2018b). The Coastal Advisory Council in Georgia is made up of local government representatives, research institutions, environmental groups, and members of the general public (GADNR 2018). The Marine Fisheries Advisory Council is made up of representatives from sport fishing, commercial fishing, fish processing, as well as members of the general public (ibid). A subgroup of Georgia's MFAC is the Blue Crab Advisory Panel, which meets at least semi-annually to address blue crab issues. In Florida, the Florida Fish and Wildlife Conservation Commission meets in different locations across the state to allow all stakeholders to participate (FWC 2018b). Florida rulemaking is a public process in which activity is published and public comments are accepted regularly (ibid). Stakeholder inclusion is therefore "highly effective" in the Atlantic region.

### **Blue crab: GOM (Mississippi, Louisiana and Texas), crab pot**

#### **Highly effective**

##### Key relevant information:

Stakeholders can participate in the evaluation and recommended management of blue crabs in their home state. In Louisiana, participation is through the Louisiana Crab Task Force. In addition, the GSMFC has a Crab

Subcommittee for public participation in the management process (GSMFC 2015). During the development of the FMP, a survey was conducted in the entire crab fishing community, and included all licensed commercial crab fishers in the GOM fishery; the same survey was repeated in 1998 (Perry and VanderKooy 2015). The GSMFC allows for public review of all management plans and assessments before they are published (GSMFC 2015). Therefore, stakeholder inclusion is "highly effective" in the Gulf of Mexico.