STATUS REVIEW REPORT:
DWARF SEAHORSE (*HIPPOCAMPUS ZOSTERAE*)

2020
National Marine Fisheries Service
National Oceanic and Atmospheric Administration

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Disclaimer

This document summarizes biological information on the dwarf seahorse, *Hippocampus zosterae*, throughout its range. It presents the best available information from published and unpublished sources. This document does not represent a decision by NMFS on whether this taxon should be listed as threatened or endangered under the Endangered Species Act.

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LIST OF ACROYNYMS AND ABBREVIATIONS

CITES	Convention on International Trade in Endangered Species
CPUE	Catch Per Unit of Effort
DPS	Distinct Population Segment
DWH	Deepwater Horizon
ESA	Endangered Species Act
FR	Federal Register
FIM	Fisheries Independent Monitoring
FWC	Florida Fish and Wildlife Conservation Commission
FWPCA	Federal Water Pollution Control Act
FWS	Fish and Wildlife Service
GBIF	Global Biodiversity Information Facility Database
HAB	Harmful Algal Bloom
IPCC	Intergovernmental Panel on Climate Change
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
PAH	Polycyclic Aromatic Hydrocarbon
Pers. comm.	Personal Communication
PVA	Population Viability Analysis
RCP	Representative Concentration Pathways
SIMM	Seagrass Integrated Mapping and Monitoring
SPOIR	Significant Portion of its Range
SRT	Status Review Team
TCM	Traditional Chinese Medicine
TL	Total Length
TMDL	Total Maximum Daily Load
TPWD	Texas Parks and Wildlife Department
U.S.	United States
USGS	Unites States Geological Survey

UNITS OF MEASUREMENT

ac	acre(s)
°C	degrees Celsius
cm	centimeter(s)
°F	degrees Fahrenheit
ft	foot/feet
ft^2	square foot/feet
in	inch(es)
km	kilometer(s)
lin ft	linear foot/feet
m	meter(s)
mi	mile(s)
N/m^2	number of individuals per square meter

1 BACKGROUND

This Status Review was conducted in response to a petition to list dwarf seahorse (*Hippocampus zosterae*) as threatened or endangered under the Endangered Species Act (ESA). On April 6, 2011, the Center for Biological Diversity requested the National Oceanic and Atmospheric Administration (NOAA) and National Marine Fisheries Service (NMFS) to list the dwarf seahorse as threatened or endangered under the ESA. Pursuant to the ESA, a Status Review or Biological Assessment shall be promptly commenced if a petition is found to present substantial scientific or commercial information that the petitioned action may be warranted (16 U.S.C. 1533(b)(3)(A)). On May 4, 2012, NMFS determined that the petition presented substantial scientific information that listing may be warranted and an assessment was necessary (77 FR 26478). At that time, NMFS requested experts and members of the public to submit information to assist in the assessment process. NMFS requested information in the following areas: (1) historical and current distribution and abundance of this species throughout its range; (2) historical and current population status and trends; (3) life history in marine environments; (4) curio, traditional medicine, and aquarium trade and/or other trade data; (5) any current or planned activities that may adversely impact the species; (6) historical and current seagrass trends and status; (7) ongoing or planned efforts to protect and restore the species and its seagrass habitats; (8) management, regulatory, and enforcement information; and, (9) any other biological information on the species. NMFS considered relevant information submitted by the public in response to the petition finding. The draft status review was submitted to 3 independent peer reviewers. Comments and information received from peer reviewers were addressed and incorporated as appropriate before finalizing the review. The peer review report is available at: https://www.cio.noaa.gov/services_programs/prplans/ID411.html

2 ESA OVERVIEW

An ESA listing determination assesses the status of a “species,” defined to include subspecies and, for any vertebrate species, any distinct population segment (DPS) that interbreeds when mature (16 U.S.C. 1532(16)). A joint NMFS-U.S. Fish and Wildlife Service (FWS) (jointly, “the Services”) policy (DPS Policy) clarifies the agencies’ interpretation of the phrase “distinct population segment” for the purposes of listing, delisting, and reclassifying a species under the ESA (61 FR 4722; February 7, 1996). A species, subspecies, or DPS is “endangered” if it is in danger of extinction throughout all or a significant portion of its range, and "threatened" if it is likely to become endangered within the foreseeable future throughout all or a significant portion of its range (ESA Sections 3(6) and 3(20), respectively; 16 U.S.C. 1532(6) and (20)). Pursuant to the ESA and our implementing regulations, NMFS determines whether species are “threatened” or “endangered” because of any of the following five factors listed in ESA Section 4(a)(1): the present or threatened destruction, modification, or curtailment of habitat or range; overutilization for commercial, recreational, scientific, or educational purposes; disease or predation; inadequacy of existing regulatory mechanisms; and any other natural or man-made factors affecting the species' existence (16 U.S.C. 1533(a)(1); 50 CFR 424.11(c)). The ESA stipulates that listing determinations should be made on the basis of the best scientific and commercial information available. To conduct a comprehensive review of dwarf seahorse, we considered information received in response to the 90-day finding, reviewed information from published and unpublished reports, and communicated directly with researchers working with dwarf seahorse and its habitat. This Status Review summarizes the best available scientific and commercial information.

3 LIFE HISTORY AND ECOLOGY

3.1 Taxonomy and Anatomy

Seahorses are bony fishes (Class Osteichthyes) most closely related to pipefishes and sticklebacks. The current, valid taxonomic name for dwarf seahorse is *Hippocampus zosterae* (Jordon and Gilbert 1882). Another common name for dwarf seahorse is pigmy seahorse (Strawn 1958). The dwarf seahorse is distinguishable from other seahorses by its small size (generally less than 5 centimeters [cm] total length [TL]) and fin ray count (usually 12 dorsal fin rays) (Gill 1905; Ginsburg 1937; Jordon and Gilbert 1882; Koldewey 2005; Vari 1982). The dwarf seahorse has 9 to 10 trunk rings and 11 or 12 pectoral fin rays (Figure 1) (Lourie et al. 2004).

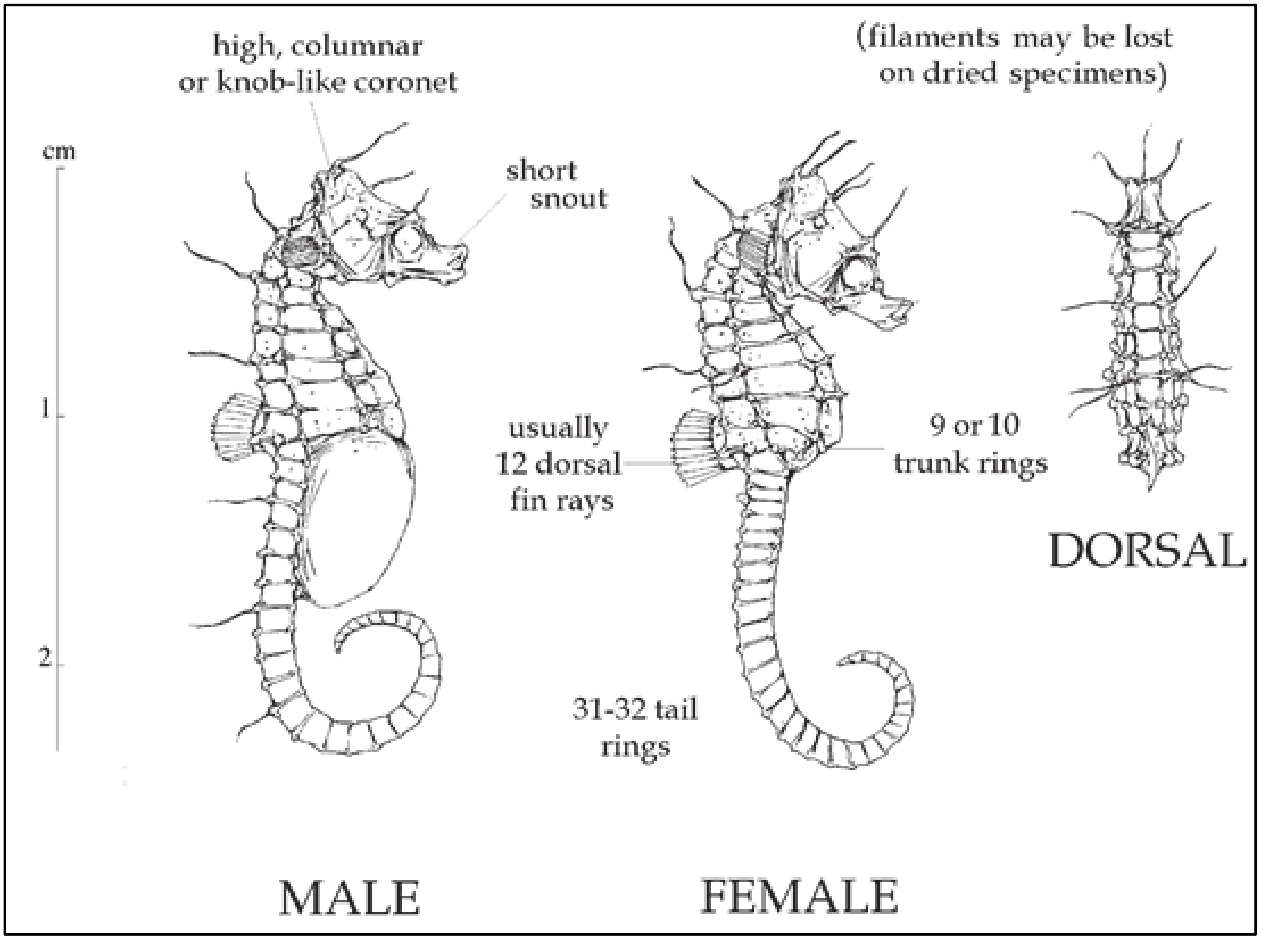


Figure 1. Descriptive illustration of the dwarf seahorse anatomy (Lourie et al. 2004).

The snout of this species is short (less than one third of the head length) and the coronet (bony projection on the top of the head) is high and columnar (Koldewey 2005; Lourie et al. 2004; Lourie et al. 1999). Males generally have longer snouts and tails than females (Lourie et al. 2004). Dwarf seahorse have a wide range of color patterns from yellow and green to black. Individuals may also have white markings or dark spots which aid in camouflage while inhabiting seagrass (Gill 1905; Lourie et al. 2004; Lourie et al. 1999; Vari 1982). Like all seahorses, the tail of the dwarf seahorse is prehensile (capable of grasping) and used to secure the animal to seagrass or floating marine vegetation in the water (Gill 1905; Walls 1975) and the eyes move independently of one another, allowing for better accuracy during feeding (Gill 1905). Dwarf seahorse move through the water not with speed, but with maneuverability, using distinctive motions of its dorsal and pectoral fins (Consi et al. 2001). The swim bladder plays a crucial role in vertical stability (Azzarello 1990; Gill 1905).

3.2 Range, Habitat Use, and Migration

In the United States, dwarf seahorse have historically been found in Texas, Louisiana, Mississippi, Alabama, and Florida (Strawn 1958). This species has also been recorded in Mexico and the greater Caribbean, including The Bahamas, Bermuda, and Cuba (Bruckner et al. 2005; Lourie et al. 2004).

Dwarf seahorse occur almost exclusively in seagrasses, though showing no particular affinity for a specific seagrass species (Masonjones et al. 2010) and not appearing to have any habitat preference for eelgrass (*Zostera* species) as originally described in Jordon and Gilbert (1882). Dwarf seahorse have a patchy distribution and are generally found in areas with higher density of seagrass blades (i.e., moderate seagrass coverage) and higher seagrass canopy (i.e., length of seagrass blades) (Lourie et al. 2004). For example, in Tampa Bay, Florida, dwarf seahorse were collected in areas with 53.2-224.0 blades per 0.1 square meter (m^2) and an average seagrass height between 27.5-66.7 cm (Masonjones and Rose 2009). Similarly, Sogard et al. (1987) found a positive correlation between seagrass blade density (ranging from 1,757-2,903 blades per m^2) and dwarf seahorse density (ranging from 0.03-0.86 dwarf seahorse per m^2). In Texas, dwarf seahorse were found in seagrass beds with a mean blade length of 14.9 cm, 41.3 shoots per coring sample, and 2.8 blades per shoot, equaling 115.6 blades per 0.8 m^2 samples (Tolan et al. 1997).

Dwarf seahorse are typically found in shallow coastal and lagoon seagrass habitats during the summer (Musick et al. 2000; Robbins 2005; Strawn 1961; Tipton and Bell 1988; Walls 1975) and deeper waters or tide pools during the winter (Lourie et al. 2004). In their review paper, Foster and Vincent (2004) reported the maximum recorded depth for the dwarf seahorse as 2 meters (m). Dwarf seahorse are found within a range of salinities (7-37) and temperatures (14-32^{o}C) depending on geographic location and time of year (Ryan Moody, Dauphin Island Sea Lab, pers. comm. to Kelcee Smith, Riverside, Inc., on July 17, 2012; Masonjones and Rose 2009; Masonjones et al. 2010; Mark Fisher, Texas Parks & Wildlife Dept., pers. comm. to Kelcee Smith, Riverside, Inc., on July 12, 2012; Mike Harden, Louisiana Dept. of Natural Resources, pers. comm. to Kelcee Smith, Riverside, Inc., July 24, 2012). However, aquarium husbandry considers dwarf seahorse to be a tropical species and recommends water temperatures of 20-22^{o}C (Koldewey 2005).

Like other seahorses, dwarf seahorse have limited active dispersal (Vincent 1995). During a 12-week study, dwarf seahorse were found to move an average of 3.16 ± 0.64 m per day and of those recaptured, 29.6% were found at an adjacent site (Masonjones et al. 2019). Several species of seahorses are believed to disperse larger distances via passive dispersal through rafting which occurs as seagrass holdfasts (roots) break loose from the substrate and are carried by ocean currents (Fedrizzi et al. 2015; Foster and Vincent 2004). Juvenile and adult dwarf seahorses may also disperse by drifting through the water column attached to drifting macroalgae (Vari 1982; Masonjones et al. 2010)—a method of passive dispersal as noted for other seahorses (Fish and Mowbray 1970; Foster and Vincent 2004; Luzzatto et al. 2013). Dispersal of juveniles via water currents has been suggested for cape seahorse (*H. capensis*) (Whitfield 1995) and has been observed in aquaria for juvenile common seahorse (*H. kuda*) (Mi et al. 1998) and tiger snout seahorse (*H. subelongatus*) (Lawrence 1998). It is likely dwarf seahorse also transport by floating, potentially in association with debris, which would result in the colonization of new areas, allowing for gene flow in the population (Fedrizzi et al. 2015; Vincent 1995).

In general, dwarf seahorse habitat is characterized by shallow, warm, nearshore seagrass beds. These habitats often occur within sheltered lagoons or embayments with reduced exposure to strong currents and heavy wave action (Iverson and Bittaker 1986). Long range dispersal may occur but is limited due to the species low mobility, small home range, and high site fidelity (Fedrizzi et al. 2015). Passive dispersal through rafting associated with drifting seagrass or macroalgae is likely responsible for any long range dispersal (Vari 1982; Masonjones et al. 2010; Fedrizzi et al. 2015).

3.3 Diet and Feeding

Seahorses are ambush predators, feeding on harpacticoid copepods and amphipods (both very small crustaceans measuring only a few millimeters in length) as they drift along the edges of seagrass beds (Huh and Kitting 1985; Tipton and Bell 1988). No seasonal changes have been reported in the diet of dwarf seahorse (Tipton and Bell 1988). Dwarf seahorse produce a stridulatory sound (a “click”) from the articulation of the supraoccipital and coronet bones in the skull during feeding, and it has been shown that dwarf seahorse click 93% of the time during feeding in a new environment, or during competition for mates (Colson et al. 1998).

3.4 Age and Growth

Dwarf seahorse are one of the smallest species of seahorse. Aquarium-raised dwarf seahorse have been recorded at 0.7-0.9 cm TL at birth and growing to 1.8 cm TL by day 17 (Koldewey 2005). There is some discussion regarding the maximum size of adults. Colson et al. (1998) reported adult dwarf seahorse 3.4-4.7 cm TL, Lourie et al. (2004) reported the species reaches 2.5 cm TL, Bruckner et al. (2005) reported adults 2.0-3.0 cm TL, Koldewey (2005) reported adults 4.4-4.7 cm TL and Rose et al. (2019) reported males up to 5.2 cm TL. A single male specimen caught at Fort De Soto, Florida, was reported as 5.4 cm standard length (Masonjones, University of Tampa, pers. comm. to Kelcee Smith, Riverside, Inc., on July 17, 2013). Masonjones et al. (2010) indicated body size was highly correlated with season; individuals born in the Florida wet season (June-September) were larger than those born in the dry season as warmer water temperatures result in rapid offspring growth (Rose et al. 2019). Dwarf seahorse are a short-lived species. The species rarely lives longer than 2 years in the wild (Koldewey 2005; Strawn 1958; Vari 1982) and up to 3 years within aquaria (Abbott 2003).

3.5 Reproductive Biology

Dwarf seahorse reach reproductive maturity at approximately 3 months of age (Strawn 1953; Strawn 1958; Koldewey 2005) and exhibit gender-specific roles in reproduction (Masonjones and Lewis 1996; Masonjones and Lewis 2000; Vincent 1994). Dwarf seahorse are generally monogamous (the practice of an individual having one mate) within a breeding season, although captive populations with high male densities display a flexible mating system with males and females courting a range of mates (Masonjones and Rose 2019). Mates are chosen by similarity in size (Jones et al. 2003; Wilson et al. 2003); dwarf seahorse will reject a potential mate if the size difference is too large (Masonjones and Lewis 1996). Once bonded, the mating pair remains together throughout a 3-day courtship ritual. After successful courtship, the female deposits unfertilized eggs into the male's brood pouch. In the brood pouch, eggs are fertilized and the embryos are nourished, osmoregulated (the body fluid balance and concentration of salts is kept stable), oxygenated (by circulating water), and protected (Jones et al. 2003; Vincent 1995a; Wilson et al. 2003; Wilson and Vincent 2000). Strawn (1958) reported a maximum number of 69 eggs found in the ovaries of a female and up to 55 young counted in the pouch of a male. Masonjones and Lewis (1996) found that males give birth to an average of 3-16 offspring per brood. Males in captivity usually give birth to fewer individuals compared to males in the wild (Masonjones et al. 2010). Throughout gestation (10-12 days; Masonjones and Lewis 2000) the female greets the male daily and the pair remains in close proximity (Jones et al. 2003; Vincent 1995; Wilson and Vincent 2000). Masonjones and Lewis (2000) reported the potential number of offspring that male and female dwarf seahorse could produce over the breeding season were 279.5 and 240.5 individuals, respectively. This difference in potential offspring between the two sexes is a result of latency as males are faster to respond to new potential mates if the pair bond is disrupted (one dies or is removed).

Genetic studies indicate that dwarf seahorse do not reproduce outside their pair bond, even if receptive mates are available (Masonjones and Lewis 1996; Masonjones and Lewis 2000; Rose et al. 2014). Rose et al. (2014) developed 8 novel microsatellites for the dwarf seahorse to conduct genetic parentage analysis to confirm that the species is monogamous. Using 4 selected loci from 16 pregnant males, the offspring were genotyped within each male's brood to determine the maternal contribution. A maximum of 4 alleles per locus segregating within each pregnant male's brood was found, a pattern consistent with each brood having exactly 1 mother and 1 father which confirms dwarf seahorse are monogamous within a mating cycle (Rose et al. 2014).

Dwarf seahorse exhibit iteroparity (multiple reproductive cycles) throughout the breeding season (Masonjones and Lewis 1996; Masonjones and Lewis 2000; Rose et al. 2014). Following the transfer of eggs, the female begins developing new eggs for the next clutch (Masonjones and Lewis 1996; Masonjones and Lewis 2000). Egg development is achieved in two days but the female is only sexually receptive for a few hours following development and is "essentially incapable of mating before the end of their previous mating partner's gestation period" (Masonjones and Lewis 2000). Under ideal conditions, the male can mate 4-20 hours after giving birth, allowing dwarf seahorse pairs to produce up to 2 broods per month (Masonjones and Lewis 2000; Strawn 1958; Vari 1982). If the female dies or is removed during gestation, the male will give birth to that clutch before finding a new mate. If a pregnant male (a male carrying fertilized eggs) dies or is removed, the female will not mate until the gestation for the interrupted pregnancy would have been complete (Masonjones and Lewis 2000).

Dwarf seahorse breeding season is generally protracted and is influenced by day length and water temperature (Koldewey 2005; Masonjones and Lewis 2000; Strawn 1958; Vari 1982). Breeding occurs year-round at latitudes south of approximately 28ºN (Rose et al. 2019). During the summer months, when the day length is longer and water temperature exceeds 30ºC, dwarf seahorse reproduce more frequently because gestation is shorter (Fedrizzi et al. 2015; Foster and Vincent 2004). For example, in Tampa Bay, Florida pregnant males are found in all months but are more abundant early summer through fall (Rose et al. 2019). Year round reproduction was also observed in the Florida Keys based on anecdotal reports from commercial collectors (FWC 2016).

4 POPULATION STRUCTURE

Fedrizzi et al. (2015) investigated dwarf seahorse population genetic structure at 8 Florida locations: 1 in the Panhandle, 2 adjacent to Tampa Bay, 4 in the Florida Keys, and 1 in Indian River Lagoon. The study found significant population structuring with strong evidence for a distinct population in the Panhandle, 2 recognizable sub-populations in the Florida Keys, and a potential fourth sub-population at Big Pine Key. Dwarf seahorse from the Indian River Lagoon were not delineated as a discrete population due to small sample size and lack of consistency in relationship to the other populations. Despite overall significant population structuring, Fedrizzi et al. observed evidence of some gene flow between sampled locations, with the exception of the Florida Panhandle. The results suggest that the populations of Florida's dwarf seahorse that are closest to each other are more genetically similar than those populations that are further apart. Interestingly, the distance between the sites sampled by Fedrizzi et al. is greater than the distance over which Florida's dwarf seahorse have been shown to actively migrate (Masonjones et al. 2019). Thus, genetic connectivity between populations is more likely the result of individuals dispersing to neighboring populations through rafting.

5 DEMOGRAPHY

Population growth rates are not well known for seahorses overall (Foster and Vincent 2004). Carlson et al. (2019) developed a population viability model for dwarf seahorse based on known life history parameters (Table 1). A deterministic age structured life table was developed for 3 age classes of male dwarf seahorse: Age-0 (from birth to just before 1 year old), Age-1, and Age-2. Three age classes were used to account for the uncertainty in maximum age. Traditionally, females are modeled in age structured life tables; however, males were modeled because males carry the fertilized eggs in a brood pouch, nourish them throughout gestation, and give birth. Adult survival rates from mark-recapture experiments and a Cormack-Jolly-Seber model were used to calculate an annual survival rate for male Age-1 and Age-2 dwarf seahorse. Based on the sampling by Masonjones et al. (2019), annual adult survival rate was calculated as 38.3% yr^{-1}. As there are no estimates of natural mortality (M) for Age-0 dwarf seahorse, the instantaneous rate of natural mortality (converted to survivorship) was estimated as the average of multiple indirect life history methods to incorporate the range of mortality mechanisms (e.g. temperature-dependent, age-scheduling, weight). Fecundity was the mean number of male offspring (assuming a 1:1 ratio of males to females) per year taken from Masonjones and Lewis (2000).

Using this information, the estimate of population growth (λ) for dwarf seahorse was 1.46 yr^{-1}. The intrinsic rate of population increase (r) was 0.38 yr^{-1}, calculated assuming the finite rate of population increase (λ) is analogous to er=λ. The estimates of the expected number of replacements (Ro) and generation time (T) were 1.60 and 1.24 yr, respectively. Nearly 99% of the stable age distribution was Age-0, reflecting the high mortality rates for this age class.

Table 1. Life History Parameters Used to Develop a Dwarf Seahorse Demographic Model. Numbers in parenthesis are the standard deviation of the mean.

Parameter	Value
Age-at-maturity	0.3 years
Maximum age (years)	2 years
Fecundity	130.2 offspring per year
Survivorship:	--
Age 0	0.00888 year (0.01127)
Age 1+	0.383 year (0.01)

6 DISTRIBUTION AND ABUNDANCE

In order to provide a better understanding of dwarf seahorse distribution and abundance, we: (1) conducted an extensive search of peer-reviewed scientific publications and technical reports; (2) contacted foreign governments, scientific agencies, educational institutions, and individual researchers to request relevant information or survey data from unpublished and published sources (cited as personal communications [pers. comm.]); and, (3) searched the Global Biodiversity Information Facility Database (GBIF) for records associated with museum specimens. Close examination of the data in the GBIF revealed that some records may have been made in error given the length of a specimen exceeded the species' maximum size or the species' nomenclature preceded classification. Further, the GBIF does not guarantee the accuracy of the biodiversity data served through its portal and web services. Because of the uncertainty in these data, we only used specimen records provided in a review conducted by the Florida Fish and Wildlife Conservation Commission (FWC) that limited records to include the period after the species was described and verified via dorsal fin ray counts (Ed Matheson, FWC, pers. comm. to Calusa Horn, NMFS PRD, on December 12, 2012). While records associated with museum specimens do not provide a clear account of abundance, they do inform presence or absence over time.

In general, dwarf seahorse records have occurred in the United States Gulf of Mexico and south Atlantic coasts, Mexico, Cuba, The Bahamas, and Bermuda since the beginning of the twentieth century. Throughout this time period, the species has remained most common in Florida, specifically west Florida from Tampa Bay to The Florida Keys. Several studies also indicated moderate occurrences in south Texas (Bruckner et al. 2005; Matlock 1992). Since the 1970s, dwarf seahorse populations are described to have steadily decreased due to loss of habitat and are noted as rare in parts of its former range (Koldewey 2005; Musick et al. 2000).

Records of dwarf seahorse distribution and abundance are detailed in Table 2 and sections below. It is unlikely that the dwarf seahorse ever fully occupied the northern Gulf of Mexico due to winter water temperatures below the species optimal range and the general lack of available seagrass habitat as compared to Florida and south Texas (Handley et al. 2007). Further, seagrasses in the northern Gulf of Mexico are restricted by a combination of physical disturbances associated with tropical weather systems, depressed local salinities associated with flood events (Eleuterius 1987; Handley et al. 2007; Pham et al. 2014; Stout and LeLong 1981), and an overall decline in water quality resulting from human impacts (Handley et al. 2007; Pham et al. 2014). Because dwarf seahorse are found nearly exclusively in seagrasses (Musick et al. 2000; Robbins 2005; Strawn 1961; Tipton and Bell 1988; Walls 1975) and abundance has been observed to increase with seagrass canopy height and blade density (Bruckner et al. 2005; Lourie et al. 2004), each section contains information describing seagrass habitat availability (See also Section 7, "Seagrass Habitat Status and Trends").

Table 2. Population estimates of dwarf seahorse

Location	Mean population estimate (95% CI)
Florida*	24,686,648
Cedar Key	30,516 (18,534 – 42,498)
Tampa Bay	2,023,224 (1,548,606 – 2,497,844)
Charlotte Harbor	2,527,572 (1,895,442 – 3,159,702)
Florida Bay	19,821,504 (15,613,150 – 24,029,858)
Indian River Lagoon	283,832 (103,342 – 464,322)
Alabama	Absent
Mississippi	Absent
Louisiana	Rare
Texas	Present in low abundance
Mexico	Present in unknown abundance
Cuba	Unknown
The Bahamas	Unknown
Bermuda	Possibly extirpated

CI: Confidence Interval

*From Carlson et al. (2019) retrospective abundance analysis for males in 2016 and doubled for total abundance (see Figure 5 for trends).

6.1 Florida

FWC collects a variety of information on many species found in marine and estuarine habitats and in 1996 established a Fisheries-Independent Monitoring survey (hereafter referred to as the FWC FIM survey or surveys) which uses a stratified-random sampling design to sample and monitor population trends. The FWC FIM survey uses seines (21.3 m in length) in shallow water (0.3-1.3 m) and otter trawls (6.1-m mouth opening) in deeper water (1.8-7.6 m). Surveys are conducted monthly in 7 estuarine regions around Florida: Northeast Florida, Indian River Lagoon, Charlotte Harbor, Sarasota Bay, Tampa Bay, Cedar Key, and Apalachicola Bay (http://myfwc.com/research/saltwater/fish/research/fim-stratified-random-sampling/; accessed January 15, 2016) (Figure 2). FWC conducted additional, shorter-term FIM surveys in other estuaries of the state including St. Andrews Bay, the Big Bend area, and Florida Bay (including the Florida Keys National Marine Sanctuary). Survey data were used to create indices of abundance to analyze trends by estuary (Figure 3). FWC FIM surveys have collected dwarf seahorse from 9 of the 10 estuaries sampled (Figure 3). FWC FIM surveys are not designed to target dwarf seahorse; therefore the data should be interpreted with caution in regard to abundance (FWC 2016). It is clear however that the small seines capture dwarf seahorse more often and in higher quantities than the FWC otter trawls. The exception to this can be seen in Florida Bay samples in which the trawl was equally successful in capturing dwarf seahorse. It should be noted however that trawling in Florida Bay was conducted in depths beginning as shallow as 1 meter whereas trawling in the other estuaries was only conducted in waters 1.8 meters and deeper. Differences in catch per unit effort (CPUE) between gear types is likely a reflection of dwarf seahorse habitat preference for shallow water (<2.0 meters) as noted by Foster and Vincent (2004).

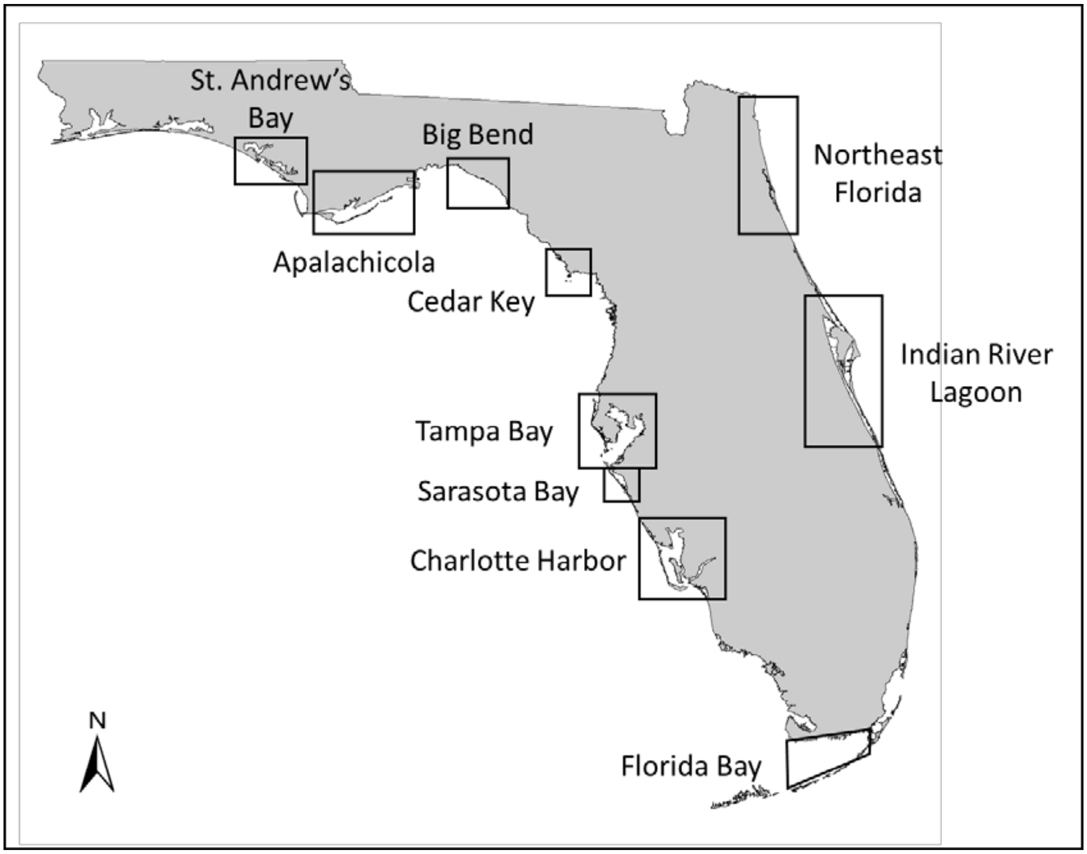


Figure 2. Locations of FWC Fishery-Independent Monitoring surveys.

Due to the large amount of data associated with the presence of dwarf seahorse across the state of Florida, we grouped distribution and abundance into 5 Regions: 1) Northeast (St. Johns River south to Jupiter Inlet), 2) South (Biscayne Bay on east coast and through the Florida Keys and Everglades National Park on the west coast), 3) Central (Charlotte Harbor north to Tampa Bay), 4) Big Bend (Cedar Key north to Apalachee Bay), and 5) Panhandle (Apalachicola Bay west to Perdido Bay). Information regarding dwarf seahorse distribution and abundance are detailed by each Florida Region below. The peer-reviewed scientific literature and technical reports, museum records, and anecdotal information (cited as pers. comm.) for each region are listed in tables within the region's section.

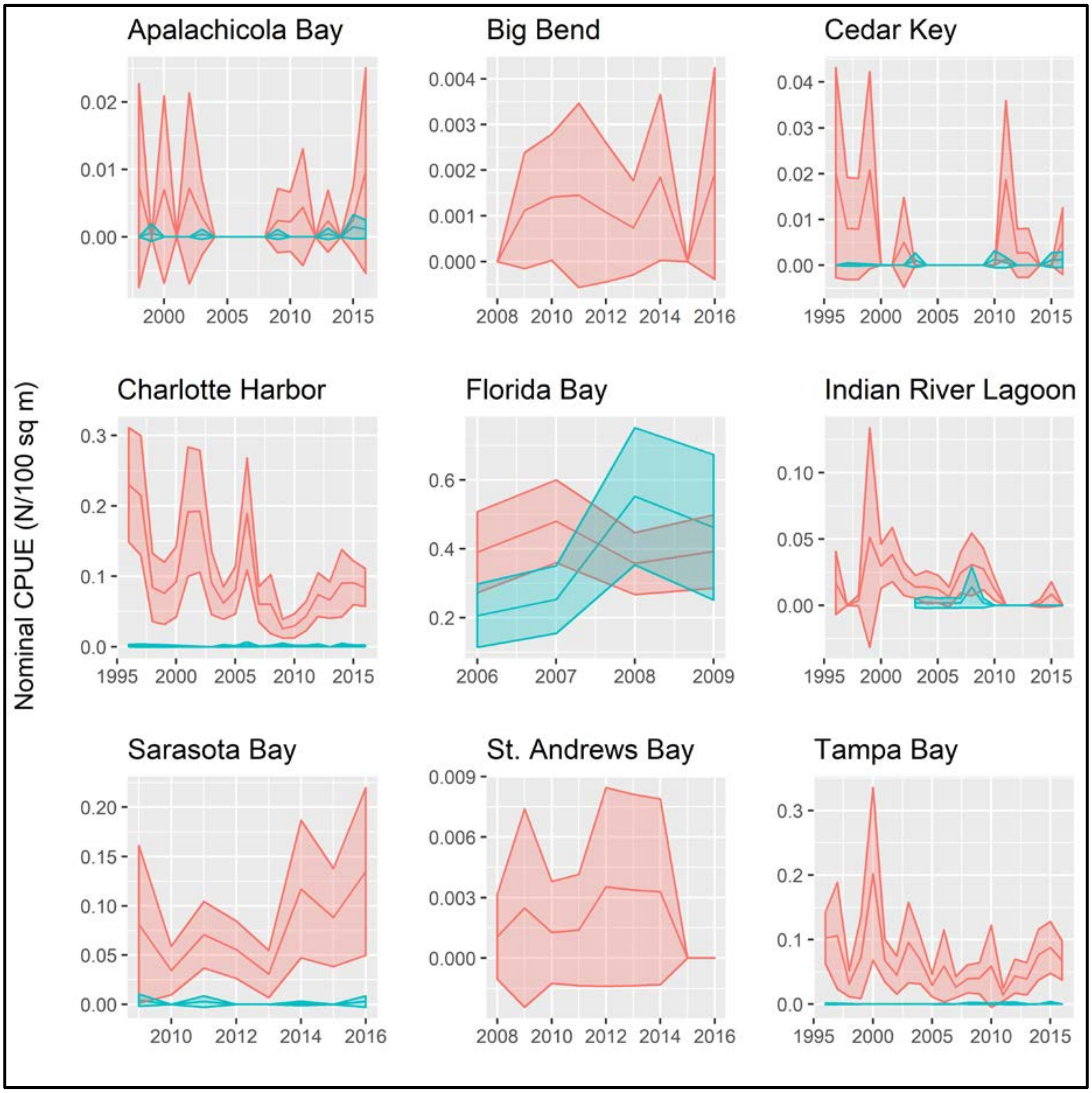


Figure 3. Long-term indices of abundance (#/100m^2) of dwarf seahorse from FWC FIM trawl (blue) and small seine (red) surveys.
Shaded areas represent the 95% confidence band.

Florida Northeast Region (St. Johns River to Jupiter Inlet)

The Florida Northeast Region of the species' range spans from the St Johns River south to Jupiter Inlet along the Atlantic Ocean coast of Florida and includes 3 interconnected estuarine lagoons: Mosquito Lagoon, Indian River Lagoon, and Banana River Lagoon (SFWMD 1994). This region includes FWC FIM surveys in Northeast Florida and Indian River Lagoon (Figure 2). The Indian River Lagoon extends approximately 155 miles through 6 coastal Florida counties from Ponce de Leon Inlet in Volusia County south to Jupiter Inlet in Palm Beach County. In the Indian River Lagoon, the FWC FIM survey data show that dwarf seahorse relative abundance has been low and variable over time, but depressed or absent since 2010 (Figure 3; Data provided by FWC 2017). Dwarf seahorse were not collected in the FWC FIM survey of Northeast Florida.

The absence of dwarf seahorse in the FWC FIM survey of the Indian River Lagoon from 2011 to 2014 is likely correlated with a harmful algal bloom (HAB) that began in 2011 and was larger than any past events in terms of geographic scale, bloom intensity, duration, and seagrass loss (SJRWMD 2012). Seagrasses in the lagoon are mapped using aerial photography every 2-3 years and surveyed visually twice per year. The 2011 seagrass coverage in the Indian River Lagoon estuary was reduced by 60%, or about 47,000 acres overall, when compared to seagrass coverage in 2010 (SJRWMD 2012). Similarly, FWC's Seagrass Integrated Mapping and Monitoring (SIMM) program reported seagrass coverage declined by almost 2,000 acres between 2009 and 2011 in the southern Indian River Lagoon (Robbins et al. 2016). These declines were followed by increases in seagrass coverage throughout the Indian River Lagoon between 2011 and 2013 (Robbins et al. 2016, Morris et al. 2016).

Florida South Region (Biscayne Bay to Everglades National Park)

The Florida South Region runs from Biscayne Bay on the east coast of Florida through the Florida Keys and into Everglades National Park on the west coast of Florida. Dwarf seahorse records within the Florida South Region, 1884-2011, are summarized in Table 3. Most of the surveys listed were conducted to estimate overall fish abundance and did not specifically target dwarf seahorse; however, collectively these records indicate the presence of dwarf seahorse in the Florida South Region over several decades.

Table 3. Summary of Dwarf Seahorse Records for the Florida South Region, 1884-2011

Year	Number	Area	Source
1884	16	Key West	Ginsburg (1937)
1896	3	Cape Florida, Biscayne Bay	Ginsburg (1937)
1906	3	Bonefish Banks, Biscayne Bay	Ginsburg (1937)
1937	3	Biscayne Bay	Ginsburg (1937)
1953	7	Key Largo	Strawn (1958)
1958	Present	Alligator Reef	Vari (1982)
1963	19	Biscayne Bay	Roessler (1965)
1963-65	43	Everglades National Park	Roessler (1970)
1964-66	626	Everglades National Park	Tabb and Roessler (1989)
1968-73	Present	Biscayne Bay	Roessler et al. (2002)
1972-73	Present	Card Sound	Brook (1977)
1973-76	160	Florida Bay	Schmidt (2002)
1980s	116	Florida Bay	Matheson Jr. et al. (1999)
1984-85	74	Western Florida Bay	Thayer and Chester (1989)
1984-85	398	Florida Bay	Sogard et al. (1987)
1990s	61	Florida Bay	Matheson Jr. et al. (1999)
1993-94	42	Biscayne Bay	Serafy et al. (1997)
1996-97	93	Key Largo	Masonjones (2001)
1998	9	Card Sound	Colson et al. (1998)
2000-01	Present	Northern Florida Bay	Powell et al. (2002)
2001	12	Biscayne Bay	Ault et al. (2001)
2003	44	Card Sound	Masonjones (pers. comm.)[1]
2003	30	Long Key to Bahia Honda Channel	Masonjones (pers. comm)[1]
2006	12	Biscayne Bay	Joan Browder (NMFS)[2]
2007	5	Biscayne Bay	Joan Browder (NMFS)[2]
2008	23	Biscayne Bay	Joan Browder (NMFS)[2]
2009	13	Biscayne Bay	Joan Browder (NMFS)[2]
2010	18	Biscayne Bay	Joan Browder (NMFS)[2]
2011	14	Biscayne Bay	Joan Browder (NMFS)[2]
2006-09	978	Northeast Florida Bay	Flaherty-Walia et al. (2013)

Source for data is indicated and records are organized in chronological order. Number indicates number of individuals collected. “Present” indicates the species was reported, but the number of individuals was not provided. [1]pers. comm. to Calusa Horn, NMFS PRD, on June 8, 2013. [2]pers. comm. to Kelcee Smith, Riverside, Inc., on February 27, 2015.

A 1963 trawl survey in Biscayne Bay collected 19 dwarf seahorse (Roessler 1965). Otter trawl surveys conducted in the southern portion of Everglades National Park from September 1964 to February 1966 collected 626 dwarf seahorse (Tabb and Roessler 1989). Surveys in southern Biscayne Bay and Card Sound, 1968-1973, captured dwarf seahorse, but did not report specific capture information (Roessler et al. 2002). Brook (1977) references the capture of dwarf seahorse in Card Sound in 1972 and 1973 using a suction dredge. Using data from the mid-1970s, Schmidt (2002) reported 160 dwarf seahorse collected from Everglades National Park and

Florida Bay with abundance fluctuating from 0.43% of the biomass composition in 1974-1975 to 0.02% of the biomass composition in 1975-1976.

In the 1980s and through the early 2000s, Matheson Jr. et al. (1999) examined changes in resident fauna and reported 116 dwarf seahorse prior to (1984-1986), and 61 following an extensive seagrass die-off event in the greater Florida Bay area (1994-1996). A fish assemblage study conducted in Biscayne Bay, 1993-1994, collected a total of 42 dwarf seahorse (Serafy et al. 1997). In 1998, a study investigating the production of sound by *Hippocampus* spp. collected nine dwarf seahorse in Card Sound (Colson et al. 1998). Twelve dwarf seahorse were collected in Biscayne Bay in 2001 during an assessment and characterization of fisheries and habitat (Ault et al. 2001). Powell et al. (2002) reported dwarf seahorse as one of the five dominant small resident species collected during a red drum (*Sciaenops ocellatus*) survey using cast nets and trawls (0.07 seahorse/100 cubic meters [m^3] and 5.85 dwarf seahorse/100 m^3, respectively). In 2003, 44 dwarf seahorse were captured in Card Sound with densities ranging from 0.00-0.82 m^2 and 30 dwarf seahorse were collected between Long Key to Bahia Honda Channel at densities ranging between 0.0-0.56 per m^2 (Heather Masonjones, University of Tampa, pers. comm. to Calusa Horn, NMFS PRD, on June 7&8, 2013).

From 2005 to 2009, the USGS surveyed portions of Everglades National Park and Florida Bay resulting in annual averages of 240 and 120 dwarf seahorse, respectively (Mike Robblee, USGS, pers. comm. to Kelcee Smith, Riverside, Inc.). Surveys by the USGS in Biscayne Bay and Florida Bay, 2005-2011, suggest that the species was relatively stable (annual average of 210 dwarf seahorse in Biscayne Bay). While dwarf seahorse collections are rare, this species is more abundant in Biscayne Bay and Florida Bay than the Florida southwest coast (Figure 4) which is likely due to the former systems having more available seagrass habitat than the latter (Mike Robblee, USGS, pers. comm. to Kelcee Smith). See also Section 7, “Seagrass Habitat Availability.”

The FWC FIM survey collected a total of 978 dwarf seahorse during seasonal (wet vs. dry) sampling of Florida Bay between 2006 and 2009 (Flaherty-Walia 2013; Figure 3). The FWC FIM survey has not been conducted in the Florida South Region since 2009 (FWC 2016).

Epifaunal surveys (surveys of animals that live on the sea floor) conducted by NOAA Fisheries in southern Biscayne Bay have documented the species annually from 2007-2011 (Joan Browder, NMFS Miami Laboratory, pers. comm. to Kelcee Smith, Riverside, Inc., on February 27, 2015). A harmful algal bloom (HAB) occurred in Biscayne Bay and Card Sound in 2013 (Morgan 2013), and in October 2015 a HAB began in Florida Bay (Staletovich 2015). Although the general status of seagrasses in Florida Bay is considered fairly stable and has remained remarkably stable over the past 25 years, unusually hot and dry conditions in summer 2015 resulted in seagrass die-off in Rankin Lake and Johnson Key Basin. The extent of the die-off and assessment of the potential for further losses are under investigation (FWC 2016; Yarbro and Carlson 2016).

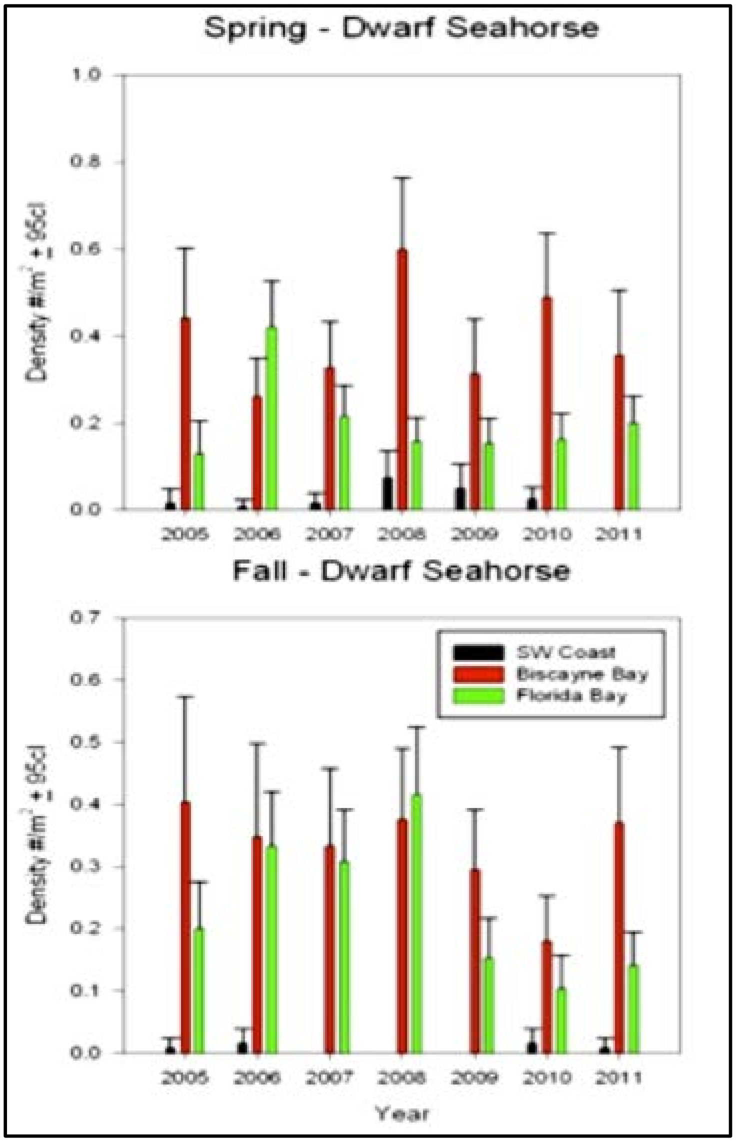


Figure 4. USGS seasonal survey data showing density of the dwarf seahorse in Florida South Region collected during spring (top graph) and fall (bottom graph) 2005-2011.

Florida Central Region (Charlotte Harbor to Tampa Bay)

The Florida Central Region portion of the species' range is from Charlotte Harbor to Tampa Bay. Dwarf seahorse records within the Florida Central Region, 1930-2011, are summarized in Table 4. Most of the surveys listed were conducted to estimate overall fish abundance and did not specifically target dwarf seahorse; however, collectively these records indicate the presence of dwarf seahorse in the Florida Central Region over several decades.

Table 4. Summary of Dwarf Seahorse Records from the Florida Central Region, Florida, 1930-2011

Year	Number	Area	Source
1930	3*	Tampa Bay	Ed Matheson (FWC)[1]
1935	3*	Tampa Bay	Ed Matheson (FWC)[1]
1936	1*	Tampa Bay	Ed Matheson (FWC)[1]
1938	3*	Tampa Bay	Ed Matheson (FWC)[1]
1939	10*	Tampa Bay	Ed Matheson (FWC)[1]
1939	2	Palmetto Key, Charlotte Harbor	Breder Jr (1940)
1940	4	Boca Grande	Fowler (1940)
1957	21*	Tampa Bay	Ed Matheson (FWC)[1]
1958	20*	Tampa Bay	Ed Matheson (FWC)[1]
1959	3*	Tampa Bay	Ed Matheson (FWC)[1]
1960	Present	Boca Ciega Bay	Vari (1982)
1960	< 20	Lemon Bay	Breder Jr (1962)
1964	1*	Tampa Bay	Ed Matheson (FWC)[1]
1965	4*	Tampa Bay	Ed Matheson (FWC)[1]
1969	3*	Tampa Bay	Ed Matheson (FWC)[1]
1968	1	Charlotte Harbor	Wang and Raney (1971)
1969	2	Charlotte Harbor	Wang and Raney (1971)
1971	1*	Tampa Bay	Ed Matheson (FWC)[1]
1972	1	Old Tampa Bay	Lindall et al. (1975)
1984	87	Tampa Bay	Tipton and Bell (1988)
1984	Present	Egmont Key, St. Petersburg	Azzarello (1990)
1985	Present	Egmont Key, St. Petersburg	Azzarello (1990)
1986	Present	Egmont Key, St. Petersburg	Azzarello (1990)
2002	16	Sarasota Bay	Serviss and Sauers (2003)
2004	1	Fort Desoto	Masonjones (pers. comm.)[2]
2004	1	Anclote River Estuary	Greenwood et al. (2006)
2004	6	Caloosahatchee River	Robbins (2005)
2005	53	Caloosahatchee River	Robbins (2005)
2005-07	922	Tampa Bay	Masonjones et al. (2010)
2006-08	894	Tampa Bay	Masonjones and Rose (2009)
2008-09	891	Tampa Bay	Masonjones and Rose (2009)
2009-10	17	Lemon Bay Estuary	Stevens et al. (2010)
2010-11	69	Tampa Bay	Masonjones (pers. comm.)[2]

Source for data is indicated and records are organized in chronological order. Number indicates number of individuals collected. “Present” indicates the species was reported, but the number of individuals was not provided. * indicates museum records. [1]pers. comm. to Calusa Horn, NMFS PRD, on December 12, 2012. [2]pers. comm. to Calusa Horn, NMFS PRD, on June 8, 2013.

Recent studies provide quantitative data regarding dwarf seahorse abundance in the Florida Central Region. In Sarasota Bay, a study directed at assessing habitat for juvenile estuarine fishery species was conducted February through June of 2002; dwarf seahorse ranked 42 out of 71 most common species collected (Serviss and Sauers 2003). Masonjones et al. (2010) conducted a study of dwarf seahorse in Tampa Bay and found mean densities across sampling areas were 0.08 N/m^2 for the years 2005-2007 (range = 0.02-0.18 N/m^2). However, these density estimates are likely inflated as the sampling site was selected because of its robust syngnathid populations relative to other locations in Tampa Bay (Rose et al. 2019, Masonjones et al. 2019). A subsequent study in the same area resulted in an even higher density (0.139 ± 0.021 N/m^2) of dwarf seahorse (Rose et al. 2019). FWC FIM survey data indicate that the relative abundance trends of dwarf seahorse in the Florida Central Region have varied over the course of the time series within the bay systems found there (Charlotte Harbor, Sarasota Bay, Tampa Bay; Figure 3) (Data provided by FWC 2017).

Florida Big Bend Region (Cedar Key to Apalachee Bay)

The Florida Big Bend Region portion of the species' range extends from Cedar Key north through Apalachee Bay. Dwarf seahorse records within the Florida Big Bend Region, 1930-2010, are summarized in Table 4. The 1950s collection of 1,587 dwarf seahorse collected at Cedar Key was from surveys using push nets, beam trawls, and minnow seines (Strawn 1958). Most recently, Baum et al. (2003) reported 2 dwarf seahorse from commercial shrimp trawls and attributed the small number of dwarf seahorse collected to the low catchability or retention due to larger mesh size utilized.

FWC FIM survey data indicate that the relative abundance trends of dwarf seahorse in Cedar Key (1996-2016) and Big Bend (2008-2016) have been variable over time; however, the low abundance of dwarf seahorse in this region (Table 5; Figure 3) could be due to winter water temperatures below the species' optimal range.

Table 5. Summary of Dwarf Seahorse Records from the Florida Big Bend Region, 1930-1999

Year	Number	Area	Source
1930	1*	Big Bend Area	Ed Matheson (FWC)[1]
1950-51	1,587	Cedar Key	Strawn (1958)
1959	Present	Cedar Key	Vari (1982)
1966	1*	Big Bend Area	Ed Matheson (FWC)[1]
1993	1*	Big Bend Area	Ed Matheson (FWC)[1]
1998-99	2	Hernando Beach, Florida	Baum et al. (2003)

Source for data is indicated and records are organized in chronological order. Number indicates number of individuals collected. "Present" indicates the species was reported, but the number of individuals was not provided. * indicates museum records. [1]pers. comm. to Calusa Horn, NMFS PRD, on December 12, 2012.

Florida Panhandle Region (Apalachicola Bay to Perdido Bay)

The Panhandle Region portion of the species' range extends from Apalachicola Bay to Perdido Bay. Dwarf seahorse records within the Florida Panhandle Region, 1980-2013, are summarized in Table 6. Throughout the twentieth century, dwarf seahorse records have been rare within the Florida Panhandle Region, which could be due to a lack of scientific surveys or winter water temperatures below the species' optimal range. Museum records were searched and obtained, but they were few, sporadic, and distributed over a long time period. Fourteen dwarf seahorse were collected in Big Lagoon using otter trawls and seines 2011- 2012 (Ryan Moody, Dauphin Island Sea Laboratory, pers. comm. to Kelcee Smith, Riverside, Inc., on July 17, 2012). In St. Joseph

Bay, 2 dwarf seahorse were captured during juvenile shark gillnet surveys in May 2012 and May 2013, but no other information was collected (Dana Bethea, NMFS Panama City Laboratory, unpublished data). In August 2013, 2 dwarf seahorse were collected during trawl surveys for juvenile gag grouper (*Mycteroperca microlepis*) in St. Andrews Bay, but no other information was recorded (Stacey Harter, NMFS Panama City Laboratory, unpublished data). The FWC FIM surveys conducted in Apalachicola Bay (1998-2016) and St. Andrew's Bay (2008-2016) indicate variable, but relatively low abundance of dwarf seahorse throughout each of the sampling periods (Figure 3).

Table 6. Summary of Dwarf Seahorse Records from Florida Panhandle Region, 1880-2013

Year	Number	Area	Source
1880s	1*	Florida Panhandle	Ed Matheson (FWC)[1]
1882	2	Laguna Grande, Pensacola	Jordon and Gilbert (1882)
1882	12*	Florida Panhandle	Ed Matheson (FWC)[1]
1883	Present	Pensacola	Vari (1982)
1896	Present	Pensacola Bay	Vari (1982)
1900	Present	Pensacola	Vari (1982)
1929	Present	Pensacola	Vari (1982)
1930	Present	Pensacola Bay	Vari (1982)
1937	Present	Pensacola	Ginsburg (1937)
1962	1*	Florida Panhandle	Ed Matheson (FWC)[1]
1979	1*	Florida Panhandle	Ed Matheson (FWC)[1]
1992	3*	Florida Panhandle	Ed Matheson (FWC)[1]
2011	3	Big Lagoon	Ryan Moody (pers. comm.)[2]
2012	11	Big Lagoon	Ryan Moody (pers. comm.)[2]
2012	1	St. Joseph Bay	Dana Bethea (NMFS)
2013	1	St. Joseph Bay	Dana Bethea (NMFS)
2013	2	St. Andrew Bay	Stacey Harter (NMFS)

Source for data is indicated and records are organized in chronological order. Number indicates number of individuals collected. "Present" indicates the species was reported, but the number of individuals was not provided. * indicates museum records [1]pers. comm. to Calusa Horn, NMFS PRD, on December 12, 2012. [2] pers. comm. to Kelcee Smith, Riverside, Inc., on July 17, 2012.

Modeled dwarf seahorse abundance

Carlson et al. (2019) estimated dwarf seahorse population size in five regions of Florida using a population viability model. Data from the life tables were converted to a post-breeding Leslie Matrix which was then input into the software package RAMAS to project population responses to various conditions. The RAMAS model accounts for much of the demographic data variability including maximum age. Initial population size estimates for the model were developed for the following subpopulations; Cedar Key, Tampa Bay, Charlotte Harbor, Florida Bay, and North Indian River Lagoon (Figure 2) based on the existing survey data. Density estimates varied from 0.0-0.59 m^2 with highest densities in the most southern Bays (i.e., Florida Bay and Biscayne Bay) and lower estimates in Tampa Bay, southwest Florida, and north Florida. The dataset of density estimates was bootstrapped 10,000 times to yield 5, 10, 25, 50, and 75% quantiles.

Because dwarf seahorse abundance is generally greatest in areas with higher density of seagrass blades and higher seagrass canopy (e.g., length of seagrass blades) (Lourie et al. 2004) and because seagrass density and overall meadow health in Florida is highly variable, Carlson et al. (2019) derived a more conservative initial estimate of subpopulation size by multiplying the 5% or 10% quantile estimates of dwarf seahorse density from a bootstrapped dataset of empirical observations (Table 2 in Carlson et al. 2019) by available seagrass density in nearshore waters (Yarbro and Carlson 2016). As dwarf seahorse are most abundant in bay systems south of 29°N latitude, Carlson et al. (2019) applied the density estimate from the 10% quantile (0.003 N/m^2) for the Tampa Bay, Charlotte Harbor and Florida Bay subpopulations (those south of 29°N latitude) and the 5% quantile (0.0009 N/m^2) for the Cedar Key and north Indian River Lagoon subpopulations (north of 29°N latitude). Subpopulation size in 2016, based on male abundance from the retrospective analysis, ranged from about 15,258 at Cedar Key to 9,910,752 in Florida Bay (Figure 5). Assuming a 1:1 sex ratio, the total estimated population (all of Florida) exceeds 24 million individual dwarf seahorse. However, Rose et al. (2019) report an unequal sex ratio in which males comprise only 41.8 percent; suggesting the total population may be even greater than the estimated 24 million individuals.

The population abundance estimates from Carlson et al. (2019) are likely conservative for the following reasons: (1) starting densities were derived from the 5% or 10% quantiles bootstrapped from empirical observations (Table 2 in Carlson et al. 2019); (2) intrinsic rate of increase (R_{max}) was assumed equal to the dominant eigenvalue of the Leslie Matrix at starting conditions prior to density-dependence (Cortes 2016), and was much lower than estimated R_{max} for other seahorse species (Denney et al. 2002, Curtis 2004); (3) the RAMAS model accounted for variability in survivorship of each age class resulting in 98% of reproduction occurring in the Age-0 class; (4) carrying capacity in seagrass habitats was capped at the 25% quantile estimate from the bootstrapped data (0.02 N/m^2); (5) a 30% mortality rate was assumed for acute cold exposure although greater thermal tolerance is suggested by Mascaró et al. (2016); and (6) a theoretical mortality rate of 100% for harmful algal bloom (HAB) exposure was assumed, with HABs assumed to cover between 25% to 50% of available seagrass habitats within a given estuary despite limited observations of HAB overlap with seagrass beds in coastal bays (NOAA-HABSOS 2018).

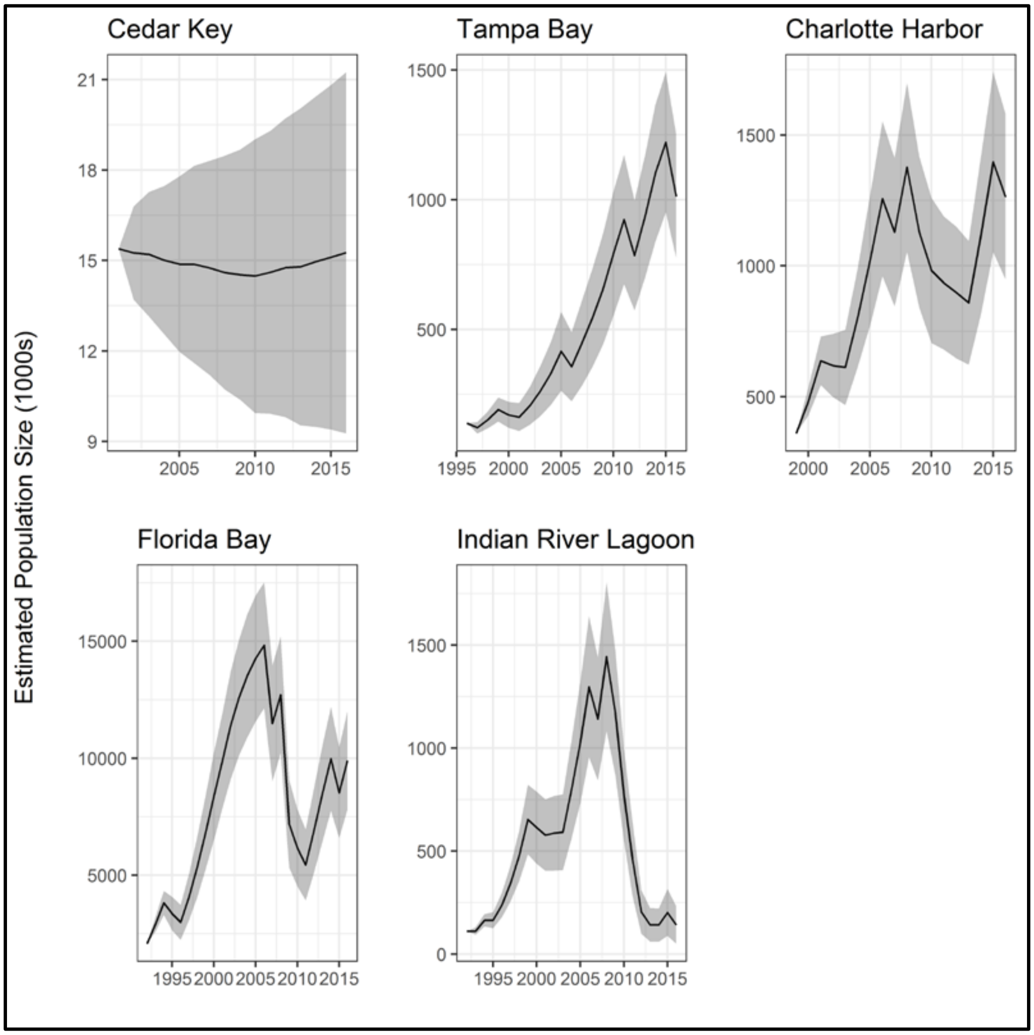


Figure 5. Estimated adult male population size through time and by region from Carlson et al. (2019) retrospective analysis.
Shaded areas represent upper and lower confidence limits.

6.2 Alabama

While Alabama is considered part of the historical geographic range, it is unknown if dwarf seahorse was ever established in the state. Anecdotal reports suggest the species may be present but published records are lacking. Boschung (1992) referenced the presence of dwarf seahorse in Alabama waters, but we were unable to locate any other published records. Additionally, there are no museum records for dwarf seahorse in Alabama (Ed Matheson, FWC, pers. comm. to Calusa Horn, NMFS PRD, on December 12, 2012). The apparent absence could be due to a lack of survey effort, limited seagrass habitat compared to the eastern Gulf of Mexico (See Figure 15 in Section 7, “Seagrass Habitat and Availability”), or winter water temperatures below the species’ optimal range.

6.3 Mississippi

There are 2 records of the dwarf seahorse in Mississippi waters. Twenty-four dwarf seahorse were collected at Cat Island in 1931 (Ginsburg 1937). FWC provided 1 additional record of a dwarf seahorse in 1970, although no specific location is given. We were unable to locate any additional records. The apparent absence from Mississippi could be due to a lack of survey effort, limited seagrass habitat compared to the eastern Gulf of Mexico (See Figure 15 in Section 7, "Seagrass Habitat and Availability"), or winter water temperatures below the species' optimal range.

6.4 Louisiana

In Louisiana, dwarf seahorse records are rare and scattered over a long time period (Table 7). The species was first recorded as present in 1910 (Vari 1982). Since then, only 8 records are known from 1966-2004. The most recent record is a single dwarf seahorse taken in a faunal survey conducted at Chandeleur Islands in 2004 (Ellinwood 2008). The rarity of records could be due to a lack of survey effort, limited seagrass habitat compared to the eastern Gulf of Mexico (See Figure 15 in Section 7, "Seagrass Habitat and Availability"), or winter water temperatures below the species' optimal range.

Table 7. Summary of Dwarf Seahorse Records from Louisiana, 1910-2004

Year	Number	Area	Source
1910	Present	Louisiana	Vari (1982)
1966	1*	Louisiana	Ed Matheson (FWC)[1]
1971	1	Barataria Bay	Mike Harden (WLF)[2]
1973	2	Lake Borgne	Mike Harden (WLF)[2]
1984	1	Bayou Bienvenue	Mike Harden (WLF)[2]
1980s	Present	Barataria Bay	Frank Cole (LaDNR)[3]
1990s	Present	Barataria Bay	Frank Cole (LaDNR)[3]
1995	6	Spanish Lake	Mike Harden (WLF)[2]
2004	1	Chandeleur Islands	Ellinwood (2008)

Source for data is indicated and records are organized in chronological order. Number indicates number of individuals collected. "Present" indicates the species was reported, but the number of individuals was not provided. * indicates museum records. [1]pers. comm. to Calusa Horn, NMFS PRD, on December 12, 2012. [2]pers. comm. to Kelcee Smith, Riverside, Inc., on July 24, 2012. [3]pers. comm. to Kelcee Smith, Riverside, Inc., on July 12, 2012.

6.5 Texas

Dwarf seahorse records in Texas, 1927-2012, are summarized in Table 8. Museum records represent 445 specimens which were collected over a long time series (1920-2000) with the greatest number collected during the 1950s and 1970s.

The Texas Parks and Wildlife Department (TPWD) has maintained a FIM survey since 1977 that covers several Texas coastal bay systems. Gillnets and bag seines have been used since the survey's inception to monitor the relative abundance and size of all species in the Galveston, Matagorda, San Antonio, Aransas, and Corpus Christi bay systems (Mambretti et al. 1990). East

Matagorda Bay was added to the survey in 1983, Sabine Lake was added in 1986, upper Laguna Madre was added in 1987, and Lower Laguna Madre was added in 1995. Dwarf seahorse has never been collected in Sabine Lake, which is likely due to low salinity and lack of seagrass habitat (Mark Fisher, TPWD, pers. comm. to Kelcee Smith, Riverside, Inc., on July 12, 2012). The species has also not been collected in the Galveston, Matagorda, or East Matagorda Bay systems. However, it is likely that the TPWD data are an underestimation of the actual number of dwarf seahorse in the state due to inadequacy of sampling gear (i.e., bag seines; Mark Fisher, TPWD, pers. comm. to Kelcee Smith on July 12, 2012). In general, the species occurs in bays south of 29°N (i.e., Aransas Bay, Corpus Christi Bay, San Antonio Bay, and the Upper and Lower Laguna Madre) (Mark Fisher, TPWD, pers. comm. to Kelcee Smith, Riverside, Inc., on July 12, 2012). Figure 6 shows Texas bay systems that collected dwarf seahorse, 1977-2011. Additional surveys since 2011 indicate the species is still present at low abundance in Texas as TPWD recorded 1 dwarf seahorse in 2012, thirteen in 2013, fourteen in 2014, twelve in 2015, and seventeen in 2016 (TPWD unpublished data). As with the historical data, most of these more recent captures (26) were collected in the Laguna Madre bay system.

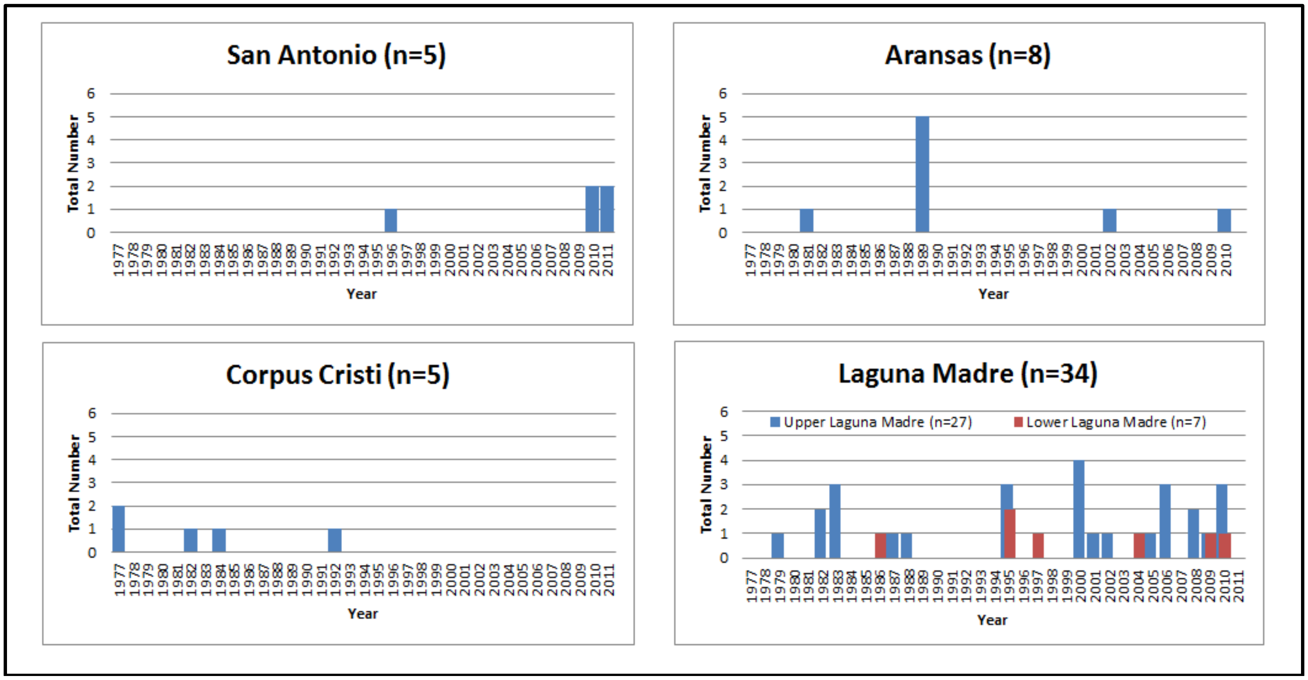


Figure 6. Dwarf seahorse abundance (total number) collected in TPWD FIM surveys in Texas bay systems. (Mark Fisher, TPWD, pers. comm. to Kelcee Smith, Riverside, Inc., on July 12, 2012).

Table 8. Summary of Dwarf Seahorse Records from Texas, 1927-2012

Year	Number	Area	Source
1927	2*	Texas	Ed Matheson (FWC)[1]
1933	Present	Corpus Christi (Harbor Island)	Ginsburg (1937)
1937	Present	Corpus Christi (Hog Island)	Ginsburg (1937)
1955	1*	Texas	Ed Matheson (FWC)[1]
1958	Present	Texas	Vari (1982)
1973	2*	Texas	Ed Matheson (FWC)[1]
1977	1	Corpus Christi	Matlock (1992)
1979	1	Upper Laguna Madre	Matlock (1992)
1981	1	Aransas Bay	Matlock (1992)
1982	1	Corpus Christi	Matlock (1992)
1982	3	Laguna Madre	Matlock (1992)
1983	3	Laguna Madre	Matlock (1992)
1984	1	Corpus Christi	Matlock (1992)
1984	1	Laguna Madre	Matlock (1992)
1985	2	San Antonio	Matlock (1992)
1985	2	Gulf of Mexico	Matlock (1992)
1986	1	Laguna Madre	Matlock (1992)
1986	3	Gulf of Mexico	Matlock (1992)
1987	1	Matagorda Bay	Matlock (1992)
1987	1	Laguna Madre	Matlock (1992)
1988	1	Laguna Madre	Matlock (1992)
1988	1	Gulf of Mexico	Matlock (1992)
1989	1	Matagorda Bay	Matlock (1992)
1989	5	Aransas Bay	Matlock (1992)
1993	27	Redfish Bay	Tolan et al. (1997)
2002	Present	Nueces Bay	Tolan (2008)
2003	Present	Nueces Bay	Tolan (2008)
2004-05	43	Laguna Madre	Stunz et al. (2006)
2005-06	2	Laguna Madre	Stunz et al. (2006)
2010	14	Aransas Bay	Masonjones (pers. comm.)[2]
2012	1	Redfish Bay	Timothy Grabowski (USGS)[3]

Source for data is indicated and records are organized in chronological order. Number indicates number of individuals collected. “Present” indicates the species was reported, but the number of individuals was not provided. * indicates museum records. [1]pers. comm. to Calusa Horn, NMFS PRD, on December 12, 2012. [2]pers. comm. Calusa Horn, NMFS PRD, on June 8, 2013. [3]pers. comm. Kelcee Smith, Riverside, Inc., on July 11, 2012.

6.6 Mexico

Dwarf seahorse records in Mexico, 1932-2002, are summarized in Table 9. Records are sporadic and infrequent, but are generally located in the following states: Yucatan (Garcia-Hernandez et al. 2009 and Vega-Cendejas 2004),Tamaulipas, Campeche, Veracruz, and Quintana Roo (Diaz

2013). Museum records from Mexico were limited to 17 specimens from 6 records (Ed Matheson, FWC, pers. comm. to Calusa Horn, NMFS PRD, on December 12, 2012).

Table 9: Summary of Dwarf Seahorse Records from Mexico, 1932-2002

Year	Number	Area	Source
1904	Present*	Northern coast of Mexico	Ed Matheson (FWC)[1]
1932	5*	--	Ed Matheson (FWC)[1]
1932	1	Campeche	Ginsburg (1937)
1936	1	Campeche	Vari (1982)
1937	1	Campeche	Vari (1982)
1953	2*	Punta de Piedro, Tamaulipas	Ed Matheson (FWC)[1]
1954	4*	Punta de Piedro, Tamaulipas	Ed Matheson (FWC)[1]
1971	1*	Cancún, Quintana Roo	Ed Matheson (FWC)[1]
1976	5*	Isla del Carmen, Campeche	Ed Matheson (FWC)[1]
1976-77	Present	Terminos Lagoon, Campeche	Sanvicente-Añorve et al. (2011)
1985-86	Present	Terminos Lagoon, Campeche	Sanvicente-Añorve et al. (2011)
1984	Present	Celestún Biosphere Reserve, Yucatan	Vega-Cendejas (2004)
1985	Present	Celestún Biosphere Reserve, Yucatan	Vega-Cendejas (2004)
1989	7	Laguna Madre, Tamaulipas	Diaz (2013)
1989-90	Present	Laguna Madre, Tamaulipas	Macias (1999)
1991-94	Present	Celestún Biosphere Reserve, Yucatan	Vega-Cendejas (2004)
1996	6	Laguna Madre, Tamaulipas	Raz-Guzman and Huidobro (2010)
1996	2	Los Troncos, Tamaulipas	Diaz (2013)
1996	2	Laguna Madre, Tamaulipas	Diaz (2013)
1996	1	Las Chacas, Veracruz	Diaz (2013)
1996	1	Nuestra Senora, Veracruz	Diaz (2013)
1996	1	Las Chacas, Veracruz	Diaz (2013)
1996	1	Laguna Madre, Tamaulipas	Diaz (2013)
1996	1	Isla Pita, Laguna Madre, Tamaulipas	Diaz (2013)
1997	1	La Enramada, Laguna Madre, Tamaulipas	Diaz (2013)
1997	3	Santa Clara, Laguna Madre, Tamaulipas	Diaz (2013)
1998	Present	Celestún Biosphere Reserve, Yucatan	Vega-Cendejas (2004)
1999	Present	Chelem, Yucatan	García-Hernández et al. (2009)
2000	Present	Chelem, Yucatan	García-Hernández et al. (2009)
2001	Present	Yalahau Lagoon, Quintana Roo	García-Hernández et al. (2009)
2000-01	Present	Celestún Biosphere Reserve, Yucatan	Vega-Cendejas (2004)
2002	Present	Yalahau Lagoon, Quintana Roo	García-Hernández et al. (2009)

Source for data is indicated and records are organized in chronological order. Number indicates number of individuals collected. “Present” indicates the species was reported, but the number of individuals was not provided. * indicates museum records. – indicated no area recorded. [1]pers. comm. to Calusa Horn, NMFS PRD, December 12, 2012.

6.7 The Bahamas, Cuba, and Bermuda

Dwarf seahorse records from The Bahamas, Bermuda, and Cuba, 1907-1974, are summarized in Table 10. The dwarf seahorse occurs throughout the Caribbean and Bermuda in insular locations (Bruckner et al. 2005); information on distribution and abundance in these areas is limited. There is only a single publication that references the presence of dwarf seahorse in The Bahamas: Vari (1982) reported the capture of the dwarf seahorse from Hog Island in 1968. Museum records provided by FWC also documented the species in 1957, but no additional information is provided for that record.

In Cuba, only 4 records of the dwarf seahorse exist. Vari (1982) reported records in 1928, 1973, and in 1975. There is a single museum record of this species in Cuba in 1974 from Guantanamo Bay (Ed Matheson, FWC, pers. comm. to Calusa Horn, NMFS PRD, on December 12, 2012).

In Bermuda, the earliest records were 18 dwarf seahorse collected from Hamilton Harbor in 1907 and 33 collected from Agors Island in 1908 (Ed Matheson, FWC, pers. comm. to Calusa Horn, NMFS PRD, on December 12, 2012). The most recent record of the dwarf seahorse occurred in 1952 (Vari 1982). However, according to the Government of Bermuda, the dwarf seahorse has not been seen in Bermuda since 1905 and is assumed to have been extirpated (become locally extinct) (http://www.conservation.bm/seahorses/).

Table 10. Summary of Dwarf Seahorse Records from The Bahamas, Bermuda, and Cuba, 1907-1975

Year	Number	Area	Source
1907	18*	Hamilton Harbor, Bermuda	Ed Matheson (FWC)[1]
1908	33*	Agors Island, Bermuda	Ed Matheson (FWC)[1]
1928	Present	Cuba	Vari (1982)
1952	Present	Bermuda	Vari (1982)
1957	Present	The Bahamas	Ed Matheson (FWC)[1]
1968	Present	Hog Island (Paradise Island), The Bahamas	Vari (1982)
1973	Present	Cuba	Vari (1982)
1974	1*	Guantanamo Bay, Cuba	Ed Matheson (FWC)[1]
1975	Present	Cuba	Vari (1982)

Source for data is indicated and records are organized in chronological order. Number indicates number of individuals collected. “Present” indicates the species was reported, but the number of individuals was not provided. * indicates museum records. [1]pers. comm. to Calusa Horn NMFS PRD, on December 12, 2012.

6.8 Summary of Dwarf Seahorse Distribution and Abundance

Our review of the literature, scientific surveys, museum records, and anecdotal information of dwarf seahorse indicates a United States distribution from south Texas throughout the north and eastern Gulf of Mexico, into the Florida Keys, and north along the Atlantic Ocean coast to Indian River Lagoon, Florida.

In the United States, the highest abundances of dwarf seahorse are in bay systems south of 29°N (Florida South Region and south Texas) and the lowest abundances are in Alabama, Louisiana, and Mississippi. As discussed above, the northern Gulf of Mexico may not have ever had an established population of dwarf seahorse given the colder water temperatures during the winter months and a general lack of seagrass habitat. Data obtained from the National Oceanic and

Atmospheric Administration’s remote sea surface temperature atlas (www.ncddc.noaa.gov) shows the average sea surface temperature during winter months (January-February) at latitudes above 29°N can drop below the assumed lower temperature limit (14.0ºC) for the dwarf seahorse (Figure 7). Because these same areas have generally less seagrass habitat, the northern Gulf of Mexico is likely the margin of the species’ range due to physiological and habitat limitations. See also Section 7, “Seagrass Habitat Availability.”

Outside of the United States, dwarf seahorse records occur in the state of Tamaulipas (near the Texas-Mexico border) and along the Yucatan Peninsula from the state of Campeche to Chelem, Mexico. Records are limited, but the species has also been documented in The Bahamas, Cuba, and Bermuda. Recent records throughout the Caribbean and Mexico are lacking so we are unsure of the species’ status in these locations.

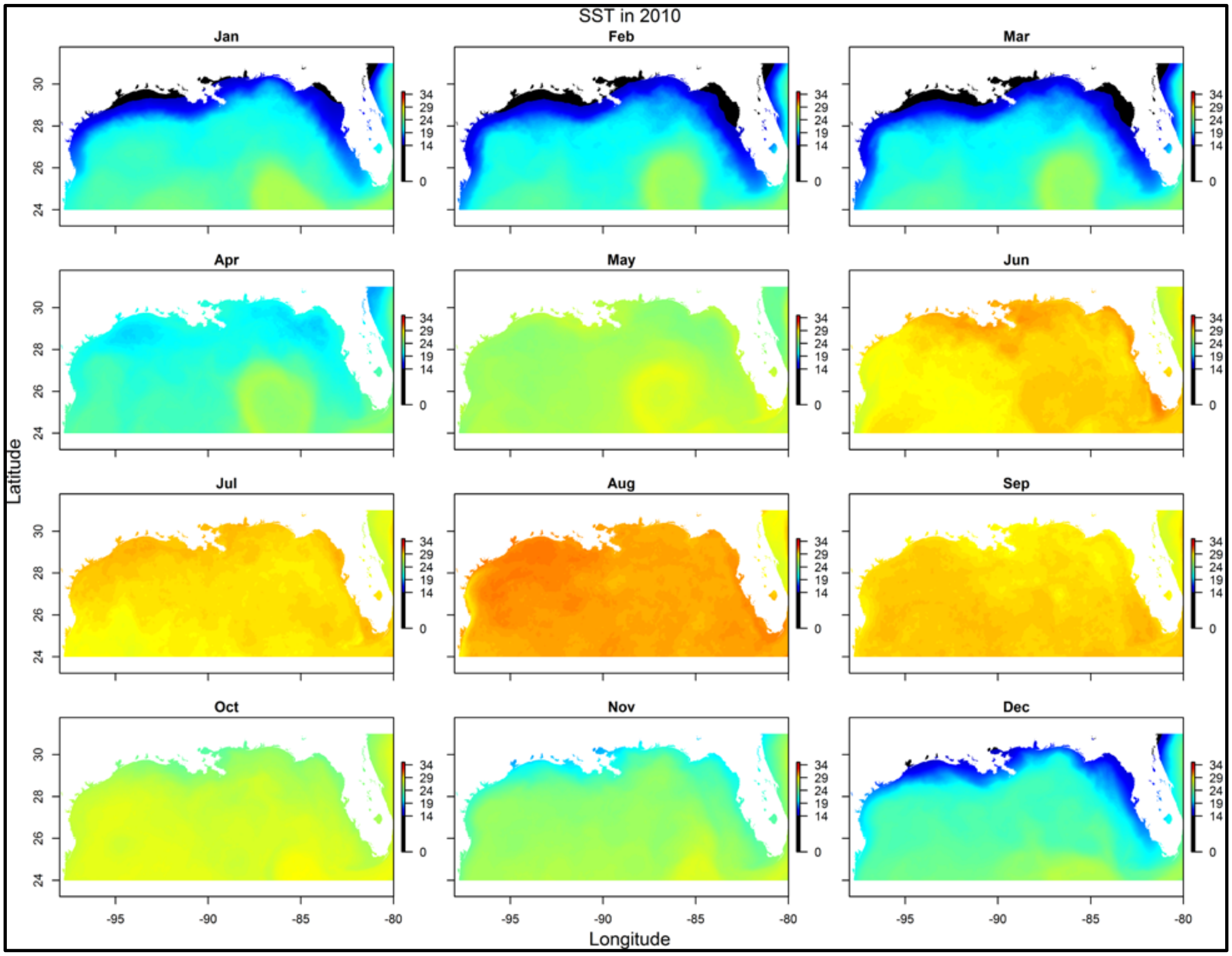


Figure 7. Monthly average sea surface temperature (SST) in the Gulf of Mexico during 2010. Areas in black represent average temperature ≤14ºC—the lower temperature limit for dwarf seahorse. Source: NASA JPL Multi-scale Ultra-high Resolution (MUR) SST Analysis fv04.1https://coastwatch.pfeg.noaa.gov/erddap/griddap/jplMURSST41.html

7 SEAGRASS HABITAT AVAILABILITY

The FWC SIMM program provides both mapping and monitoring data for seagrasses throughout Florida's coastal waters. Based on the most recent mapping data available, there are about 2,480,000 acres of seagrass in Florida nearshore waters (Yarbro and Carlson 2016). Along the Gulf of Mexico coast, the Florida South Region (over 1.6 million acres) comprises the largest contiguous seagrass bed in the continental United States (Figure 8). As discussed above, this region has the highest abundance of dwarf seahorse in the United States. While southwest Florida contains far less seagrass (approximately 143,000 acres) this area supports a relatively high abundance of dwarf seahorse as well. The Florida Panhandle Region has the least amount of seagrass acreage (Figure 8) and while dwarf seahorse are found there, abundance is low.

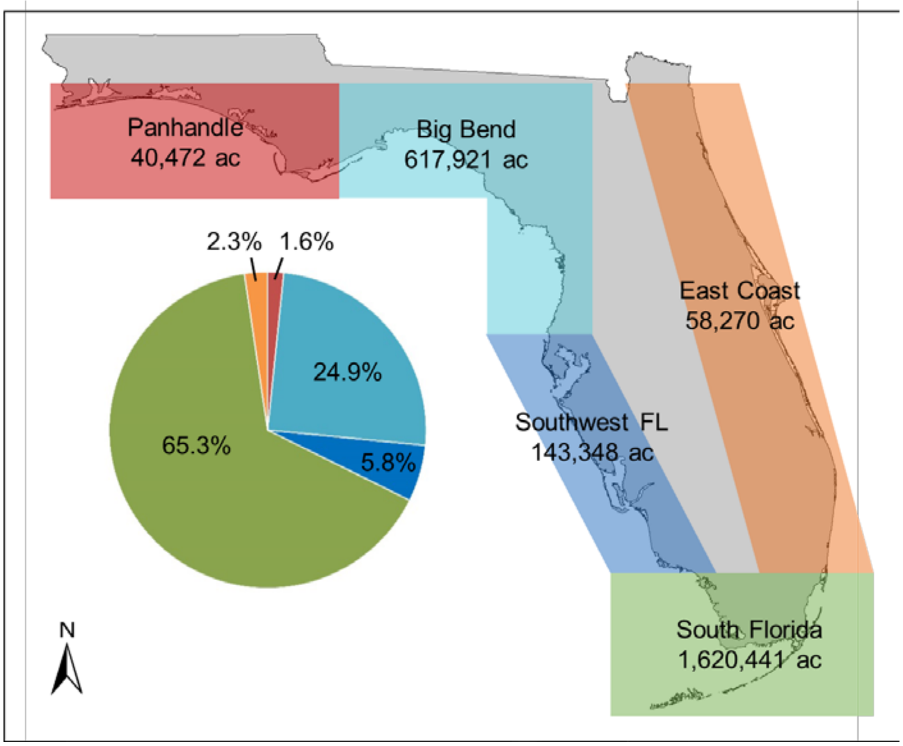


Figure 8. Distribution of seagrass acreage in Florida coastal waters (adapted from Yarbro and Carlson 2016). For the purposes of this document, "Panhandle" is equivalent to Florida Panhandle Region, "Big Bend" is equivalent to Florida Big Bend Region, "Southwest Florida" is equivalent to Florida Central Region, "South Florida" is equivalent to Florida South, and "East Coast" is equivalent to Florida Northeast Region.

Most seagrass acreage in Florida is either stable or increasing (Yarbro and Carlson 2013, Yarbro and Carlson 2016), with loss documented in only 3 of the 30 bays systems assessed in the most recent trend analysis (Yarbro and Carlson 2016). However, this latest trend analysis did not include data associated with the 2015 seagrass die-off in Florida Bay.

Seagrass distribution is sparse in Alabama and Mississippi (Figure 9). In Alabama, there were 1,690 acres of available seagrass habitat in 2002 (Vittor 2004). Sturm et al. (2007) noted the greatest acreage occurring in Mobile Bay and the lowest in Perdido Bay. Despite Mississippi Sound having an average depth of 2 m and consisting of over 14,826 acres of submerged bottom, only 3% of the sound contains seagrass (Moncrief 2007). In 1969, about 12,982 acres of seagrasses were documented in Mississippi Sound and in 1992 only 1,482 acres remained (Moncrief 2007). Seagrass coverage in coastal Alabama has decreased over time due to dredge and fill operations, increased turbidity caused by shoreline development, and multiple storms (Stout and LeLong 1981; Sturm et al. 2007). The primary factor leading to seagrass habitat loss in Mississippi is likely water quality changes associated with severe storms (e.g., flooding, salinity, type of substrate, and wind and wave energy) (Handley et al. 2007; Moncrief 2007; Pham et al. 2014).

Louisiana seagrasses are limited to shoals west of the Chandeleur Islands (Consentino-Manning et al. 2015; Poirrier 2007) (Figure 10). Areal coverage estimates since the 1960s show fluctuation in seagrass coverage with a pre-2010 estimation at 11,149 acres (Handley et al., 2007). Although rare (9 records in 94 years), the most recent dwarf seahorse records in Louisiana are from the Chandeleur Islands (Table 7). The landscape was changed in 2010 with the *Deepwater Horizon* (DWH) oil spill, and the lack of consistent mapping prior to the spill complicates understanding the decadal-scale changes in this area (Pham et al. 2014). In Section 8.4, we describe the extent of injury to seagrass systems resulting from the DWH spill.

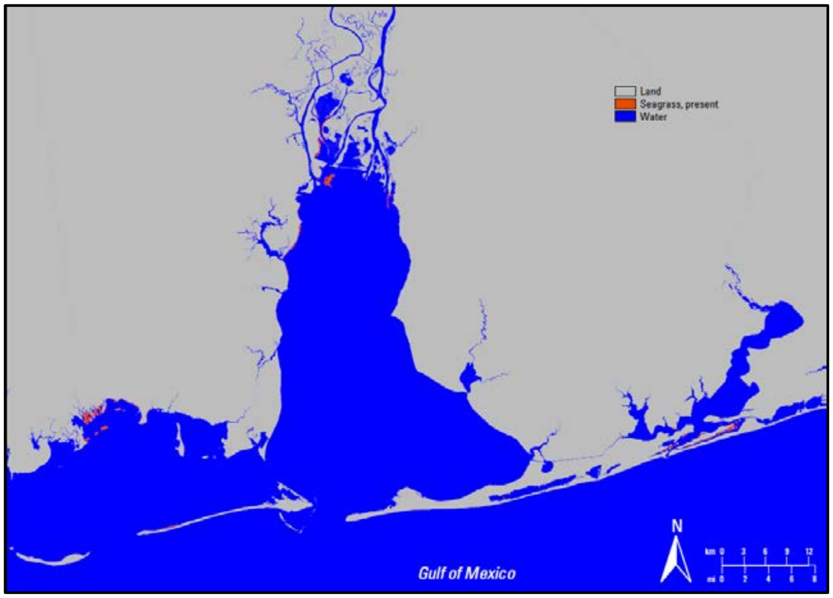


Figure 9. Distribution of seagrasses along coastal Alabama and Mississippi, 2002, showing seagrass distribution limited to upper Mobile Bay and Perdido Bay, Alabama, and the northern shoreline of Mississippi Sound, Mississippi (Figure 3 in Sturm et al. 2007).

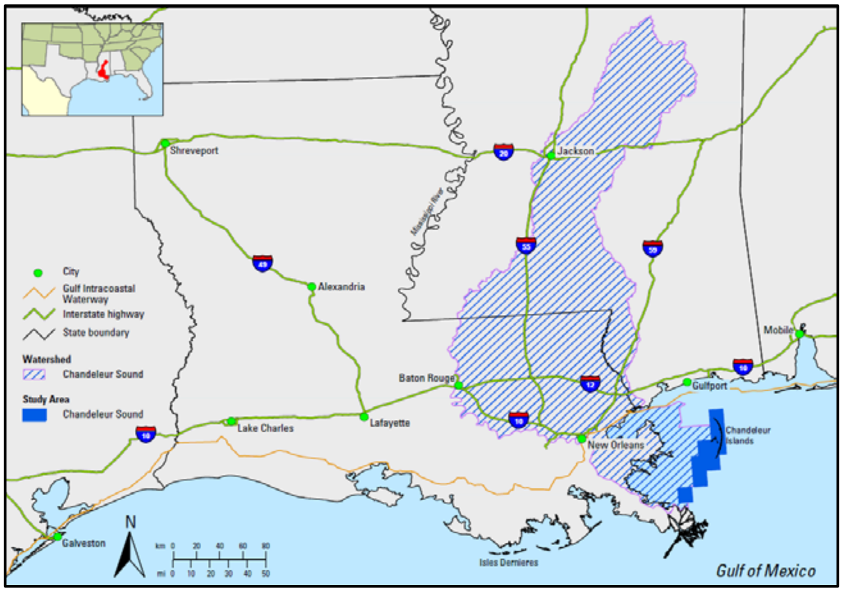
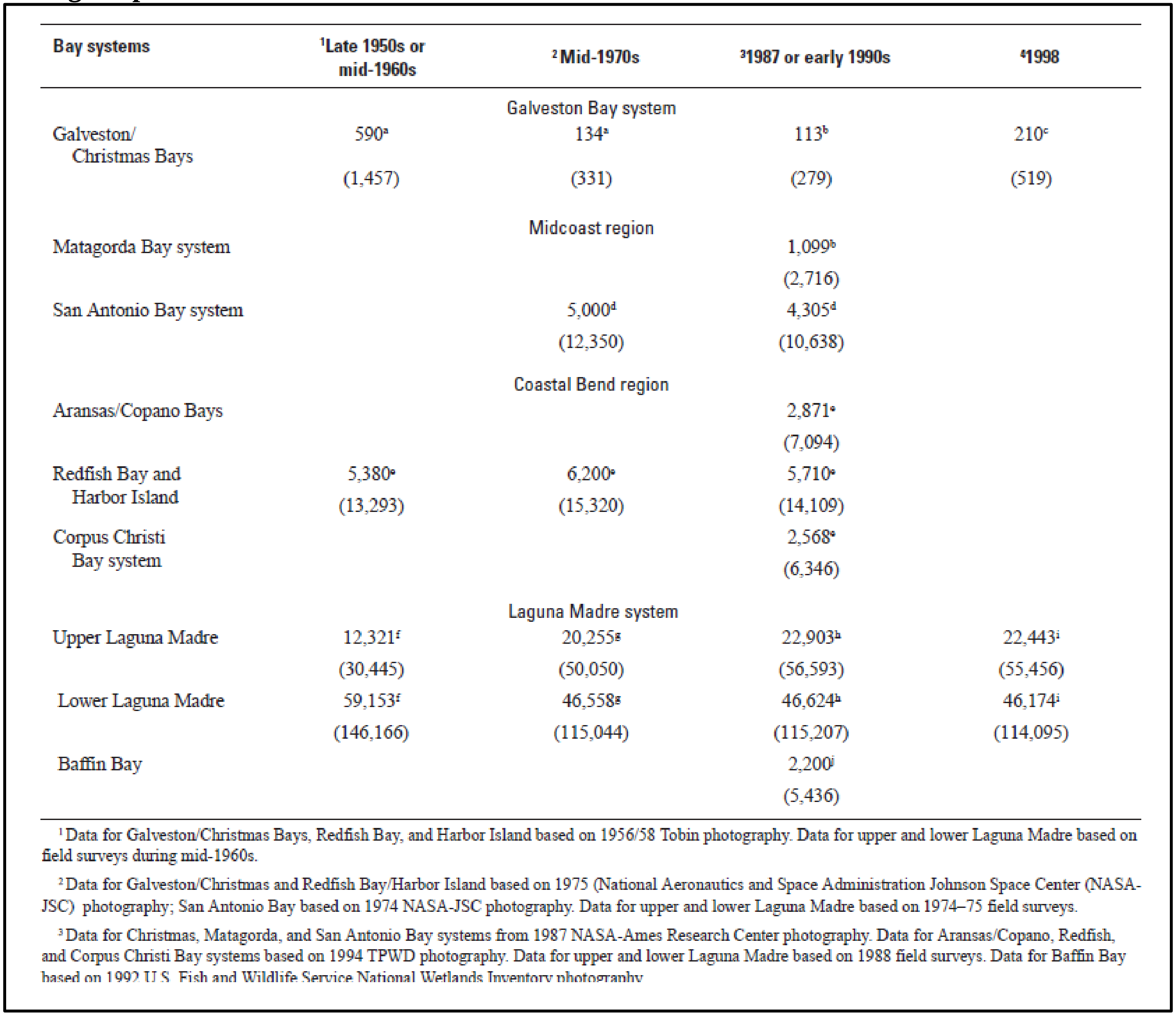


Figure 10. Watershed for the state of Louisiana showing shoals west of the Chandeleur Island (blue boxes) where seagrasses are known to occur (Figure 1 in Poirrier 2007).

The relationship between available seagrass habitat and dwarf seahorse distribution and abundance is the same for Texas bay systems (Pulich Jr and Onuf 2007). The Laguna Madre Bay system supports the greatest amount of seagrass habitat in Texas (169,551 acres, 79% of total; Table 11) and is the bay system with the highest abundance and most recent captures of dwarf seahorse (Mark Fisher, TPWD, pers. comm. to Kelcee Smith, Riverside, Inc., on July 12, 2012; Table 8).

For areas outside the United States, there is limited seagrass information. In Mexico, satellite photos from 2000 and 2001 in the state of Veracruz and the Yucatán peninsula indicated that there were approximately 3,672 square miles of seagrass (Green and Short 2003). In The Bahamas, there are 425,870 hectares of saline wetlands that contain mangroves at 20 sites (Bacon 1993) and seagrasses are often found at low energy sites in association with these mangrove sites (Bucchan 2000; Geracem et al. 1998). The most extensive seagrass mapping has occurred in San Salvador and Grand Exuma, Bahamas, and, while total acreage was not reported, seagrass beds in these locations are generally comprised of turtle grass (Bucchan 2000; Geracem et al. 1998; Sealey and Patus 2015). The last seagrass assessment in Cuba occurred 1972-1973; 4 species were found to cover 75% of the 1,702-square-mile area of the northwestern Cuban shelf (approximately 817,000 acres) (Green and Short 2003). In Bermuda, there were an estimated 5,189 acres of seagrass in 1997 but a field survey in 2004 indicated 22 meadows representing 1,173 acres had been lost or severly deteriorated (Murdoch et al. 2007). Today, Bermuda has approximately 3,953 acres of seagrass (https://environment.bm/seagrass-beds, accessed January 17, 2018).

Table 11. Summary of Seagrass Coverage for Texas Bay Systems over Time Periods. (Table 1 in Pulich Jr and Onuf 2007). Values reported in hectares with corresponding acreage in parentheses.



Bay systems	[1]Late 1950s or mid-1960s	[2]Mid-1970s	[3]1987 or early 1990s	[4]1998
		Galveston Bay system		
Galveston/ Christmas Bays	590[a] (1,457)	134[a] (331)	113[b] (279)	210[c] (519)
		Midcoast region		
Matagorda Bay system			1,099[b] (2,716)	
San Antonio Bay system		5,000[d] (12,350)	4,305[d] (10,638)	
		Coastal Bend region		
Aransas/Copano Bays			2,871[e] (7,094)	
Redfish Bay and Harbor Island	5,380[e] (13,293)	6,200[e] (15,320)	5,710[e] (14,109)	
Corpus Christi Bay system			2,568[e] (6,346)	
		Laguna Madre system		
Upper Laguna Madre	12,321[f] (30,445)	20,255[g] (50,050)	22,903[h] (56,593)	22,443[i] (55,456)
Lower Laguna Madre	59,153[f] (146,166)	46,558[g] (115,044)	46,624[h] (115,207)	46,174[i] (114,095)
Baffin Bay			2,200[j] (5,436)	

[1] Data for Galveston/Christmas Bays, Redfish Bay, and Harbor Island based on 1956/58 Tobin photography. Data for upper and lower Laguna Madre based on field surveys during mid-1960s.

[2] Data for Galveston/Christmas and Redfish Bay/Harbor Island based on 1975 (National Aeronautics and Space Administration Johnson Space Center (NASA-JSC) photography; San Antonio Bay based on 1974 NASA-JSC photography. Data for upper and lower Laguna Madre based on 1974–75 field surveys.

[3] Data for Christmas, Matagorda, and San Antonio Bay systems from 1987 NASA-Ames Research Center photography. Data for Aransas/Copano, Redfish, and Corpus Christi Bay systems based on 1994 TPWD photography. Data for upper and lower Laguna Madre based on 1988 field surveys. Data for Baffin Bay based on 1992 U.S. Fish and Wildlife Service National Wetlands Inventory photography

Seagrass Habitat Availability Summary

The two factors that seem to have the greatest influence on the distribution of dwarf seahorse are water temperature and seagrass. Winter water temperatures in the northern Gulf of Mexico are, on average, below the species' optimal range. Lower temperatures may be further limiting during spawning periods as studies have shown fish are especially temperature-sensitive during this phase (Asch and Ehrisman 2018). Additionally, seagrass habitat for dwarf seahorse occurs less frequently in the northern Gulf of Mexico compared to areas off Florida and Texas. It is possible that the marginal range of the dwarf seahorse (i.e., Alabama, Mississippi, and Louisiana) has lost the most seagrass habitat, leading to few records of the species. Alternatively, seagrass habitat along the northern Gulf of Mexico may have always been sparse due to biophysical conditions. Conversely there is extensive, nearshore seagrass acreage that is stable or increasing in Florida (27 out of 30 estuaries surveyed; Yarbro and Carlson 2016) and the Laguna Madre Bay system in south Texas which contains the greatest amount of seagrass habitat in Texas. Accordingly, dwarf seahorse have been recorded more frequently and in higher numbers in the southern part of the Gulf of Mexico compared to the northern areas.

8 ANALYSIS OF LISTING FACTORS

Pursuant to the ESA and our implementing regulations, NMFS determines whether species are threatened or endangered based on any one or a combination of the following Section 4(a)(1) factors: (1) the present or threatened destruction, modification, or curtailment of habitat or range; (2) overutilization for commercial, recreational, scientific, or educational purposes; (3) disease or predation; (4) inadequacy of existing regulatory mechanisms; and (5) other natural or man-made factors affecting the species' existence. Below, we provide information on threats from each of the five factors as they relate to the dwarf seahorse.

8.1 Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

Water Quality

As discussed above, the dwarf seahorse occurs exclusively in shallow water seagrass habitats and its abundance and distribution is correlated to taller seagrass canopy (i.e., length of seagrass blades) and greater density of seagrass blades (i.e., greater coverage) (Lourie et al. 2004). The primary cause of seagrass loss within the range of dwarf seahorse has been identified as degradation of water quality (Duarte 2002; Erftemeijer and Lewis 2006; Green and Short 2003; Greening et al. 2011; Handley et al. 2007; Hughes et al. 2009; Short et al. 2011; Waycott et al. 2009).

Harmful algal blooms (HABs) can be influenced by water quality and can also cause poor water quality. There are several forms of HABs including red tide (caused by the exudates of a single-celled marine dinoflagellate *Karenia brevis*), brown tide, and blue-green algae (cyanobacteria), though red tide is most commonly associated with fish kills in coastal waters. Many factors contribute to HABs as algae flourish when winds and water currents are favorable as well when high nutrient concentrations are introduced (i.e., fertilizers washing into the watershed). HABs are a source of ecological disturbance that alter water quality, bottom-dwelling species composition, and patterns of primary productivity through hypoxia (low dissolved oxygen) and shading (reduced sunlight penetration into the water column). Over the last several decades, the frequency and geographic distribution of HABs have been increasing worldwide (Anderson et al. 2008; Gilbert et al. 2005), particularly in the Gulf of Mexico (Heisler et al. 2008). HABs have recently occurred in dwarf seahorse habitat in Florida Bay, Biscayne Bay, and Indian River Lagoon (See Section 6.1, "Florida" above), resulting in seagrass loss and possible seahorse mortality; however, evidence suggests seagrass and dwarf seahorse are resilient. For example, during the 1990s a high biomass HAB resulted in extensive seagrass die-offs in Florida Bay and Tampa Bay, Florida, and Laguna Madre, Texas. Both the seagrasses and dwarf seahorse subpopulations seem to have recovered within these systems and are considered stable or increasing (See Section 6.1, "Florida," Section, 6.5 "Texas," and Section 7, "Seagrass Habitat Availability" above). A large and persistent HAB event (red tide) affected the southwest coast of Florida from Tampa Bay to Charlotte Harbor throughout much of 2018. While this bloom affected a variety of fauna and may have affected offshore seagrass habitat, it appears that the bloom generally remained outside of the 3 major estuaries in this region where dwarf seahorse are found (Tampa Bay, Sarasota Bay, and Charlotte Harbor).

Due to its salinity tolerances, *K. brevis* is rarely found in waters with salinities less than 24 ppm, so red tide events typically do not directly affect resident estuarine populations. Only 5% of water samples collected during Florida red tides in the past 50 years (N=26,672) have occurred in salinities lower than 24 (Landsberg and Steidinger 1998; Brown et al. 2006). One of the most severe red tide events on the West Coast of Florida occurred in 2005, with substantial penetration by the red tide into Tampa Bay (see Figure 1b in Flaherty & Landsberg 2011). Flaherty & Landsberg (2011) report a significant decline in FIM cpue for Gulf pipefish (*Syngnathus scovelli*) in 2005, which was 54% lower than the previous year and 72% lower than the average cpue from all other years (1996-2007). For dwarf seahorse, the FIM data showed a substantial (-71%) but statistically insignificant decline in relative abundance in 2005, with a substantial (+110%) recovery in 2006. Interannual variation in dwarf seahorse relative abundance in the FIM data for Tampa Bay ranged from -71% to +156% (mean±SD: 20%±75%), with no statistically significant interannual changes detected.

Overlays of synthesized local ecological knowledge (LEK) of decades of regional HAB events (*K. brevis* counts from State of Florida sampling 2000-2019) and comprehensive mapping of seagrass coverage (geodata.myfwc.com; accessed Dec 2019) revealed penetration of HAB events into Indian River Lagoon and possibly Charlotte Harbor, partial penetration into Tampa Bay, and little to no penetration into Florida Bay (Figure 11) (Karnauskas et al. 2019). It should be noted that the LEK features summarized by Karnuaskas et al. (2019) and presented in Figure 11 include HAB events beyond red tide (e.g., green algae, cyanobacteria), and the FWC red tide sampling stations consistently indicate minimal penetration of toxic levels of *K. brevis* into the bays and estuaries (red circles in Figure 11). The Carlson et al. (2019) assumption of 30-50% red tide mortality for dwarf seahorse seems conservative for the species given the scale of overlap with seagrass habitats and the even more limited overlap of toxic levels of red tide with estuarine seagrass habitats over the past two decades.

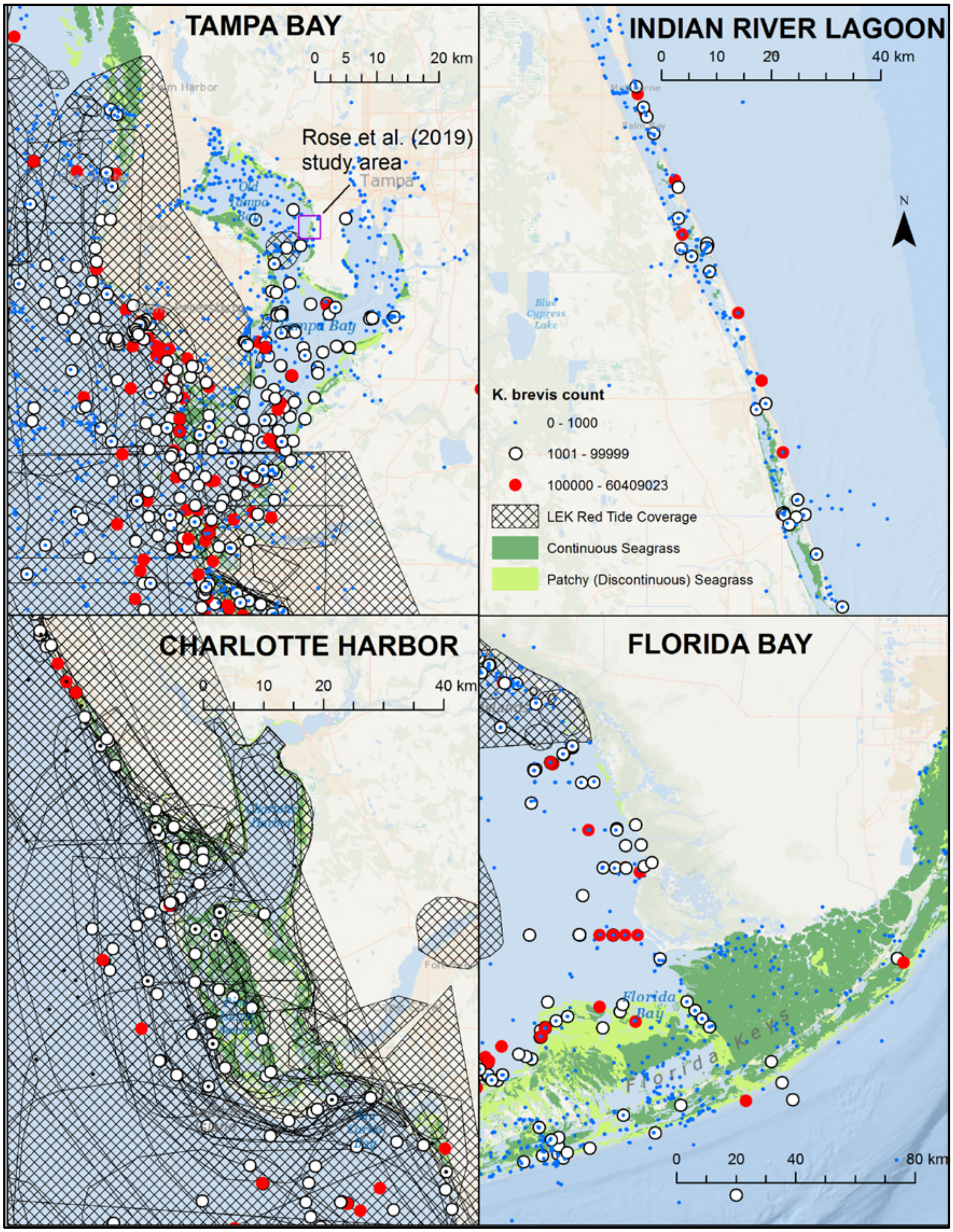


Figure 11. Harmful algal blooms in Tampa Bay,Charlotte Harbor, Indian River Lagoon, and Florida Bay. Data from local ecological knowledge (LEK) collected by Karnauskas et al. 2019 (cross hatch polygons), including green algae and cyanobacteria blooms; State of Florida red tide (*K. brevis*) cell counts from 2000-2019 (Source: geodata.myfwc.com; accessed Dec 2019); and seagrass distributions reported by the State of Florida (Source: geodata.myfwc.com; accessed Dec 2019). K. brevis counts <1000 are considered background levels, <100,000 are considered a bloom, and >100,000 are considered toxic (Flaherty & Landsberg 2011).

Water quality can also be affected by sediment suspension and siltation associated with coastal construction activities (e.g., dredging) as it decreases light transparency, physically buries plants, increases water depth, modifies tidal current, and can also lead to reduced vitality or death in benthic fauna associated with the seagrass beds. In a study in Laguna Madre, Texas, Erftemeijer and Lewis (2006) evaluated construction/dredging on estuarine organisms in adjacent habitats and found a decline in all estuarine organisms' abundance pre- versus post-dredging, including a decline in dwarf seahorse abundance (from 49 to 2). The critical threshold for turbidity and sedimentation, as well as the duration that seagrass can survive periods of high turbidity or excessive sedimentation, vary greatly among species (Erftemeijer and Lewis 2006) and there is evidence that seagrass habitat can rebound from effects due to deteriorated water quality once conditions return to favorable. For example, the combined factors of increased turbidity, physical removal, burial during dredging, and deteriorated water quality contributed to the loss of approximately 81% of the seagrasses in Tampa Bay, Florida, in the 1980s (Lewis III 1976; Lewis III and Estavez 1988). Recently, through increased water clarity, decreased phytoplankton populations, declines in nitrogen loads coming into the bay, and seagrass planting efforts (TBEP 2015), seagrass habitat in Tampa Bay is considered "increasing" (Yarbro and Carlson 2013; Yarbro and Carlson 2016). In Galveston Bay, Texas, the complete loss of seagrass in the 1970s was connected to a combination of dredge-and-fill operations, adjacent shoreline development, and land subsidence, along with natural events (i.e., hurricanes, freshwater pulses) (Pulich Jr and Onuf 2007; Pulich and White 1991); however, the reintroduction and recolonization of shoal grass and star grass in mid-West Bay near Galveston Island State Park in 1998 has helped lead to the restoration of seagrasses in the lower Galveston Bay system (Ikenson 2001; Pulich Jr and Onuf 2007) (Table 11). Although dredge-and-fill activities can and do adversely affect seagrass habitat, these activities and the construction of in- and over-water structures are scrutinized through federal, state, and local permitting programs. The U.S. Army Corps of Engineers, under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act, has federal authority over the issuance of dredge-and-fill permits. This permitting process includes language to protect and conserve seagrasses through field evaluations, consultations, and recommendations to avoid, minimize, and mitigate for impacts to seagrasses (See Section 9, "Conservation Efforts").

Damage from Vessels

Vessel groundings can cause damage to seagrass beds, especially when the roots and/or rhizomes (underground stems) are destroyed. Propeller scars are created when soil and plants are excavated by a vessel operating in water shallower than the depth of the skeg and propeller. Propeller scars can leave behind non-vegetated trenches that may be up to 40 cm deep, 50 cm wide, and hundreds of meters long (Kenworthy et al. 2006). Propeller scarring can disturb the sediments and uproot seagrasses, damaging the leaves and root/rhizome systems which are responsible for the growth and maintenance of seagrass beds. Once damage occurs, wind, wave, and current-induced erosion may further enlarge propeller scars, compounding injury to the seagrass beds, and extending recovery time to decades (Kenworthy et al. 2006; Whitfield et al. 2004). Recovery relies on natural re-colonization of seagrass species and natural sediment filling. Recovery times for slower growing species can range 2-8 years (Andorfer and Dawes 2002) with complete recovery in 10 years (Lewis III and Estavez 1988) and some species can take decades to recover to pre-injury conditions (Uhrin and Holmquist 2003). Habitat fragmentation may negatively influence the animals that use seagrass beds (Beck et al. 2001; Uhrin and Holmquist 2003), creating even more damage to the seagrass ecosystem. In Florida, moderate to heavy scarring was found to be most prevalent in Tampa Bay, Charlotte Harbor, the Florida Keys, Biscayne Bay, and Indian River Lagoon (Sargent et al. 1995). In Texas, propeller scarring has been documented in Redfish and Aransas Bays (Pulich Jr and Onuf 2007). Management options exist to help prevent seagrass scarring. For example, local governments in Florida have been using a "Four Point Approach" (education, channel marking, enforcement, and limited-motoring zones) since 1995 to reduce seagrass loss (Sargent et al. 1995) (See also Section 9, "Conservation Efforts"). In an effort to protect shallow seagrass habitat, the Everglades National Park Management Plan was recently updated to include a mandatory boater education and permit program and designated more than 100,000 acres as "pole and troll" zones (areas where boats cannot use motors) (NPS 2015).

Trawling

Historically, the shrimp trawl fishery has represented one of the largest fisheries in the Gulf of Mexico (Stallings et al. 2014; Vidal and Pauly 2004). Magnuson et al. (1990) provided an overview of where shrimp effort occurs and how it is distributed within the Southeast: "About one-third of shrimp effort in the Southeast occurs in bays, rivers, and estuaries; two-thirds occurs outside the coastline. Of the total effort, 92% is in the Gulf [of Mexico]; most of that is in waters shallower than 27 m." However, since 2001, there has been a dramatic decrease in effort associated with the southeast U.S. shrimp fishery. The decline has been attributed to low shrimp prices, rising fuel costs, competition with imported products, and the impacts of hurricanes in the Gulf of Mexico (NMFS 2014).

In December 2012, NMFS completed a detailed characterization of U.S. Gulf of Mexico and South Atlantic penaeid and rock shrimp fisheries based on July 2007 through December 2010 observer data collected through NMFS's mandatory shrimp observer program (i.e., Scott-Denton et al. [2012]). Scott-Denton et al. (2012) summarized trip, vessel, environmental, and gear characteristics, quantified fish and protected species captures by area and target species, and estimated CPUE trends and spatial distribution for target and non-target species. Scott-Denton et al. (2012) stated: "The majority of tows (~70%) sampled were off the coasts of Texas and Louisiana. Based on total hours towed, the highest concentrated effort occurred off South Texas and southwestern Florida. Gear information, such as net characteristics, bycatch reduction devices, and turtle excluder devices were fairly consistent among areas and target species."

There are 3 primary types of trawls: otter trawl, skimmer trawl, and roller frame trawls. The otter trawl, essentially the sole gear used in large-scale, offshore commercial shrimp fisheries, is widely considered to be one of the most destructive types of gear to the benthos because it has direct contact with the bottom; however, otter trawls are most often operated in deeper water (29-209 feet, 9-64 m) over bottom types where dwarf seahorse do not occur (i.e., sand or mud). Small otter trawls are also used for inshore bait shrimping in the state waters of Florida, Alabama, Mississippi, Louisiana, and Texas. Skimmer trawls are primarily used in inshore waters of Louisiana, Mississippi, and Alabama; however, all Gulf of Mexico states except Texas include skimmer trawls as an allowable gear. Skimmer trawls are pushed by the vessel rather than towed, rendering them more maneuverable, and are designed to fish higher in the water column compared to otter trawls thus reducing their potential impact on dwarf seahorse habitat. The roller frame trawl is used by small vessels fishing for live-bait shrimp (typically at night) over uneven or vegetated sea bottoms inshore at depths less than 25 ft (7.6 m). The roller frame trawl is designed to reduce damage to the substrate by rolling over, rather than dragging through, the benthos. Meyer et al. (1999) found that roller frame trawls have little to no direct effect on turtle grass (*Thalassia testudinum*) shoot density, structure, or biomass. The use of roller frame trawls is limited to Florida with no other states reporting this gear type (Epperly et al. 2002).

The extent of how much dwarf seahorse habitat is being damaged by trawl gear is currently unknown; however, all Gulf of Mexico states have various size and time-area restrictions on trawling gear (SERO 2014) that, in part, protect the seagrass habitat and associated animals (i.e., dwarf seahorse; Epperly et al. 2002). In Florida, trawling for food shrimp is prohibited in the Florida Big Bend Region through seasonal closures (Florida Administrative Code 68B-31.017). Commercial shrimp trawling is also closed in specific areas of Florida Bay (Florida South Region; Florida Administrative Code 68B-31.0136), and all trawling is completely prohibited in Everglades National Park and John Pennekamp Coral Reef State Park (both within the Florida South Region) (FWC 2016). See also the discussion of other areas closed in Florida in Section 8.5, “Inadequacy of Existing Regulatory Mechanisms”. While seagrass habitat is limited in Mississippi and Alabama, recreational trawling within the boundaries of the Gulf Islands National Seashore and trawling in the Grand Bay portion of Mississippi Sound and the upper portion of Mobile Bay is prohibited (Mississippi Ordinance 2.016 [2004]; SERO 2014). Texas employs seasonal closures and specific bay system restrictions and prohibits trawling in “nursery areas” (tributary bays, bayous, inlets, lakes and rivers that serve as significant growth and development environments for post-larval and juvenile shrimp) (Texas Parks & Wildlife Department, http://tpwd.texas.gov/regulations/outdoor-annual/fishing/shellfish-regulations/shrimp-regulations, accessed April 21, 2016.)

Climate Change

The Intergovernmental Panel on Climate Change (IPCC) in its fifth and most recent assessment report (IPCC 2014) presented four Representative Concentration Pathways (RCPs) to assess future climate changes, risks, and impacts. The RCPs describe 4 possible twenty-first century pathways of greenhouse gas emissions and atmospheric concentrations, air pollutant emissions, and land use. The IPCC did not identify any scenario as being more likely to occur than any other. Because we cannot predict whether and how climate conditions may change, it is NOAA policy to assume climate conditions will be similar to the status quo in making ESA listing determinations. The RCP8.5 pathway (“business as usual” scenario) predicts very high greenhouse gas emissions (IPCC 2014) in evaluating potential climate effects. The following paragraphs will discuss the potential impacts of climate change on dwarf seahorse and seagrasses.

It is anticipated that many species of marine plants and animals will align their distributions to match their physiological tolerances under changing environmental conditions (Doney et al. 2012; IPCC 2014; Wong et al. 2014). Fodrie et al. (2010) compared studies conducted from

1971-1979 with data from 2006-2007 and found that some fish species may already be adjusting their range due to changes in abiotic factors. Under RCP8.5, the predicted increase in mean global temperature from the period 1986-2005 to the end of the twenty-first century (2081-2100) is approximately 4ºC (IPCC 2014). This increase will lead to warmer water temperatures and range shifts for vegetated coastal habitats and animals that rely on these habitats. For example, the northern limit of mangrove forests is generally set by the 20ºC mean winter isotherm (Duke et al. 1998); the migration of the isotherm with climate change is expected to lead to a northern expansion of mangrove shoreline in the Gulf of Mexico (Burrows et al. 2011; Comeaux et al. 2012; Perry and Mendelssohn 2009; Raabe et al. 2012; Wong et al. 2014).

Changes in seagrass distribution patterns occur with increased water temperature, as seagrasses can respond to environmental changes quickly, especially at the edges of their distribution where there are currently mixes of tropical and temperate species (Björk et al. 2008). Short and Neckles (1999) found that increased water temperature can alter growth and other physiological functions of plants resulting in species composition changes, distribution shifts, and changes in the patterns of sexual reproduction. Temperature tolerances vary widely across seagrass species—temperatures that exceed 25ºC adversely impact temperate seagrasses and temperatures above 43ºC adversely impact tropical seagrasses (Biebl and McRoy 1971; Björk et al. 2008; Campbell et al. 2006; Diaz-Almela et al. 2007; Ehlers et al. 2008). Seagrasses within Florida Bay and the Everglades, Florida, may be near their thermal limits in the summer months, making these habitats vulnerable to climate change if high temperatures are sustained and compounded by other stressors (Koch et al. 2013). Given dwarf seahorse reliance on seagrass habitat, any changes in the distribution or coverage of seagrass could also affect dwarf seahorse populations.

Beyond climate change effects to dwarf seahorse habitat, the species may also be directly affected by increased water temperature. While there have been no thermal tolerance studies performed on dwarf seahorse, they are considered a tropical species and aquarium husbandry recommends water temperature maintained at 20-26ºC (Masonjones 2001, Koldewey 2005). Therefore, the northern distributional limits of dwarf seahorse are likely based, at least in part, on over-wintering water temperatures. It is unknown what level of temperature increases could affect the current distribution and range of dwarf seahorse, though the United States southeast is predicted to have among the smallest changes in mean annual temperature (IPCC 2014).

Sea level rise resulting from climate change is projected to continue during the twenty-first century at a rate faster than observed from 1971 to 2010. The projected increase in sea level for the period 2081-2100, relative to 1986-2005, is 0.45-0.82 m with medium confidence under the scenario RCP8.5 (IPCC 2014). Sea level rise is expected to occur in more than 95% of the ocean area by the end of the twenty-first century, though it will not be uniform across regions (IPCC 2014). About 70% of the coastlines worldwide are projected to experience a sea level change within ±20% of the global mean (IPCC 2014). It is unknown how sea level rise could affect the current distribution and range of dwarf seahorse; however, Saunders et al. (2014) found that sea level rise could impact the habitat given inland migration of coastal habitats, loss of habitat at the seaward edge, vertical accretion to maintain position with sea level rise, adaptation to new conditions, or a combination thereof. As sea levels increase, it is assumed that the deep edge of the seagrass bed will migrate inland. Inland migration of seagrass beds will not likely result in a loss of habitat in open areas; however, seagrasses occurring in urbanized areas will experience "coastal squeeze" due to seawalls and other man-made structures designed to prevent flooding (i.e., hardening of the shoreline) (Wong et al. 2014). Meyer (2013) developed a model to predict potential impacts to seagrasses due to sea level rise and shoreline hardening within St. Joseph Sound and Clearwater Harbor, Florida. Assuming sea level rise remained constant at the observed 2.4-millimeter to 2.8-millimeter per year rate, Meyer determined these areas could experience a 0.30 m sea level rise over the next 90 years (2010-2100), resulting in a loss of 14 square kilometers (km^2) of existing habitat and a gain of 6 km^2 of additional habitat (4 km^2 of new habitat and 2 km^2 of new colonization) (Meyer 2013).

Summary of Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

There are several factors that may influence the amount of seagrass habitat available for dwarf seahorse, ranging from harmful algal blooms and water quality degradation to direct removal from trawling and prop scarring. Most of these factors are likely to negatively affect seagrass habitat, though increased temperatures from climate change may afford conditions conducive for seagrass expansion. In the case of sea level rise, urbanized areas with hardened shorelines could prevent the natural spread of seagrasses (Wong et al. 2014); however, in natural areas, seagrasses would be free to spread inshore. The net effect of these factors in the future is largely unknown. Efforts to protect and restore habitats have shown positive results: in several Florida and Texas bay systems, increased water clarity, education and enforcement, and planting efforts are helping to reestablish and, in most Florida estuaries, increase seagrass habitat (Handley et al. 2007; Yarbro and Carlson 2013; Yarbro and Carlson 2016). While trawling does occur, most occurs outside of dwarf seahorse habitat using gear with little impact on the species (FWC 2016; SERO 2014).

8.2 Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Aquarium Trade

In the greater Caribbean, the dwarf seahorse is collected live as a marine ornamental fish for the aquarium trade (Bruckner et al. 2005). In the United States, the harvest of marine ornamental species is restricted to Florida and Hawaii (Larkin and Adams 2003). Because dwarf seahorse does not occur in Hawaii, we examine the Florida regulations below.

In Florida, the dwarf seahorse is considered a marine ornamental and can be harvested for commercial purposes with the appropriate license in the Marine Life fishery (FWC 2016) (See Section 8.5, "Inadequacy of Existing Regulatory Mechanisms"). The Marine Life fishery pertains to the non-lethal harvest of saltwater fish, invertebrates, and plants for commercial purposes, primarily as ornamentals for the aquarium market (Florida Administrative Code 68B-42.006, F.A.C). In order to maintain collected organisms in a healthy condition, harvesters are limited to the use of hand-held nets, barrier nets, drop nets, slurp guns, storage bags, rolling frame trawls, and rods (FWC 2016). The recreational harvest of the dwarf seahorse is also permitted in Florida with a saltwater fishing license which permits the collection of up to 5 dwarf seahorse per person per day (included in a 20-organism per day Marine Life aggregate bag limit); however, the annual recreational harvest is not monitored.

In a recent document summarizing the management history for dwarf seahorse, the FWC fishery-dependent monitoring database was examined for commercial Marine Life dwarf seahorse harvest, 1990-2014 (FWC 2016). In the 20 years prior to the development of the current regulations (1990-2009; See Section 8.5, "Inadequacy of Existing Regulatory Mechanisms"), commercial harvest of dwarf seahorse averaged approximately 44,000 individuals per year. In 2009, FWC implemented a 400 dwarf seahorse limit per person or per vessel per day, whichever is less (FWC 2016). In the seven years since this trip limit was adopted (2010-2016), average annual harvest has been reduced to approximately 20,000 individuals per year, a reduction of approximately 55% per year (FWC unpublished data, Figure 12). The majority of these landings occurred between Tampa Bay and Miami (Figure 13) which includes the Florida Central Region and Florida South Region. The 2009 trip limit significantly reduced harvest in the Tampa Bay to Ft. Myers region as compared to other regions, and mean trip-level harvest since the limit was imposed has been well below the limit (Figure 14).

While the majority of seahorses collected in the United States remain in the domestic market, a small international market does exist. In 2004, all seahorses (*Hippocampus* spp.) were added to Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (See Section 8.5, "Inadequacy of Existing Regulatory Mechanisms – International Trade"). From 2004 to 2014, the United States exported a total of 2,190 dwarf seahorse: 657 wild-caught and 1,533 captive-bred (USFWS 2014).

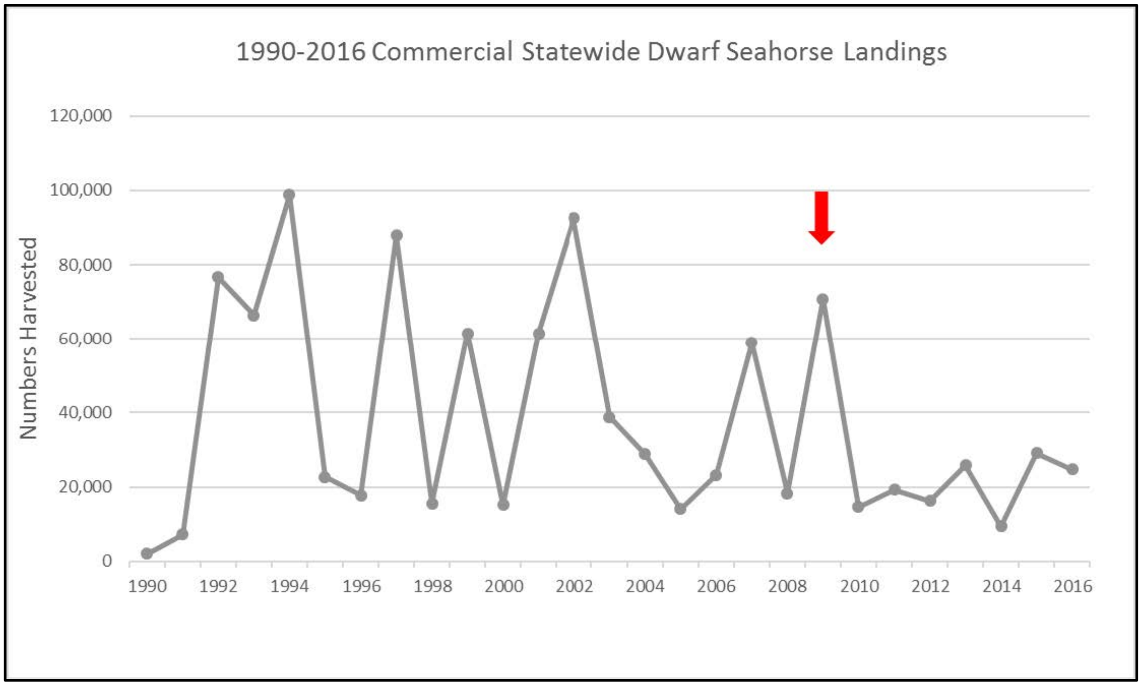


Figure 12. Statewide commercial dwarf seahorse landings for Florida (numbers harvested), 1990-2016. Arrow indicates the year in which a trip limit was implemented (FWC unpublished data).

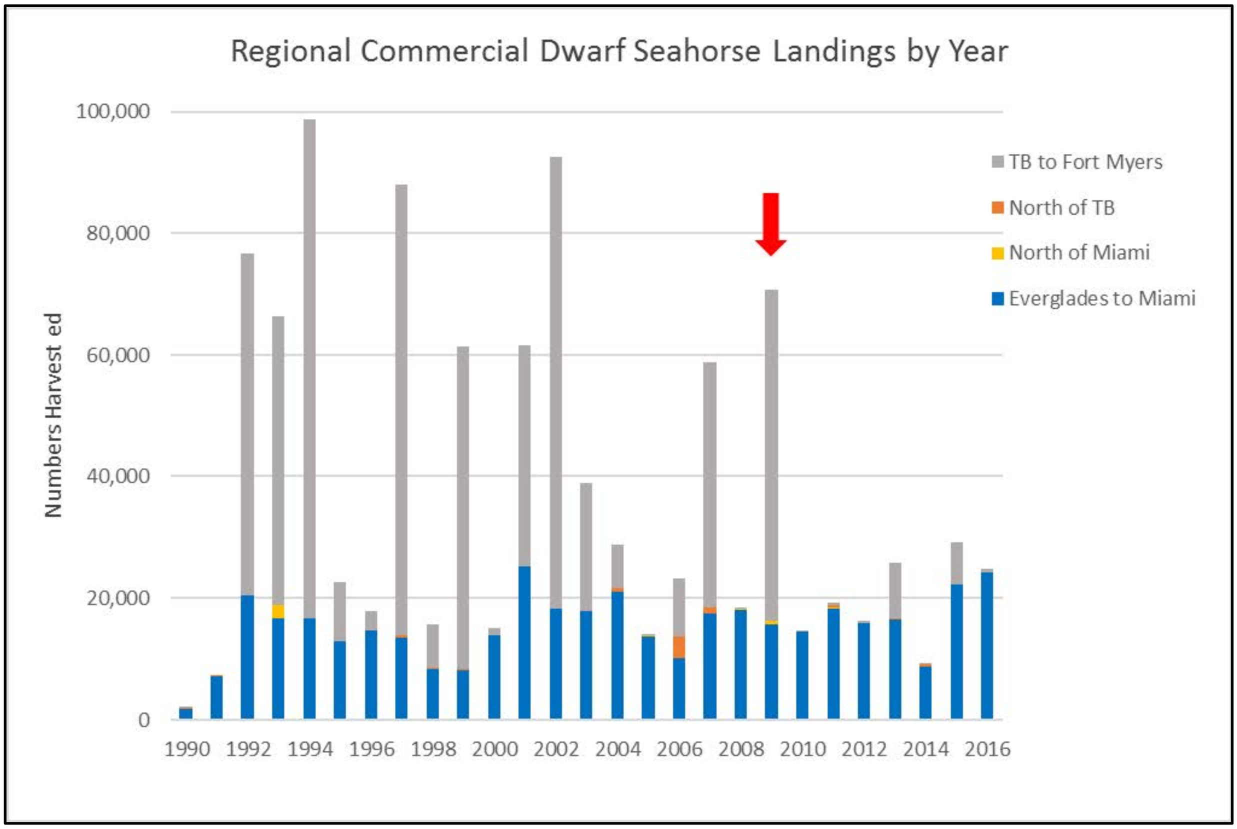


Figure 13. Regional commercial dwarf seahorse landings in Florida (numbers harvested), 1990-2014. Arrow indicates the year in which the modified trip limit was implemented (FWC unpublished data). Tampa Bay is abbreviated TB.

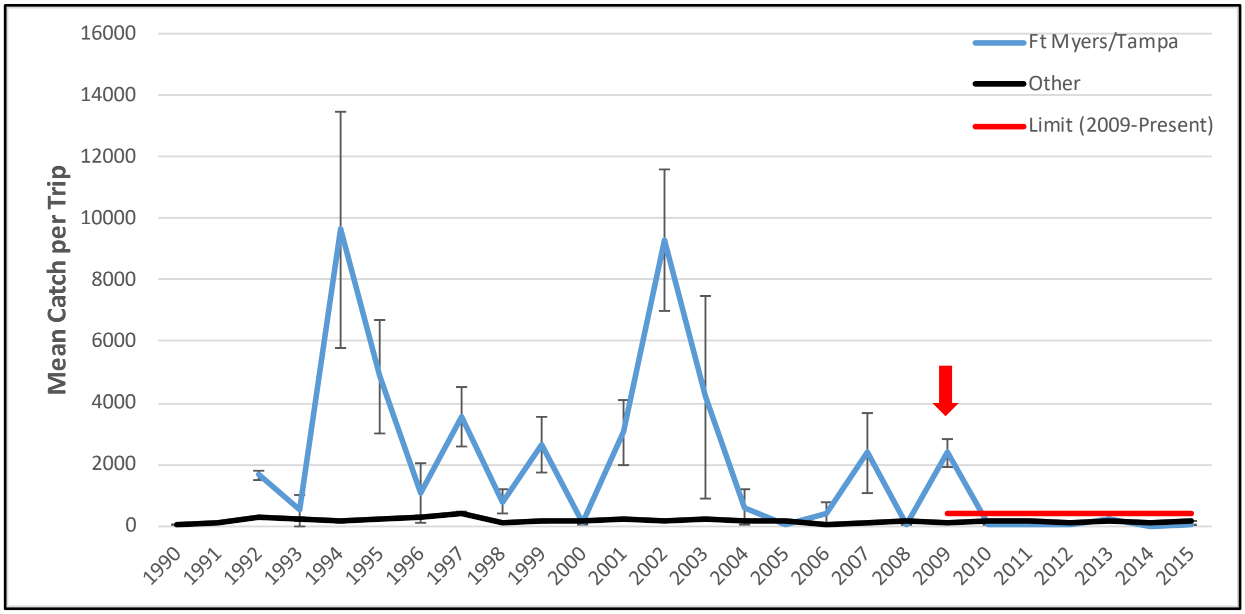


Figure 14. Commercial dwarf seahorse catch per trip in Florida (numbers harvested), 1990-2015. Arrow indicates the year in which the modified trip limit was implemented (FWC unpublished data).

Curio Trade
The harvest of seahorses for the curio market was recorded in Florida as early as the 1950s (Strawn 1961). Bruckner et al. (2005) documented a commercial fishery for the dwarf seahorse in Old Tampa Bay in which they were harvested and dried. Grey et al. (2005) found there were approximately 5,000-10,000 retail outlets for marine curios in Florida, but, because there are no quantitative studies focused on the marine curio trade, the quantitative impact of the curio market on dwarf seahorse is unknown. The impact is likely minimal since overall landings were greatly reduced following the 2009 regulations (FWC 2016).

Traditional Chinese Medicine
Currently, the dwarf seahorse is not in high demand in the Traditional Chinese Medicine (TCM) market (Vincent 1995). Smaller, bony seahorses, such as the dwarf seahorse, are considered poor quality and are not valuable for the purpose of TCM (Lourie et al. 2004; Vincent 1996). At this time, the available information does not suggest that the dwarf seahorse is being exported for TCM purposes.

Bycatch
Seahorses are targeted in small-scale artisanal fisheries by free-divers and collectors, but bycatch in trawls and other commercial gears appears to be a larger source of catch and subsequent harvest (Vincent, 1996; Baum et al., 2003; Lawson et al., 2017). There are high levels of bycatch associated with the inshore shrimp trawling fisheries in the southeastern United States (Diamond 2004; Hall et al. 2000). Although the number of dwarf seahorse being removed from the population by non-selective fishing methods is not monitored, there is some concern over the increase in trawling effort during the peak reproductive season of dwarf seahorse (August and September) (Stallings et al. 2014). Fishers operating in areas with the greatest potential for overlap with dwarf seahorse habitat do so under state-mandated gear types, specific fishing endorsements, bag-limits, and time-area closures (See Section 8.5, “Regulations on Harvest”). At this time, the level of dwarf seahorse bycatch is unknown. Baum et al. (2003) analyzed bycatch of the lined seahorse (*Hippocampus erectus*) in the bait-shrimp trawl fishery in Hernando Beach, Florida and estimated about 72,000 seahorses were incidentally caught per year. Baum et al. (2003) reported only two dwarf seahorse were captured as part of this study. Using the ratio of dwarf seahorse caught to lined seahorse caught, Carlson et al. (2019) estimated that 157 dwarf seahorse are incidentally caught per year in this fishery.

Summary of Overutilization for Commercial, Recreational, Scientific, or Educational Purposes
In summary, the overutilization of dwarf seahorse is a potential threat to the species. The commercial harvest of dwarf seahorse was reduced by 55% per year (2010-2016) following the 2009 FWC regulations to the Marine Life fishery (FWC 2016). The impact on dwarf seahorse from the recreational fishery, the marine curio trade, and as bycatch in inshore shrimp trawl fisheries is unknown because there is no quantitative data. Unlike larger seahorses, the dwarf seahorse was likely never affected by the TCM market due to its small size.

8.3 Disease and Predation

Predation is probably greatest for juvenile dwarf seahorse, which can be eaten by crabs (Strawn 1958), fish, and wading birds (Kleiber et al. 2010). It is likely that any seahorse found in larger predators' stomachs (such as skates and rays, and water birds) (Lourie et al. 1999) are the result of incidental or opportunistic feeding; they are not believed to be primary prey item for any species (Kleiber et al. 2010). We are not aware of any documentation indicating disease effects on the dwarf seahorse in the wild population.

8.4 Inadequacy of Existing Regulatory Mechanisms

Regulations on Harvest

In the United States, the harvest of marine ornamentals is restricted to Florida and Hawaii (Larkin and Adams 2003) where species are harvested alive and sold in the aquarium trade (See Section 8.2, "Aquarium Trade"). In 2015, NOAA Fisheries met with FWC to assess the impact harvest of marine ornamentals has on dwarf seahorse populations. In response, the FWC Division of Marine Fisheries Management published a document (FWC 2016) that summarizes the management history and current regulations for recreational and commercial harvesters of marine ornamentals in Florida waters (Florida Administrative Code 68B-42). While there is no United States Federal management plan for the majority of marine life species, the FWC regulations extend into federal waters for marine life species.

Under existing Florida regulations, recreational collectors of marine ornamentals must have a saltwater fishing license, are subject to a bag limit (5 of each species per person per day, which is included in a 20-organism per day marine life aggregate bag limit), are restricted by specific authorized gear types and time-area closures, and must land marine life species alive (FWC 2016). Commercial harvesters of marine ornamentals in Florida are restricted by authorized gear types and time-area closures, must land marine life species alive, are required to have a Saltwater Products License with a Restricted Species endorsement and a Marine Life endorsement, and are limited to 400 dwarf seahorse per person or per vessel per day (whichever is less). In addition, commercial harvesters that take dwarf seahorse as bycatch, using gear not authorized for use in the Marine Life Fishery, are limited to the daily recreational bag limits listed above and must hold a Marine Life Bycatch endorsement. The commercial Marine Life Fishery is order driven, meaning that harvesters will wait until they have a request before they begin collecting (FWC 2016). The collectors do not hold animals and await a sale; rather they respond to an order.

The commercial Marine Life Fishery is a limited entry fishery, meaning participants may only enter the fishery by acquiring an endorsement that is eligible for transfer from a participant leaving the fishery. Currently, there are 152 Marine Life endorsement holders, many of which are non-transferable. Therefore, the number of participants in the fishery is continually being reduced as fishers leave the industry. Specific for seahorses, the 5-year (2010-2014) average number of endorsement holders collecting dwarf seahorse was 17 and approximately 5-6 collectors specialized in the dwarf seahorse (FWC 2016). An analysis of commercial dwarf seahorse Trip Tickets indicated the catch per trip has reduced in recent years following the 2009 implementation of the 400 seahorse trip limit, though there are still trips that exceed the limit (NMFS 2015). One individual collector reported exceeding the trip limit 26 times over 80 trips between 2010 and 2015. Harvest in excess of the trip limit totaled over 11,000 dwarf seahorses. Other harvesters may also be exceeding the limits but not reporting their catches accurately.

The gear types authorized for use by recreational collectors and commercial harvesters targeting dwarf seahorse are limited to hand-held nets, barrier nets, drop nets, slurp guns, storage bags, and a seahorse trawl (a trawl with an opening no larger than 12 inches by 48 inches, not weighing more than 5 pounds wet, and towed no greater than idle speed by a vessel no greater than 15 feet in length). Roller frame trawls may only be used to collect dwarf seahorses or other marine life species by endorsement holders that hold a valid live bait shrimping license.

The harvest of all Marine Life species, including dwarf seahorse, is prohibited from a large portion of their ranges in Florida because of a series of time-area closures over nearshore seagrass beds along the Gulf of Mexico coast. In the Florida Big Bend Region (Figure 15), shrimp harvest is closed from July 1 through August 31 of each year (Florida Administrative Code 68B-31.017). In the Florida South Region (Figure 16), trawling is prohibited within Biscayne National Park, Dry Tortugas National Park, and Everglades National Park, and from Ecological Reserves, Sanctuary Preservation Areas, and Special-use Research Only areas within the Florida Keys National Marine Sanctuary. Additionally, the harvest of all seahorse species is prohibited in John Pennekamp Coral Reef State Park in the Upper Keys (also the Florida South Region) (Florida Administrative Code 68B-42.0036) (Figure 16). Time and area closures within the known areas of greatest abundance of dwarf seahorse likely afford protection to both dwarf seahorse and their habitat.

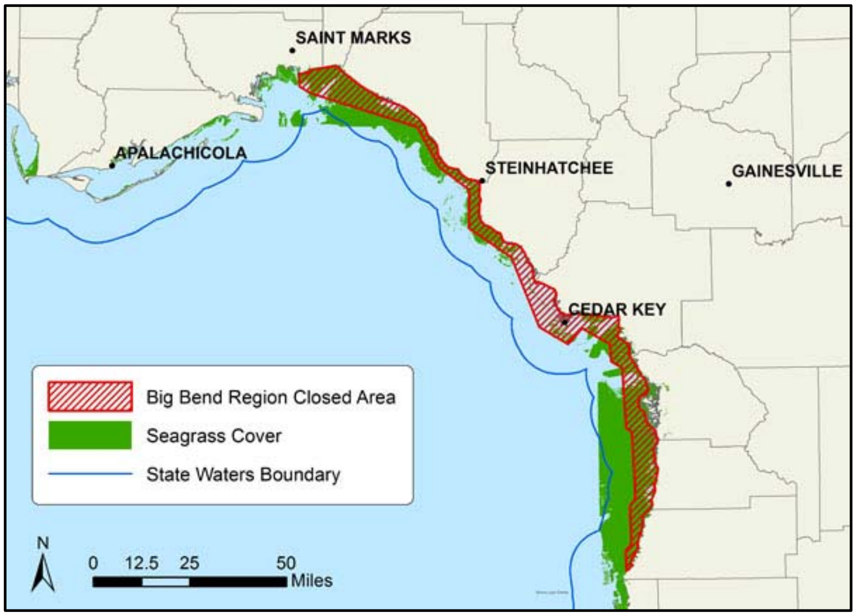


Figure 15. Map of Florida Big Bend Region closed to shrimp harvest from July 1 through August 31 of each year (Figure 2 in FWC 2016)

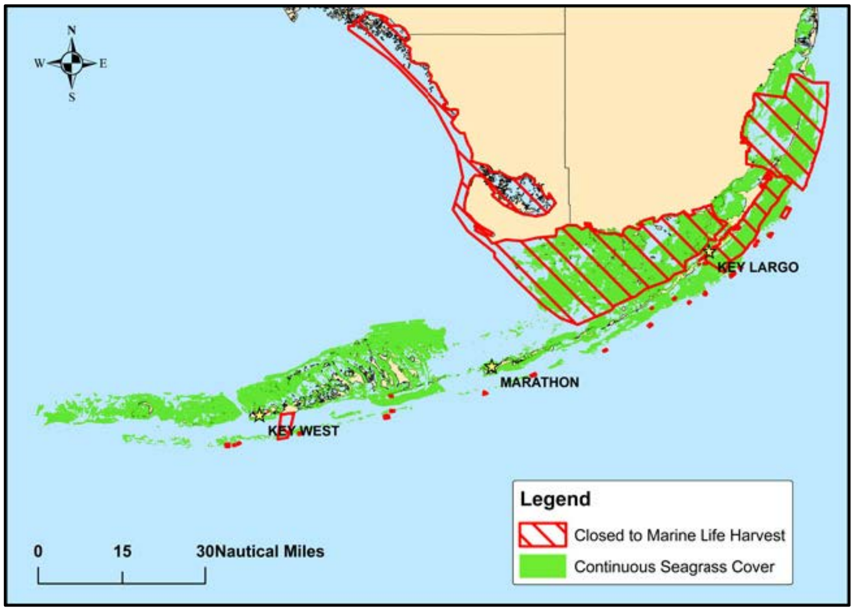


Figure 16. Map of Florida South Region closed to the harvest of Marine Life species (Figure 1 in FWC 2016)

Harvest regulations are sparse for other countries within the range of the dwarf seahorse, including The Bahamas, Cuba, and Mexico. The Bahamas does not have any specific regulations or harvest controls for seahorses, and we are unaware of any fishery in The Bahamas specifically targeting dwarf seahorse. Information from Cuba on environmental laws which regulate fishing and that protect the dwarf seahorse was not available. In Mexico, dwarf seahorse are listed on NOM-059-SEMARNAT-2001 as a species subject to “Special Protection” and any removal of the species must be done in accordance to the Mexican General Law of Wildlife (Diaz 2013), which establishes the conditions for capture, transport permits, and authorizations (Bruckner et al. 2005). Mexico prohibits the intentional capture and trade of wild seahorses, permitting only the commercialization of cultured and incidentally caught seahorses.

International Trade Regulation

In 2004, all seahorses (*Hippocampus* spp.) were added to Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). CITES is an international agreement between governments established with the aim of ensuring that international trade in specimens of wild animals and plants does not threaten their survival. Appendix II lists species that are not necessarily now threatened with extinction but that may become so unless trade is closely controlled. The international trade of Appendix-II species may be authorized by an export permit or re-export certificate. Permits or certificates are granted if the relevant authorities are satisfied that certain conditions are met, above all that trade will not be detrimental to the survival of the species in the wild (referred to as a “Non-Detriment Finding”) (See Article IV of Appendix II of CITES). Millions of seahorses are traded internationally each year and the CITES listing has not curbed this trade (Foster et al. 2014). As previously discussed in Section 8.2, few dwarf seahorse removed from wild, domestic populations are exported; dwarf seahorse makes up less than 0.01% of the seahorses in trade (Foster and Vincent 2004). Grey et al. (2005) document dwarf seahorse in exports to the

Philippines for curio purposes; however, the 2009 state regulations in Florida may have curtailed this curio trade (FWC 2016). The enforcement of CITES regulations are dependent upon traders' declarations (Armstrong and Crawford 1998; Lourie et al. 2004) and the exporting and importing countries enforcement and implementation of Non-Detriment Findings. Yet, there is a report of an illegal export of over 100 live dwarf seahorses without a CITES permit from the United States to Essex, England (Burleigh 2006). The origin of the seahorses was unknown.

Summary of Inadequacy of Existing Regulatory Mechanisms

While harvest regulations are sparse in other countries within the range of dwarf seahorse (The Bahamas, Cuba, Bermuda, and Mexico), changes in the Marine Life Fishery harvest limits since the 2009 domestic regulations have been extensive in Florida. In the seven years since the limit was adopted (2010-2016), average annual commercial harvest has been reduced by approximately 55% per year (44,000 to 20,000 individuals per year). However, further enforcement of the commercial harvest regulations, specifically the 400 specimen trip limit, is warranted as trip limits are still being exceeded (NMFS 2015). The prohibition of dwarf seahorse harvest from a large portion of their range in Florida, because of a series of time-area closures over nearshore seagrass beds along the Gulf of Mexico coast where the species occurs in high abundance, is likely beneficial. The annual recreational harvest is not monitored, but recreational collectors of marine ornamentals must have a saltwater fishing license, are subject to a bag limit of 5 dwarf seahorse, are restricted by specific authorized gear types, and must land marine life species alive (FWC 2016). Few dwarf seahorse removed from wild, domestic populations are exported and those that are removed are governed by Appendix II of CITES.

8.5 Other Natural or Manmade Factors Affecting the Species

Life History Characteristics

In general, seahorses are characterized by a patchy distribution, low mobility, small home range, lengthy parental care, and mate fidelity. It has been suggested these life history characteristics play a role in their ecological vulnerability (Foster and Vincent 2004; Jones and Avise 2001; Lourie et al. 2004; Masonjones et al. 2010, 2019; Rose et al. 2019). Low mobility could mean that dwarf seahorse would be slow to recolonize overexploited populations (Foster and Vincent 2004); however, recent evidence suggests genetic connectivity between dwarf seahorse populations along the Gulf of Mexico coast of Florida is likely the result of individuals dispersing to neighboring populations over great distances (Fedrizzi et al. 2015). Life history characteristics that help dwarf seahorse compensate for increased vulnerability to overfishing or changes to habitat include rapid growth, early maturity, frequent reproduction, and parental care. We found no indication of depensatory effects (effects that lead to a decrease in the breeding population) whereby sex ratios become skewed when monogamous species are faced with small population size. The short generation times of seahorses in general allow subpopulations to fluctuate rapidly in response to environmental factors.

Deepwater Horizon

The semi-submersible *Deepwater Horizon* (DWH) drilling rig experienced an explosion and fire on April 20, 2010, while working on an exploratory well in the Gulf of Mexico (approximately 50 miles southeast of the Mississippi River Delta, Louisiana, and 87 miles south of Dauphin

Island, Alabama). The rig subsequently sank, and oil and natural gas began leaking into the Gulf of Mexico. The well was temporarily capped on July 15, 2010, which significantly reduced the amount of leaking oil, but the well was not ultimately sealed and declared “effectively dead” until September 19, 2010. Official estimates indicated 53,000-62,000 barrels were released per day as a result of the event, totaling an estimated 4.9 million barrels (McNutt et al. 2011; NRDA 2012). In addition, approximately 2.1 million gallons of chemical dispersant were applied to surface waters (1.4 million gallons) and directly at the wellhead (0.77 million gallons) from May 15 to July 12, 2010 (Kujawinski et al. 2011).

In response to the spill, NOAA assembled a Submerged Aquatic Vegetation technical working group of experts to assess oil exposure and determine if seagrass resources were injured. The group identified 5 sites with known seagrass communities that were threatened by potential exposure to oil: Big Lagoon, Florida; Robinson Island in Perdido Bay, Alabama; Horn Island, Mississippi; Petit Bois Island, Mississippi; and the Chandeleur Islands, Louisiana. Of the 5 sites, only the seagrass beds in the Chandeleur Islands were found to be exposed based on evidence of extensive oiling on nearby shorelines (Consentino-Manning et al. 2015). Samples of sediments, seagrasses, and invertebrates within affected seagrass beds in the Chandeleur Islands showed concentrations of total polycyclic aromatic hydrocarbons (PAHs) 8 to 12 times greater, on average, than ambient conditions (Consentino-Manning et al. 2015). Seagrass habitats were lost from oiling and from physical disturbance as part of response actions. The seagrass at the Chandeleur Islands, which is uniquely valuable in the region, was particularly affected, resulting in more than 270 acres of seagrass destroyed (PDARP 2015). Injuries to seagrass habitats were also documented within the boundaries of Gulf Islands National Seashore and in Jean Lafitte National Historic Park and Preserve (PDARP 2015).

In addition, fish exposed to oil can be affected directly through uptake by the gills, ingestion of oil or oiled prey, effects on egg and larval survival, or changes in the ecosystem that support the fish (USFWS 2010). Adult fish may experience reduced growth, enlarged livers, changes in heart and respiration rates, fin erosion, and reproductive impairment when exposed to oil (Snyder et al. 2015; USFWS 2010). PAHs are considered the most toxic component of crude oil to marine life and are ubiquitous pollutants in the marine environment (Snyder et al. 2015). Exposure to PAHs has been linked with a variety of sub-lethal effects in fish, including DNA damage, internal and external lesions, gill and organ abnormalities, reduced adult fitness, altered and reduced growth, decreased fecundity, and reduced survival to maturity (Snyder et al. 2015). Despite widespread contamination of offshore waters and, to a lesser extent, coastal waters, the results of a study by Moody et al. (2013) provided little evidence for large-scale acute or persistent oil-induced impacts on organisms that complete all or a portion of their life cycle within an estuary in Point-aux-Pins, Alabama. Fodrie and Heck Jr (2011) concluded that immediate, catastrophic losses of 2010 year classes were largely avoided, and that no shifts in species composition occurred following the spill. Fodrie and Heck Jr (2011) also noted that there was increasing evidence that the acute impacts of the spill may be concentrated in the deep ocean rather than shallow-water, coastal ecosystems.

There have been no studies on the effects of the DWH spill specific to dwarf seahorse. Based on the species' sole reliance on seagrass for its habitat, it is likely that any individuals residing around the Chandeleur Islands, Louisiana, could have been exposed to toxins from the DWH spill. However, the exposed sites are located at the northern latitudes of the species' range and records indicate that the species is not very abundant in those areas (See Section 6.4, "Louisiana," and Section 7, "Seagrass Habitat and Availability"). Therefore, we anticipate the impacts of DWH to dwarf seahorse were minimal due to their low abundance in that area.

Future oil spills have the potential to impact dwarf seahorse and the seagrass habitats upon which the species relies. Because oil and gas production occurs far west of Florida, any spill would need to be transported a great distance by currents before reaching the nearshore waters of Florida where most dwarf seahorse are found. However, the Bureau of Ocean Energy Management's oil spill risk analysis concluded that there is little to no risk of oil making contact with southern Florida coastal waters (BOEM 2013), so it is also unlikely that future oil spills will directly affect dwarf seahorse populations.

Anthropogenic (Man-made) Noise

Studies conducted in controlled aquaculture tanks suggest noise exposure will increase stress in seahorses (i.e., less time attached to holdfasts, greater parasite loading, decreased weight) (Anderson et al. 2011). It is currently unknown to what extent dwarf seahorse are affected by man-made noise in the open, estuarine environment but other species showed decreased feeding and courtship as a result of increased noise (Claassens and Hodgson 2018).

Weather Events

Like all inshore species, dwarf seahorse and their associated seagrass habitat are vulnerable to severe weather events. During severe weather events, dwarf seahorse may be stripped from seagrass holdfasts and moved inshore or out to sea, both of which could result in mortality. Similarly, seagrass beds can be damaged by severe weather events due to increased turbidity and wave action (Erftemeijer and Lewis 2006; Pulich and White 1991; USGS 2004; Watling and Norse 1988). Extreme weather events can cause increases in freshwater inflow, suspension of particles, nutrient loading, decreases in salinity and water clarity, and increases or decreases in water temperature (Dixon and Perry 2003; Tomasko et al. 2005). These effects can impact seagrass beds over short- or long-term periods and could also result in dwarf seahorse displacement, relocation, or mortality.

Given that dwarf seahorse are limited in their geographic range as a result of thermal tolerances, cold weather events can result in mortality. A severe cold weather event affected Florida in January 2010 (see Figure 7) that resulted in the death of a variety of temperature-sensitive fish species (Adams et al. 2011). While we cannot say with certainty how this event affected dwarf seahorse, we expect that it resulted in mortality along the northern gulf coast where temperatures fell below known tolerance limits for extended periods of time (Figure 8). Fishery-independent monitoring by FWC recorded slight drops in mean density of dwarf seahorse at 6 of 8 survey areas (75%) between 2009 and 2010; however, these reductions were not statistically significant. Masonjones et al. (2019) described a population crash in Tampa Bay between 2009 and 2010, hypothesized to be caused by cold weather. Despite any mortality associated with the cold event in 2010, the subpopulation trend for dwarf seahorse in Tampa Bay continued to increase from 2010 through 2016 (Figure 3). Similarly, USGS surveys indicated stable or increasing populations following the 2010 "Florida Freeze" cold weather event (Figure 4). Cold weather events are of particular concern along the northern limits of dwarf seahorse range as these are the areas most likely and most often affected by reduced temperatures.

Summary of Other Natural or Man-made Factors Affecting the Species

In summary, other natural or man-made effects are likely a minimal threat to dwarf seahorse. All seahorses exhibit life history characteristics that allow for increased vulnerability to overfishing or changes to habitat, including sparse distribution, low mobility, small home ranges, lengthy parental care, and mate fidelity. However, dwarf seahorse also exhibit life history characteristics that may help the species compensate for these risks, including rapid growth, early maturity, and frequent reproduction (See Section 5, "Demography"). Additionally, genetic connectivity between dwarf seahorse subpopulations along the Gulf of Mexico coast of Florida show individuals can disperse to neighboring populations over greater distances than they were previously known to migrate (Fedrizzi et al. 2015; Foster and Vincent 2004).

9 CONSERVATION EFFORTS

Regulations Associated with Water Quality

The Federal Water Pollution Control Act, and amendments (FWPCA) (33 U.S.C. 1251-1376), also called the "Clean Water Act," mandates Federal protection of water quality. The law also provides for assessment of injury, destruction, or loss of natural resources caused by discharge of pollutants. Section 404 of the FWPCA prohibits the discharge of dredged or fill material into navigable waters without a permit. The main responsibility for water quality management resides with the states in the implementation of water quality standards, the administration of the National Pollutant Discharge Elimination System (NPDES) program (where the state has received United States Environmental Protection Agency (EPA) approval to do so), and the management of non-point sources of pollution. Section 303(d) of the Clean Water Act requires states to identify waters that do not meet or are not expected to meet water quality standards. Each state develops Total Maximum Daily Loads (TMDLs) for its water quality-limited waters. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that load among the various point and non-point sources of that pollutant. Section 402 of the Clean Water Act created a system for permitting wastewater discharges. Collectively the NPDES sets specific limits on discharge of various types of pollutants from point-source outfalls. A non-point source control program focuses primarily on the reduction of agricultural siltation and chemical pollution resulting from rain runoff into streams. Efforts to reduce non-point pollution currently rely on the use of land management practices to reduce surface runoff through programs administered primarily by the Department of Agriculture. Dwarf seahorse habitat may be protected by the implementation, administration, and management of water quality standards.

Congress passed the Coastal Zone Management Act (16 U.S.C. 1451–1464) and Estuarine Areas Act (16 USCS 1224 through 1226) for estuaries and coastal areas. Comprehensive planning programs, carried out at the state level, were established to enhance, protect, and utilize coastal resources. Federal activities must comply with the individual state programs. Dwarf seahorse habitat may be protected by planning and regulating development that could cause damage to sensitive coastal habitats.

Regulatory Mechanisms for Climate Change

Greenhouse gas emissions are regulated through multi-state and international agreements and through statutes and regulations, at the national, state, or provincial level. One of the key international agreements relevant to attempts to control greenhouse gas emissions, the Copenhagen Accord, was developed in 2009 by the Conference of Parties to the United Nations Framework Convention on Climate Change. The Copenhagen Accord identifies specific information provided by Parties on quantified economy-wide emissions targets for 2020 and on nationally appropriate mitigation actions to the goal of capping increasing average global temperature at 2°C above pre-industrial levels. At the 2015 meeting in Paris the Parties reached a landmark agreement that brought "all nations into a common cause to undertake ambitious efforts to combat climate change…" The Paris Agreement aims to (1) keep global temperature rise this century below the 2°C previously identified, (2) strengthen the ability of countries to address climate change, and (3) establish financial flows, new technology frameworks, and enhanced capacity building. The most recent conference of the Parties to the United National Framework Convention on Climate Change was held in Katowice, Poland, in December 2018. However, the United States is no longer a party to this agreement.

National and international efforts to limit climate change are ambitious, but their success is uncertain because major agreements are still being formulated, and the outcomes of ongoing activities are not yet known. Likewise, the effects of climate change on dwarf seahorse and their habitat are also not yet known (See Section 8.1, "Climate Change," above). Still, climate change predictions by the IPCC (IPCC 2014) suggest that temperature increases within the range of dwarf seahorse may be less than other areas in North America, even without additional efforts to constrain greenhouse gas emissions. Sea level rise associated with climate change could lead to a decline in the extent of dwarf seahorse habitat within some climate zones and an expansion in others. It is unknown how regulations addressing climate change may contribute to dwarf seahorse distribution and habitat.

Other Regulatory Mechanisms Affecting Dwarf Seahorse

The National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. 4321-4347) requires an environmental review process of all Federal actions. This includes preparation of an environmental impact statement for major Federal actions that may affect the quality of the human environment. Less rigorous environmental assessments are reviewed for most other actions, while some actions are categorically excluded from formal review. These reviews provide an opportunity for both the agency and the public to comment on projects that may impact fish and wildlife habitat.

The Fish and Wildlife Coordination Act (FWCA) (16 U.S.C. 661-666) is the primary law providing for consideration of fish and wildlife habitat values in conjunction with Federal water development activities. The FWCA applies to water-related activities proposed by non-Federal entities for which a Federal permit or license is required. Under this law, the Secretaries of the Interior and Commerce may investigate and advise on the effects of federal water development projects on fish and wildlife habitat. Such reports and recommendations, which require concurrence of the state fish and wildlife agency(ies) involved, must accompany the construction agency's request for congressional authorization, although the recommendations are nonbinding. The most significant permits or licenses required are Section 404 and discharge permits under the Clean Water Act of 1972 and Section 10 permits under the Rivers and Harbors Act of 1899. The USFWS and NMFS may review the proposed permit action and make recommendations to the permitting agencies to avoid or mitigate any potential adverse effects on fish and wildlife habitat. Though nonbinding, these recommendations must be given consideration by the permitting agency.

The Gulf of Mexico Program (GMP) is a network of citizens that manage and protect the resources of the Gulf of Mexico in ways consistent with the economic well-being of the region. Administered by the EPA, the GMP engages many organizations across the northern Gulf of Mexico region for issues regarding seagrass habitat conservation and restoration. The GMP includes representatives from state (e.g., TPWD and FWC) and federal agencies (e.g., USGS and the National Estuary Program), non-profit organizations (e.g., Tampa Bay Watch and The Nature Conservancy), the scientific community, business and industry, and an organized citizens' group whose members are individually appointed by the governors of the 5 Gulf states (Texas, Louisiana, Mississippi, Alabama, and Florida). It is unknown if and to what degree this program may benefit dwarf seahorse.

10 ASSESSMENT OF EXTINCTION RISK FOR DWARF SEAHORSE (*HIPPOCAMPUS ZOSTERAE*)

10.1 Introduction

The ESA (Section 3) defines endangered species as “any species which is in danger of extinction throughout all or a significant portion of its range.” Threatened species is defined as “any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.” A Status Review Team (SRT) was convened to compile the best available information on dwarf seahorse and conduct a risk assessment through evaluation of the demographic risks, threats, and extinction risk facing the species or distinct population segments (DPS). This information is ultimately used by NMFS, after consideration of the legal and policy dimensions of the ESA standards and benefits of ongoing conservation efforts, to make a listing determination. For purposes of this risk assessment, the SRT, comprised of one fishery biologist from the Southeast Fisheries Science Center and two resource managers from the Southeast Regional Office, was convened to review the best available information in this Status Review document, conduct a DPS analysis, and evaluate the overall risk of extinction facing dwarf seahorse.

10.2 Distinct Population Segment Analysis

Criteria for Identification of Distinct Population Segments

Under the ESA, a listing determination may address a “species,” which is defined to also include subspecies and, for any vertebrate species, any DPS that interbreeds when mature (16 U.S.C. 1532(16)). The joint policy of the USFWS and NMFS provides guidelines for defining DPSs below the taxonomic level of species (61 FR 4722; February 7, 1996). The policy identifies two elements to consider in a decision regarding whether a population qualifies as a DPS: discreteness and significance of the population segment to the species.

> *Discreteness* - A DPS may be considered discrete if it is markedly separate from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors, or if it is delimited by international governmental boundaries. Genetic differences between the population segments being considered may be used to evaluate discreteness.
>
> *Significance* - If a population segment is considered discrete, its biological and ecological significance must then be evaluated. Significance is evaluated in terms of the importance of the population segment to the overall welfare of the species. Some of the considerations that can be used to determine a discrete population segment’s significance to the taxon as a whole include:
>
> 1) Persistence of the population segment in an unusual or unique ecological setting;
> 2) Evidence that loss of the population segment would result in a significant gap in the range of the taxon; and
> 3) Evidence that the population segment differs markedly from other populations of the species in its genetic characteristics.

Distinct Population Segment Analysis - SRT Results

The original petition requested that the species be considered for endangered or threatened status as a single entity throughout its range. While the agency has discretion to evaluate a species as a DPS, a congressional report (S. Rep. 96-151) indicates that we should do so sparingly. The SRT held discussions as to whether this species should be considered throughout its range or as distinct populations. Given the limited information available, the team concluded there may be discrete populations but without additional data we are unsure whether individual populations are likely ecologically significant to the overall welfare of the species, especially those on the fringe of the range. Therefore, we conducted the extinction risk analysis of dwarf seahorse as a single species without further consideration of DPSs.

10.3 Extinction Risk Analysis

The ability to measure or document risk factors to a species is often limited and information is often not quantitative or lacking altogether. Therefore, in assessing extinction risk of a species, it is important to include both qualitative and quantitative information. In previous NMFS status reviews, review teams have used a risk matrix method to organize and summarize the professional judgment of a panel of knowledgeable scientists. This approach is described in detail by Wainright and Kope (1999) and has been used in Pacific salmonid status reviews as well as in reviews of Pacific hake, walleye pollock, Pacific cod, Puget Sound rockfishes, Pacific herring, and black abalone (for links to these reviews see https://www.fisheries.noaa.gov/find-species). In the risk matrix approach, the condition of the species is summarized according to four demographic risk criteria: abundance, growth rate/productivity, spatial structure/connectivity, and diversity. These viability criteria, outlined in McElhany et al. (2000), reflect concepts that are well-founded in conservation biology and that individually and collectively provide strong indicators of extinction risk. Using these concepts, the SRT estimated the extinction risk of dwarf seahorse after conducting a demographic risk analysis. Likewise, the SRT performed a threats assessment for dwarf seahorse by scoring the severity of current threats to the species and their impact on the species through the foreseeable future. The summary of the demographic risks and threats obtained by this approach was then considered by the SRT in determining the species' overall level of extinction risk. Specifics on each analysis are provided separately below.

Foreseeable Future

For the purpose of this extinction risk analysis, the term "foreseeable future" was defined as the timeframe over which threats can be predicted reliably to impact the biological status of the species. In determining an appropriate "foreseeable future" timeframe, we first considered the life history of dwarf seahorse, including longevity and generation time. At approximately 1-3 years (Abbott 2003; Koldewey 2005; Strawn 1958; Vari 1982), dwarf seahorse longevity is very short in comparison to many other teleost fish. Dwarf seahorse reach sexual maturity in about 3 months (Strawn 1953; Strawn 1958; Koldewey 2005); therefore, generation time, which is defined as the time it takes, on average, for a sexually mature female to be replaced by offspring with the same spawning capacity, is 1.24 yr. As an early-maturing species, with fast growth rates and high productivity, dwarf seahorse subpopulations are likely able to respond quickly to conservation actions. However, this life history strategy can also make the species susceptible to stochastic events or newly arising threats. Therefore, we believe the foreseeable future should include several generation times. In this review, we have defined foreseeable future as about 8 generation times or 10 years. We then discussed whether we could confidently predict the impact of threats on the species out to 10 years and agreed that since the main threats to the species were likely habitat loss and overutilization, we had the background knowledge and expertise to confidently predict the impact of these threats on the biological status of the species within this timeframe.

Demographic Risk Analysis

The SRT chose to score the four demographic factors in regards to their contribution to extinction risk of dwarf seahorse. Qualitative scoring of each factor used numerals 1-5 representing the following categories:

1. Very low risk
2. Low risk
3. Medium risk
4. High risk
5. Very high risk

The range, average, and mode of scores produced by the team are presented for both the present and over the forseeable future (Figure 17).

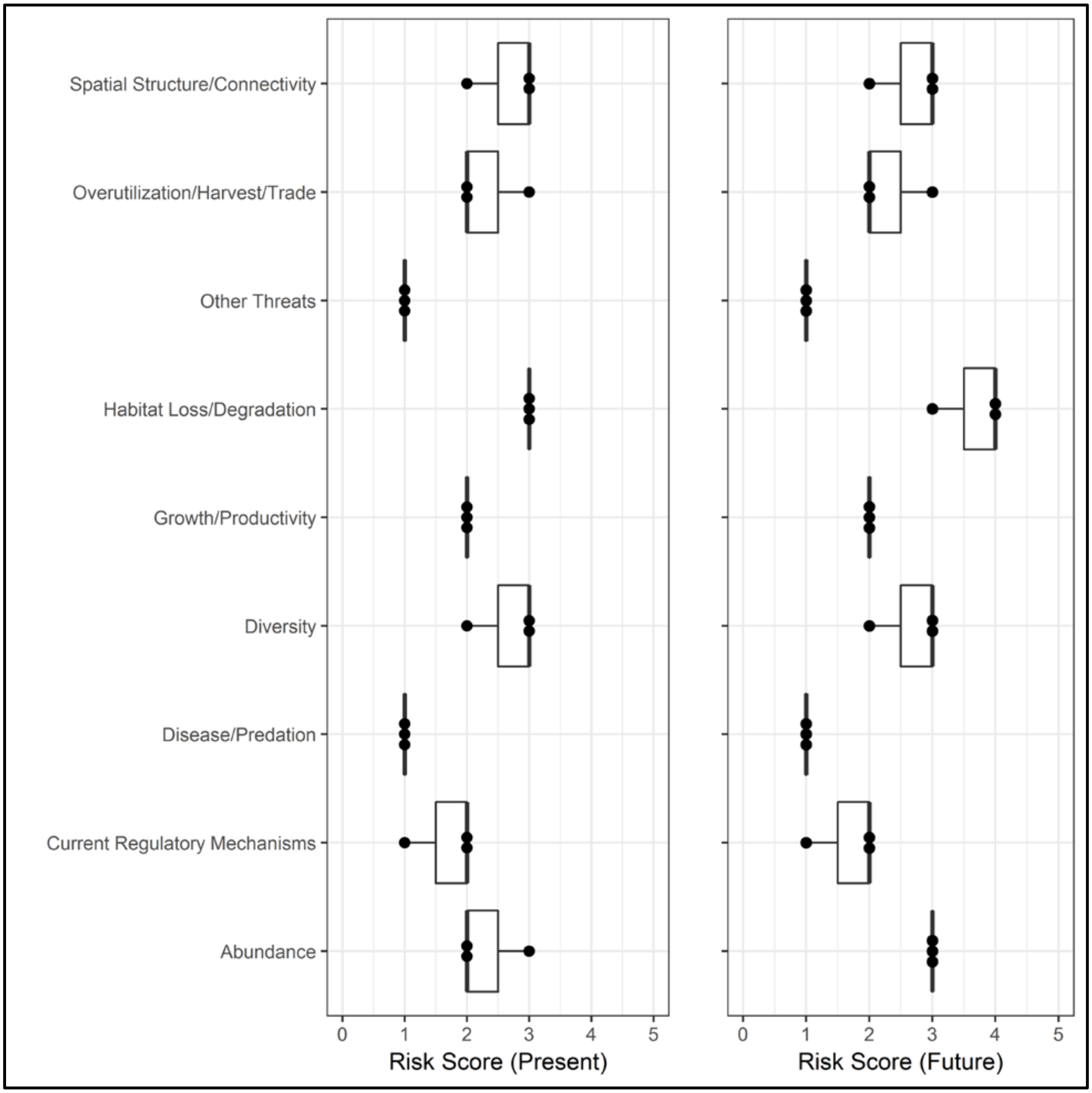


Figure 17. Extinction risk analysis for dwarf seahorse conducted by the three-person status review team. Results show the range, median, and mode scoring for each of the threats presently and over the foreseeable future.

Abundance

The best available information on dwarf seahorse abundance indicates that the species may still be present along the east coasts of Mexico and Texas and along both coasts of Florida. Lack of data from outside the U.S. hindered the SRT's ability to analyze abundance trends in foreign locations. Within the U.S., dwarf seahorse appears to be most common in Florida, though it is also present at a much lower level of abundance in south Texas. Outside of Florida and Texas, observations and records of the dwarf seahorse are uncommon. Seasonally low water temperatures establish geographic range boundaries, which likely contribute to the limited number of records of the dwarf seahorse in waters of the northern Gulf coast (Florida panhandle to north Texas). Additionally, limited seagrass habitat along the northern Gulf coast also likely restricts dwarf seahorse in this region given their strong affinity for dense seagrass habitat. There are three sources that can be used to estimate the species relative abundance: U.S. Geological Survey data and the FWRI-FWC Fisheries Independent Monitoring (FIM) program in Florida and the Texas Parks and Wildlife Department (TPWD) monitoring program in Texas. Additionally, a population modeling study by Carlson et al. (2019) provides insight into the abundance of dwarf seahorse in Florida and the potential changes to this population in light of ongoing threats.

The FWC FIM program provided survey data for several estuarine areas in Florida including Apalachicola Bay, Cedar Key, Tampa Bay, Sarasota Bay, Charlotte Harbor, Florida Bay, and Indian River Lagoon. The best available information provided by the FIM program shows that the dwarf seahorse is not abundant in northern Florida and has not been recorded in the Florida Keys National Marine Sanctuary. Surveys conducted within estuaries of northern Florida, found that the species is rare in Apalachicola Bay and Cedar Key, and has never been recorded in Choctawhatchee Bay or Northeast Florida. In the Indian River Lagoon, on Florida's east coast, the species has been low in relative abundance throughout the survey beginning in 1996, though dwarf seahorse was completely absent between 2011 and 2013. The disappearance of the dwarf seahorse in the Indian River Lagoon could be the direct result of harmful algal blooms (HAB) that have been impacting the estuary over recent years (SJRWMD, 2012; FWC, 2014). During the late 1980s and early 1990s another significant HAB occurred in Florida Bay, which resulted in a massive seagrass die-off and a reduction in dwarf seahorse abundance (Matheson Jr. et. al 1999). However, survey data from 2006-2009 suggest that dwarf seahorse persist in Florida Bay and that the population appears stable (FWC FIM unpublished data).

In Florida, the species appears to be most abundant in five estuaries: Charlotte Harbor, Tampa Bay, Sarasota Bay, Florida Bay, and Biscayne Bay (Figures 3 and 4), which the SRT believes to be the core area of abundance critical to the population. Long-term dwarf seahorse abundance in Charlotte Harbor and Tampa Bay estuaries has declined, but population abundance has remained stable at a lower level since the 2009 trip limit regulations went into effect. Rose et al. (2019) found Tampa Bay dwarf seahorses were a robust stock with stable densities across 3 years with year-round breeding. Additionally, Tampa Bay dwarf seahorse densities in 2008-2009 (Rose et al. 2019) were significantly higher than those reported for 2005-2007 (Masonjones et al. 2010). The U.S. Geological Survey data from Florida Bay and Biscayne Bay suggest the relative abundance of dwarf seahorse was stable within these systems over the short duration of their study. Cumulatively the best available information on the dwarf seahorse's status suggests that Florida Bay has the highest relative abundance of the dwarf seahorse.

Results of a retrospective analysis indicate that the abundance of dwarf seahorse in 2016, exceeded 24 million individuals as the estimated number of males ranged from 15,258 in Cedar Key to 9,910,752 in Florida Bay (Carlson et al. 2019). To assess the accuracy of the retrospective analysis we compared the estimated annual subpopulation sizes to the relative abundance indices from the FWC FIM small seine surveys for Cedar Key, Charlotte Harbor, Tampa Bay and Indian River Lagoon (Figure 18). Modeled population sizes tended to be lower than reported abundance from FWC early in each time series but tracked the trends in relative abundance reported by FWC well later in the time series. The poor fit early in the time series is likely the result of extremely conservative initial population estimates modeled by Carlson et al. (2019). Despite these conservative initial population sizes, the modeled data appeared to equilibrate mid-way through the time series as trends between the modeled and reported data showed similar patterns. An evaluation of correlations between PVA and FWC seine data over the last 10 years found 34%, 27%, 7%, and 40% correlations between Cedar Key, Charlotte Harbor, Indian River Lagoon, and Tampa Bay data, respectively. Assessing model fit for the Florida Bay subpopulation was made more difficult by the shorter time series of data available. We compared the restrospective analysis results with USGS survey data, FWC FIM small seine data, and FWC FIM trawl data (Figure 19). The limited trends available from FWC and the USGS surveys suggested the model captured the decline in population abundance associated with the decline in seagrass as well as the subsequent recovery in the region.

The general agreement in recent trends suggests the PVA model captured the primary drivers of dwarf seahorse abundance. Additionally, PVA results suggest that even with conservative assumptions regarding initial population sizes for the different subpopulations, carrying capacity, sex ratio, and age at maturity, the dwarf seahorse population numbers in the tens of millions in Florida waters (Carlson et al. 2019). Back of the envelope computations of the Carlson et al. (2019) population estimates divided by the total seagrass habitat area result in seahorse density estimates (N/m^2) significantly lower than those empirically observed, suggesting the PVA is conservative in its assessment of total population size (see Table 2 in Carlson et al. 2019; Rose et al. 2019, Figures 3-4 this document).

The Carlson et al 2019 analysis generated initial population sizes based on dwarf seahorse density estimates in the literature through 2010. However, since that time additional estimates have become available. To again check the accuracy of the population estimates resulting from the retrospective analysis, we completed some rudimentary calculations based on the new density estimates for Tampa Bay (0.139 N/m^2 - Rose et al. 2019, 0.095 N/m^2 - Masonjones et al. 2019) and Florida Bay (0.00392 N/m2 seines or 0.00462 N/m2 in trawls – FWC unpublished data). Simply multiplying the new density estimates by the acreage of seagrass in Tampa Bay (most recent seagrass survey is 2014) or Florida Bay (most recent seagrass survey is 2010-2011), respectively provided estimates of approximately 15.5 - 22.6 million dwarf seahorse in Tampa Bay during 2014 and between 6.0 and 7.1 million dwarf seahorse in Florida Bay during the period of 2010-2011. This analytical approach could overestimate seahorse abundance if the sampling domain for the density estimate is a site of localized dwarf seahorse abundance. However, density estimates based on CPUE are influenced by catchability, which varies between sampling gears. Mean nominal CPUE reported by FIM for dwarf seahorse in Tampa Bay for 2009 was 4.02e-04 and 1.25e-05 for bag seine and otter trawl, respectively. These nominal CPUEs are 2.9% and 0.1% of the densities reported by Rose et al. (2019) for the same time period, and suggest that population sizes of dwarf seahorse based on expanding nominal FIM CPUE to seagrass area could be underestimates, assuming seahorses are uniformly distributed within seagrass habitats across the FIM sampling domain. Thus, the difference in estimated abundance between the two estuaries using this approach is likely attributable to sampling design as the Tampa Bay studies by Masonjones et al. (2019) and Rose et al. (2019) were actively targeting dwarf seahorse using specialized gears in an area believed to contain high densities, whereas the Florida Bay study was a general nekton survey using less efficient gears (trawls and seines) for collecting dwarf seahorse. Importantly, this approach does suggest that field estimates of abundance, when expanded for the full range of dwarf seahorse habitats, can greatly exceed the estimates generated by the Carlson et al. (2019) modeling approach.

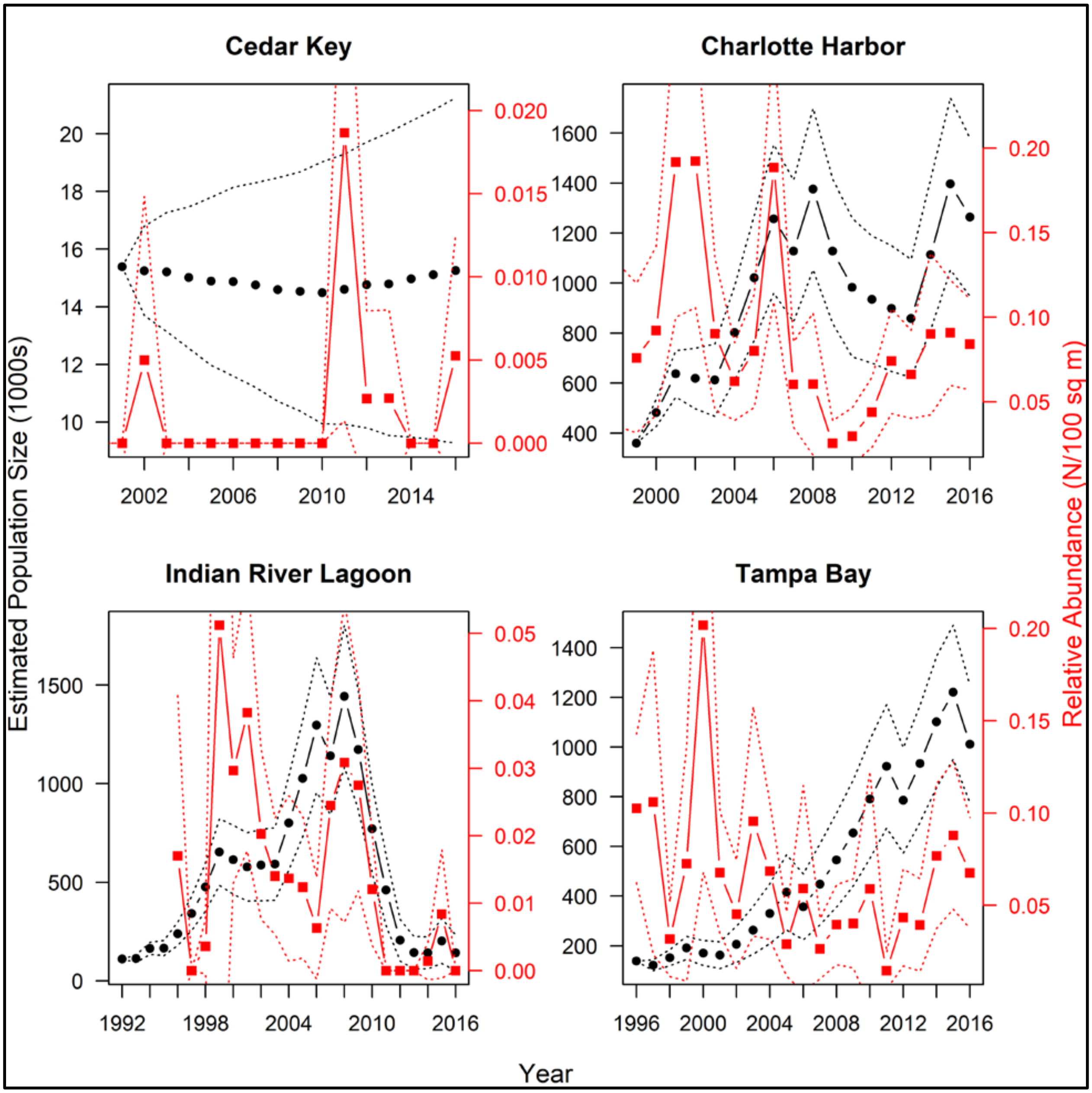


Figure 18. Comparison of estimated population sizes from the PVA (black lines) to relative abundance indices from FWC FIM small seine surveys (red lines).
Note PVA starting assumptions were extremely conservative relative to empirically-measured densities.

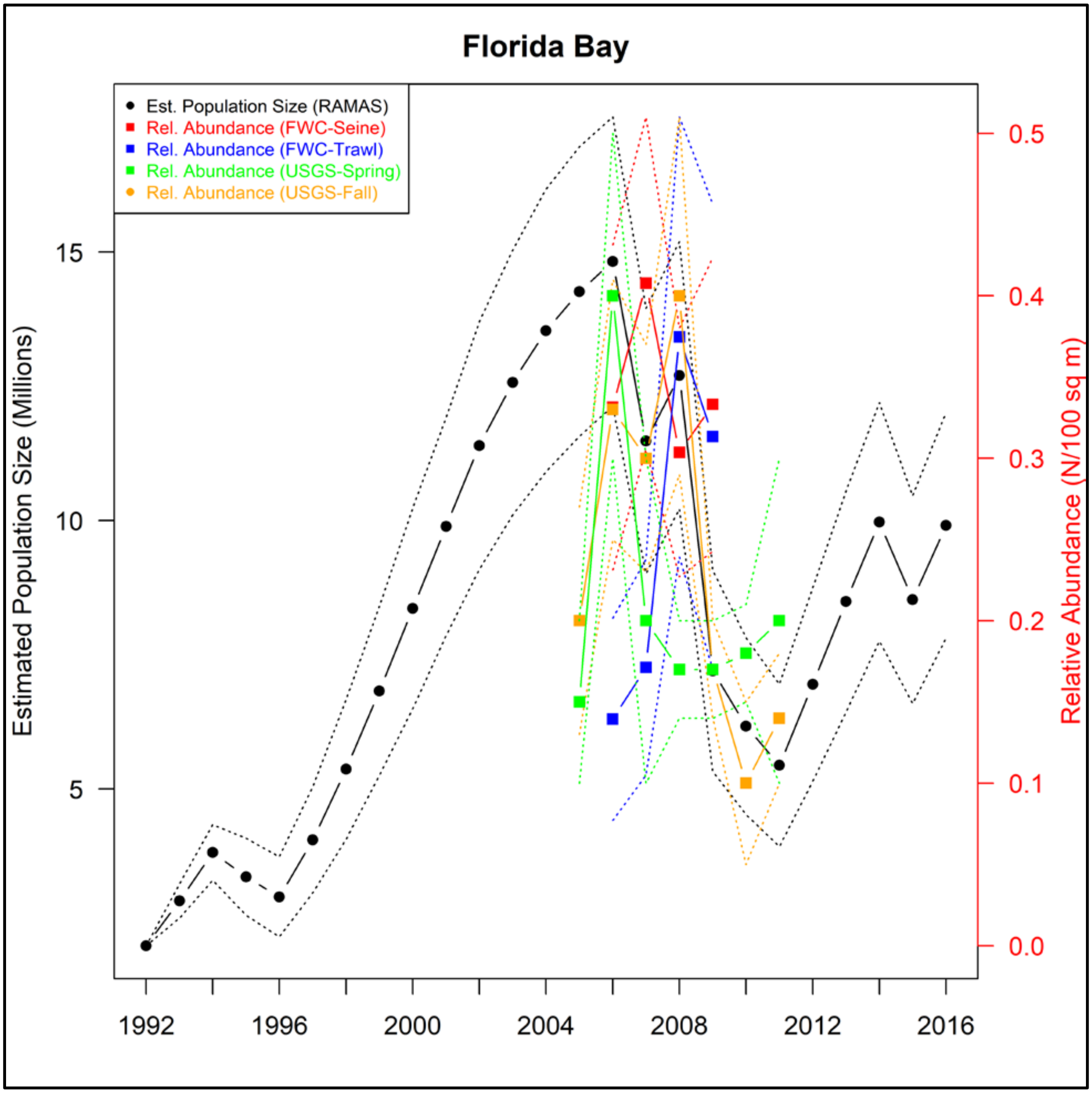


Figure 19. Comparison of estimated population size from the PVA (black) to relative abundance indices from FWC FIM small seine data (red), FWC FIM trawl data (blue), the USGS Spring survey (green) and the USGS fall survey (yellow).

In Texas, dwarf seahorse abundance is low and restricted to the central and southern coastal systems including Aransas Bay, Corpus Christi Bay, San Antonio Bay, and the Upper and Lower Laguna Madre. The species has not been recorded in TPWD surveys conducted in Galveston, Matagorda, and East Matagorda Bay systems. Of the bays where dwarf seahorse have been recorded, relative abundance is highest in Upper Laguna Madre, though abundance is still very low within this system compared to the Florida estuaries. Data series for the other bays (Aransas, Corpus Christi, San Antonio, and Lower Laguna Madre) have fewer than 10 records each and therefore the SRT was unable to discern population trends. The SRT believes that Upper Laguna Madre is likely the core area of abundance for the southwestern portion of the species range within U.S. waters.

Populations with very low abundance that occur over a condensed geographic scale are more likely to be impacted by stochastic events. Recolonization and recovery is dependent on the ability of surrounding populations to provide recruits to the depleted area. In some cases, a population may have suffered a stochastic event and not been encountered in surveys for several years before eventually returning to the area (see Figure 3). Similarly, periodic HABs continue to occur in Texas lagoons, but some bays, like Laguna Madre, have consistently recorded dwarf seahorse in surveys indicating that subpopulations can tolerate stochasticity in their environment. Regardless, it is not prudent to base an assessment of risk to species abundance on such few observations as reported from Texas.

Commercial harvest and bycatch of the dwarf seahorse in Florida is a factor that impacts species abundance. The dwarf seahorse is targeted by the commercial ornamental fishery to be sold for aquarium markets. According to dealer reports, harvest appears to be focused from Tampa Bay to Fort Myers and from Florida Bay to Miami (FWC, 2012). However, commercial harvest is prohibited within the Everglades National Park which encompasses a significant portion of Florida Bay (Figure 16). The dwarf seahorse is also among those species likely captured by non-selective trawl fishing gear targeting bait shrimp because this trawling often occurs in seagrass habitat. The populations in Charlotte Harbor and Tampa Bay have been variable since surveys began in 1996, but have stabilized since new regulations limiting harvest were adopted in 2009. Because no reported large-scale stochastic events have recently occurred within these systems, it is reasonable to infer that high levels of commercial harvest prior to the 2009 trip limit likely caused at least a portion of the observed historical declines in Charlotte Harbor and Tampa Bay (Figures 12-13).

The best available information indicates that habitat loss and degradation, stochastic events, and commercial harvest are factors that impact dwarf seahorse abundance. However, the species only appears to be at risk of local extirpations where populations have very low abundance, or are isolated due to the distance between habitat patches or estuary systems, as the species has limited active movements and small home ranges.

Based on the above information the SRT considered the risk of dwarf seahorse extinction based on abundance. Scores ranged from 2 to 3, with a mean of 2.3 and a mode of 2 (Figure 17). The team concluded that based on the population estimate resulting from the population viability model, the abundance of dwarf seahorse presents a low risk of extinction and that the population is robust enough to withstand threats currently facing the species. This result is similar to the IUCN Red List assessment which identified dwarf seahorses as a species of “least concern” in terms of their threat status (Masonjones et al. 2017). When considering the contribution of abundance to the risk of extinction over the foreseeable future the team scored abundance as a moderate risk (3), given the unknowns associated with increased potential for stochastic events triggered by climate change.

Population growth rate and productivity

The life history characteristics of the dwarf seahorse (i.e., early age at maturity, rapid growth, high fecundity, and parental care) suggest that this species has a relatively high intrinsic rate of population increase (R_{max}=1.49 yr^{-1}) and high compensatory capacity (Kindsvater et al. 2016). The dwarf seahorse has relatively high fecundity compared to other seahorse species, though fecundity is much lower than other teleosts. Current demographic analysis suggest that healthy subpopulations have high intrinsic rates of population increase and would be able to tolerate high levels of direct and indirect mortality. However, the species also has complex courtship behaviors and is constrained by its habitat specificity and small home range. With the dwarf seahorse's complex reproductive behaviors, many factors (i.e., stochastic events, directed fishing, bycatch) could disrupt courtship and mating and consequently reduce productivity.

The SRT believes that the dwarf seahorse subpopulations in Charlotte Harbor, Sarasota Bay, Tampa Bay, Florida Bay, and Biscayne Bay are more productive than those of other estuaries and bays within the species' range. The best available information suggests that several other estuaries and bay systems in Florida and Texas have subpopulations which may be at risk of an Allee effect (e.g., inability to find a mate and subsequently low levels of population growth from future recruitment), though these are all systems along the fringe of the dwarf seahorse range and therefore may have naturally low abundance.

The SRT also considered scenarios developed by Carlson et al. (2019) for dwarf seahorse abundance in 5 bay systems: Cedar Key, Tampa Bay, Charlotte Harbor, Florida Bay and northern Indian River Lagoon (Figure 5). Scenarios were initiated at the earliest time data was available on the coverage of the seagrass canopy from Yarbro and Carlson (2016) taking into account changes in seagrass density, commercial harvest, bycatch and mortality related to harmful algal blooms and cold temperature events. Three of the 5 subpopulations (Tampa Bay, Charlotte Harbor, Florida Bay) slightly increase in abundance (3-8%) whereas the Cedar Key and northern Indian River Lagoon subpopulations did not increase in abundance.

Carlson et al. (2019) also explored future scenarios to test the effect of the most likely threats to dwarf seahorse (Figure 20). As the harvest of dwarf seahorse by the Marine Life fishery has been limited, the greatest threats to future seahorse subpopulations include the loss of seagrass habitat, and increased harmful algal blooms, which can cause acute mortality. Carlson et al. (2019) explored optimistic (increase seagrass coverage and current levels) and pessimistic scenarios based on increased rates of mortality, loss of seagrass habitat and likelihood of HAB increasing from historically observed levels. The population was projected forward 10 years based on the IUCN Redlist criteria for future threats. Starting conditions for these projections were conservatively assumed at the lower 5 or 10% quantiles from bootstrapped empirical estimates of abundance (see Table 2 in Carlson et al. 2019).

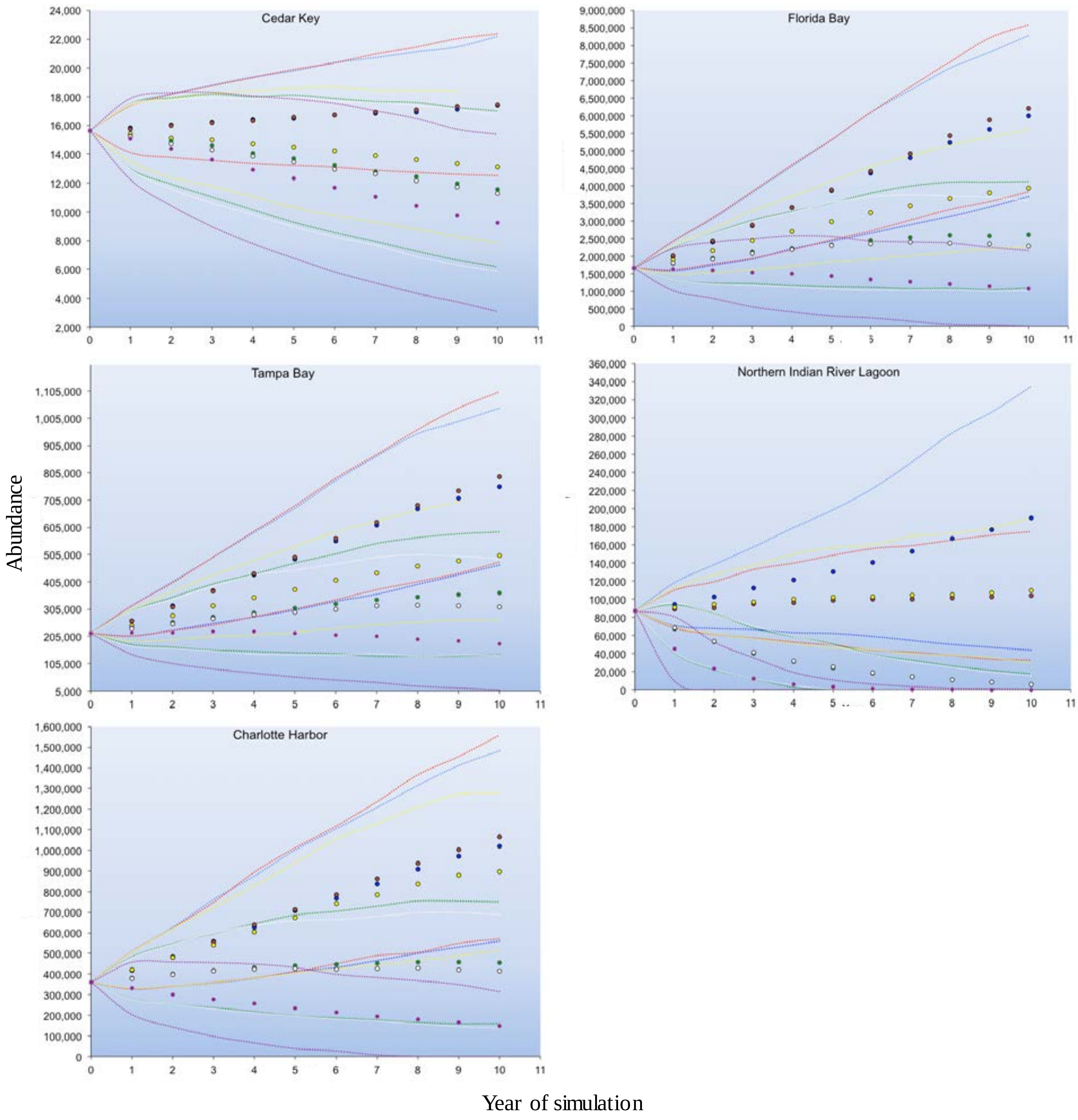


Figure 20. Future projections of dwarf seahorse abundance from Carlson et al. 2019.
Most optimistic projections shown in red and blue while the most pessimistic projections are shown in white and pink. Each projection is based on varying baseline scenario data run within the model.

Projected stock trajectories under potential future conditions were mostly stable in Cedar Key, declining in Northern Indian River Lagoon and generally increasing under the vast majority of scenarios for the other three locations (Figure 13). Only the most pessimistic scenario for Indian River Lagoon resulted in extinction within ten years.

Scenarios testing the effects of harmful algal blooms accompanied by reduced seagrass habitat affected all subpopulations' abilities to grow. The subpopulation to be most affected was the Indian River Lagoon which experienced significant declines in abundance. Abundance of dwarf seahorse in Indian River Lagoon declined from a starting size of about 86,000 males to less than 6,000 in ten years. Other subpopulations were able to maintain their baseline levels of abundance despite losses of habitat.

The SRT determined that population growth rate and productivity of dwarf seahorse presents a low risk of extinction to the species. Each member of the team scored this demographic variable as a level 2 risk, both currently and over the foreseeable future (Figure 17).

Spatial structure/connectivity

The dwarf seahorse has low mobility, occupying a limited activity space and small home range within a specific habitat (seagrasses). These life history traits suggest that the species is not likely to disperse actively. However, movement by passive dispersal occurs as seahorses use their prehensile tail to hold on to seagrass or macroalgae which are carried by currents (Foster and Vincent 2004; Masonjones et al. 2010; Fedrizzi et al. 2015). A population genetics study on *Hippocampus kuda* in the Philippines suggested colonization of distant habitats by a small number of founding individuals may be common in seahorses associated with the *H. kuda* complex (Teske et al. 2005).

The species' short lifespan, narrow habitat preference, and low mobility increase extinction vulnerability as the dwarf seahorse is susceptible to population fragmentation and loss of population connectivity. Successful repopulation or colonization may depend on a sufficient number of individuals emigrating to a habitat containing seagrass to establish themselves. It is essential that seagrass habitat patches exist between subpopulations as dispersal capabilities are restricted by the availability of seagrass habitat. Historically, the dwarf seahorse has shown that it can recover from stochastic events where populations have been impacted or even temporarily extirpated, but low relative abundance in some areas may limit repopulation.

Based on the best available information on the spatial structure/connectivity of dwarf seahorse subpopulations the SRT believes this demographic variable presents a moderate extinction risk. Team scores ranged from 2 to 3, with a mean of 2.7 and a mode of 3 (Figure 17). Differences in scores were largely a reflection of personal thoughts on how far dwarf seahorse may disperse via rafting, and thus how connected the subpopulations could be.

Diversity

The loss of diversity can reduce a species' reproductive fitness, fecundity, and survival, thereby contributing to declines in abundance and population growth rate and increasing species extinction risk (Gilpin and Soule, 1986). There is no indication that the dwarf seahorse is at risk due to a significant change or loss of variation in life history characteristics, population demography, morphology, behavior, or genetics.

The SRT considered diversity to present a moderate extinction risk to dwarf seahorse (Figure 17). The team considered this a moderate risk given the lack of genetic information, particularly from Texas and how that population may relate to the Florida population. Similarly, a 2015 report indicated population structuring in which the Panhandle represents a separate population from other areas of Florida. Given the large distance between the subpopulations in the Florida panhandle and other parts of Florida the team expressed concern over the transfer of genetic material. Expanding the research of Fedrizzi et al. (2015) to include dwarf seahorse from Texas could provide additional information on the diversity of dwarf seahorse, the relationship between those in Texas versus those from Florida, and whether additional regulatory measures may be necessary.

Summary of demographic risk analysis

The SRT found that the dwarf seahorse's life history traits in and of themselves are likely well-adapted for the species' ecological niche. However, the available information on other threats (i.e., habitat loss or degradation and overutilization) may interact with these life history traits to increase the species' extinction risk. The dwarf seahorse's habitat preference and low mobility could increase the species' ecological vulnerability, as the species may be slow to recolonize depleted areas. Similarly, patchy spatial distributions in combination with low relative population abundance make the species susceptible to habitat degradation and overexploitation. Life history traits, such as complex reproductive behavior and monogamous mating may also increase the species' vulnerability. However, the species' ability to mature early, and reproduce multiple times throughout a prolonged breeding season offset much of the vulnerability.

Threats Assessment

Destruction or modification of habitat

The SRT considered the destruction or modification of habitat to be the largest threat facing dwarf seahorse into the foreseeable future. As discussed in the status review, there are a number of threats impacting seagrass habitats upon which dwarf seahorse rely, including water quality, damage from vessels and trawling, and climate change. Regulations and educational programs have and continue to be implemented in an attempt to reduce impacts from water quality, vessels, and trawling. In light of the long-term HAB in the Indian River Lagoon resulting in large-scale losses of seagrasses and the collapse of the dwarf seahorse subpopulation there, the SRT is particularly concerned with HABs, their interaction with water quality, and their potential to negatively affect dwarf seahorse. Another HAB was present along the west coast of Florida between Charlotte Harbor and Tampa Bay during the summer and fall of 2018. HAB monitoring data indicate *K. brevis* (red tide) did not enter Tampa Bay or Charlotte Harbor (Figure 21) which may have spared dwarf seahorse inhabitating these estuaries. Subsequent dwarf seahorse sampling in Tampa Bay during 2019 indicates a robust dwarf seahorse population in Old Tampa Bay and Ft. DeSoto areas (H. Masonjones, University of Tampa, pers. comm. to Adam Brame, NOAA Fisheries, on October 13, 2019). It is also worth noting that the 2018 HAB did not affect Florida Bay (Figure 22) where surveys and model simulations suggest dwarf seahorse are found in the highest abundance. The SRT is also concerned about the impact of climate change affecting seagrass habitat into the future. Climate change is expected to impact seagrass habitat, though the temporal rate and degree to which this occurs is not known with certainty. The team scored this threat as a moderate risk for dwarf seahorse, with all team members giving it a score of 3 (Figure 17). Considering the unknowns associated with climate change and HABs over the future, the team scored this threat slightly higher when considering it over the foreseeable future (Figure 17).

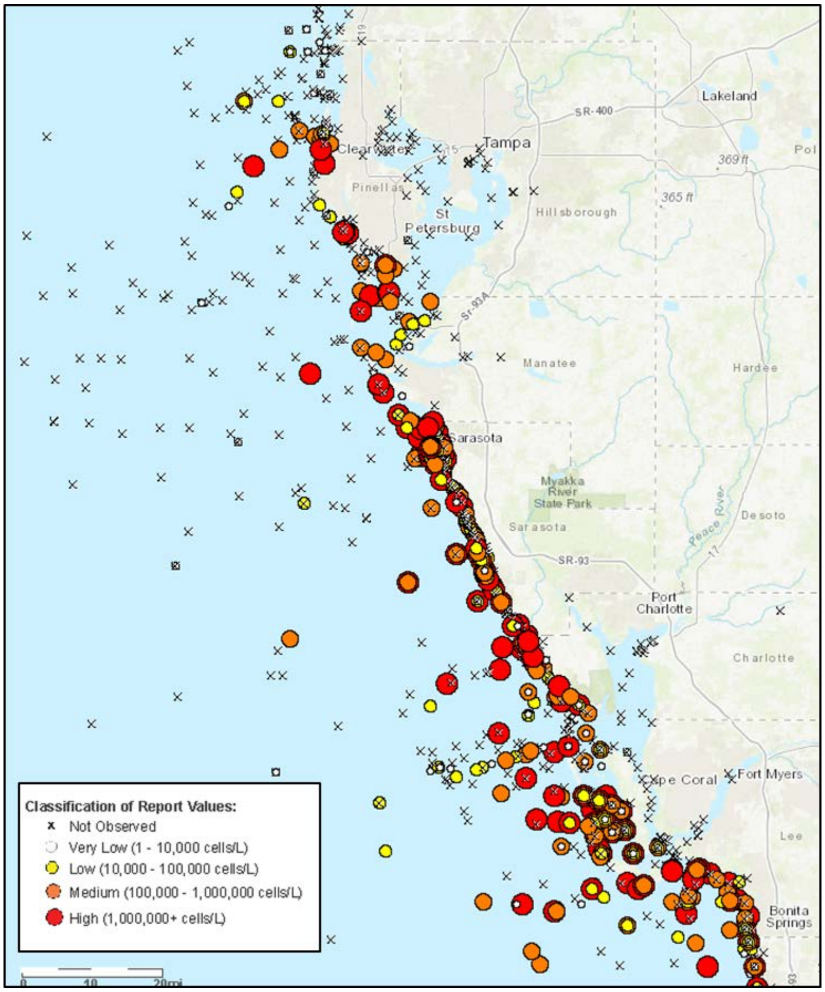


Figure 21. Cell counts of *Karenia brevis* (red tide) from HAB monitoring on the west coast of Florida during 2018

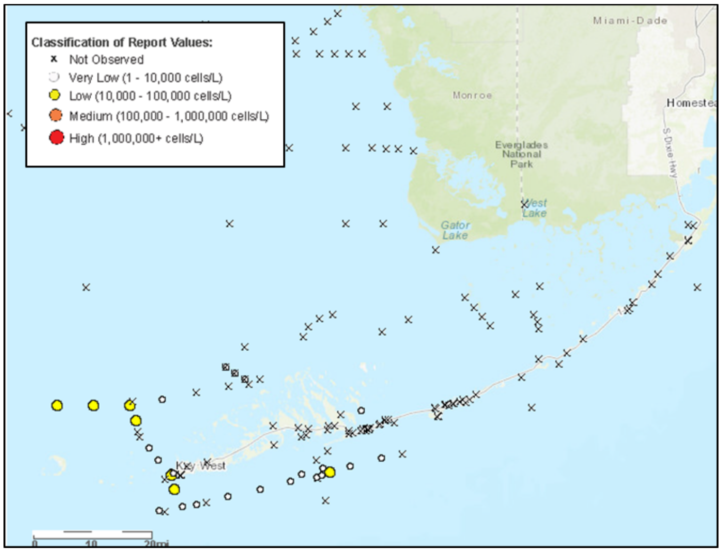


Figure 22. Cell counts of *Karenia brevis* (red tide) from HAB monitoring in Florida Bay during the summer of 2018.

Overutilization

The commercial harvest of the dwarf seahorse is restricted to Florida, but is the second greatest threat to the species, aside from habitat loss and degradation. The dwarf seahorse is harvested largely for the aquarium markets and removals have resulted in declines in local subpopulation abundance since the early 1990s. In general, seahorses are one of the most popular and heavily exploited marine ornamentals harvested in Florida. Dwarf seahorse landings are significantly higher than other seahorse species—landings data shows that seahorse harvest consists almost solely of dwarf seahorse.

Data indicate that over a 25 year timeframe, dwarf seahorse landings have fluctuated with tens of thousands being harvested annually. Historical declines in abundance observed in Charlotte Harbor and Tampa Bay suggest that harvest may be impacting these core subpopulations. A 2009 trip limit regulation has reduced the harvest of dwarf seahorse (Figures 12 and 13) and the population appears to have stabilized as a result (Figures 3 and 5). Additionally, there is a significant portion of Florida Bay that is protected by the prohibition on commercial fishing within the Everglades National Park boundaries. The protection against commercial harvest and bycatch within this system likely played a significant role in the species ability to recover from the HABs that impacted Florida Bay during the late 1980s and early 1990s.

While the use of any net with a mesh area exceeding 500 square feet is prohibited in nearshore and inshore waters of Florida (Florida 68B- 4.0081(3)(e)), there is a bait-shrimp fishery that operates within these boundaries. This fishery relies upon small trawls to collect shrimp for bait and given this fishery operates in seagrass habitat, it is reasonable to infer that a substantial number of dwarf seahorse are removed as bycatch. Seahorses may be more vulnerable to injuries, mortality, and disruption of reproduction in habitats that are disturbed by heavy trawls deployed for longer periods and over greater areas (Baum et al., 2003). Baum et al. (2003) analyzed bycatch of the lined seahorse (*Hippocampus erectus*) in the bait-shrimp trawl fishery and estimated about 72,000 seahorses were incidentally caught per year. Baum et al. (2003)

reported only two dwarf seahorse were captured as part of this study. In developing bycatch estimates for use in their population viability model, Carlson et al. (2019) used the ratio of dwarf seahorse caught to lined seahorse caught and estimated that 157 dwarf seahorse are incidentally caught per year.

The SRT assumes that demand for the dwarf seahorse in the marine ornamental fishery and aquarium markets will continue. The extent to which heavy commercial harvest is impacting dwarf seahorse populations in Florida is largely unknown; although there are some indications that overharvest may be impacting populations in Charlotte Harbor and Tampa Bay. An analysis by NMFS (2015) led to suggestions of time area closures and a 200 seahorse per trip limit to further limit harvest. The State of Florida considered these suggestions and proposed new regulations based on this analysis. Ultimately the new regulations were not adopted as the state believed the current trip limit was sufficient. While the SRT believes that dwarf seahorse is likely being negatively impacted, the relative abundance trend information since 2009 is stable (as an indirect indicator of status) in areas where dwarf seahorse is significantly harvested (e.g., southwest Florida and southeast Florida, including the Florida Keys; Figure 3). Dwarf seahorse are characterized by rapid growth, early age at maturity, and short generation time that would indicate that the species have high intrinsic rates of population increase. This suggests that populations can recover from declines following a reduction in fishing effort (Curtis et al. 2008).

The SRT concluded that the species is at a low to moderate risk due to overexploitation from commercial harvest, combined with other threats, such as lack of adequate existing regulatory mechanisms. Scores associated with this threat ranged between 2 and 3, with a mean of 2.3 and a mode of 2 (Figure 17). Given that the team considered similar rates of utilization in the future, scores were the same when considering the threat over the foreseeable future.

Disease or predation

The SRT determined that disease and predation present a very low extinction risk to dwarf seahorse. The team was not able to find documentation of disease affecting wild dwarf seahorses. With respect to predation, the team assumed mortality rates from predation are likely higher for juvenile seahorses than adults. The dwarf seahorse is presumed to have few predators and is likely only opportunistically predated upon by fishes, crabs, and wading birds. The dwarf seahorse’s excellent camouflage is well-adapted for the species’ ecological niche and likely reduces the level of predation on the species.

All members of the SRT scored disease and predation as a very low risk in the ERA, both now and over the foreseeable future (Figure 17).

Inadequacy of existing regulatory mechanisms

With respect to inadequacy of existing regulatory mechanisms, there are only three regulations that relate to *Hippocampus* species in general. First, within the state of Florida, the FWC has developed a rule to control fishing effort in the commercial marine life fishery that includes marine ornamentals like the dwarf seahorse (68B-42, F.A.C.). The regulations include requirements for specific fishing licenses and tiered endorsements, as well as a commercial trip limit of 400 dwarf seahorses per day. There is no cap on the total annual take of dwarf seahorse and there are no seasonal restrictions or closures. Enforcement of the trip limit regulation has been problematic as at least one commercial harvester has continued to exceed the 400 dwarf seahorse limit since its inception. This harvester exceeded the trip limit 26 trips out of 80 between 2010 and 2015 (NMFS 2015). There are no restrictions on the number of seahorses that can be collected as bycatch, as long as the landings value of all marine life bycatch does not exceed $5,000 annually (68B-42, F.A.C.; Florida Marine Fisheries Commission, 2009).

The assessment of individual species and fishing effort are necessary to determine whether existing regulations are likely to be effective at maintaining the sustainability of the resources. To date, however, the commercial removal of the dwarf seahorse and its impact on the population has not been assessed. The SRT was unable to determine exactly how the daily bag limit was established (400 dwarf seahorse per person per day) and its ability to prevent overharvest or how effective it will be at long-term sustainability. However, the 2009 bag limit regulation seems to have stabilized the population since implementation (Figure 3).

The second regulation that may affect seahorses (*Hippocampus* spp.) is the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)—an international agreement between governments established with the aim of ensuring that international trade in specimens of wild animals and plants does not threaten their survival. Seahorses are listed under Appendix II of CITES. Appendix II includes species that are not necessarily threatened with extinction, but in which trade must be controlled in order to avoid utilization incompatible with their survival. International trade of Appendix II species is permitted when export permits are granted from the country of origin. In order to issue an export permit, the exporting country must find that the animals were legally obtained and their export will not be detrimental to the survival of the species in the wild (referred to as a ‘‘non-detriment finding’’). However, almost all the dwarf seahorses harvested from the wild populations in the U.S. remain in U.S. markets and therefore are not subject to the CITES regulation of trade under Appendix II.

The third regulation that provides protections for seahorses is the listing of dwarf seahorse as a species subject to “Special Protection” under Mexican law. This limits any removal of the species to rules of the Mexican General Law of Wildlife (Diaz 2013) which establishes the conditions for capture, and transport permits, and authorizations (Bruckner et al. 2005). We are unsure of the adequacy of this regulation at this time.

The SRT believes that demand for the dwarf seahorse in the marine ornamental fishery and aquarium markets will continue into the future. The extent to which current regulations are adequate at protecting the dwarf seahorse population was difficult to evaluate. The SRT believes that the lack of regulatory mechanisms intended to control commercial harvest is likely having detrimental effects on population abundance and productivity, but overall it presents a low extinction risk (Figure 17). Given the team’s belief that these regulations will remain in place and that they will continue to affect harvest in a similar manner into the future, our scores remained unchanged when considering this threat over the foreseeable future.

Other natural or man-made factors

The status review identified several potential natural or man-made factors that could serve as potential threats to dwarf seahorse. These included the species' life history strategy, anthropogenic noise, oil spills, and high-impact storm events. The SRT does not believe that any of these other threats are likely to be a source of high extinction risk to dwarf seahorse. In the ERA, the SRT ranked this category of threats as a very low risk both currently and in the foreseeable future (Figure 17).

Overall Extinction Risk – Synthesis and Finding

Guided by the results from the demographics risk analysis as well as the threats assessment, the SRT members used their informed professional judgment to make an overall extinction risk determination for the species. For these analyses, the SRT defined three levels of extinction risk:

- High risk: A species or DPS with a high risk of extinction is at or near a level of abundance, productivity, spatial structure, and/or diversity that places its continued persistence in question. The demographics of a species or DPS at such a high level of risk may be highly uncertain and strongly influenced by stochastic or depensatory processes. Similarly, a species or DPS may be at high risk of extinction if it faces clear and present threats (e.g., confinement to a small geographic area; imminent destruction, modification, or curtailment of its habitat; or disease epidemic) that are likely to create imminent and substantial demographic risks.
- Moderate risk: A species or DPS is at moderate risk of extinction if it is on a trajectory that puts it at a high level of extinction risk in the foreseeable future (see description of "High risk" above). A species or DPS may be at moderate risk of extinction due to projected threats or declining trends in abundance, productivity, spatial structure, or diversity. The appropriate time horizon for evaluating whether a species or DPS will be at high risk in the foreseeable future depends on various case- and species-specific factors. For example, the time horizon may reflect certain life history characteristics (e.g., long generation time or late age-at maturity) and may also reflect the time frame or rate over which identified threats are likely to impact the biological status of the species or DPS (e.g., the rate of disease spread). (The appropriate time horizon is not limited to the period that status can be quantitatively modeled or predicted within predetermined limits of statistical confidence. The biologist (or Team) should, to the extent possible, clearly specify the time horizon over which it has confidence in evaluating moderate risk.)
- Low risk: A species or DPS is at low risk of extinction if it is not at moderate or high level of extinction risk (see "Moderate risk" and "High risk" above). A species or DPS may be at low risk of extinction if it is not facing threats that result in declining trends in abundance, productivity, spatial structure, or diversity. A species or DPS at low risk of extinction is likely to show stable or increasing trends in abundance and productivity with connected, diverse populations.

To allow individuals to express uncertainty in determining the overall level of extinction risk facing dwarf seahorse, the SRT adopted the "likelihood point" method which has been used in previous status reviews (e.g., Pacific salmon, Southern Resident Killer Whale, Puget Sound Rockfish, Pacific herring, and black abalone) to structure the team's thinking and express levels of uncertainty in assigning threat risk categories. For this approach, each team member distributed 10 ‘likelihood points’ among the three extinction risk levels. After scores were provided, the team discussed the range of perspectives for each of the species, and the supporting data on which it was based, and each member was given the opportunity to revise scores if desired after the discussion. The scores were then tallied (mode, median, range), discussed, and summarized for the species.

Finally, the SRT did not make recommendations as to whether dwarf seahorse should be listed as threatened or endangered. Rather, the SRT drew scientific conclusions about the overall risk of extinction faced by this species under present conditions and in the foreseeable future based on an evaluation of the species’ demographic risks and assessment of threats.

Table 12 represents the overall extinction risk scoring completed by the SRT. Likelihood points were split between low risk and moderate risk, though cumulative results indicate that the team believes there is currently a low risk of extinction for dwarf seahorse.

Table 12. Overall extinction risk as scored by likelihood points by the three member SRT

Number of likelihood points	Low Risk	Moderate Risk	High Risk
Member 1	6	4	0
Member 2	7	3	0
Member 3	6	4	0
Total	19	11	0

The best available information indicates that within the U.S., dwarf seahorses occur in Florida and to a lesser extent in south Texas but do not appear to extend into the northern Gulf of Mexico (i.e., Alabama, Mississippi, and Louisiana) as previously believed. The SRT acknowledges that there is a lack of abundance data in the northern Gulf of Mexico, but the species is temperature limited and due to the seasonal cold water temperatures in that region (Figure 8), it is unlikely that dwarf seahorse was ever common in the northern Gulf of Mexico. The SRT determined that there is evidence of a historical decrease in relative abundance especially in areas where dwarf seahorses are naturally abundant. However, the most productive subpopulations have relatively stable abundance trends—albeit at low relative abundance.

Outside of the U.S., data on abundance and population trends are lacking. Evidence suggests the species is present along the east coast of Mexico but without abundance data the SRT is unable to make further conclusions. Therefore, the team made conclusions based solely on the best available data from within the U.S.

The SRT had concerns regarding the level of commercial harvest, bycatch, and lack of regulatory mechanisms and determined that these threats are likely having effects on the species—especially those local subpopulations that occur in some of the most heavily exploited areas. In addition, overutilization will serve to exacerbate the demographic risks currently faced by the species. Although there was some concern regarding overutilization, bycatch, and lack of regulations, the SRT felt that habitat degradation (i.e., harmful algae blooms and coastal construction) and projected losses due to sea level rise resulting from climate change were the most significant threat to the species. The predicted losses of seagrass habitat due to sea level rise combined with the prolonged commercial harvest may increase the species demographic risks as impacted populations may be limited in their abilities to recolonize depleted areas based on dwarf seahorse's low mobility and narrow habitat preference. However, the team concluded that overall the species is at a low risk of extinction as it is highly productive and faces no high risk threats.

10.4 Significant Portion of Its Range

As noted in the Introduction above, the definitions of both "threatened" and "endangered" under the ESA contain the term "significant portion of its range" (SPOIR) as an area smaller than the entire range of the species which must be considered when evaluating a species' risk of extinction. Under the final SPOIR policy announced in July 2014, should we find that the species is of low extinction risk throughout its range, we must go on to consider whether the species may have a higher risk of extinction in a significant portion of its range (79 FR 37577; July 1, 2014). Specifically, we are asked to examine the existing contribution of each dwarf seahorse portion to the viability of the taxon as a whole across its range.

Consistent with the 2014 policy, when we conduct a SPOIR analysis, we first identify any portions of the range that warrant further consideration. The range of a species can theoretically be divided into portions in an infinite number of ways. However, as noted in the policy, there is no purpose to analyzing portions of the range that are not reasonably likely to be significant or in which a species may not be endangered or threatened. To identify only those portions that warrant further consideration we consider whether there is substantial information indicating that (1) the portions may be significant, and (2) the species may be in danger of extinction in those portions or is likely to become so within the foreseeable future. We emphasize that answering these questions in the affirmative is not a determination that the species is endangered or threatened throughout a significant portion of its range; rather, it is a step in determining whether a more detailed analysis of the issue is required (79 FR 37578; July 1, 2014). Making this preliminary determination triggers a need for further review, but does not prejudge whether the portion actually meets these standards such that the species should be listed. If this preliminary determination identifies a particular portion or portions for potential listing, those portions are then fully evaluated under the ‘‘significant portion of its range’’ authority to determine whether the portion in question is biologically significant to the species *and* whether the species is endangered or threatened in that portion.

In two recent District Court cases challenging listing decisions made by the USFWS, the definition for ‘‘significant’’ in the SPOIR Policy was invalidated. The courts held that the threshold component of the definition was ‘‘impermissible,’’ because it set too high a standard. Specifically, the courts held that under the threshold in the policy, a species would never be listed based on the status of the portion, because in order for a portion to meet the threshold, the species would be threatened or endangered rangewide. *Center for Biological Diversity, et al.* v. *Jewell,* 248 F. Supp. 3d 946, 958 (D. Ariz. 2017); *Desert Survivors* v. *DOI* 321 F. Supp. 3d. 1011 (N.D. Cal., 2018). Accordingly, while we used the threshold identified in the policy, which was effective at the time the SRT met, our analysis does not rely on the definition in the policy, but instead responds to the second *Desert Survivors* case (336 F. Supp. 3d 1131, 1134–1136; N.D. CA August, 2018), in which the Court stated that there is no geographic limitation to the holding that the definition of ‘‘significant’’ is impermissible. As such, our analysis independently construes and applies a biological significance standard, drawing from the record developed by the SRT with respect to viability characteristics (*i.e.,* abundance, productivity, spatial distribution, and genetic diversity) of the members of the portions, in determining if a portion is a significant portion of a species' range. We considered how the loss of the portion, given the current available information on abundance levels, would affect the species rangewide in a variety of ways. We also considered how the loss of the portion would affect the spatial distribution of the species (i.e., would there be a loss of connectivity, would there be a loss of genetic diversity, or would there be an impact on the population growth rate of the remainder of the species).

Within the range of dwarf seahorse we considered multiple population portions including: (1) south and southwest Florida, (2) east coast of Florida, (3) northwest Florida, (4) Texas, and (5) eastern Mexico. After a review of the best available information, we concluded that only the east coast of Florida and northwest Florida portions have elevated risk of extinction. The other portions considered were either not at risk of extinction (south and southwest Florida) or there was insufficient data available to develop an opinion on extinction risk (Texas and eastern Mexico). Therefore, we proceeded to consider the biological significance of only the two portions with elevated extinction risk.

The subpopulation of dwarf seahorse along the east coast of Florida, especially in Indian River Lagoon, appears to be at an elevated risk of extinction. Under conservative starting conditions, the retrospective analysis showed this subpopulation has varied in abundance through time and persists at a stable but very low abundance as of 2016 (Carlson et al. 2019). The projected PVA runs indicate the population is stable or slightly increasing under optimistic scenarios but decreasing under all pessimistic scenarios, with the most pessimistic run leading to localized extinction (Carlson et al. 2019). The ongoing threat of poor water quality and harmful algal blooms has drastically reduced seagrass coverage and in turn dwarf seahorse abundance in this portion of its range. If this subpopulation was lost, there would be a reduction in the geographic extent of dwarf seahorse; however, there is no evidence to indicate that the taxon would be lost as a result. This portion does not currently have the abundance or habitat capacity to buffer surrounding stocks against environmental threats and is not responsible for connecting other portions. The east coast of Florida subpopulation has been in decline for several years but we have not seen this result in a decline in the adjacent south and southwest Florida subpopulation suggesting the contribution of the east coast is limited. While, Fedrizzi et al. (2015) showed there is some gene flow between this portion and others via passive dispersal, the genetic contributions of the east coast portion to the rest of the population's range is limited by ocean currents and winds that dictate passive dispersal. Therefore we would not expect the loss of this portion to contribute significantly to a loss of genetic diversity and the remaining population would contain enough diversity to allow for adaptations to changing environmental conditions. In conclusion, we determined that the east coast of Florida portion's contribution to the population in terms of abundance, spatial distribution, and diversity is of low biological importance and overall does not appear significant to the viability of the species. Thus we find the east coast of Florida does not represent a significant portion of the dwarf seahorse range.

Dwarf seahorse in northwest Florida (including Apalachicola, Big Bend, Cedar Key, and St. Andrew's Bay) appear to be at a low risk of extinction despite low abundance and the threats facing the species within this portion of its range. Historically, this subpopulation has been far less abundant than other subpopulations based on the retrospective analysis and fisheries surveys. Overall we find that the contribution that this stock makes to the species' abundance is low. This subpopulation is found on the northern periphery of the species range based on thermal tolerances and thus is most susceptible to mortality from cold weather events. A recent genetic analysis indicates the western-most portion of this subpopulation (Pensacola, Florida) is genetically distinct from the rest of the population (Fedrizzi et al. 2015) but we are unsure of mixing along the boundary further to the south of this portion. If the northwest Florida portion was lost, dwarf seahorse rangewide would lose some potential genetic adaptation. Yet, given this subpopulation's small size and limited genetic connectivity to the overall taxon, we do not believe this potential loss would affect the species' ability to persist. The remaining subpopulations would continue to provide genetic diversity to the species as whole. There is no evidence to indicate that the loss of genetic diversity from the northwest Florida portion of the dwarf seahorse range would result in the remaining portions lacking enough genetic diversity to allow for adaptations to changing environmental conditions. While it is possible that the unique genetic signature of the northwest Florida portion conveys some type of adaptive potential to the species rangewide, we do not currently have evidence of this. In particular, it is unclear if this subpopulation is uniquely adapted genetically to tolerate colder conditions. The projected PVA runs indicate the subpopulation is generally stable (Carlson et al. 2019). Pessimistic PVA scenarios resulted in decreased abundance for this portion of the population, but not extinction (Carlson et al. 2019). Although this portion has some extinction risk, its low abundance and limited connectivity suggest it is not significant to the viability of the species overall.

In summary, we find that there is no portion of the dwarf seahorse's range that is both significant to the species as a whole and endangered or threatened. After considering all the portions we believe that some portions (east coast of Florida and northwest Florida) carry an elevated risk of extinction; however, these portions are not biologically significant to the species. In contrast, the south and southwest Florida subpopulation appears to be biologically important in terms of abundance, connectivity, and productivity but this subpopulation is robust and not at risk of extinction now or in the foreseeable future. Thus, we find no reason to list this species based on a significant portion of its range.

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