Giant Manta Ray Consultation Framework
NOAA Fisheries Southeast Region

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Purpose and Scope

To inform the Southeast Region's (SERO) Endangered Species Act (ESA) Section 7 consultation activities for giant manta ray (*Mobula birostris*), this document consolidates, summarizes, and interprets the best available information obtained through the listing process and subsequent research by state, federal, and university partners. This collection of information provides ESA Section 7 assistance, and identifies actions that can be taken early in the consultation process to promote species conservation and improve overall consultation efficiency for the action agency. This document synthesizes information and should be considered a job aid, used as general guidance only.

Table 1: Giant manta ray ESA listing documents

ESA Status	Listing Rule/Date	Critical Habitat	Recovery Outline
Threatened	83 FR 2916/January 22, 2018	Not Prudent (84 FR 66652; December 5, 2019)	December 2019

Species Description

Image 1: Dorsal surface. Photo: Josh Stewart

Image 2: Ventral surface. Photo: G.P. Schmahl

Manta rays are filter-feeding rays in the family Mobulidae, characterized by a terminal mouth, diamond-shaped bodies with wing-like pectoral fins, and cephalic fins. The dorsal surface of the giant manta ray is predominantly black with white shoulder patches on the upper back (Image 1). These white shoulder patches are bright and prominent and look like distinct triangles. The ventral surface (belly) on a giant manta ray is generally white, with a distinct black/gray spot pattern, which is mostly located around the lower abdomen (Image 2). The ventral surface remains largely unchanged throughout their lives, and the unique pattern of spots may be used to identify individuals. While rare, color polymorphisms do occur, these individuals can be almost entirely black or almost entirely white on both their dorsal and ventral surfaces, which can also be used to identify individuals (Venables et al. 2019)

Growth and Reproduction

The giant manta ray may be the largest living ray species, attaining a maximum size of 26 ft (800 cm) disc width (DW) with anecdotal reports up to 29 ft (910 cm) DW (Compagno 1999; Alava et al. 2002; Carpenter et al. 2023). Males mature at 350–400 cm DW and females mature at 380–500 cm DW (White et al. 2006; Last et al. 2016; Stewart et al. 2018). A giant manta ray born in captivity measured approximately 6 feet (1.8 meters) DW at birth (Okinawa Churaumi Aquarium, cited in Deakos 2012). Female age-at-maturity is estimated as 8.6 years of age, but first pregnancy may be delayed by up to 4 years (making first age of pregnancy 12 years) depending upon food availability (Rambahiniarison et al. 2018). Gestation for the lone observed captive birth was 374 days (Orr 2007). The maximum age is estimated at 45 years, based on the longevity of the reef manta ray; generation length is therefore estimated as 29 years (Marshall et al. 2022). The giant manta ray is among the longest-living ray and has an extremely conservative life history; with the average female producing 4-7 pups during its estimated lifespan (Marshall et al. 2022).

Diet and Feeding

Giant manta rays are filter feeders that primarily feed on planktonic organisms such as euphausiids, copepods, mysids, decapod larvae, and shrimp, with some studies noting their consumption of small and moderate sized fishes as well (Bigelow and Schroeder 1953; Carpenter and Niem 2001; Graham et al. 2012; Rohner et al.2017; Stewart et al. 2016a; Stewart et al. 2016b; Burgess et al. 2017). Manta rays feed by swimming with open mouths, capturing prey while expelling seawater through the gill slits. The filtering apparatus in these animals is a highly modified gill plates, comprising long, parallel arrays of "leaf-like filter lobes"(Paig-Tran et al. 2011; Paig-Tran et al. 2013). The gill plates filter out water, leaving behind food particles that are then directed to the esophagus through cross-flow without clogging (Paig-Tran et al. 2013; Divi et al. 2018). This ricochet separation filtration allows giant manta rays to retain prey of various sizes, even if they are smaller than the filter pores, which means they can effectively feed on mixed plankton assemblages, where prey ranges in size from small calanoid copepods to larger mysids and euphausiids (Stewart et al. 2016a)

Distribution

Within its range, *M. birostris* inhabits tropical, subtropical, and temperate bodies of water and is commonly found offshore, in oceanic waters, and near productive coastlines, with water temperatures generally between 20°C and 30°C (Duffy and Abbott 2003; Marshall et al. 2009; Kashiwagi et al. 2011; Freedman and Roy 2012; Graham et al. 2012; Hacohen-Domené et al. 2017; Farmer et al. 2022). The species has also been observed in estuarine waters near oceanic inlets, with use of these waters as potential nursery grounds (Adams and Amesbury 1998; Milessi and Oddone 2003; Medeiros et al. 2015; Pate and Marshall 2020; Farmer et al. 2022).

While the species is thought to be highly migratory, given these recorded long-distance movements as well as a lack of genetic sub-structuring, a global photo-identification database has not verified any individual movement across ocean basins (Marshall and Holmberg 2018), suggesting a low degree of interchange. A study by Stewart et al. (2016a), which incorporated tagging; stable isotope; and genetic data from animals found in the Indo-Pacific (i.e., Indonesia, Sri Lanka, Mexico nearshore, and Mexico offshore), found evidence that *M. birostris* occur in well-structured subpopulations with a high degree of residency and low migratory rates.

Giant manta rays are commonly sighted in aggregations at many locations throughout their range. The timing of these sightings varies by region (for example, the majority of sightings in Brazil occur during June and September; in the archipelago of Cabo Verde, reliable sightings occurred between July and January; in Raja Ampat, Indonesia, sightings are higher during the months of February to July; in New Zealand, sightings mostly occur between January and March; and in Bahía de Banderas, Mexico, occurrences peaked from January to March and again from May to October). These aggregations seem to correspond with the movement of zooplankton, climatic fluctuations (e.g., El Niño Southern Oscillation), current circulation and tidal patterns, seasonal upwelling, seawater temperature, and possibly mating behavior (Couturier et al. 2012; De Boer et al. 2015; Armstrong et al. 2016; Hacohen-Domené et al. 2017; Beale et al. 2019; Nicholson-Jack et al. 2021; Domínguez-Sánchez et al. 2023, Garzon et al. 2023). In the northeastern Atlantic Ocean and Gulf of Mexico, the distribution of manta rays is influenced primarily by sea surface temperature, with a clear expansion to the north during warmer months (Farmer et al. 2022). Giant manta rays are most commonly detected at productive nearshore and shelf-edge upwelling zones at surface thermal frontal boundaries within a temperature range of approximately 20–30°C. The highest nearshore occurrence is predicted to take place off northeast Florida during April, with the distribution extending northward along the shelf-edge as temperatures warm, leading to higher occurrences north of Cape Hatteras, North Carolina from June to October, and then south of Savannah, Georgia from November to March as temperatures cool (Figure 1; Farmer et al. 2022). In the Gulf of Mexico, the highest nearshore occurrence is predicted around the Mississippi River delta from April to June and again from October to November (Figure 1; Farmer et al. 2022).

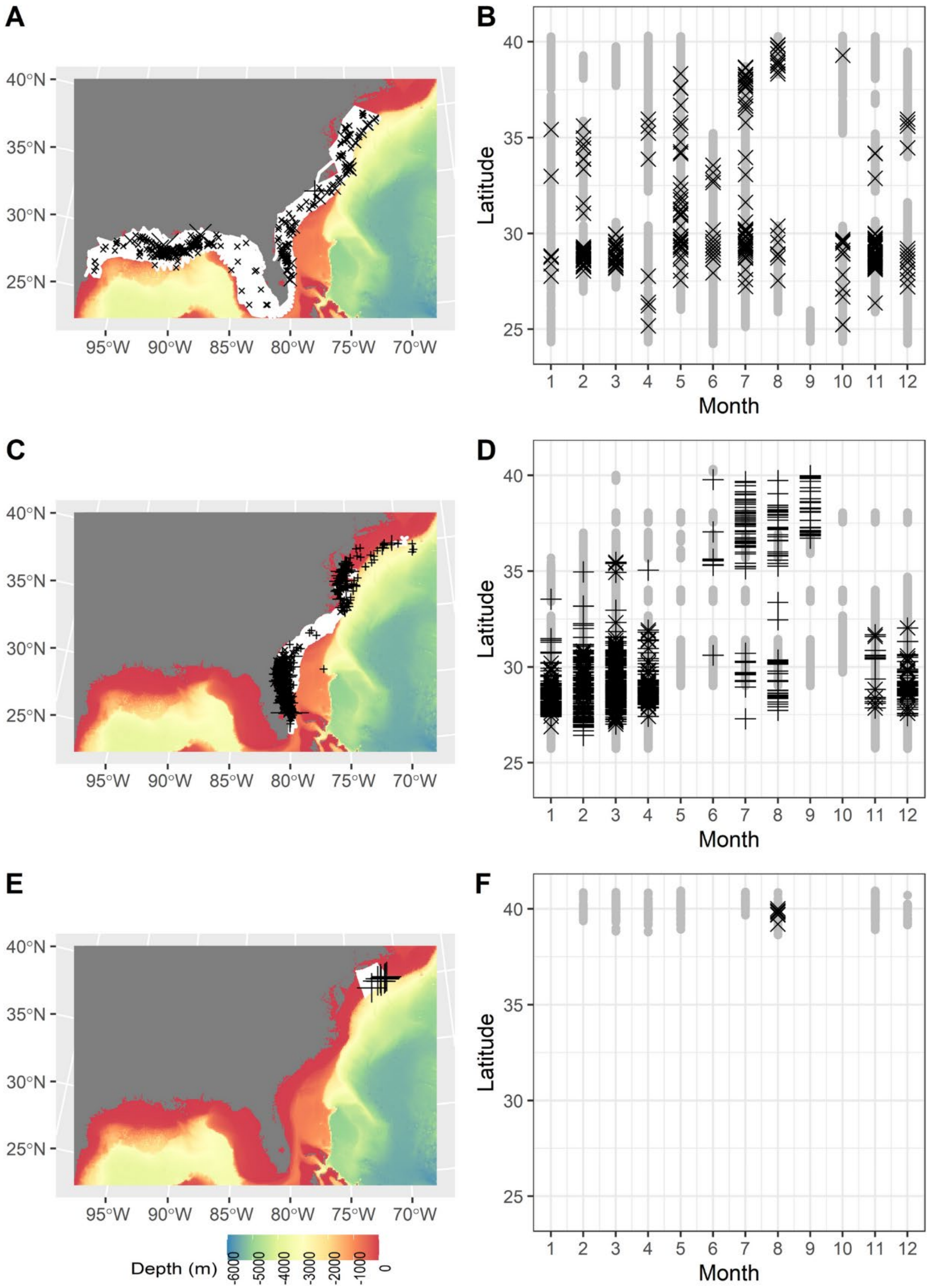

Figure 1: Spatial distribution relative to coarse-scale bathymetry (red = shallow; blue = deep) and survey effort (white lines) and (B) spatio-temporal distribution of survey effort (gray circles) and manta ray sightings (X: on effort, + : off effort; scaled to number reported within survey) by Southeast Fisheries

Science Center, (C,D) North Atlantic Right Whale Consortium, and (E,F) Normandeau Associates aerial surveys for New York State Energy Research and Development Authority. Source: Farmer et al. (2022).

Movement and Habitat Use

Giant manta rays seem to prefer areas where upwelling occurs, most likely due to the increase in primary productivity, which in turn supports abundant zooplankton, their main prey. Giant manta rays also appear to exhibit a high degree of plasticity in terms of their use of depths within their habitat. The giant manta ray can exhibit diel patterns in habitat use, moving inshore during the day to clean and socialize in shallow waters, and then moving offshore at night to feed to depths of 1,000 meters (Hearn et al. 2014; Rohner et al. 2017). Recent research has also found that during the day, giant manta rays tend to primarily keep to surface waters (<5 m) with limited vertical movements, while at night, they have been observed continuously oscillating up and down through the water column, likely to forage on vertically migrating zooplankton (Andrzejaczek et al. 2021). Tagging studies have shown that the species conducts night descents of up to 200-450 m depths (Rubin et al. 2008; Stewart et al. 2016) but is capable of diving to depths exceeding 1,000 m (Marshall et al. 2022). Diving behavior is likely influenced by season and shifts in prey location associated with the thermocline. Surface basking is also a technique giant manta rays use to maintain optimum body temperature before and after deep dives (Canese et al. 2011; Thorrold et al. 2014).

Regional observations suggest that giant manta rays are frequently associated with nearshore habitats; as such, they are at elevated risk for exposure to a variety of threats (Farmer et al., 2022). In the Southeast, giant manta rays are sighted nearshore and in intracoastal waterways, coastal bays, tidal outflows, inlets, river mouths (feeding around outfall plumes), and estuaries (Adams and Amesbury 1998; Milessi and Oddone 2003; Pate and Marshall 2020; Farmer et al. 2022; C. Horn pers. obs).There is a strong management interest in understanding the inshore extent of giant manta movements in bays and tidal inlets. Farmer et al (2022)'s distribution model predictions suggest seasonal trends with high probability of occurrence in large bays (e.g., Tampa Bay, Chesapeake Bay); however, reported sightings in bays are extremely limited and it is unclear if this is due to reduced water clarity, rarity of use, or low survey effort. Giant manta rays have been reported in bays and inlets in Brazil (Bucair et al. 2021; Medeiros et al. 2015), and several anecdotal reports of use of shallow tropical bays in the U.S. Caribbean have been verified. Inshore sighting have also been documented in: Choctawhatchee Bay, Apalachicola Bay, Sarasota Bay, Tampa Bay, Indian River Lagoon, Port Canaveral (Florida); Garden Island Bay, East and West Bay, Chandeleur Sound (Louisiana); Mississippi Sound (Mississippi), and Laguna Madre (Texas) (Farmer et al. 2022). In addition, NOAA fisheries and partners are conducting research activities where giant manta rays are known to aggregate, along Florida's east coast in the western north Atlantic, in the Mississippi delta region in the Gulf of Mexico, and in the Flower Garden Banks National Marine Sanctuary (FGBNMS) and surrounding banks in the Gulf of Mexico. These are three unique locations where giant manta rays appear to congregate and can be reliable studied by scientists in the Southeast U.S. (C. Horn, NMFS, pers. comm.).

In the U.S. Caribbean, giant manta rays have been sighted in Puerto Rico and the U.S Virgin Islands. In the U.S. Virgin Islands, giant manta rays have been sighted in shallow coastal bays, including Cane's Bay, Maho Bay, and Francis Bay (Farmer et al. 2022). In Puerto Rico, the majority of giant manta sightings are from the area surrounding Culebra, Vieques, and Mona Islands (Farmer et al. 2022).

Nursery Habitat

Documenting nursery habitats is a priority in manta ray research and conservation (Stewart et al. 2018a), yet the juvenile life stages remain particularly understudied. To date, only three nursery areas for giant manta rays (*M. birostris* and *M. cf. birostris*) have been described worldwide, two of which occur within the Southeast U.S. (Stewart et al. 2018a; Pate and Marshall 2020). Stewart et al. (2018a) described juvenile nursery habitat within the FGBNMS in the Gulf of Mexico; Pate and Marshall (2020) identified a nursery habitat along a highly developed coastline in southeast Florida. These nursery areas were described based on the frequent observations of juveniles, high site fidelity, and repeated use across years (Heupel et al. 2017).

Section 7 Considerations

This section provides information to assist biologists with section 7 consultations. This examination considered published scientific literature, as well as unpublished data provided by non-governmental, state, and federal agencies. The best available information indicates that giant manta rays are distributed throughout the Southeast U.S., occurring in the Western North Atlantic, Gulf of Mexico, and Caribbean. Within these areas, they are sighted at continental shelf-edges, upwelling areas, and in productive coastal areas, including inshore locations such as inlets, intracoastal waterways, bays, and estuaries. Giant manta rays do not occur in freshwater or marsh habitats (e.g., freshwater lakes and rivers, tidal and non-tidal marshes, mangroves, riparian areas); therefore, it is not necessary to consider them in consultations that occur within these habitats.

Please refer to the SERO Section 7 Mapper for more detailed information regarding where to consult on giant manta rays in the Southeast Region.

No Effect Determination

When making a "no effect" determination, it is not necessary to mention the species in the consultation. Below are common activities that could conclude "no effect" for giant manta rays.

Turbidity: Short term, discrete projects (e.g., shoreline stabilization, pile-supported structures, and boat ramps) can result in a temporary increase in turbidity, turbidity curtains should be used to control and reduce turbidity, and projects must adhere to state water quality standards. Giant manta rays are able to swim through or avoid any temporary increase in turbidity without harm, as they exposed to turbidity and lower water clarity throughout their environments. Therefore, we believe any potential exposure to a short-term increase in

turbidity because of the construction will have no effect on giant manta rays. However, projects that have the potential to increase turbidity long-term maybe considered NLAA (Table 2).
Movement and access to foraging habitat: We believe the following structures will have no effect on giant manta rays (will not limit their movement or ability to access foraging habitat). Activities that occur along the shoreline: shoreline stabilization, pile-supported structures, and boat ramps. The placement of such materials along the shoreline would not create an obstruction for species to move around these features to access foraging and refuge habitat in surrounding areas. The placement of a single pile or buoy for an ATON also would not create an obstruction when placed in open water. Note: no effect determinations refer to the presence of the structures; the effects of installation may be different.

Entanglement: The presence of flexible materials in the water (e.g., turbidity curtains, in-water lines, mooring lines, ATONs) could create an entanglement risk to giant manta rays. Manta rays are obligate ram ventilators, meaning that they need to swim constantly to “breathe.” Therefore, entanglement in line rapidly leads to asphyxiation. While these entanglements can be lethal, there are no reports of entanglement in turbidity curtains, non-looping in-water lines, or in-water lines enclosed in plastic or rubber sleeves. Therefore, if the following project design criteria are used, we believe that there will be no effect to giant manta rays from entanglement in construction material.

- All in-water lines (e.g., mooring lines, rope, chain, and cable, including the lines to secure the turbidity curtains) must be stiff, taut, properly secured, and non-looping to minimize excess line and the risk of entanglement. If flexible lines are used, they must be enclosed in plastic or rubber sleeves/tubes that add rigidity and prevent the line from looping and tangling.
- Turbidity curtains and in-water equipment must be placed in a manner that does not entrap species within the construction area or block access for them to navigate around the construction area.

May Affect Determination (Not Likely to Adversely Affect [NLAA] or Likely to Adversely Affect [LAA]) for the Species

For proposed actions that may affect giant manta rays, the biologist must carefully analyze the effects of the proposed action to confirm whether a NLAA or LAA determination is most applicable (Table 2). An activity that is typically NLAA for an activity could be LAA for a different consultation if circumstances are significantly different or best-management practices or project design criteria are not incorporated. The biologist must carefully analyze the effects of the proposed action to confirm whether NLAA or LAA is most applicable. An activity that is typically NLAA for an activity could be LAA for a different consultation if circumstances are significantly different or certain best-practices or project design criteria are not incorporated.

Minimization Measures

Regardless of consultation type (i.e., formal or informal), a constructive dialog between SERO Protected Resources Division and the action agency can shape the proposed action to minimize negative effects on conservation and recovery of the species. For example, the biologist can seek ways to incorporate mitigation measures and best practices, recommend different equipment, materials, or methods, or require monitoring and environmental windows to ensure the proposed action is carried out in the most careful and least impactful manner possible. Such minimization measures are required, as part of any non-jeopardy formal consultation (i.e., a LAA determination) under the Incidental Take Statement. In those instances, "Terms and Conditions" designed to monitor and minimize the impact of any such take on the species will be developed.

Best Management Practices for Reducing and Avoiding Effects to Giant Manta Ray

Consider the following when including giant manta rays in the consultation:

- Require the use of the SERO Protected Species Construction Conditions and other applicable PDCs.
- Require the use of the SERO Vessel Strike Avoidance Measures.
- Report sightings by email to:manta.ray@noaa.gov. The applicant's agent will report during construction; the applicant will report post-construction.
- Ensuring projects prevent debris from entering the environment.

Additional considerations depending on the scope of the action could include the incorporation of environmental windows to minimize risk and probability of adverse effects. Action agencies should work with SERO to time activities when risk is minimized and enact conservation measures to reduce level and duration of exposure. This Species Distribution Model (Farmer et al. 2022) will help mangers compute the likelihood of an interaction and recommend environmental windows to minimize risk.

- To identify environmental windows to time activities to minimize risk action agencies should consider the Species Distribution Models predictions that are detailed in Farmer et al. (2022)

The following additional measures may be required when incidental take of giant manta is anticipated:

- NMFS-approved protected species observers are required for certain actions (e.g., fisheries and relocation trawling). These observers are sometimes tasked with photographing, data collection, and in certain situations sampling and tagging.
- Use of applicable safe handling guidance including but not limited to the promotion of circle hook and non-stainless steel usage instead of standard J-hooks and treble hooks
- SERO educational signs and other relevant education or outreach materials.

Table 2: Threats, Routes of Effect, and Potential Impacts that May Affect Giant Manta Ray and Considerations for Effects Determinations

Activity	Route of Effects	Potential Impact to Species	Considerations
Federal Fisheries	• Potential hooking, entanglement, and capture in fishing gear, including, but not limited to, hook and line, longlines, trawls, gillnets, and seine gear types	• Injury or mortality resulting from capture • Obligate ram ventilators are more likely to drown as a result of bycatch (Ellis et al. 2016; Dapp et al. 2015) • Post release mortality(if estimates are not available, a proxy species may be used)	• Safe handling and release procedures – Available for recreational and commercial gears • Timing and location? Do operations occur during times and within areas of high manta ray abundance? For detailed information on the species distribution, see Farmer et al. (2022) • Increase observer coverage, data collection, monitoring, assess post release survivorship
State Fisheries, Fishing, Fisheries related Research	• Potential hooking, entanglement, and capture in commercial, recreational, or research fishing gears (e.g., rod-and reel gear, trawls, gillnets, seines) • Vessel traffic	• Injury or mortality resulting from incidental capture / foul hooking • Post release mortality • Vessel strike could result in injury or mortality	• Safe handling and release procedures – Available for recreational and commercial gears • Fishery Observers, data collection, monitoring, sampling, possibly tagging • Gear type, deployment duration, deployment frequency • Require posting of educational signage, anglers outreach, and fishing line disposal receptacles
Fishing Pier – (i.e., Beach side piers only and inlets. ICW pier interactions are extremely unlikely to occur).	• Interaction with recreational fishing gears and entanglement • Potential disturbance during construction	• Injury, disfigurements, amputations resulting from foul hooking and/or entanglement (Pate et al. 2020) • Interactions with construction equipment are typically extremely unlikely to occur due to species' mobility • Noise associated with pile driving	• Location (is the pier located in an area of high manta ray abundance)? • Artificial lighting can concentrate zooplankton that may attract manta rays to the project area • Require posting of educational signage, anglers outreach, and fishing line disposal receptacles • Construction conditions and noise abatement measures

Activity	Route of Effects	Potential Impact to Species	Considerations
Energy (Oil and Gas)	• Exploration activities (e.g., sonar, exploratory drilling, noise) • Entanglement • Direct fouling by oil/contaminants • Prey loss and/or contamination • Habitat degradation, contaminants • Vessel traffic	• Direct mortality through exposure to oil / contaminates • Entanglement lines/hoses during diver surveys/ maintenance • Prey loss and /or health impacts from ingestion of contaminated food sources (zooplankton) • Habitat degradation, avoidance, and displacement from an action area • Vessel strike could result in injury or mortality	• Pollution / spill safeguards/ reporting requirements • Does the action area occur within important nursery habitats? • Will visual surveys be conducted prior to activities? • Are there shutdown procedures in place if a listed species observed? BMPs • What is the average speed of support vessels and deployment frequency? Are vessel speed restrictions in place? • Avoidance of important habitats (Farmer et al. 2022) to reduce impact • What is the average speed of support vessels and how frequently they are deployed?
Energy (Power Plant)	• Power plant entrainment at intake canals	• Entrainment, incidental takes associated with intake; see St. Lucie Plant, NRC	• BMPs including rescue and relocation
Energy (Offshore Wind)	• Increased ocean noise • Potential magnetic displacement (Keller et al. 2021) • Habitat degradation, displacement, avoidance, and contaminant • Vessel traffic	• Increased ocean noise, which could affect the behavior, disrupt foraging, breeding, cause a stress response, etc. • Introduce electro-magnetic fields that may impact navigation, predator detection, communication, etc. • Habitat degradation avoidance / displacement from action area • Vessel strike could result in injury or mortality	• Does the action area occur within important habitats like migration routes or juvenile nurseries? • BMPs and noise abatement measures • Avoidance of important habitats (Farmer et al. 2022) to reduce impact • What is the average speed of support vessels and how frequently they are deployed?
Aquaculture	• Physical barrier • Poses an entanglement risk • Alter water quality and/or habitat • Vessel traffic	• Physical barrier could block or impede movement in the area? • Injury or mortality resulting from entanglement in lines	• Type of equipment and duration of in-water construction?

Activity	Route of Effects	Potential Impact to Species	Considerations
	• Construction activities • Attraction	• Water quality/habitat degradation could reduce foraging habitat • Vessel strike could result in injury or mortality • Habitat degradation avoidance, and /or displacement from the area • Attraction to increased nutrients, altered movement patterns	• Duration of the permit (i.e., how long will the project be in operation so we know how long any structures would be in the water)? • What is the configuration and design of the aquaculture equipment? • Avoidance of important habitats (Farmer et al. 2022) to reduce impact • What are the maintenance plans for the facility (e.g., how often will nets/lines be inspected) • What is the average speed of support vessels and how frequently they are deployed?
Dredging (e.g., Hopper, Clamshell, Cutter Head)	• Potential disturbance during construction • Short and/or long-term habitat alteration and avoidance • Vessel traffic • Relocation trawling (if there is relocation trawling prior to dredging)	• Interaction with equipment is extremely unlikely to occur due to species' mobility • Vessel strike could result in injury or mortality (Pate and Marshall 2020; McGregor et al. 2019) • If relocation trawling is proposed, there is potential injury and mortality	• What is the average speed of support vessels and how many vessels will be in the project area at a given time? • Type of equipment to be used and the duration of dredging? • Are there shutdown procedures in place if a listed species is observed? • Will there be tow time limits for relocation trawls? • Will observers be present? If so, ensure data collection, tissue sampling, and possible tagging
Marina, Dock, Ramp, & Slips	• Potential impacts during construction • Vessel traffic • Entanglement	• Interaction with construction equipment is extremely unlikely to occur due to species' mobility • Noise associated with construction activities is typically NLAA if it is below the injury threshold level of > 2g fish • Vessel strike could result in injury or mortality	• Type of equipment and duration of in-water construction? • Construction conditions and noise abatement measures • Number and vessel speed. Are speed restrictions in place? • If in water lines, will PDCs be implemented?

Activity	Route of Effects	Potential Impact to Species	Considerations
		• Flexible in water lines (e.g., mooring lines) pose an entanglement risk	• Require posting of educational signage, anglers outreach, and fishing line disposal receptacles
Beach Nourishment	• Potential interaction with construction equipment • Vessel traffic • Entanglement • Short and/or long-term habitat alteration	• Interactions with equipment is extremely unlikely to occur due to species' mobility • Flexible in water lines (e.g., mooring lines) pose an entanglement risk • Vessel strike could result in injury or mortality • Habitat avoidance or displacement from the action area	• Type of equipment and duration of in-water construction? • Project duration (temporary or long-term) • What is the average speed of support vessels? • If in water lines, will PDCs be implemented? • Project location and habitat type. Is there similar habitat nearby?
Habitat Restoration	• Potential interactions with construction equipment • Habitat alteration • Vessel traffic	• Interaction with equipment is extremely unlikely to occur due to species' mobility • Habitat avoidance or displacement from the action area • Vessel strike could result in injury or mortality	• Type of habitat affected. Are there any beneficial effects? Creation or restoration reef habitat or other positive water quality / habitat enhancements • Type of equipment and duration of in-water construction • What is the average speed of support vessels and deployment frequency?
Outfalls, Water Releases, & Effluent Discharge	• Long term habitat alteration • Foraging energetic	• Inability to use habitat or reduction in prey because water quality parameters are not suitable? • Habitat degradation and avoidance or displacement from the action area	• Project location and habitat type. Is there similar habitat nearby? • Project duration (temporary or long-term) • Reduction in habitat and prey availability
Artificial Reef	• Potential for entanglement in fishing line that gets wrapped around the structure • Blasting impacts, if explosives are used to sink vessels • Physical injury from placed material	• These projects are typically NLAA, but need to consider potential for entanglement (if entanglement is not, extremely unlikely to occur, it may be LAA) • Use of explosives typically LAA	• Project location and habitat type. Is there similar habitat nearby? • Noise abatement measures? • Type of equipment to be used and duration of in-water construction? • Duration of the permit (consider how often USACE may request reauthorization since most artificial reef permits are ongoing

Activity	Route of Effects	Potential Impact to Species	Considerations
		• Noise associated with construction activities is typically NLAA if it is below the injury threshold level of > 2 g fish. • Interaction with construction equipment and placement of material is extremely unlikely to occur due to species' mobility	leading to an increase in structures placed in the marine environment over time)?

Section 7 and Recovery Integration

Conservation Activities and Recommendations

It is important to work with action agencies to promote proactive efforts to help conserve and recover the species. This will help the agency comply with its Section 7(a)(1) obligations, fill data gaps, improve the environmental baseline of species, and recover species so they no longer need the protections of the ESA. Regardless of consultation type (i.e., informal or formal consultation), conservation activities discussed early in the consultation process may be included as part of the proposed action. During formal consultation (i.e., a LAA determination), these may also be implemented through non-binding "Conservation Recommendations."

Cooperative engagement between action agencies and SERO provides an opportunity to establish or strengthen partnerships and provide action agencies the opportunity to proactively implement measures beneficial to ESA species. Action agencies should give thought to possible conservation activities based on the project type, location, and the applicant performing the activity and consider whether conservation recommendations can be incorporated into a project.

The Giant Manta Ray Recovery Outline (NMFS 2019) was published in 2019. The outline is meant to serve as a preliminary strategy for recovery of the species and recommends conservation actions that facilitate recovery of the species. Table 3 describes those interim recovery actions.

Table 3: Interim Recovery Actions

Interim Recovery Actions
Improve understanding of bycatch and investigate best methods for safe release of giant manta rays caught in U.S. fisheries
Improve understanding of associated mortality rates in key commercial fisheries (including at-vessel and post-release mortality), including impacts of various factors such as gear type, temperature, temporal and spatial fishing effort, etc., for informing future fisheries management strategies to reduce fisheries interactions and associated mortality.
Improve understanding of taxonomy, population distribution, abundance, trends, and structure through research, monitoring, and modeling
Identify and protect key habitat areas, including breeding and nursery grounds through research, monitoring, modeling, and management
Improve understanding of movement and seasonal distribution to inform future management measures for minimizing impacts to the species during key life history functions.
Investigate the impact of other threats to the species (e.g., foul-hooking, vessel strikes, entanglement, climate change, pollution, tourism) through research, monitoring, modeling, and management
Coordinate with partners to reduce threats (e.g., foul-hooking, vessel strikes, entanglements, pollution, and tourism) through outreach and education in order to prevent additional mortalities.

Through integrating interim recovery actions into a proposed action, action agencies can contribute to closing existing data gaps and to the recovery of listed species, while minimizing their adverse effects and improving consultation quality and efficiency. Our understanding of the probability and magnitude of stressors in a federal action can influence the project implementation timeline in several ways including prompt determination of informal vs. formal consultation requirements; identification of environmental windows to avoid/minimize adverse effects; or development of effective best management practices. Closing these data gaps (Table 4) is a recovery priority and can result in more timely and accurate consultations in the future. Studies that are implemented in advance of or during larger projects can also accomplish consultation and recovery objectives—species avoidance, refinement of environmental windows, reduced planning time, implementation of recovery actions, etc. Similarly, studies that fill data gaps associated with demographic information (e.g., abundance, mortality rates) can also help evaluate potential population level consequences. In this regard, resolving gaps in species demographic information can improve the accuracy of jeopardy analyses and our overall understanding of recovery. The same principles described above apply to improve consultation efficiency and recovery in multiple project types. Table 4 provides examples of several existing data gaps and research needs for the giant manta ray in the Southeast.

Table 4: Existing Data Gaps and Research Needs for Giant Manta Rays in the Southeast U.S.

Activity	Data Gap	Research Need
Federal and State Fisheries	No data on giant manta ray post release mortality	Evaluate giant manta ray post release mortality using pop-off satellite tags, blood chemistry analyses, and / or acoustic tags and receivers
Federal and State Fisheries	Very limited data on bycatch, bycatch risk, and effectives of mitigation / safe release practices	Evaluate bycatch risks, mitigation efforts, and impacts on populations of giant manta rays caught in Southeast U.S. fisheries, particularly shrimp trawl, pelagic longline, and purse seines
Large-Scale Actions (e.g., energy developement, federal and state fisheries, programmatic, aquaculture)	Very limited demographic data	Conduct age, maturity, and fecundity research that focuses on improving understanding of age, size at maturity, and reproductive status for giant manta rays

Activity	Data Gap	Research Need
All Actions (e.g., nearshore construction, dredge and fill, energy development, fisheries and other large-scale actions)	Limited data on important habitats	Identify breeding, aggregation sites, and nursery grounds; evaluate physical and environmental features driving site fidelity and/or repeated use of areas by giant manta rays
Large-Scale Actions (e.g., energy developement, federal and state fisheries, programmatic, aquaculture)	Limited data on abundance, trends, and species distribution	Conduct in-water tagging and aerial surveys to increase understanding of distribution, abundance, and trends of giant manta rays
All Actions (e.g., fishing piers, nearshore construction, dredge and fill, marina expansion, boat ramps, energy development and other large-scale actions)	Very limited data on sub-lethal threat including frequency, severity, and potential mitigation	Investigate sub-lethal threats (e.g., foul hooking, vessel strikes, entanglement, climate change, pollution) to determine their frequency and severity (e.g., photographic mark-recapture, necropsy, plastic bioaccumulation)
All Actions (e.g., fishing piers, state and federal fisheries, nearshore construction, marina construction or expansion, boat ramps, energy development, other large-scale actions)	Very limited data on the prey species, composition, and movement patterns etc.	Investigate environmental and prey patterns (e.g., prey species, composition, biomass, size spectra) that can aid predicting spatiotemporal distribution and movement of giant manta rays

Literature Cited

Adams, D. H., & Amesbury, E. (1998). Occurrence of the manta ray, Manta birostris, in the Indian River Lagoon, Florida. Florida Scientist, 7-9.

Alava E, Dolumbaló E, Yaptinchay AA, Trono RB (2002) Fishery and trade of whale sharks and manta rays in the Bohol Sea, Philippines. In: Fowler S, Reed T, Dipper F (eds) Elasmobranch Biodiversity, Conservation and Management: Proceedings of the International Seminar and Workshop Sabah, Malaysia, pp 132-148

Andrzejaczek S, Schallert RJ, Forsberg K, Arnoldi NS, Cabanillas-Torpoco M, Purizaca W, Block BA (2021) Reverse diel vertical movements of oceanic manta rays off the northern coast of Peru and implications for conservation. Ecol Solut Evidence. 2:e12051. https://doi.org/10.1002/2688-8319.12051

Armstrong AO, Armstrong AJ, Jaine FRA, Couturier LIE, Fiora K, Uribe-Palomino J, Weeks SJ, Townsend KA, Bennett MB, Richardson AJ (2016) Prey Density Threshold and Tidal Influence on Reef Manta Ray Foraging at an Aggregation Site on the Great Barrier Reef. PLoS ONE 11: 1-18 doi 10.1371/journal.pone.0153393

Beale CS, Stewart JD, Setyawan E, Sianipar AB, Erdmann MV (2019) Population dynamics of oceanic manta rays (Mobula birostris) in the Raja Ampat Archipelago, West Papua, Indonesia, and the impacts of the El Niño-Southern Oscillation on their movement ecology. Divers Distrib 25:1472–1487. https://doi.org/10.1111/ddi.12962

Bucair, N., Venables, S. K., Balboni, A. P. and Marshall, A. D. (2021). Sightings trends and behavior of manta rays in Fernando de Noronha Archipelago, Brazil. Mar. Biodivers. Rec. 14, 1–11.

Bigelow HB, Schroeder WC. (1953). Sawfishes, guitarfishes, skates and rays. Fishes of the Western North Atlantic. Memoirs of Sears Foundation for Marine Research 1: 514.

Burgess KB, Couturier LI, Marshall AD, Richardson AJ, Weeks SJ, Bennett MB. (2017). Manta birostris, predator of the deep? Insight into the diet of the giant manta ray through stable isotope analysis. R Soc Open Sci 3: 160717 doi 10.1098/rsos.16071.

Canese, S., Cardinali, A., Romeo, T., Giusti, M., Salvati, E., Angiolillo, M., and Greco, S. (2011). Diving behavior of the giant devil ray in the Mediterranean Sea. Endangered Species Research, 14(2), 171-176.

Carpenter KE, Niem VH. (2001). FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific. Volume 5. Bony fishes part 3 (Menidae to Pomacentridae). FAO Library

Carpenter M, Parker D, Dicken ML, Griffiths CL (2023) Multi-decade catches of manta rays (Mobula alfredi, M. birostris) from South Africa reveal significant decline. Front. Mar. Sci. 10:1128819. doi: 10.3389/fmars.2023.1128819

Couturier, L. I. E., Marshall, A. D., Jaine, F. R. A., Kashiwagi, T., Pierce, S. J., Townsend, K. A., ... & Richardson, A. J. (2012). Biology, ecology and conservation of the Mobulidae. Journal of fish biology, 80(5), 1075-1119.

Compagno, L. J. (1999). Systematics and body form. Sharks, skates, and rays: the biology of elasmobranch fishes, 1-42.

Dapp, D.R., Walker, T.I., Huveneers, C. and Reina, R.D. (2016). Respiratory mode and gear type are important determinants of elasmobranch immediate and post-release mortality. J. Fish Bio, 17: 507-524. https://doi.org/10.1111/faf.12124.

De Boer MN, Saulino JT, Lewis TP, Notarbartolo-Di-Sciara G (2015) New records of whale shark (Rhincodon typus), giant manta ray (Manta birostris) and Chilean devil ray (Mobula tarapacana) for Suriname. Marine Biodiversity Records 8: N.PAG-00 doi 10.1017/S1755267214001432

Deakos, M. H. (2012). The reproductive ecology of resident manta rays (Manta alfredi) off Maui, Hawaii, with an emphasis on body size. Environmental Biology of Fishes, 94(2), 443-456.

Duffy CAJ, Abbott D (2003) Sightings of mobulid rays from northern New Zealand, with confirmation of the occurrence of Manta birostris in New Zealand waters. New Zeal J Mar Fresh 37: 715-721 doi <Go to ISI>://WOS:000187604400004

Domínguez-Sánchez PS, Širović A, Fonseca-Ponce IA, Zavala-Jiménez AA, Rubin RD, Kumli KR, Ketchum JT, Galván-Magaña F, Wells RJD, Stewart JD (2023) Occupancy of acoustically tagged oceanic manta rays, Mobula birostris, in Bahia de Banderas, Mexico. Mar Biol 170, 128. https://doi.org/10.1007/s00227-023-04278-1

Divi, Raj V., Strother James A.. and E. W. Misty Paig-Tran. (2018). Manta rays feed using ricochet separation, a novel nonclogging filtration mechanism. Science Advances. 4, 9. /doi/abs/10.1126/sciadv.aat9533}.

Ellis, J. R., McCully Phillips, S. R., & Poisson, F. (2017). A review of capture and post-release mortality of elasmobranchs. Journal of fish biology, 90(3), 653-722.

Farmer, N.A., Garrison, L.P., Horn, C. et al. (2022). The distribution of manta rays in the western North Atlantic Ocean off the eastern United States. Sci Rep 12, 6544. https://doi.org/10.1038/s41598-022-10482-8.

Freedman, R. and Roy, S.S. (2012). Spatial patterning of Manta birostris in United States east coast offshore habitat. Applied Geography 32, 652–665.

Graham, R. T., Witt, M. J., Castellanos, D. W., Remolina, F., Maxwell, S., Godley, B. J. (2012). Satellite tracking of manta rays highlights challenges to their conservation. PLoS ONE 7:e36834. doi: 10.1371/journal.pone.0036834.

Garzon F, Seymour ZTA, Monteiro ZL, Graham RT (2023) Spatial ecology of a newly described oceanic manta ray population in the Atlantic Ocean. Mar Biol 170, 68. https://doi.org/10.1007/s00227-023-04219-y

Hacohen-Domené A, Martínez-Rincón RO, Galván-Magaña F, Cárdenas-Palomo N, Herrera-Silveira J (2017) Environmental factors influencing aggregation of manta rays (Manta birostris) off the northeastern coast of the Yucatan Peninsula. Marine Ecology 38 doi 10.1111/maec.12432

Hearn AR, Acuña D, Ketchum JT, Peñaherrera C, Green J, Marshall A, Guerrero M, Shillinger G (2014) Elasmobranchs of the Galapagos Marine Reserve: 23-59 doi 10.1007/978-3-319-02769-2_2

Heupel, M. R., Carlson, J. K., and Simpfendorfer, C. A. (2007). Shark nursery areas: concepts, definition, characterization and assumptions. Mar. Ecol. Prog. Series 337, 287–297.

Kashiwagi T, Marshall AD, Bennett MB, Ovenden JR (2011) Habitat segregation and mosaic sympatry of the two species of manta ray in the Indian and Pacific Oceans: Manta alfredi and M. birostris—CORRIGENDUM. Marine Biodiversity Records 4: e86

Last, P., Naylor, G., Séret, B., White, W., de Carvalho, M., & Stehmann, M. (Eds.). (2016). Rays of the World. CSIRO publishing.

Marshall A, Barreto R, Carlson J, Fernando D, Fordham S, Francis MP, Derrick D, Herman K, Jabado RW, Liu KM, Rigby CL, Romanov E (2022) Mobula birostris (amended version of 2020 assessment). The IUCN Red List of Threatened Species 2022: e.T198921A214397182. https://dx.doi.org/10.2305/IUCN.UK.2022-1.RLTS.T198921A214397182.en. Accessed on 26 September 2023.

Marshall AD, Holmberg J. Manta Matcher Photo-identification Library. 2018. https://mantamatcher.org

Marshall A, Compagno L, Bennett M. (2009). Redescription of the genus Manta with resurrection of Manta alfredi (Krefft,1868) (Chondrichthyes; Myliobatoidei; Mobulidae). Zootaxa 2301:1–28

McGregor, F., Richardson, A. J., Armstrong, A. J., Armstrong, A. O., and Dudgeon, C. L. (2019). Rapid wound healing in a reef manta ray masks the extent of vessel strike. PloS one, 14(12). doi.org/10.1371/journal.pone.0225681.

Medeiros, A., Luiz, O. and Domit, C. (2015). Occurrence and use of an estuarine habitat by giant manta ray Manta birostris. J. Fish Biol. 86, 1830–1838.

Milessi, A.C. and Oddone, M.C. (2003). Primer registro de Manta birostris (Donndorff 1798) (Batoidea: Mobulidae) en el Rio de La Plata, Uruguay. Gayana 67, 126–129.

Nicholson-Jack AE, Harris JL, Ballard K, Turner KME, Stevens GMW (2021) A hitchhiker guide to manta rays: Patterns of association between Mobula alfredi, M. birostris, their symbionts, and other fishes in the Maldives. PLOS ONE 16(7): e0253704. https://doi.org/10.1371/journal.pone.0253704

Orr, James (2007). Japan tunes in to birth of giant manta ray. The Guardian. Environment. Acceessed January 16, 2024. https://www.theguardian.com/environment/2007/jun/18/japan.conservation

Paig-Tran EW., Kleinteich T., and Summers A.P. (2013). The filter pads and filtration mechanisms of the devil rays: Variation at macro and microscopic scales. J Morphol; 274(9):1026-43. doi: 10.1002/jmor.20160. Epub 2013 May 20. PMID: 23686500.

Paig-Tran EW., Bizzarro J. J., Strother J. A., and Summers A. P. (2011). Bottles as models: Predicting the effects of varying swimming speed and morphology on size selectivity and filtering efficiency in fishes. J. Exp. Biol. 214, 1643–1654

Pate, JH., Macdonald, C., and Wester, J. (2020). Surveys of recreational anglers reveal knowledge gaps and positive attitudes towards manta ray conservation in Florida. Aquatic Conserv: Mar Freshw Ecosyst. https://doi.org/10.1002/aqc.3508

Pate J.H., Marshall A.D. (2020). Urban manta rays: potential manta ray nursery habitat along a highly developed Florida coastline. Endang Species Res 43:51-64. https://doi.org/10.3354/esr01054.

Rambahiniarison JM, Lamoste MJ, Rohner CA, Murray R, Snow S, Labaja J, Araujo G and Ponzo A (2018) Life History, Growth, and Reproductive Biology of Four Mobulid Species in the Bohol Sea, Philippines. Front. Mar. Sci. 5:269. doi: 10.3389/fmars.2018.00269

Rohner CA, Burgess KB, Rambahiniarison JM, Stewart JD, Ponzo A, Richardson AJ. (2017). Mobulid rays feed on euphausiids in the Bohol Sea. R Soc Open Sci 4: 161060 doi 10.1098/rsos.161060.

Rohner, C. A., Pierce, S. J., Marshall, A. D., Weeks, S. J., Bennett, M. B., and Richardson, A. J. (2013). Trends in sightings and environmental influences on a coastal aggregation of manta rays and whale sharks. Mar. Ecol. Prog. Series 482, 153–168. doi: 10.3354/meps10290.

Rubin R, Kumli K, Chilcott G (2008) Dive characteristics and movement patterns of acoustic and satellite-tagged manta rays (Manta birostris) in the Revillagigedos Islands of Mexico Joint Meeting of Ichthyologists and Herpetologists Montreal, Canada

Stewart, J. D., Nuttall, M., Hickerson, E. L., and Johnston, M. A. (2018). Important juvenile manta ray habitat at flower garden banks national marine sanctuary in the northwestern Gulf of Mexico. Mar. Biol. 165:111. doi: 10.1007/s00227-018-3364-5.

Stewart, J. D., Beale, C. S., Fernando, D., Sianipar, A. B., Burton, R. S., Semmens, B. X., et al. (2016a). Spatial ecology and conservation of manta birostris in the indo-pacific. Biol. Conserv. 200, 178–183. doi: 10.1016/j.biocon.2016.05.016.

Stewart, J. D., Hoyos-Padilla, E. M., Kumli, K. R., and Rubin, R. D. (2016b). Deep-water feeding and behavioral plasticity in Manta birostris revealed by archival tags and submersible observations. Zoology 119, 406–413. doi: 10.1016/j.zool.2016.05.010.

Thorrold, S. R., Afonso, P., Fontes, J., Braun, C. D., Santos, R. S., Skomal, G. B., and Berumen, M. L. (2014). Extreme diving behaviour in devil rays links surface waters and the deep ocean. Nature communications, 5, 4274. https://doi.org/10.1038/ncomms5274.

Venables, S. K., Marshall, A. D., Germanov, E. S., Perryman, R. J., Tapilatu, R. F., Hendrawan, I. G., and Kennington, W. J. (2019). It's not all black and white: investigating color polymorphism in manta rays across Indo-Pacific populations. Proceedings of the Royal Society B, 286 (1912), 20191879.

White WT, Giles J, Dharmadi, Potter IC (2006) Data on the bycatch fishery and reproductive biology of mobulid rays (Myliobatiformes) in Indonesia. Fisheries Research 82: 65-73 doi 10.1016/j.fishres.2006.08.008