Mahi (Costa Rica and Peru)

Coryphaena hippurus

©Monterey Bay Aquarium

Costa Rica and Peru

Drifting longlines

October 30 2013

Seafood Watch Consulting Researcher

Disclaimer

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

Seafood Watch Standard used in this assessment: Standard for Fisheries vF2

Table of Contents

About Seafood Watch

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

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

Parties interested in capture fisheries, aquaculture practices and the sustainability of ocean ecosystems are welcome to use Seafood Reports in any way they find useful. For more information about Seafood Watch® and Seafood Reports, please contact the Seafood Watch® program at Monterey Bay Aquarium by calling 1-877-229-9990.

Guiding Principles

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

Based on this principle, Seafood Watch had developed four sustainability **criteria** for evaluating wildcatch fisheries for consumers and businesses. These criteria are:

- How does fishing affect the species under assessment?
- How does the fishing affect other, target and non-target species?
- How effective is the fishery's management?
- How does the fishing affect habitats and the stability of the ecosystem?

Each criterion includes:

- Factors to evaluate and score
- Guidelines for integrating these factors to produce a numerical score and **rating**

Once a rating has been assigned to each criterion, we develop an overall recommendation. Criteria ratings and the overall recommendation are color-coded to correspond to the categories on the Seafood Watch pocket guide and online guide:

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

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

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

[1] "Fish" is used throughout this document to refer to finfish, shellfish and other invertebrates

Summary

Mahi mahi (*Coryphaena hippurus*) is found worldwide in tropical and subtropical waters. This assessment focuses on the mahi mahi fisheries in Ecuador (26% of total imports into the US), Peru (24%), and Costa Rica (3.5%). Imports comprise more than 95% of the mahi mahi on the US market. Mahi mahi destined for export from these countries are landed using surface set longlines and are fished by artisanal vessels (Ecuador, Peru) as well as small-scale semi- industrial vessels (Costa Rica).

Mahi mahi is short lived, highly fecund and, hence, is moderately resistant to fishing pressure. Recent analyses of CPUE data suggests that biomass is stable, although quantitative analyses of stock status and fishing mortality rates for this species are lacking.

Mahi mahi is a highly seasonal fishery and this species is the primary component of the catch in these fisheries. However, Costa Rican, Peruvian and Ecuadorian mahi mahi fishers all catch sea turtles with varying frequency. Estimates of sea turtle fishing mortality in Costa Rica are ambiguous and, while several studies have demonstrated that there is significant interaction between turtles and Peruvian artisanal longline fishers, mortality rates are generally low. The available data from the Ecuadorian mahi mahi fishery suggests that sea turtles are captured infrequently.

Peruvian longline fisheries account for much of the observed mortality of adult waved albatrosses, and hooking and entanglement in fishing gear poses a serious risk to the survival of this species. Waved albatrosses are considered critically endangered by the IUCN.

Discard rates are unknown for the mahi mahi fisheries in Costa Rica, Peru and Ecuador. Small- scale operators, like those in Costa Rica, Ecuador and Peru, typically have low discards, as artisanal fishers are able to utilize most of the incidental catch.

Recently, a management plan for the Ecuadorian mahi mahi fishery has been adopted, and includes comprehensive policies regarding catch parameters, bycatch mitigation, scientific oversight and enforcement. This plan is very encouraging, but its efficacy remains to be seen. In Peru, the mahi mahi fishery has been the subject of an assessment carried out by an NGO, but the conclusions of this report and any governmental review are unavailable, although there are some existing minimum size limitations. In Costa Rica, there is no management plan in place, although some measures have been undertaken, with mixed results, to reduce sea turtle bycatch. In Guatemala, there is no management plan in place. There do not appear to be any plans to pursue research into the state of the stock, nor to monitor the impacts of this fishery on mahi mahi populations.

All of the mahi mahi imported to the United States from Costa Rica, Peru and Ecuador is caught using surface-set longlines, which do not touch the bottom substrate, therefore, no gear mitigation is necessary. Apex predators (sharks) are captured and generally retained in the mahi mahi fisheries of Costa Rica, Peru and Ecuador, but do not comprise a significant proportion of the catch during the austral summer months when the majority of mahi mahi are landed.

All fisheries in this report are engaged in a Fishery Improvement Project (FIP). FIPs are in place in Ecuador and Peru, and are in development in Costa Rica. Engagement in a FIP does not affect the Seafood Watch score as we base our assessments on the current situation. Monterey Bay Aquarium is a member organization of the Conservation Alliance for Seafood Solutions. The Alliance has outlined guidelines for credible Fishery Improvement Projects. As such, Seafood Watch will support procurement from fisheries engaged in a FIP provided it can be verified by a third party that the FIP meets the Alliance guidelines. It is not the responsibility of Monterey Bay Aquarium to verify the credibility or progress of a FIP, or promote the fisheries engaged in improvement projects.

Final Seafood Recommendations

SPECIES/FISHERY	CRITERION 1: IMPACTS ON THE SPECIES	CRITERION 2: IMPACTS ON OTHER SPECIES	CRITERION 3: MANAGEMENT EFFECTIVENESS	CRITERION 4: HABITAT AND ECOSYSTEM	OVERALL RECOMMENDATION
Dolphinfish Costa Rica Eastern Central Pacific, Drifting longlines, Costa Rica	Yellow (2.644)	Red (1.530)	Red (1.410)	Green (3.870)	**(2.167)**
Dolphinfish Peru Southeast Pacific, Drifting longlines, Peru	Yellow (2.644)	Red (1.000)	Red (1.410)	Green (3.870)	**(1.948)**

Scoring Guide

Scores range from zero to five where zero indicates very poor performance and five indicates the fishing operations have no significant impact.

Final Score = geometric mean of the four Scores (Criterion 1, Criterion 2, Criterion 3, Criterion 4).

- **Best Choice/Green** = Final Score >3.2, and no Red Criteria, and no Critical scores
- **Good Alternative/Yellow** = Final score >2.2-3.2, and neither Harvest Strategy (Factor 3.1) nor Bycatch Management Strategy (Factor 3.2) are Very High Concern[2], and no more than one Red Criterion, and no Critical scores
- **Avoid/Red** = Final Score ≤2.2, or either Harvest Strategy (Factor 3.1) or Bycatch Management Strategy (Factor 3.2) is Very High Concern or two or more Red Criteria, or one or more Critical scores.

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

Introduction

Scope of the analysis and ensuing recommendation

Mahi mahi (*Coryphaena hippurus*) is found worldwide in tropical and subtropical waters. This assessment focuses on the mahi mahi fisheries in Peru, Ecuador and Costa Rica which together account for over 67% of the mahi mahi imported to the US. In Ecuador, Peru and Costa Rica mahi mahi destined for export are landed using surface set longlines and are fished by artisanal vessels (Ecuador, Peru) and small-scale semi-industrial vessels (Costa Rica). This species is also retained for domestic consumption in tuna purse seine and gillnet fisheries (IATTC 2011a).

Species Overview

Coryphaena hippurus is one of two species in the family Coryphaenidae, along with the pompano dolphinfish (*C. equiselis*). Both species have a global distribution, and, while pompano dolphinfish are typically smaller than mahi mahi, they share a similar morphology and coloration. Accordingly, pompano dolphinfish are often mistaken for juvenile mahi mahi (Froese and Pauly 2011) and are sometimes sold as mahi mahi (Whoriskey, et al. 2011).

Mahi mahi are mid-trophic level predators, feeding primarily on other fishes and, occasionally, crustaceans and squid (Polovino et al. 2009, Froese and Pauly 2012). They are found worldwide (Figure 1) in tropical and subtropical waters warmer than 20°C (FAO 2004). This species is extremely fast growing and reach sexual maturity in the first year of life. Size at maturity varies throughout its range (for a summary, see Collette et al. 2011). For example, in the Western Central Atlantic female mahi mahi mature at approximately 41.9 cm (50%, 16.5 in; McBride et al. 2012) and males mature at approximately 47.6 cm (50%, 18.7 in; Schwenke and Buckel 2008), whereas in the Eastern Caribbean , 50% of males and females mature at 91 cm and 83 cm, respectively (Oxenford 1999). Females are highly fecund, producing as many as 1.5 million eggs per spawning event, and short lived, with a typical lifespan of less than 5 years (Collette et al. 2011, Froese and Pauly 2012). Mahi mahi are sexually dimorphic, with males significantly larger than females; in the tropical Pacific maximum sizes of 149cm fork length (FL) for males and 137cm FL for females have been recorded (Uchiyama and Boggs, 2006). Mahi mahi school in feeding aggregations and these schools are commonly associated with floating objects, hence, they are often captured near fish aggregation devices (FADs; Olson and Galván-Magaña, 1996).

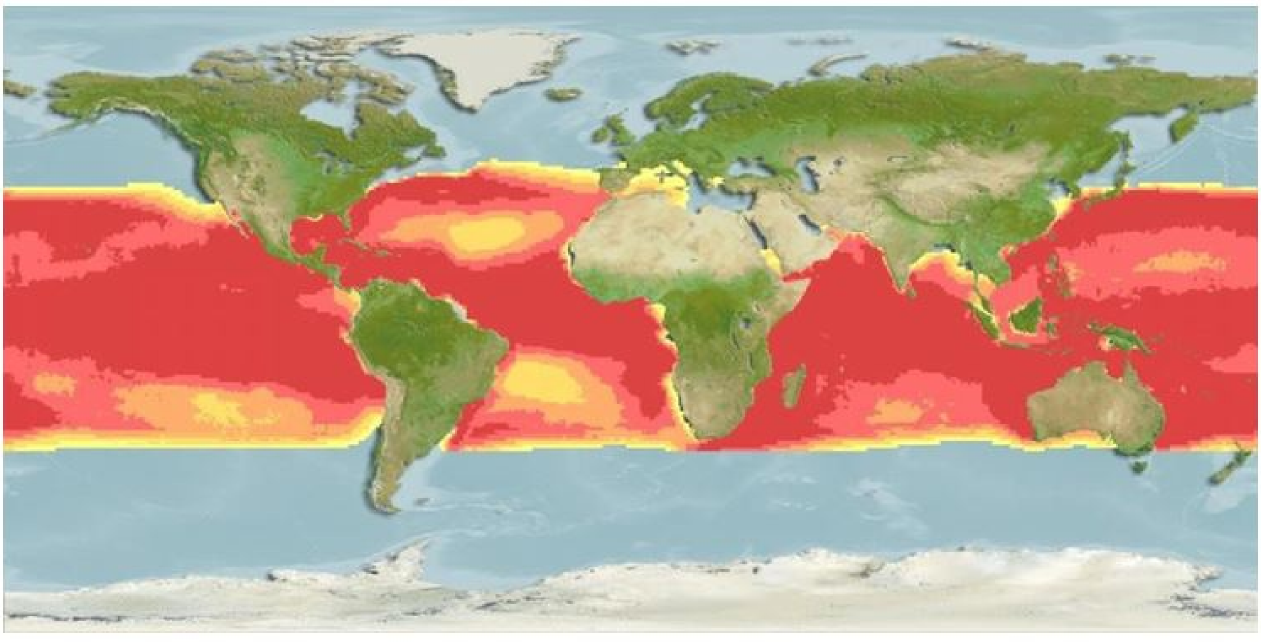

Figure 1 Distribution of mahi mahi. Color variation indicates probability of presence, with mahi mahi more likely to be found in darker areas (www.aquamaps.org).

In the Eastern Pacific Ocean the Inter-American Tropical Tuna Commission (IATTC) is charged with the management of tuna and bycatch species in the Pacific Ocean, including mahi mahi. Ecuador, Peru and Costa Rica, along with 17 other member nations are bound by the recommendations and management guidelines set forth by this organization.

The Ecuadorian mahi mahi fishery is managed through the Sub-Secretariat of Fisheries Resources (SRP). The Ecuadoran government is currently working towards establishing sustainable fishing practices for highly migratory and straddling stocks, in accordance with the United Nations Convention on the Law of the Sea (UNCLOS, CNDM 2009) and the FAO. In February 2011, Ecuador adopted a national plan of action (NPOA), which sets forth a number of management guidelines for the conservation and management of the mahi mahi fishery.
In Peru, the development, implementation and enforcement of fishery policy is overseen by the Ministerio de la Producción. This agency works closely with the Instituto del Mar del Perú (IMARPE), which is charged with conducting research on fishery resources for the purpose of informing management policy.

Costa Rica's marine fisheries are managed by the Instituto Costarricense de Pesca y Acuicultura (INCOPESCA).

Production Statistics

Mahi mahi are fished by commercial and artisanal vessels throughout its range. Mahi mahi landings have increased 7.5 fold over the last 60 years (Figure 2). Worldwide, the top producers include Brazil, Taiwan, Ecuador, Indonesia and Italy, although FAO reports mahi mahi landings in 51 nations and territories (FAO 2011). The increase in mahi mahi landings may be attributable to increased fishing effort, improved reporting (Whoriskey et al. 2011) and/or an increase in mahi mahi stocks due to competitive release stemming from the decline of apex predators (Polovina et al. 2009).

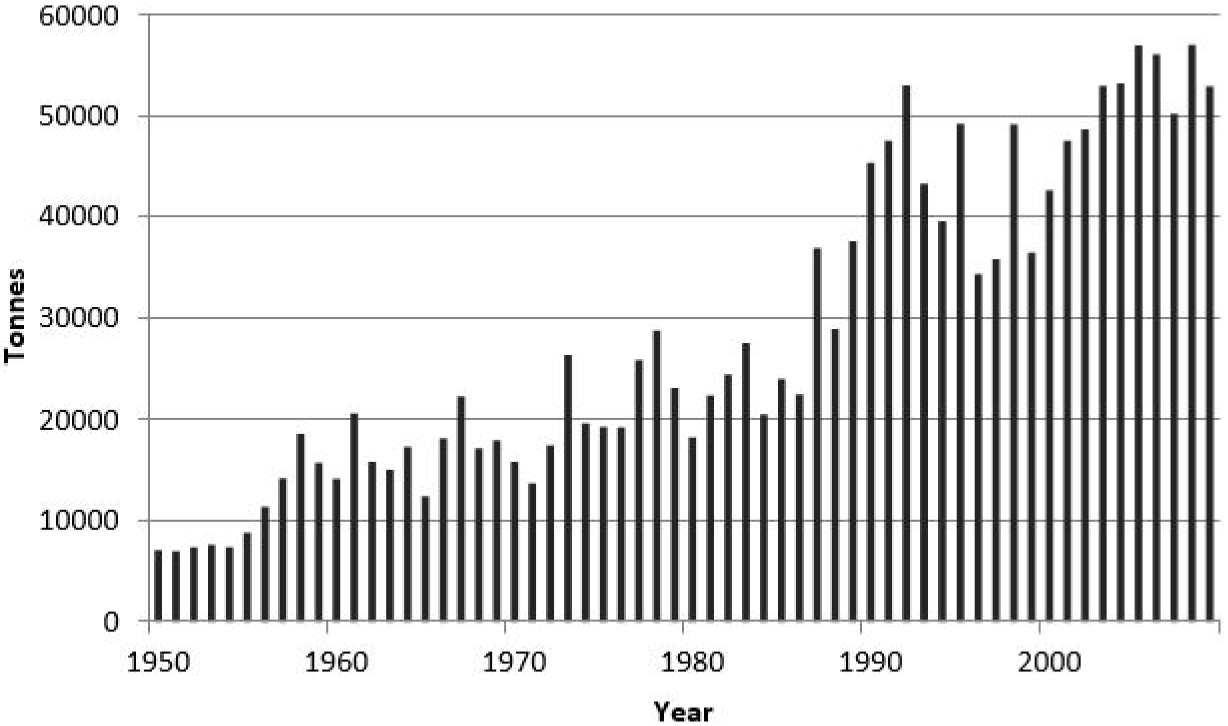

Figure 2 Worldwide mahi mahi landings by year (FAO 2011). Note: Mahi mahi landings from Peru are not reported by FAO and are therefore not included in this figure.

In the Eastern Pacific Ocean mahi mahi is a highly seasonal resource, with availability peaking during the austral summer. The confluence of the Humboldt LME and the Pacific -Central American LME is one of the most productive marine ecosystems in the world (Sherman and Hempel 2009) and it is in this region, where the effects of El Niño Southern Oscillation (ENSO) events are most pronounced. During ENSO years, when sea surface temperatures rise, there is typically a pulse in the mahi mahi stock, particularly off the coast of Peru (Lasso and Zapata 1999). In contrast, in La Niña years, when sea temperatures drop, mahi mahi are comparably scarce (FAO 2011).

Ecuador has the largest artisanal fleet in the region (Project GloBAL, n.d.) and mahi mahi is an important resource, representing 50% of the total large pelagic landings in the last decade (CNDM 2009) and 65% of the total landings of the contemporary artisanal fleet, making mahi mahi one of the most economically important fisheries in the country (Guerrero, 2010; Figure 3). The use of motherships has allowed small scale fishers in Ecuador to exploit fishing grounds beyond the EEZ (P. Guerrero pers. comm.).

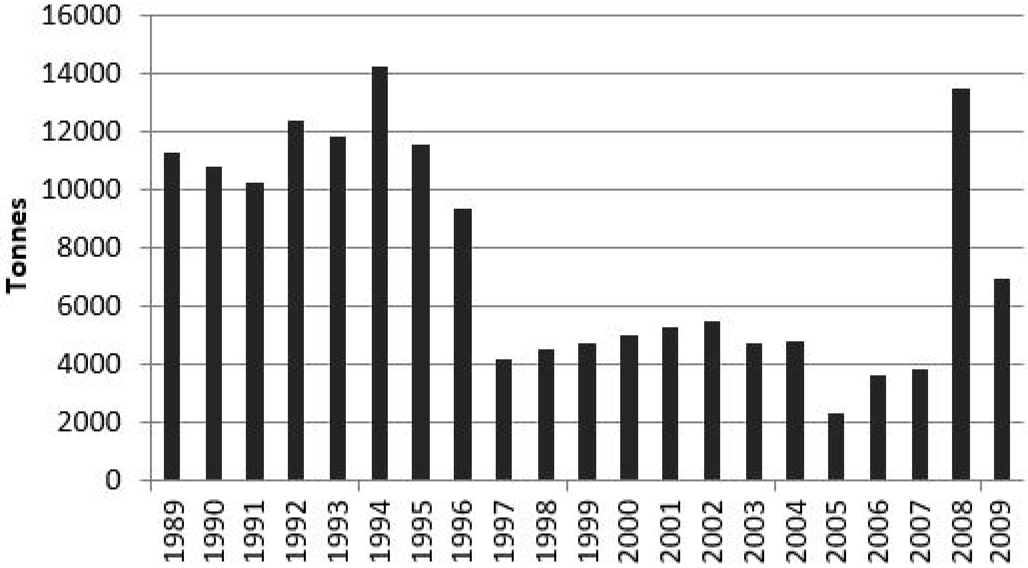

Figure 3 Mahi mahi landings by year, Ecuador (data from FAO, 2011)

Mahi mahi are also landed in Peru by an artisanal fleet (J. Alfaro-Shigueto, pers. com). The FAO does not include Peru in its reporting of worldwide fishery captures, although the Ministerio de la Producción publishes statistics on Peru's mahi mahi landings (www.produce.gob.pe, Figure 4). In 2009 Peru landed 57,153 mt. of mahi mahi, which, when compared to the entire FAO reported global catch for that same year, of 53,011 mt, underscores the importance of Peruvian mahi mahi fishery.

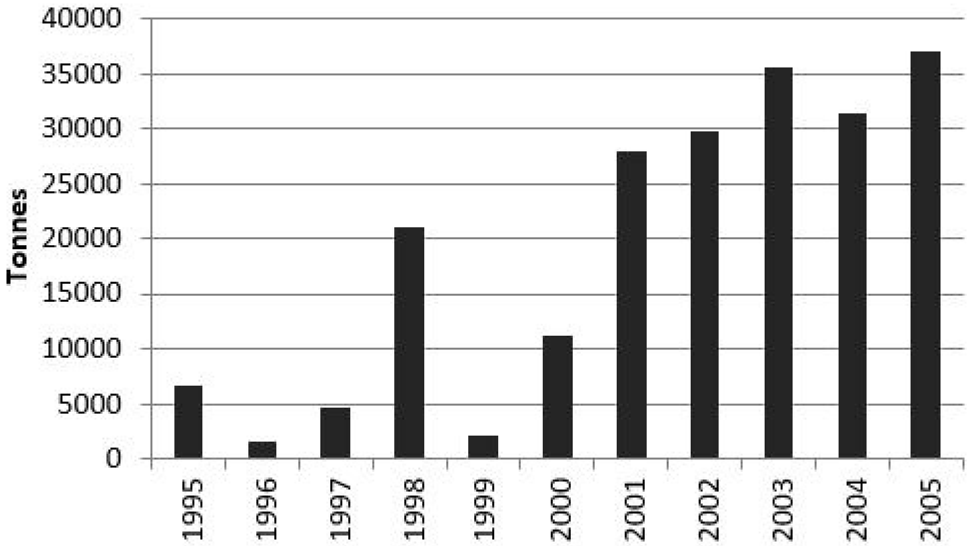

Figure 4 Mahi mahi landings by year, Peru (data from PRODUCE, 2010)

While Costa Rica has fishing ports on both the Pacific Ocean and Caribbean Sea, the vast majority of mahi mahi capture takes place in the Pacific Ocean (FAO 2011) by a small-scale semi-industrial fleet (Arauz 2000; Figure 5). Landings of large pelagic fish, including mahi mahi, have increased in recent years and now comprise approximately 50% of Costa Rica's reported catch (Trujillo et al. 2012).

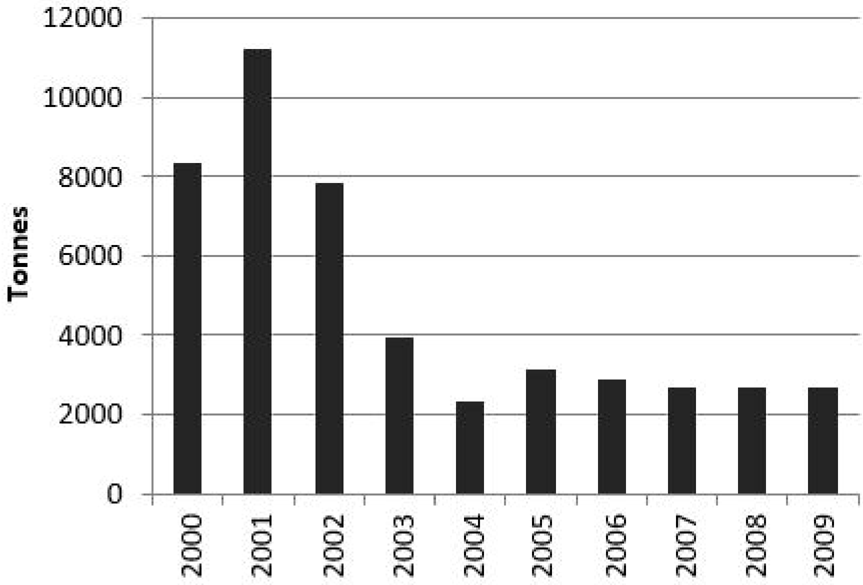

Figure 5 Mahi mahi catch by year, Costa Rica (data from FAO, 2011).

Importance to the US/North American market.

The majority of mahi mahi available in the United States comes from imports from Central and South America and Southeast Asia, with over 73% originating in Ecuador (26.0%, of total imports), Peru (24.3%) or Taiwan (23.3%). Other major trade partners include Costa Rica (3.5%) and Mexico (3.0%) (NMFS 2011). In 2010 domestic landings comprised less than 5% of the mahi mahi available in the U.S. marketplace that year (NMFS 2010). In recent years the U.S. has not exported or re-exported mahi mahi (NMFS 2011).

Common and market names.

C.hippurus is most commonly marketed as mahi mahi or dolphinfish in the United States, although it is also known as dorado throughout Latin America and perico in Peru.

Primary product forms

Mahi mahi is primarily available as fresh or frozen fillets

Assessment

This section assesses the sustainability of the fishery(s) relative to the Seafood Watch Criteria for Fisheries, available at http://www.seafoodwatch.org.

Criterion 1: Impacts on the species under assessment

This criterion evaluates the impact of fishing mortality on the species, given its current abundance. The inherent vulnerability to fishing rating influences how abundance is scored, when abundance is unknown.

The final Criterion 1 score is determined by taking the geometric mean of the abundance and fishing mortality scores. The Criterion 1 rating is determined as follows:

- *Score >3.2=Green or Low Concern*
- *Score >2.2 and ≤3.2=Yellow or Moderate Concern*
- *Score ≤2.2=Red or High Concern*

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

Criterion 1 Summary

DOLPHINFISH				
Region | Method	**Inherent Vulnerability**	**Abundance**	**Fishing Mortality**	**Score**
Costa Rica/Eastern Central Pacific Drifting longlines | Costa Rica	2.00: Medium	3.00: Moderate Concern	2.33: Moderate Concern	Yellow (2.64)
Peru/Southeast Pacific Drifting longlines | Peru	2.00: Medium	3.00: Moderate Concern	2.33: Moderate Concern	Yellow (2.64)

Criterion 1 Assessment

SCORING GUIDELINES

Factor 1.1 - Inherent Vulnerability

- *Low—The FishBase vulnerability score for species is 0-35, OR species exhibits life history characteristics that make it resilient to fishing, (e.g., early maturing).*
- *Medium—The FishBase vulnerability score for species is 36-55, OR species exhibits life history characteristics that make it neither particularly vulnerable nor resilient to fishing, (e.g., moderate age at sexual maturity (5-15 years), moderate maximum age (10-25 years), moderate maximum size, and middle of food chain).*
- *High—The FishBase vulnerability score for species is 56-100, OR species exhibits life history characteristics that make is particularly vulnerable to fishing, (e.g., long-lived (>25 years), late maturing (>15 years), low reproduction rate, large body size, and top-predator). Note: The FishBase vulnerability scores is an index of the inherent vulnerability of marine fishes to fishing based on life history parameters: maximum length, age at first maturity, longevity, growth rate, natural mortality rate, fecundity, spatial behaviors (e.g., schooling, aggregating for breeding, or consistently returning to the same sites for feeding or reproduction) and geographic range.*

Factor 1.2 - Abundance

- *5 (Very Low Concern)—Strong evidence exists that the population is above target abundance level (e.g., biomass at maximum sustainable yield, BMSY) or near virgin biomass.*
- *4 (Low Concern)—Population may be below target abundance level, but it is considered not overfished*
- *3 (Moderate Concern) —Abundance level is unknown and the species has a low or medium inherent vulnerability to fishing.*
- *2 (High Concern)—Population is overfished, depleted, or a species of concern, OR abundance is unknown and the species has a high inherent vulnerability to fishing.*
- *1 (Very High Concern)—Population is listed as threatened or endangered.*

Factor 1.3 - Fishing Mortality

- *5 (Very Low Concern)—Highly likely that fishing mortality is below a sustainable level (e.g., below fishing mortality at maximum sustainable yield, FMSY), OR fishery does not target species and its contribution to the mortality of species is negligible (≤ 5% of a sustainable level of fishing mortality).*
- *3.67 (Low Concern)—Probable (>50%) chance that fishing mortality is at or below a sustainable level, but some uncertainty exists, OR fishery does not target species and does not adversely affect species, but its contribution to mortality is not negligible, OR fishing mortality is unknown, but the population is healthy and the species has a low susceptibility to the fishery (low chance of being caught).*
- *2.33 (Moderate Concern)—Fishing mortality is fluctuating around sustainable levels, OR fishing mortality is unknown and species has a moderate-high susceptibility to the fishery and, if species is depleted, reasonable management is in place.*
- *1 (High Concern)—Overfishing is occurring, but management is in place to curtail overfishing, OR fishing mortality is unknown, species is depleted, and no management is in place.*
- *0 (Critical)—Overfishing is known to be occurring and no reasonable management is in place to curtail overfishing.*

DOLPHINFISH

Factor 1.1 - Inherent Vulnerability

COSTA RICA/EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA
PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

Medium

Mahi mahi has been given a FishBase score of 39/100 denoting high to moderate resilience to fishing (Froese and Pauly 2012)

Factor 1.2 - Abundance

COSTA RICA/EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA
PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

Moderate Concern

There is currently no stock assessment for mahi mahi in the Eastern Pacific Ocean (EPO), although there are research efforts underway to assess mahi mahi stock biomass in the EPO (IATTC 2013, Aires-da-Silva et al. 2013).

Justification:

Ecuador has recently undertaken a study of the Eastern Pacific mahi mahi to ascertain the status of these stocks but, at present there are no data available. Scientists from Ecuador's Undersecretary of Fisheries (Subsecretaría del Recursos Pesqueros; SRP) are currently working with the Interdisciplinary Center for Marine Sciences (Centro Interdisciplinario de Ciencias Marinas; CICIMAR) in Mexico and IATTC to develop abundance indices for mahi mahi in the Eastern Pacific (P. Guerrero, pers. comm., IATTC 2013, Aires-da-Silva et al. 2013). Preliminary nominal CPUE data from purse seiners suggests abundance is stable (Aires-da-Silva et al. 2013).

Factor 1.3 - Fishing Mortality

COSTA RICA/EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA
PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

Moderate Concern

As with biomass, there is limited data available on mahi mahi fishing mortality. Patterson and Martinez (1991) assessed the exploitation of mahi mahi off Ecuador and found the fishing mortality rates (0.51-0.63) to exceed the maximum sustainable rate (0.40-0.49), as predicted by length based population projections. There is little reason to believe the data in this study are accurate today however, given their age and the species short longevity.

Justification:

In 2008, SRP began a mahi mahi fishery monitoring program, although no data from this effort has been published as yet (P. Guerrero, pers. comm.). It should be noted that for each Ecuador, Peru and Costa Rica the reported mahi mahi catch likely includes both *C. hippurus* and *C. equiselis*, however *C. equiselis* is generally considered to comprise a minor portion of the catch (Lasso and Zapata 1999, IATTC 2013).

Criterion 2: Impacts on other species

All main retained and bycatch species in the fishery are evaluated in the same way as the species under assessment were evaluated in Criterion 1. Seafood Watch® defines bycatch as all fisheries-related mortality or injury to species other than the retained catch. Examples include discards, endangered or threatened species catch, and ghost fishing.

To determine the final Criterion 2 score, the score for the lowest scoring retained/bycatch species is multiplied by the discard rate score (ranges from 0-1), which evaluates the amount of non-retained catch (discards) and bait use relative to the retained catch. The Criterion 2 rating is determined as follows:

- *Score >3.2=Green or Low Concern*
- *Score >2.2 and ≤3.2=Yellow or Moderate Concern*
- *Score ≤2.2=Red or High Concern*

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

Criterion 2 Summary

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

DOLPHINFISH - COSTA RICA/EASTERN CENTRAL PACIFIC - DRIFTING LONGLINES - COSTA RICA				
Subscore: 1.530	**Discard Rate:** 1.00	**C2 Rate:** 1.530		
Species	**Inherent Vulnerability**	**Abundance**	**Fishing Mortality**	**Subscore**
Green sea turtle	1.00:High	1.00:Very High Concern	2.33:Moderate Concern	Red (1.526)
Leatherback turtle	1.00:High	1.00:Very High Concern	2.33:Moderate Concern	Red (1.526)
Hawksbill turtle	1.00:High	1.00:Very High Concern	2.33:Moderate Concern	Red (1.526)
Loggerhead turtle	1.00:High	1.00:Very High Concern	2.33:Moderate Concern	Red (1.526)
Olive ridley turtle	1.00:High	2.00:High Concern	2.33:Moderate Concern	Red (2.159)

DOLPHINFISH - PERU/SOUTHEAST PACIFIC - DRIFTING LONGLINES - PERU				
Subscore: 1.000	**Discard Rate:** 1.00	**C2 Rate:** 1.000		
Species	**Inherent Vulnerability**	**Abundance**	**Fishing Mortality**	**Subscore**
Green sea turtle	1.00:High	1.00:Very High Concern	1.00:High Concern	Red (1.000)

Leatherback turtle	1.00:High	1.00:Very High Concern	1.00:High Concern	Red (1.000)
Hawksbill turtle	1.00:High	1.00:Very High Concern	1.00:High Concern	Red (1.000)
Loggerhead turtle	1.00:High	1.00:Very High Concern	1.00:High Concern	Red (1.000)
waved albatross	1.00:High	1.00:Very High Concern	1.00:High Concern	Red (1.000)
Olive ridley turtle	1.00:High	2.00:High Concern	1.00:High Concern	Red (1.414)

Criterion 2 Assessment

SCORING GUIDELINES

Factor 2.1 - Inherent Vulnerability

(same as Factor 1.1 above)

Factor 2.2 - Abundance

(same as Factor 1.2 above)

Factor 2.3 - Fishing Mortality

(same as Factor 1.3 above)

GREEN SEA TURTLE

Factor 2.1 - Inherent Vulnerability

COSTA RICA/EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA
PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

High

Generally, sea turtles have low inherent resilience. These species are long lived, in some cases taking as long as 40 years to reach sexual maturity (Mortimer & Donnelly 2008), and experience high hatchling and juvenile mortality (Abreu-Grobois and Plotkin 2008; IUCN 2011).

Factor 2.2 - Abundance

COSTA RICA/EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA
PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

Very High Concern

Populations of all sea turtles are imperiled worldwide (IUCN 2011). A number of factors have contributed to decline of these species including conflict with fisheries, pollution, nesting habitat loss, and direct hunting. Sea turtle eggs have historically been an important resource for coastal communities around the world and the unregulated harvest of eggs has been credited with the decline of several species (IUCN 2011). Longline fishing has contributed significantly to the decline of leatherback and loggerhead sea turtle populations in the Eastern Pacific (Sarti Martinez 2000, Lewison et al. 2004).

Factor 2.3 - Fishing Mortality

COSTA RICA/EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA

Moderate Concern

While pelagic longline fisheries are widely regarded as one of the main sources of fishing mortality for turtles (Lewison and Crowder 2007), no assessment of the impacts of these fisheries from Costa Rica and Ecuador on turtle populations has been conducted. Thus, the fishery contribution from these sources is unknown. Both countries have some measures in place that have been found to be effective in reducing turtle mortality when used correctly (i.e. circle hooks – see below and Criterion 3.2). In Peru, while the fishery-specific mortality on turtle populations is also unknown, there is some indication that the artisanal longline and net fleets may be having a severe impact. There are also no management measures in place to reduce mortality.

Justification:

Sea turtle conflict with mahi mahi longliners in the Eastern Pacific is, to some extent unavoidable. These five species of sea turtle each spend some aspect of their life history off the northwest coast of South America, bringing them into contact with Ecuador, Peru and Costa Rica's mahi mahi fishing fleets (Figure 8).

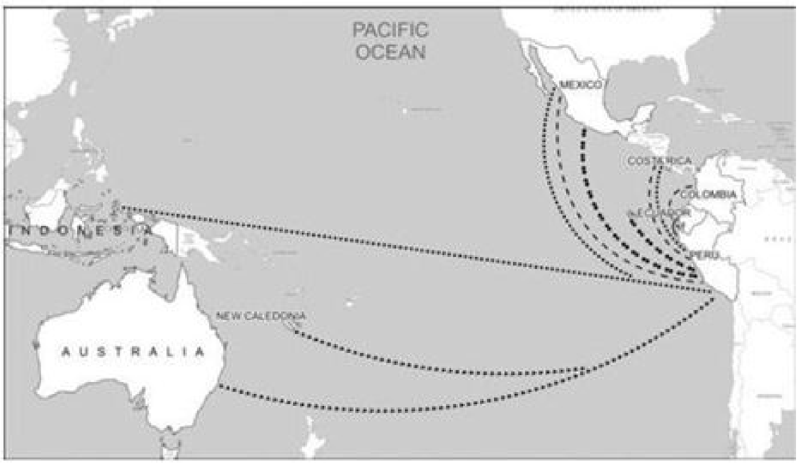

Fig. 2. Schematic view of linkages of turtles breeding stocks to Peruvian foraging grounds. Leatherback turtles (•): western and eastern Pacific rockeries (Eckert & Sarti 1997; Shillinger *et al.* 2008; Dutton *et al.* 2010). Olive ridleys (– –): Colombia, Mexico and Costa Rica (Zeballos & Arias-Schreiber 2001; Velez-Zuazo & Kelez 2010). Green turtles (♦ ♦): Galapagos Islands and Mexico (Hays-Brown & Brown 1982; Velez-Zuazo & Kelez 2010). Loggerhead turtles (▶▶): Australia and New Caledonia (Alfaro-Shigueto *et al.* 2004; Boyle *et al.* 2009). Hawksbill turtles (–): Mainland Ecuador as the closest nesting rockery for the species.

Figure 6 From Alfaro-Shigueto (2011) illustrating the movement of turtle stocks throughout the Southeastern Pacific Ocean.

Numerous observer programs have found that sea turtles are frequently caught in shallow longline sets (Lewison and Crowder 2007). For example, in Costa Rica's fishery, olive ridley hooking rates sometimes exceeds CPUE rates for mahi mahi (Swimmer et al. 2011). Despite the high initial survivability of most hookings, there may be delayed mortality due to the stress of capture or the secondary effects of hooking or hook removal, which cannot be accounted for through catch observation alone (Swimmer et al. 2006). Furthermore, the presence of observers likely affects fisher behavior, with vessels carrying observers being more likely to land captured turtles and remove the hooks with relative care, rather than simply rip out the hook or cut the line with the turtles still in the water (Arauz 2000).

Estimates of fishery captures of sea turtles vary considerably. For example, in separate studies of the Costa Rican mahi mahi fishery, Whoriskey et al. (2011) and Swimmer et al. (2012) found a catch rate (turtles/mahi mahi) of 0.17 and 2.21, respectively. Although, it should be noted that the Swimmer et al. (2012) study only partially overlapped with the traditional mahi mahi season, thus one would expect lower mahi mahi catch rates, which may account for the high turtle:mahi mahi ratio. A recent study of the effects of hook type on sea turtle bycatch in the Ecuadorian and Costa Rican mahi mahi fishery showed generally low hooking rates for sea turtles in these nations (Table 1). Alfaro-Shigueto et al. 2011 estimated a mean of 1061 greens, 133 olive ridleys, 2613 loggerheads and 6 leatherbacks are caught per year in the Peruvian mahi mahi longline fishery, and concluded that interactions with Peru's artisanal longline and net fleets may be severely impacting the populations of sea turtles in the Pacific (Alfaro-Shigueto et al. 2011).

While sea turtles are regularly hooked in the southeastern Pacific mahi mahi fishery, they are usually released alive, as the hook proximity to the surface allows the turtles to continue to surface to breathe (Swimmer et al. 2006, Witzell 1999). Governments and NGOs have focused much of their bycatch mitigation efforts for the mahi mahi fishery on reducing turtle hooking and entanglements. Loggerhead, hawksbill and olive ridley turtles are most often caught via biting baited hooks (Swimmer 2006, Largarcha et al. 2005) whereas leatherback and green turtles are more likely to become entangled in lines or to be hooked in flippers (Largarcha et al. 2005, Witzell 1999).

Hook modifications are the primary means of reducing sea turtle capture. Circle hooks are generally considered to be "turtle friendly," usually resulting in lower capture rates and fewer deep hookings when compared to J-hooks (i.e. Andraka et al. 2013, Swimmer et al. 2006, 2011). There is an effort underway to encourage fishers in this region to replace the traditional J-style hooks with circle hooks (Mug et al. 2008). Fishers in Costa Rica routinely use circle hooks (E. Villagran pers. comm., R. Arauz pers. comm.) while Ecuador is actively encouraging fishers to switch from J to circle hooks (P. Guerrero pers. comm). J-hooks are still used predominantly in Peru.

In addition to lower catch rates for turtles, these hooks have been shown to result in lower catch rates for mahi mahi when compared to J-hooks (Largarcha et al. 2005, Mug et al. 2008), although circle hooks do yield a higher quality, and hence, more valuable mahi mahi catch (R. Arauz pers. comm.). The addition of an "appendage" to the commonly used 14/0 circle hook, showed a general decrease in CPUE for all species, including a reduction in sea turtle hookings by 52% and a 23% reduction in tunas and billfish captures (Swimmer et al., 2011). Despite the benefits for sea turtles, the economic cost of lower tuna, billfish and mahi mahi (R. Arauz pers. comm.) landings may make the use of these hooks impracticable (R. Arauz, pers. comm., Andraka et al. 2013). Other hook modifications (10°offset 14/0 circle hooks, Swimmer et al. 2010), or bait modifications (blue dyed bait, Swimmer et al., 2005) have failed to measurably reduce sea turtle catch rates.

Sea turtle bycatch in Costa Rican longline fisheries has been the subject of several recent studies (i.e. Arauz 2000, Swimmer et al. 2005, 2006, 2010, 2011, Whorisky et al. 2011, Andraka et al. 2013) with fairly ambiguous results. Sea turtle CPUE (per 1,000 hooks) varies from 1.5 (C 16/0 hooks, Andraka et al. 2013), to 9.05 (C 14-16/0, Whoriskey et al. 2011), to 19 (C 14/0 Swimmer et al. 2010). These discrepancies may be due in part to sampling proximity to nesting beaches or during times of year with higher or lower turtle densities (Andraka et al. 2013), although significant uncertainty remains around the impact of Costa Rican mahi mahi fishers on local and regional turtle populations.

The Ecuadorian government is currently working on several fronts to increase circle hook usage in the mahi mahi fleet including supplying circle hooks for a J-hook exchange program, training fishers on proper handling and release of hooked or entangled turtles and exploring technologies to reduce entanglement (P. Guerrero pers. comm.). The government has recently reduced the import tariff on circle hooks, while leaving this tax in place for J-hooks, in order to ensure the widespread availability of circle hooks at competitive prices. The end goal of these activities is to mandate the use of circle hooks and other mitigation measures, once circle hooks are readily available to Ecuadorian fishers.

	Ecuador				Costa Rica	
	J-hook CPUE	C 15/0 CPUE	J-hook (No.4,5) CPUE	C 14/0 CPUE	J-hook (No. 2,3) CPUE	C 16/0 CPUE
Target species:						
Coryphaena hippurus	144.13	86.34	151.94	101.93	24.66	27.86
Sea turtles:						
Caretta caretta	0	0	0.09	0	-	-
Chelonia mydas	0.41	0.34	0.45	0	-	-
Eretmochelys imbricata	0.49	0.08	0.54	0.45	0.03	0.08
Lepidochelys olivacea	1.07	1.17	1.16	0.81	2.32	1.5

Figure 7 Sea turtle catch rates by hook type in Ecuador (J vs. C15/0 and J vs.C14/0) and Costa Rica's (J vs. C16/0) mahi mahi fishery (Andraka et al. 2013). Catch per unit effort (CPUE) rates are per 1,000 hooks.

There was a directed sea turtle fishery in Peru through much of the 1990's and evidence suggests that some harvest continued following the 1995 ban on the commercial capture of turtles (Arauz, 1999, Alfaro-Shigueto et al. 2011). A hook exchange program has been initiated by a coalition of organizations (Pro Delphinus, WWF, NFWF, NOAA), but there are currently no government mandated measures in place to reduce sea turtle bycatch (J. Alfaro-Shigueto pers. comm., A. Gonzales, pers. comm.).

PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

High Concern

While pelagic longline fisheries are widely regarded as one of the main sources of fishing mortality for turtles (Lewison and Crowder 2007), no assessment of the impacts of these fisheries from Costa Rica and Ecuador on turtle populations has been conducted. Thus, the fishery contribution from these sources is unknown. Both countries have some measures in place that have been found to be effective in reducing turtle mortality when used correctly (i.e. circle hooks – see below and Criterion 3.2). In Peru, while the fishery-specific mortality on turtle populations is also unknown, there is some indication that the artisanal longline and net fleets may be having a severe impact. There are also no management measures in place to reduce mortality.

Justification:

Sea turtle conflict with mahi mahi longliners in the Eastern Pacific is, to some extent unavoidable. These five species of sea turtle each spend some aspect of their life history off the northwest coast of South America, bringing them into contact with Ecuador, Peru and Costa Rica's mahi mahi fishing fleets (Figure 8).

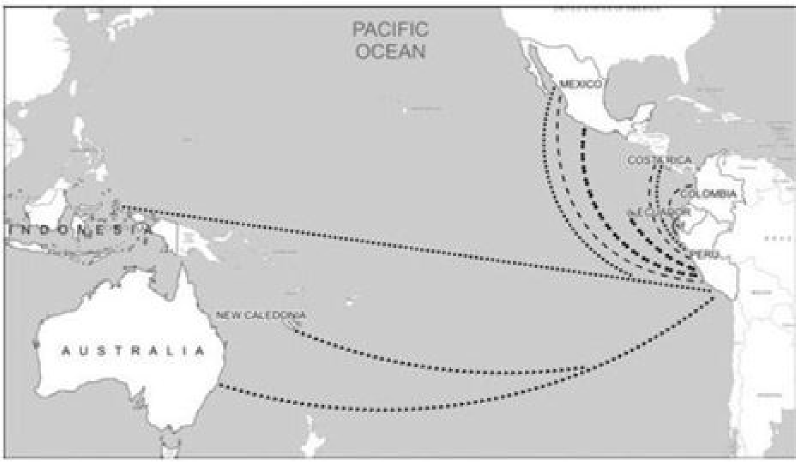

Fig. 2. Schematic view of linkages of turtles breeding stocks to Peruvian foraging grounds. Leatherback turtles (•): western and eastern Pacific rockeries (Eckert & Sarti 1997; Shillinger *et al.* 2008; Dutton *et al.* 2010). Olive ridleys (– –): Colombia, Mexico and Costa Rica (Zeballos & Arias-Schreiber 2001; Velez-Zuazo & Kelez 2010). Green turtles (♦ ♦): Galapagos Islands and Mexico (Hays-Brown & Brown 1982; Velez-Zuazo & Kelez 2010). Loggerhead turtles (▶▶): Australia and New Caledonia (Alfaro-Shigueto *et al.* 2004; Boyle *et al.* 2009). Hawksbill turtles (–): Mainland Ecuador as the closest nesting rockery for the species.

Figure 8 From Alfaro-Shigueto (2011) illustrating the movement of turtle stocks throughout the Southeastern Pacific Ocean.

Numerous observer programs have found that sea turtles are frequently caught in shallow longline sets (Lewison and Crowder 2007). For example, in Costa Rica's fishery, olive ridley hooking rates sometimes exceeds CPUE rates for mahi mahi (Swimmer et al. 2011). Despite the high initial survivability of most hookings, there may be delayed mortality due to the stress of capture or the secondary effects of hooking or hook removal, which cannot be accounted for through catch observation alone (Swimmer et al. 2006). Furthermore, the presence of observers likely affects fisher behavior, with vessels carrying observers being more likely to land captured turtles and remove the hooks with relative care, rather than simply rip out the hook or cut the line with the turtles still in the water (Arauz 2000).

Estimates of fishery captures of sea turtles vary considerably. For example, in separate studies of the Costa Rican mahi mahi fishery, Whoriskey et al. (2011) and Swimmer et al. (2012) found a catch rate (turtles/mahi mahi) of 0.17 and 2.21, respectively. Although, it should be noted that the Swimmer et al. (2012) study only partially overlapped with the traditional mahi mahi season, thus one would expect lower mahi mahi catch rates, which may account for the high turtle:mahi mahi ratio. A recent study of the effects of hook type on sea turtle bycatch in the Ecuadorian and Costa Rican mahi mahi fishery showed generally low hooking rates for sea turtles in these nations (Table 1). Alfaro-Shigueto et al. 2011 estimated a mean of 1061 greens, 133 olive ridleys, 2613 loggerheads and 6 leatherbacks are caught per year in the Peruvian mahi mahi longline fishery, and concluded that interactions with Peru's artisanal longline and net fleets may be severely impacting the populations of sea turtles in the Pacific (Alfaro-Shigueto et al. 2011).

While sea turtles are regularly hooked in the southeastern Pacific mahi mahi fishery, they are usually released alive, as the hook proximity to the surface allows the turtles to continue to surface to breathe (Swimmer et al. 2006, Witzell 1999). Governments and NGOs have focused much of their bycatch mitigation efforts for the mahi mahi fishery on reducing turtle hooking and entanglements. Loggerhead, hawksbill and olive ridley turtles are most often caught via biting baited hooks (Swimmer 2006, Largarcha et al. 2005) whereas leatherback and green turtles are more likely to become entangled in lines or to be hooked in flippers (Largarcha et al. 2005, Witzell 1999).

Hook modifications are the primary means of reducing sea turtle capture. Circle hooks are generally considered to be "turtle friendly," usually resulting in lower capture rates and fewer deep hookings when

compared to J-hooks (i.e. Andraka et al. 2013, Swimmer et al. 2006, 2011). There is an effort underway to encourage fishers in this region to replace the traditional J-style hooks with circle hooks (Mug et al. 2008). Fishers in Costa Rica routinely use circle hooks (E. Villagran pers. comm., R. Arauz pers. comm.) while Ecuador is actively encouraging fishers to switch from J to circle hooks (P. Guerrero pers. comm). J-hooks are still used predominantly in Peru.

In addition to lower catch rates for turtles, these hooks have been shown to result in lower catch rates for mahi mahi when compared to J-hooks (Largarcha et al. 2005, Mug et al. 2008), although circle hooks do yield a higher quality, and hence, more valuable mahi mahi catch (R. Arauz pers. comm.). The addition of an "appendage" to the commonly used 14/0 circle hook, showed a general decrease in CPUE for all species, including a reduction in sea turtle hookings by 52% and a 23% reduction in tunas and billfish captures (Swimmer et al., 2011). Despite the benefits for sea turtles, the economic cost of lower tuna, billfish and mahi mahi (R. Arauz pers. comm.) landings may make the use of these hooks impracticable (R. Arauz, pers. comm., Andraka et al. 2013). Other hook modifications (10°offset 14/0 circle hooks, Swimmer et al. 2010), or bait modifications (blue dyed bait, Swimmer et al., 2005) have failed to measurably reduce sea turtle catch rates.

Sea turtle bycatch in Costa Rican longline fisheries has been the subject of several recent studies (i.e. Arauz 2000, Swimmer et al. 2005, 2006, 2010, 2011, Whorisky et al. 2011, Andraka et al. 2013) with fairly ambiguous results. Sea turtle CPUE (per 1,000 hooks) varies from 1.5 (C 16/0 hooks, Andraka et al. 2013), to 9.05 (C 14-16/0, Whoriskey et al. 2011), to 19 (C 14/0 Swimmer et al. 2010). These discrepancies may be due in part to sampling proximity to nesting beaches or during times of year with higher or lower turtle densities (Andraka et al. 2013), although significant uncertainty remains around the impact of Costa Rican mahi mahi fishers on local and regional turtle populations.

The Ecuadorian government is currently working on several fronts to increase circle hook usage in the mahi mahi fleet including supplying circle hooks for a J-hook exchange program, training fishers on proper handling and release of hooked or entangled turtles and exploring technologies to reduce entanglement (P. Guerrero pers. comm.). The government has recently reduced the import tariff on circle hooks, while leaving this tax in place for J-hooks, in order to ensure the widespread availability of circle hooks at competitive prices. The end goal of these activities is to mandate the use of circle hooks and other mitigation measures, once circle hooks are readily available to Ecuadorian fishers.

	Ecuador				Costa Rica	
	J-hook CPUE	C 15/0 CPUE	J-hook (No.4,5) CPUE	C 14/0 CPUE	J-hook (No. 2,3) CPUE	C 16/0 CPUE
Target species:						
Coryphaena hippurus	144.13	86.34	151.94	101.93	24.66	27.86
Sea turtles:						
Caretta caretta	0	0	0.09	0	-	-
Chelonia mydas	0.41	0.34	0.45	0	-	-
Eretmochelys imbricata	0.49	0.08	0.54	0.45	0.03	0.08
Lepidochelys olivacea	1.07	1.17	1.16	0.81	2.32	1.5

Figure 9 Sea turtle catch rates by hook type in Ecuador (J vs. C15/0 and J vs.C14/0) and Costa Rica's (J vs. C16/0) mahi mahi fishery (Andraka et al. 2013). Catch per unit effort (CPUE) rates are per 1,000 hooks.

There was a directed sea turtle fishery in Peru through much of the 1990's and evidence suggests that some harvest continued following the 1995 ban on the commercial capture of turtles (Arauz, 1999, Alfaro-Shigueto et al. 2011). A hook exchange program has been initiated by a coalition of organizations (Pro Delphinus, WWF, NFWF, NOAA), but there are currently no government mandated measures in place to reduce sea turtle bycatch (J. Alfaro-Shigueto pers. comm., A. Gonzales, pers. comm.).

Factor 2.4 - Discard Rate

COSTA RICA/EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA
PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

< 20%

Discard rates are unknown for the mahi mahi fisheries in Ecuador, Peru, Costa Rica and Guatemala. Small-scale operators typically have lower discard rates than industrial scale vessels (Kelleher 2005), because artisanal fishers are able to utilize more of the incidental catch. Kelleher (2005) assumed a discard rate of <1 to 5% for artisanal fisheries. In keeping with this standard, the discard rate for the mahi mahi fisheries in Ecuador, Peru and Costa Rica was categorized as <20%. Kelleher (2005) also found that industrial scale longliners targeting HMS, like those used in the Guatemalan mahi mahi fishery, averaged a discard rate of 28.5%, however, the majority of incidentally captured fish is consumed in the domestic market (E. Villagrán, pers. comm.) so the discard rate in this fishery is likely significantly lower.

LEATHERBACK TURTLE

Factor 2.1 - Inherent Vulnerability

COSTA RICA/EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA
PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

High

Generally, sea turtles have low inherent resilience. These species are long lived, in some cases taking as long as 40 years to reach sexual maturity (Mortimer & Donnelly 2008), and experience high hatchling and juvenile mortality (Abreu-Grobois and Plotkin 2008; IUCN 2011).

Factor 2.2 - Abundance

COSTA RICA/EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA
PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

Very High Concern

Populations of all sea turtles are imperiled worldwide (IUCN 2011). A number of factors have contributed to decline of these species including conflict with fisheries, pollution, nesting habitat loss, and direct hunting. Sea turtle eggs have historically been an important resource for coastal communities around the world and the unregulated harvest of eggs has been credited with the decline of several species (IUCN 2011). Longline fishing has contributed significantly to the decline of leatherback and loggerhead sea turtle populations in the Eastern Pacific (Sarti Martinez 2000, Lewison et al. 2004).

Factor 2.3 - Fishing Mortality

COSTA RICA/EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA

Moderate Concern

While pelagic longline fisheries are widely regarded as one of the main sources of fishing mortality for turtles (Lewison and Crowder 2007), no assessment of the impacts of these fisheries from Costa Rica and Ecuador on turtle populations has been conducted. Thus, the fishery contribution from these sources is unknown. Both countries have some measures in place that have been found to be effective in reducing turtle mortality when used correctly (i.e. circle hooks – see below and Criterion 3.2). In Peru, while the fishery-specific mortality on turtle populations is also unknown, there is some indication that the artisanal longline and net fleets may be having a severe impact. There are also no management measures in place to reduce mortality.

Justification:

Sea turtle conflict with mahi mahi longliners in the Eastern Pacific is, to some extent unavoidable. These five species of sea turtle each spend some aspect of their life history off the northwest coast of South America, bringing them into contact with Ecuador, Peru and Costa Rica's mahi mahi fishing fleets (Figure 8).

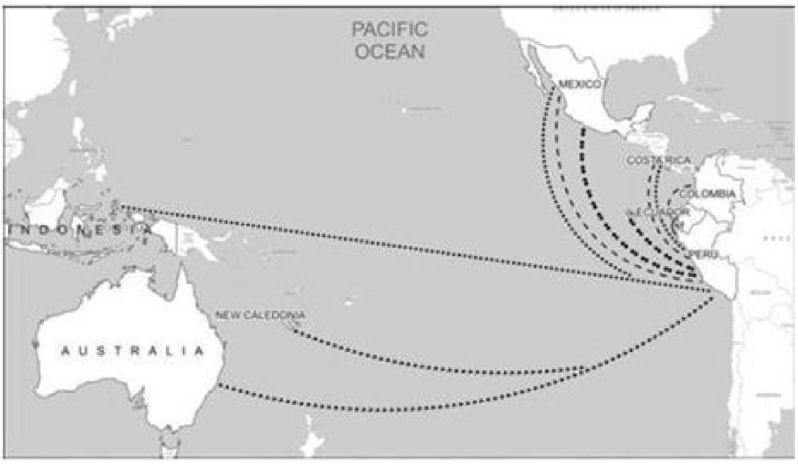

Fig. 2. Schematic view of linkages of turtles breeding stocks to Peruvian foraging grounds. Leatherback turtles (•): western and eastern Pacific rockeries (Eckert & Sarti 1997; Shillinger *et al.* 2008; Dutton *et al.* 2010). Olive ridleys (‒ ‒): Colombia, Mexico and Costa Rica (Zeballos & Arias-Schreiber 2001; Velez-Zuazo & Kelez 2010). Green turtles (♦ ♦): Galapagos Islands and Mexico (Hays-Brown & Brown 1982; Velez-Zuazo & Kelez 2010). Loggerhead turtles (►►): Australia and New Caledonia (Alfaro-Shigueto *et al.* 2004; Boyle *et al.* 2009). Hawksbill turtles (‒): Mainland Ecuador as the closest nesting rockery for the species.

Figure 10 From Alfaro-Shigueto (2011) illustrating the movement of turtle stocks throughout the Southeastern Pacific Ocean.

Numerous observer programs have found that sea turtles are frequently caught in shallow longline sets (Lewison and Crowder 2007). For example, in Costa Rica's fishery, olive ridley hooking rates sometimes exceeds CPUE rates for mahi mahi (Swimmer et al. 2011). Despite the high initial survivability of most hookings, there may be delayed mortality due to the stress of capture or the secondary effects of hooking or hook removal, which cannot be accounted for through catch observation alone (Swimmer et al. 2006). Furthermore, the presence of observers likely affects fisher behavior, with vessels carrying observers being more likely to land captured turtles and remove the hooks with relative care, rather than simply rip out the hook or cut the line with the turtles still in the water (Arauz 2000).

Estimates of fishery captures of sea turtles vary considerably. For example, in separate studies of the Costa Rican mahi mahi fishery, Whoriskey et al. (2011) and Swimmer et al. (2012) found a catch rate (turtles/mahi mahi) of 0.17 and 2.21, respectively. Although, it should be noted that the Swimmer et al. (2012) study only partially overlapped with the traditional mahi mahi season, thus one would expect lower mahi mahi catch rates, which may account for the high turtle:mahi mahi ratio. A recent study of the effects of hook type on sea turtle bycatch in the Ecuadorian and Costa Rican mahi mahi fishery showed generally low hooking rates

for sea turtles in these nations (Table 1). Alfaro-Shigueto et al. 2011 estimated a mean of 1061 greens, 133 olive ridleys, 2613 loggerheads and 6 leatherbacks are caught per year in the Peruvian mahi mahi longline fishery, and concluded that interactions with Peru's artisanal longline and net fleets may be severely impacting the populations of sea turtles in the Pacific (Alfaro-Shigueto et al. 2011).

While sea turtles are regularly hooked in the southeastern Pacific mahi mahi fishery, they are usually released alive, as the hook proximity to the surface allows the turtles to continue to surface to breathe (Swimmer et al. 2006, Witzell 1999). Governments and NGOs have focused much of their bycatch mitigation efforts for the mahi mahi fishery on reducing turtle hooking and entanglements. Loggerhead, hawksbill and olive ridley turtles are most often caught via biting baited hooks (Swimmer 2006, Largarcha et al. 2005) whereas leatherback and green turtles are more likely to become entangled in lines or to be hooked in flippers (Largarcha et al. 2005, Witzell 1999).

Hook modifications are the primary means of reducing sea turtle capture. Circle hooks are generally considered to be "turtle friendly," usually resulting in lower capture rates and fewer deep hookings when compared to J-hooks (i.e. Andraka et al. 2013, Swimmer et al. 2006, 2011). There is an effort underway to encourage fishers in this region to replace the traditional J-style hooks with circle hooks (Mug et al. 2008). Fishers in Costa Rica routinely use circle hooks (E. Villagran pers. comm., R. Arauz pers. comm.) while Ecuador is actively encouraging fishers to switch from J to circle hooks (P. Guerrero pers. comm). J-hooks are still used predominantly in Peru.

In addition to lower catch rates for turtles, these hooks have been shown to result in lower catch rates for mahi mahi when compared to J-hooks (Largarcha et al. 2005, Mug et al. 2008), although circle hooks do yield a higher quality, and hence, more valuable mahi mahi catch (R. Arauz pers. comm.). The addition of an "appendage" to the commonly used 14/0 circle hook, showed a general decrease in CPUE for all species, including a reduction in sea turtle hookings by 52% and a 23% reduction in tunas and billfish captures (Swimmer et al., 2011). Despite the benefits for sea turtles, the economic cost of lower tuna, billfish and mahi mahi (R. Arauz pers. comm.) landings may make the use of these hooks impracticable (R. Arauz, pers. comm., Andraka et al. 2013). Other hook modifications (10°offset 14/0 circle hooks, Swimmer et al. 2010), or bait modifications (blue dyed bait, Swimmer et al., 2005) have failed to measurably reduce sea turtle catch rates.

Sea turtle bycatch in Costa Rican longline fisheries has been the subject of several recent studies (i.e. Arauz 2000, Swimmer et al. 2005, 2006, 2010, 2011, Whorisky et al. 2011, Andraka et al. 2013) with fairly ambiguous results. Sea turtle CPUE (per 1,000 hooks) varies from 1.5 (C 16/0 hooks, Andraka et al. 2013), to 9.05 (C 14-16/0, Whoriskey et al. 2011), to 19 (C 14/0 Swimmer et al. 2010). These discrepancies may be due in part to sampling proximity to nesting beaches or during times of year with higher or lower turtle densities (Andraka et al. 2013), although significant uncertainty remains around the impact of Costa Rican mahi mahi fishers on local and regional turtle populations.

The Ecuadorian government is currently working on several fronts to increase circle hook usage in the mahi mahi fleet including supplying circle hooks for a J-hook exchange program, training fishers on proper handling and release of hooked or entangled turtles and exploring technologies to reduce entanglement (P. Guerrero pers. comm.). The government has recently reduced the import tariff on circle hooks, while leaving this tax in place for J-hooks, in order to ensure the widespread availability of circle hooks at competitive prices. The end goal of these activities is to mandate the use of circle hooks and other mitigation measures, once circle hooks are readily available to Ecuadorian fishers.

	Ecuador				Costa Rica	
	J-hook CPUE	C 15/0 CPUE	J-hook (No.4,5) CPUE	C 14/0 CPUE	J-hook (No. 2,3) CPUE	C 16/0 CPUE
Target species:						
Coryphaena hippurus	144.13	86.34	151.94	101.93	24.66	27.86
Sea turtles:						
Caretta caretta	0	0	0.09	0	-	-
Chelonia mydas	0.41	0.34	0.45	0	-	-
Eretmochelys imbricata	0.49	0.08	0.54	0.45	0.03	0.08
Lepidochelys olivacea	1.07	1.17	1.16	0.81	2.32	1.5

Figure 11 Sea turtle catch rates by hook type in Ecuador (J vs. C15/0 and J vs.C14/0) and Costa Rica's (J vs. C16/0) mahi mahi fishery (Andraka et al. 2013). Catch per unit effort (CPUE) rates are per 1,000 hooks.

There was a directed sea turtle fishery in Peru through much of the 1990's and evidence suggests that some harvest continued following the 1995 ban on the commercial capture of turtles (Arauz, 1999, Alfaro-Shigueto et al. 2011). A hook exchange program has been initiated by a coalition of organizations (Pro Delphinus, WWF, NFWF, NOAA), but there are currently no government mandated measures in place to reduce sea turtle bycatch (J. Alfaro-Shigueto pers. comm., A. Gonzales, pers. comm.).

PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

High Concern

While pelagic longline fisheries are widely regarded as one of the main sources of fishing mortality for turtles (Lewison and Crowder 2007), no assessment of the impacts of these fisheries from Costa Rica and Ecuador on turtle populations has been conducted. Thus, the fishery contribution from these sources is unknown. Both countries have some measures in place that have been found to be effective in reducing turtle mortality when used correctly (i.e. circle hooks – see below and Criterion 3.2). In Peru, while the fishery-specific mortality on turtle populations is also unknown, there is some indication that the artisanal longline and net fleets may be having a severe impact. There are also no management measures in place to reduce mortality.

Justification:

Sea turtle conflict with mahi mahi longliners in the Eastern Pacific is, to some extent unavoidable. These five species of sea turtle each spend some aspect of their life history off the northwest coast of South America, bringing them into contact with Ecuador, Peru and Costa Rica's mahi mahi fishing fleets (Figure 8).

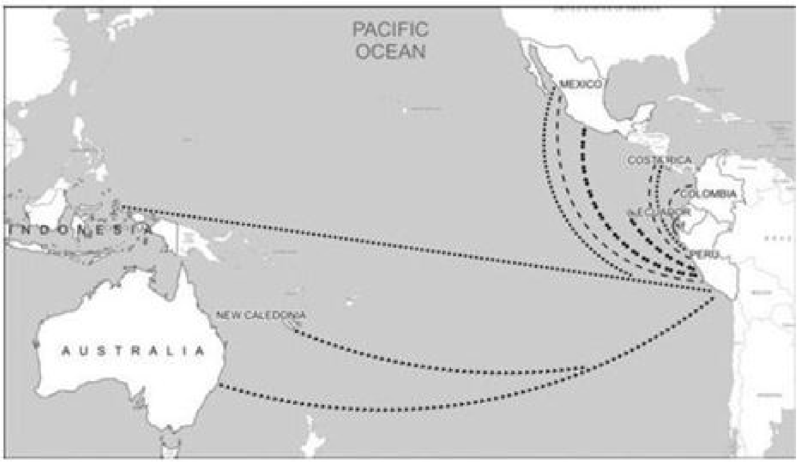

Fig. 2. Schematic view of linkages of turtles breeding stocks to Peruvian foraging grounds. Leatherback turtles (•): western and eastern Pacific rockeries (Eckert & Sarti 1997; Shillinger *et al.* 2008; Dutton *et al.* 2010). Olive ridleys (−−): Colombia, Mexico and Costa Rica (Zeballos & Arias-Schreiber 2001; Velez-Zuazo & Kelez 2010). Green turtles (♦ ♦): Galapagos Islands and Mexico (Hays-Brown & Brown 1982; Velez-Zuazo & Kelez 2010). Loggerhead turtles (▶▶): Australia and New Caledonia (Alfaro-Shigueto *et al.* 2004; Boyle *et al.* 2009). Hawksbill turtles (−): Mainland Ecuador as the closest nesting rockery for the species.

Figure 12 From Alfaro-Shigueto (2011) illustrating the movement of turtle stocks throughout the Southeastern Pacific Ocean.

Numerous observer programs have found that sea turtles are frequently caught in shallow longline sets (Lewison and Crowder 2007). For example, in Costa Rica's fishery, olive ridley hooking rates sometimes exceeds CPUE rates for mahi mahi (Swimmer et al. 2011). Despite the high initial survivability of most hookings, there may be delayed mortality due to the stress of capture or the secondary effects of hooking or hook removal, which cannot be accounted for through catch observation alone (Swimmer et al. 2006). Furthermore, the presence of observers likely affects fisher behavior, with vessels carrying observers being more likely to land captured turtles and remove the hooks with relative care, rather than simply rip out the hook or cut the line with the turtles still in the water (Arauz 2000).

Estimates of fishery captures of sea turtles vary considerably. For example, in separate studies of the Costa Rican mahi mahi fishery, Whoriskey et al. (2011) and Swimmer et al. (2012) found a catch rate (turtles/mahi mahi) of 0.17 and 2.21, respectively. Although, it should be noted that the Swimmer et al. (2012) study only partially overlapped with the traditional mahi mahi season, thus one would expect lower mahi mahi catch rates, which may account for the high turtle:mahi mahi ratio. A recent study of the effects of hook type on sea turtle bycatch in the Ecuadorian and Costa Rican mahi mahi fishery showed generally low hooking rates for sea turtles in these nations (Table 1). Alfaro-Shigueto et al. 2011 estimated a mean of 1061 greens, 133 olive ridleys, 2613 loggerheads and 6 leatherbacks are caught per year in the Peruvian mahi mahi longline fishery, and concluded that interactions with Peru's artisanal longline and net fleets may be severely impacting the populations of sea turtles in the Pacific (Alfaro-Shigueto et al. 2011).

While sea turtles are regularly hooked in the southeastern Pacific mahi mahi fishery, they are usually released alive, as the hook proximity to the surface allows the turtles to continue to surface to breathe (Swimmer et al. 2006, Witzell 1999). Governments and NGOs have focused much of their bycatch mitigation efforts for the mahi mahi fishery on reducing turtle hooking and entanglements. Loggerhead, hawksbill and olive ridley turtles are most often caught via biting baited hooks (Swimmer 2006, Largarcha et al. 2005) whereas leatherback and green turtles are more likely to become entangled in lines or to be hooked in flippers (Largarcha et al. 2005, Witzell 1999).

Hook modifications are the primary means of reducing sea turtle capture. Circle hooks are generally considered to be "turtle friendly," usually resulting in lower capture rates and fewer deep hookings when

compared to J-hooks (i.e. Andraka et al. 2013, Swimmer et al. 2006, 2011). There is an effort underway to encourage fishers in this region to replace the traditional J-style hooks with circle hooks (Mug et al. 2008). Fishers in Costa Rica routinely use circle hooks (E. Villagran pers. comm., R. Arauz pers. comm.) while Ecuador is actively encouraging fishers to switch from J to circle hooks (P. Guerrero pers. comm). J-hooks are still used predominantly in Peru.

In addition to lower catch rates for turtles, these hooks have been shown to result in lower catch rates for mahi mahi when compared to J-hooks (Largarcha et al. 2005, Mug et al. 2008), although circle hooks do yield a higher quality, and hence, more valuable mahi mahi catch (R. Arauz pers. comm.). The addition of an "appendage" to the commonly used 14/0 circle hook, showed a general decrease in CPUE for all species, including a reduction in sea turtle hookings by 52% and a 23% reduction in tunas and billfish captures (Swimmer et al., 2011). Despite the benefits for sea turtles, the economic cost of lower tuna, billfish and mahi mahi (R. Arauz pers. comm.) landings may make the use of these hooks impracticable (R. Arauz, pers. comm., Andraka et al. 2013). Other hook modifications (10°offset 14/0 circle hooks, Swimmer et al. 2010), or bait modifications (blue dyed bait, Swimmer et al., 2005) have failed to measurably reduce sea turtle catch rates.

Sea turtle bycatch in Costa Rican longline fisheries has been the subject of several recent studies (i.e. Arauz 2000, Swimmer et al. 2005, 2006, 2010, 2011, Whorisky et al. 2011, Andraka et al. 2013) with fairly ambiguous results. Sea turtle CPUE (per 1,000 hooks) varies from 1.5 (C 16/0 hooks, Andraka et al. 2013), to 9.05 (C 14-16/0, Whoriskey et al. 2011), to 19 (C 14/0 Swimmer et al. 2010). These discrepancies may be due in part to sampling proximity to nesting beaches or during times of year with higher or lower turtle densities (Andraka et al. 2013), although significant uncertainty remains around the impact of Costa Rican mahi mahi fishers on local and regional turtle populations.

The Ecuadorian government is currently working on several fronts to increase circle hook usage in the mahi mahi fleet including supplying circle hooks for a J-hook exchange program, training fishers on proper handling and release of hooked or entangled turtles and exploring technologies to reduce entanglement (P. Guerrero pers. comm.). The government has recently reduced the import tariff on circle hooks, while leaving this tax in place for J-hooks, in order to ensure the widespread availability of circle hooks at competitive prices. The end goal of these activities is to mandate the use of circle hooks and other mitigation measures, once circle hooks are readily available to Ecuadorian fishers.

	Ecuador				Costa Rica	
	J-hook CPUE	C 15/0 CPUE	J-hook (No.4,5) CPUE	C 14/0 CPUE	J-hook (No. 2,3) CPUE	C 16/0 CPUE
Target species:						
Coryphaena hippurus	144.13	86.34	151.94	101.93	24.66	27.86
Sea turtles:						
Caretta caretta	0	0	0.09	0	-	-
Chelonia mydas	0.41	0.34	0.45	0	-	-
Eretmochelys imbricata	0.49	0.08	0.54	0.45	0.03	0.08
Lepidochelys olivacea	1.07	1.17	1.16	0.81	2.32	1.5

Figure 13 Sea turtle catch rates by hook type in Ecuador (J vs. C15/0 and J vs.C14/0) and Costa Rica's (J vs. C16/0) mahi mahi fishery (Andraka et al. 2013). Catch per unit effort (CPUE) rates are per 1,000 hooks.

There was a directed sea turtle fishery in Peru through much of the 1990's and evidence suggests that some harvest continued following the 1995 ban on the commercial capture of turtles (Arauz, 1999, Alfaro-Shigueto et al. 2011). A hook exchange program has been initiated by a coalition of organizations (Pro Delphinus, WWF, NFWF, NOAA), but there are currently no government mandated measures in place to reduce sea turtle bycatch (J. Alfaro-Shigueto pers. comm., A. Gonzales, pers. comm.).

Factor 2.4 - Discard Rate

COSTA RICA/EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA
PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

< 20%

Discard rates are unknown for the mahi mahi fisheries in Ecuador, Peru, Costa Rica and Guatemala. Small-scale operators typically have lower discard rates than industrial scale vessels (Kelleher 2005), because artisanal fishers are able to utilize more of the incidental catch. Kelleher (2005) assumed a discard rate of <1 to 5% for artisanal fisheries. In keeping with this standard, the discard rate for the mahi mahi fisheries in Ecuador, Peru and Costa Rica was categorized as <20%. Kelleher (2005) also found that industrial scale longliners targeting HMS, like those used in the Guatemalan mahi mahi fishery, averaged a discard rate of 28.5%, however, the majority of incidentally captured fish is consumed in the domestic market (E. Villagrán, pers. comm.) so the discard rate in this fishery is likely significantly lower.

HAWKSBILL TURTLE

Factor 2.1 - Inherent Vulnerability

COSTA RICA/EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA
PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

High

Generally, sea turtles have low inherent resilience. These species are long lived, in some cases taking as long as 40 years to reach sexual maturity (Mortimer & Donnelly 2008), and experience high hatchling and juvenile mortality (Abreu-Grobois and Plotkin 2008; IUCN 2011).

Factor 2.2 - Abundance

COSTA RICA/EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA
PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

Very High Concern

Populations of all sea turtles are imperiled worldwide (IUCN 2011). A number of factors have contributed to decline of these species including conflict with fisheries, pollution, nesting habitat loss, and direct hunting. Sea turtle eggs have historically been an important resource for coastal communities around the world and the unregulated harvest of eggs has been credited with the decline of several species (IUCN 2011). Longline fishing has contributed significantly to the decline of leatherback and loggerhead sea turtle populations in the Eastern Pacific (Sarti Martinez 2000, Lewison et al. 2004).

Factor 2.3 - Fishing Mortality

COSTA RICA/EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA

Moderate Concern

While pelagic longline fisheries are widely regarded as one of the main sources of fishing mortality for turtles (Lewison and Crowder 2007), no assessment of the impacts of these fisheries from Costa Rica and Ecuador on turtle populations has been conducted. Thus, the fishery contribution from these sources is unknown. Both countries have some measures in place that have been found to be effective in reducing turtle mortality when used correctly (i.e. circle hooks – see below and Criterion 3.2). In Peru, while the fishery-specific mortality on turtle populations is also unknown, there is some indication that the artisanal longline and net fleets may be having a severe impact. There are also no management measures in place to reduce mortality.

Justification:

Sea turtle conflict with mahi mahi longliners in the Eastern Pacific is, to some extent unavoidable. These five species of sea turtle each spend some aspect of their life history off the northwest coast of South America, bringing them into contact with Ecuador, Peru and Costa Rica's mahi mahi fishing fleets (Figure 8).

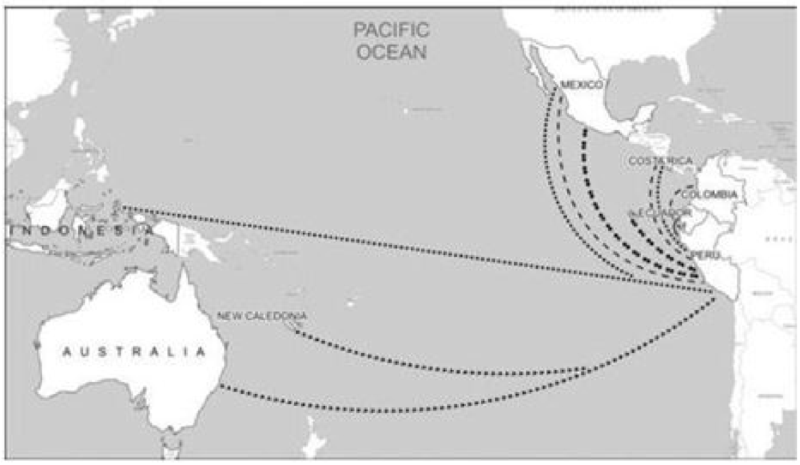

Fig. 2. Schematic view of linkages of turtles breeding stocks to Peruvian foraging grounds. Leatherback turtles (•): western and eastern Pacific rockeries (Eckert & Sarti 1997; Shillinger *et al.* 2008; Dutton *et al.* 2010). Olive ridleys (– –): Colombia, Mexico and Costa Rica (Zeballos & Arias-Schreiber 2001; Velez-Zuazo & Kelez 2010). Green turtles (♦ ♦): Galapagos Islands and Mexico (Hays-Brown & Brown 1982; Velez-Zuazo & Kelez 2010). Loggerhead turtles (▶▶): Australia and New Caledonia (Alfaro-Shigueto *et al.* 2004; Boyle *et al.* 2009). Hawksbill turtles (–): Mainland Ecuador as the closest nesting rockery for the species.

Figure 14 From Alfaro-Shigueto (2011) illustrating the movement of turtle stocks throughout the Southeastern Pacific Ocean.

Numerous observer programs have found that sea turtles are frequently caught in shallow longline sets (Lewison and Crowder 2007). For example, in Costa Rica's fishery, olive ridley hooking rates sometimes exceeds CPUE rates for mahi mahi (Swimmer et al. 2011). Despite the high initial survivability of most hookings, there may be delayed mortality due to the stress of capture or the secondary effects of hooking or hook removal, which cannot be accounted for through catch observation alone (Swimmer et al. 2006). Furthermore, the presence of observers likely affects fisher behavior, with vessels carrying observers being more likely to land captured turtles and remove the hooks with relative care, rather than simply rip out the hook or cut the line with the turtles still in the water (Arauz 2000).

Estimates of fishery captures of sea turtles vary considerably. For example, in separate studies of the Costa Rican mahi mahi fishery, Whoriskey et al. (2011) and Swimmer et al. (2012) found a catch rate (turtles/mahi mahi) of 0.17 and 2.21, respectively. Although, it should be noted that the Swimmer et al. (2012) study only partially overlapped with the traditional mahi mahi season, thus one would expect lower mahi mahi catch rates, which may account for the high turtle:mahi mahi ratio. A recent study of the effects of hook type on sea turtle bycatch in the Ecuadorian and Costa Rican mahi mahi fishery showed generally low hooking rates

for sea turtles in these nations (Table 1). Alfaro-Shigueto et al. 2011 estimated a mean of 1061 greens, 133 olive ridleys, 2613 loggerheads and 6 leatherbacks are caught per year in the Peruvian mahi mahi longline fishery, and concluded that interactions with Peru's artisanal longline and net fleets may be severely impacting the populations of sea turtles in the Pacific (Alfaro-Shigueto et al. 2011).

While sea turtles are regularly hooked in the southeastern Pacific mahi mahi fishery, they are usually released alive, as the hook proximity to the surface allows the turtles to continue to surface to breathe (Swimmer et al. 2006, Witzell 1999). Governments and NGOs have focused much of their bycatch mitigation efforts for the mahi mahi fishery on reducing turtle hooking and entanglements. Loggerhead, hawksbill and olive ridley turtles are most often caught via biting baited hooks (Swimmer 2006, Largarcha et al. 2005) whereas leatherback and green turtles are more likely to become entangled in lines or to be hooked in flippers (Largarcha et al. 2005, Witzell 1999).

Hook modifications are the primary means of reducing sea turtle capture. Circle hooks are generally considered to be "turtle friendly," usually resulting in lower capture rates and fewer deep hookings when compared to J-hooks (i.e. Andraka et al. 2013, Swimmer et al. 2006, 2011). There is an effort underway to encourage fishers in this region to replace the traditional J-style hooks with circle hooks (Mug et al. 2008). Fishers in Costa Rica routinely use circle hooks (E. Villagran pers. comm., R. Arauz pers. comm.) while Ecuador is actively encouraging fishers to switch from J to circle hooks (P. Guerrero pers. comm). J-hooks are still used predominantly in Peru.

In addition to lower catch rates for turtles, these hooks have been shown to result in lower catch rates for mahi mahi when compared to J-hooks (Largarcha et al. 2005, Mug et al. 2008), although circle hooks do yield a higher quality, and hence, more valuable mahi mahi catch (R. Arauz pers. comm.). The addition of an "appendage" to the commonly used 14/0 circle hook, showed a general decrease in CPUE for all species, including a reduction in sea turtle hookings by 52% and a 23% reduction in tunas and billfish captures (Swimmer et al., 2011). Despite the benefits for sea turtles, the economic cost of lower tuna, billfish and mahi mahi (R. Arauz pers. comm.) landings may make the use of these hooks impracticable (R. Arauz, pers. comm., Andraka et al. 2013). Other hook modifications (10°offset 14/0 circle hooks, Swimmer et al. 2010), or bait modifications (blue dyed bait, Swimmer et al., 2005) have failed to measurably reduce sea turtle catch rates.

Sea turtle bycatch in Costa Rican longline fisheries has been the subject of several recent studies (i.e. Arauz 2000, Swimmer et al. 2005, 2006, 2010, 2011, Whorisky et al. 2011, Andraka et al. 2013) with fairly ambiguous results. Sea turtle CPUE (per 1,000 hooks) varies from 1.5 (C 16/0 hooks, Andraka et al. 2013), to 9.05 (C 14-16/0, Whoriskey et al. 2011), to 19 (C 14/0 Swimmer et al. 2010). These discrepancies may be due in part to sampling proximity to nesting beaches or during times of year with higher or lower turtle densities (Andraka et al. 2013), although significant uncertainty remains around the impact of Costa Rican mahi mahi fishers on local and regional turtle populations.

The Ecuadorian government is currently working on several fronts to increase circle hook usage in the mahi mahi fleet including supplying circle hooks for a J-hook exchange program, training fishers on proper handling and release of hooked or entangled turtles and exploring technologies to reduce entanglement (P. Guerrero pers. comm.). The government has recently reduced the import tariff on circle hooks, while leaving this tax in place for J-hooks, in order to ensure the widespread availability of circle hooks at competitive prices. The end goal of these activities is to mandate the use of circle hooks and other mitigation measures, once circle hooks are readily available to Ecuadorian fishers.

	Ecuador				Costa Rica	
	J-hook CPUE	C 15/0 CPUE	J-hook (No.4,5) CPUE	C 14/0 CPUE	J-hook (No. 2,3) CPUE	C 16/0 CPUE
Target species:						
Coryphaena hippurus	144.13	86.34	151.94	101.93	24.66	27.86
Sea turtles:						
Caretta caretta	0	0	0.09	0	-	-
Chelonia mydas	0.41	0.34	0.45	0	-	-
Eretmochelys imbricata	0.49	0.08	0.54	0.45	0.03	0.08
Lepidochelys olivacea	1.07	1.17	1.16	0.81	2.32	1.5

Figure 15 Sea turtle catch rates by hook type in Ecuador (J vs. C15/0 and J vs.C14/0) and Costa Rica's (J vs. C16/0) mahi mahi fishery (Andraka et al. 2013). Catch per unit effort (CPUE) rates are per 1,000 hooks.

There was a directed sea turtle fishery in Peru through much of the 1990's and evidence suggests that some harvest continued following the 1995 ban on the commercial capture of turtles (Arauz, 1999, Alfaro-Shigueto et al. 2011). A hook exchange program has been initiated by a coalition of organizations (Pro Delphinus, WWF, NFWF, NOAA), but there are currently no government mandated measures in place to reduce sea turtle bycatch (J. Alfaro-Shigueto pers. comm., A. Gonzales, pers. comm.).

PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

High Concern

While pelagic longline fisheries are widely regarded as one of the main sources of fishing mortality for turtles (Lewison and Crowder 2007), no assessment of the impacts of these fisheries from Costa Rica and Ecuador on turtle populations has been conducted. Thus, the fishery contribution from these sources is unknown. Both countries have some measures in place that have been found to be effective in reducing turtle mortality when used correctly (i.e. circle hooks – see below and Criterion 3.2). In Peru, while the fishery-specific mortality on turtle populations is also unknown, there is some indication that the artisanal longline and net fleets may be having a severe impact. There are also no management measures in place to reduce mortality.

Justification:

Sea turtle conflict with mahi mahi longliners in the Eastern Pacific is, to some extent unavoidable. These five species of sea turtle each spend some aspect of their life history off the northwest coast of South America, bringing them into contact with Ecuador, Peru and Costa Rica's mahi mahi fishing fleets (Figure 8).

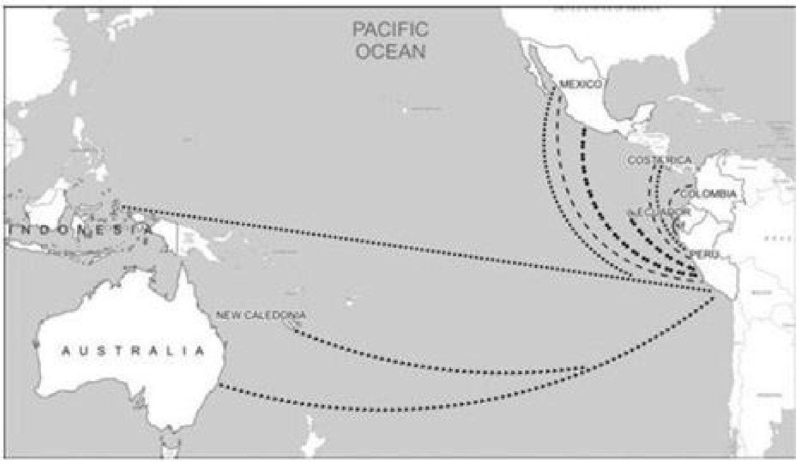

Fig. 2. Schematic view of linkages of turtles breeding stocks to Peruvian foraging grounds. Leatherback turtles (•): western and eastern Pacific rockeries (Eckert & Sarti 1997; Shillinger *et al.* 2008; Dutton *et al.* 2010). Olive ridleys (– –): Colombia, Mexico and Costa Rica (Zeballos & Arias-Schreiber 2001; Velez-Zuazo & Kelez 2010). Green turtles (♦ ♦): Galapagos Islands and Mexico (Hays-Brown & Brown 1982; Velez-Zuazo & Kelez 2010). Loggerhead turtles (►►): Australia and New Caledonia (Alfaro-Shigueto *et al.* 2004; Boyle *et al.* 2009). Hawksbill turtles (–): Mainland Ecuador as the closest nesting rockery for the species.

Figure 16 From Alfaro-Shigueto (2011) illustrating the movement of turtle stocks throughout the Southeastern Pacific Ocean.

Numerous observer programs have found that sea turtles are frequently caught in shallow longline sets (Lewison and Crowder 2007). For example, in Costa Rica's fishery, olive ridley hooking rates sometimes exceeds CPUE rates for mahi mahi (Swimmer et al. 2011). Despite the high initial survivability of most hookings, there may be delayed mortality due to the stress of capture or the secondary effects of hooking or hook removal, which cannot be accounted for through catch observation alone (Swimmer et al. 2006). Furthermore, the presence of observers likely affects fisher behavior, with vessels carrying observers being more likely to land captured turtles and remove the hooks with relative care, rather than simply rip out the hook or cut the line with the turtles still in the water (Arauz 2000).

Estimates of fishery captures of sea turtles vary considerably. For example, in separate studies of the Costa Rican mahi mahi fishery, Whoriskey et al. (2011) and Swimmer et al. (2012) found a catch rate (turtles/mahi mahi) of 0.17 and 2.21, respectively. Although, it should be noted that the Swimmer et al. (2012) study only partially overlapped with the traditional mahi mahi season, thus one would expect lower mahi mahi catch rates, which may account for the high turtle:mahi mahi ratio. A recent study of the effects of hook type on sea turtle bycatch in the Ecuadorian and Costa Rican mahi mahi fishery showed generally low hooking rates for sea turtles in these nations (Table 1). Alfaro-Shigueto et al. 2011 estimated a mean of 1061 greens, 133 olive ridleys, 2613 loggerheads and 6 leatherbacks are caught per year in the Peruvian mahi mahi longline fishery, and concluded that interactions with Peru's artisanal longline and net fleets may be severely impacting the populations of sea turtles in the Pacific (Alfaro-Shigueto et al. 2011).

While sea turtles are regularly hooked in the southeastern Pacific mahi mahi fishery, they are usually released alive, as the hook proximity to the surface allows the turtles to continue to surface to breathe (Swimmer et al. 2006, Witzell 1999). Governments and NGOs have focused much of their bycatch mitigation efforts for the mahi mahi fishery on reducing turtle hooking and entanglements. Loggerhead, hawksbill and olive ridley turtles are most often caught via biting baited hooks (Swimmer 2006, Largarcha et al. 2005) whereas leatherback and green turtles are more likely to become entangled in lines or to be hooked in flippers (Largarcha et al. 2005, Witzell 1999).

Hook modifications are the primary means of reducing sea turtle capture. Circle hooks are generally considered to be "turtle friendly," usually resulting in lower capture rates and fewer deep hookings when

compared to J-hooks (i.e. Andraka et al. 2013, Swimmer et al. 2006, 2011). There is an effort underway to encourage fishers in this region to replace the traditional J-style hooks with circle hooks (Mug et al. 2008). Fishers in Costa Rica routinely use circle hooks (E. Villagran pers. comm., R. Arauz pers. comm.) while Ecuador is actively encouraging fishers to switch from J to circle hooks (P. Guerrero pers. comm). J-hooks are still used predominantly in Peru.

In addition to lower catch rates for turtles, these hooks have been shown to result in lower catch rates for mahi mahi when compared to J-hooks (Largarcha et al. 2005, Mug et al. 2008), although circle hooks do yield a higher quality, and hence, more valuable mahi mahi catch (R. Arauz pers. comm.). The addition of an "appendage" to the commonly used 14/0 circle hook, showed a general decrease in CPUE for all species, including a reduction in sea turtle hookings by 52% and a 23% reduction in tunas and billfish captures (Swimmer et al., 2011). Despite the benefits for sea turtles, the economic cost of lower tuna, billfish and mahi mahi (R. Arauz pers. comm.) landings may make the use of these hooks impracticable (R. Arauz, pers. comm., Andraka et al. 2013). Other hook modifications (10°offset 14/0 circle hooks, Swimmer et al. 2010), or bait modifications (blue dyed bait, Swimmer et al., 2005) have failed to measurably reduce sea turtle catch rates.

Sea turtle bycatch in Costa Rican longline fisheries has been the subject of several recent studies (i.e. Arauz 2000, Swimmer et al. 2005, 2006, 2010, 2011, Whorisky et al. 2011, Andraka et al. 2013) with fairly ambiguous results. Sea turtle CPUE (per 1,000 hooks) varies from 1.5 (C 16/0 hooks, Andraka et al. 2013), to 9.05 (C 14-16/0, Whoriskey et al. 2011), to 19 (C 14/0 Swimmer et al. 2010). These discrepancies may be due in part to sampling proximity to nesting beaches or during times of year with higher or lower turtle densities (Andraka et al. 2013), although significant uncertainty remains around the impact of Costa Rican mahi mahi fishers on local and regional turtle populations.

The Ecuadorian government is currently working on several fronts to increase circle hook usage in the mahi mahi fleet including supplying circle hooks for a J-hook exchange program, training fishers on proper handling and release of hooked or entangled turtles and exploring technologies to reduce entanglement (P. Guerrero pers. comm.). The government has recently reduced the import tariff on circle hooks, while leaving this tax in place for J-hooks, in order to ensure the widespread availability of circle hooks at competitive prices. The end goal of these activities is to mandate the use of circle hooks and other mitigation measures, once circle hooks are readily available to Ecuadorian fishers.

	Ecuador				Costa Rica	
	J-hook CPUE	C 15/0 CPUE	J-hook (No.4,5) CPUE	C 14/0 CPUE	J-hook (No. 2,3) CPUE	C 16/0 CPUE
Target species:						
Coryphaena hippurus	144.13	86.34	151.94	101.93	24.66	27.86
Sea turtles:						
Caretta caretta	0	0	0.09	0	-	-
Chelonia mydas	0.41	0.34	0.45	0	-	-
Eretmochelys imbricata	0.49	0.08	0.54	0.45	0.03	0.08
Lepidochelys olivacea	1.07	1.17	1.16	0.81	2.32	1.5

Figure 17 Sea turtle catch rates by hook type in Ecuador (J vs. C15/0 and J vs.C14/0) and Costa Rica's (J vs. C16/0) mahi mahi fishery (Andraka et al. 2013). Catch per unit effort (CPUE) rates are per 1,000 hooks.

There was a directed sea turtle fishery in Peru through much of the 1990's and evidence suggests that some harvest continued following the 1995 ban on the commercial capture of turtles (Arauz, 1999, Alfaro-Shigueto et al. 2011). A hook exchange program has been initiated by a coalition of organizations (Pro Delphinus, WWF, NFWF, NOAA), but there are currently no government mandated measures in place to reduce sea turtle bycatch (J. Alfaro-Shigueto pers. comm., A. Gonzales, pers. comm.).

Factor 2.4 - Discard Rate

COSTA RICA/EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA
PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

< 20%

Discard rates are unknown for the mahi mahi fisheries in Ecuador, Peru, Costa Rica and Guatemala. Small-scale operators typically have lower discard rates than industrial scale vessels (Kelleher 2005), because artisanal fishers are able to utilize more of the incidental catch. Kelleher (2005) assumed a discard rate of <1 to 5% for artisanal fisheries. In keeping with this standard, the discard rate for the mahi mahi fisheries in Ecuador, Peru and Costa Rica was categorized as <20%. Kelleher (2005) also found that industrial scale longliners targeting HMS, like those used in the Guatemalan mahi mahi fishery, averaged a discard rate of 28.5%, however, the majority of incidentally captured fish is consumed in the domestic market (E. Villagrán, pers. comm.) so the discard rate in this fishery is likely significantly lower.

LOGGERHEAD TURTLE

Factor 2.1 - Inherent Vulnerability

COSTA RICA/EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA
PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

High

Generally, sea turtles have low inherent resilience. These species are long lived, in some cases taking as long as 40 years to reach sexual maturity (Mortimer & Donnelly 2008), and experience high hatchling and juvenile mortality (Abreu-Grobois and Plotkin 2008; IUCN 2011).

Factor 2.2 - Abundance

COSTA RICA/EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA
PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

Very High Concern

Populations of all sea turtles are imperiled worldwide (IUCN 2011). A number of factors have contributed to decline of these species including conflict with fisheries, pollution, nesting habitat loss, and direct hunting. Sea turtle eggs have historically been an important resource for coastal communities around the world and the unregulated harvest of eggs has been credited with the decline of several species (IUCN 2011). Longline fishing has contributed significantly to the decline of leatherback and loggerhead sea turtle populations in the Eastern Pacific (Sarti Martinez 2000, Lewison et al. 2004).

Factor 2.3 - Fishing Mortality

COSTA RICA/EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA

Moderate Concern

While pelagic longline fisheries are widely regarded as one of the main sources of fishing mortality for turtles (Lewison and Crowder 2007), no assessment of the impacts of these fisheries from Costa Rica and Ecuador on turtle populations has been conducted. Thus, the fishery contribution from these sources is unknown. Both countries have some measures in place that have been found to be effective in reducing turtle mortality when used correctly (i.e. circle hooks – see below and Criterion 3.2). In Peru, while the fishery-specific mortality on turtle populations is also unknown, there is some indication that the artisanal longline and net fleets may be having a severe impact. There are also no management measures in place to reduce mortality.

Justification:

Sea turtle conflict with mahi mahi longliners in the Eastern Pacific is, to some extent unavoidable. These five species of sea turtle each spend some aspect of their life history off the northwest coast of South America, bringing them into contact with Ecuador, Peru and Costa Rica's mahi mahi fishing fleets (Figure 8).

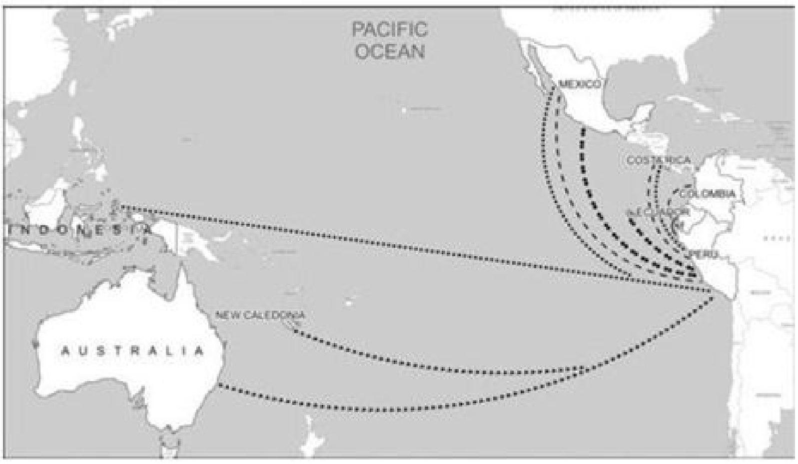

Fig. 2. Schematic view of linkages of turtles breeding stocks to Peruvian foraging grounds. Leatherback turtles (•): western and eastern Pacific rockeries (Eckert & Sarti 1997; Shillinger *et al.* 2008; Dutton *et al.* 2010). Olive ridleys (−−): Colombia, Mexico and Costa Rica (Zeballos & Arias-Schreiber 2001; Velez-Zuazo & Kelez 2010). Green turtles (♦ ♦): Galapagos Islands and Mexico (Hays-Brown & Brown 1982; Velez-Zuazo & Kelez 2010). Loggerhead turtles (▶▶): Australia and New Caledonia (Alfaro-Shigueto *et al.* 2004; Boyle *et al.* 2009). Hawksbill turtles (−): Mainland Ecuador as the closest nesting rockery for the species.

Figure 18 From Alfaro-Shigueto (2011) illustrating the movement of turtle stocks throughout the Southeastern Pacific Ocean.

Numerous observer programs have found that sea turtles are frequently caught in shallow longline sets (Lewison and Crowder 2007). For example, in Costa Rica's fishery, olive ridley hooking rates sometimes exceeds CPUE rates for mahi mahi (Swimmer et al. 2011). Despite the high initial survivability of most hookings, there may be delayed mortality due to the stress of capture or the secondary effects of hooking or hook removal, which cannot be accounted for through catch observation alone (Swimmer et al. 2006). Furthermore, the presence of observers likely affects fisher behavior, with vessels carrying observers being more likely to land captured turtles and remove the hooks with relative care, rather than simply rip out the hook or cut the line with the turtles still in the water (Arauz 2000).

Estimates of fishery captures of sea turtles vary considerably. For example, in separate studies of the Costa Rican mahi mahi fishery, Whoriskey et al. (2011) and Swimmer et al. (2012) found a catch rate (turtles/mahi mahi) of 0.17 and 2.21, respectively. Although, it should be noted that the Swimmer et al. (2012) study only partially overlapped with the traditional mahi mahi season, thus one would expect lower mahi mahi catch rates, which may account for the high turtle:mahi mahi ratio. A recent study of the effects of hook type on sea turtle bycatch in the Ecuadorian and Costa Rican mahi mahi fishery showed generally low hooking rates

for sea turtles in these nations (Table 1). Alfaro-Shigueto et al. 2011 estimated a mean of 1061 greens, 133 olive ridleys, 2613 loggerheads and 6 leatherbacks are caught per year in the Peruvian mahi mahi longline fishery, and concluded that interactions with Peru's artisanal longline and net fleets may be severely impacting the populations of sea turtles in the Pacific (Alfaro-Shigueto et al. 2011).

While sea turtles are regularly hooked in the southeastern Pacific mahi mahi fishery, they are usually released alive, as the hook proximity to the surface allows the turtles to continue to surface to breathe (Swimmer et al. 2006, Witzell 1999). Governments and NGOs have focused much of their bycatch mitigation efforts for the mahi mahi fishery on reducing turtle hooking and entanglements. Loggerhead, hawksbill and olive ridley turtles are most often caught via biting baited hooks (Swimmer 2006, Largarcha et al. 2005) whereas leatherback and green turtles are more likely to become entangled in lines or to be hooked in flippers (Largarcha et al. 2005, Witzell 1999).

Hook modifications are the primary means of reducing sea turtle capture. Circle hooks are generally considered to be "turtle friendly," usually resulting in lower capture rates and fewer deep hookings when compared to J-hooks (i.e. Andraka et al. 2013, Swimmer et al. 2006, 2011). There is an effort underway to encourage fishers in this region to replace the traditional J-style hooks with circle hooks (Mug et al. 2008). Fishers in Costa Rica routinely use circle hooks (E. Villagran pers. comm., R. Arauz pers. comm.) while Ecuador is actively encouraging fishers to switch from J to circle hooks (P. Guerrero pers. comm). J-hooks are still used predominantly in Peru.

In addition to lower catch rates for turtles, these hooks have been shown to result in lower catch rates for mahi mahi when compared to J-hooks (Largarcha et al. 2005, Mug et al. 2008), although circle hooks do yield a higher quality, and hence, more valuable mahi mahi catch (R. Arauz pers. comm.). The addition of an "appendage" to the commonly used 14/0 circle hook, showed a general decrease in CPUE for all species, including a reduction in sea turtle hookings by 52% and a 23% reduction in tunas and billfish captures (Swimmer et al., 2011). Despite the benefits for sea turtles, the economic cost of lower tuna, billfish and mahi mahi (R. Arauz pers. comm.) landings may make the use of these hooks impracticable (R. Arauz, pers. comm., Andraka et al. 2013). Other hook modifications (10°offset 14/0 circle hooks, Swimmer et al. 2010), or bait modifications (blue dyed bait, Swimmer et al., 2005) have failed to measurably reduce sea turtle catch rates.

Sea turtle bycatch in Costa Rican longline fisheries has been the subject of several recent studies (i.e. Arauz 2000, Swimmer et al. 2005, 2006, 2010, 2011, Whorisky et al. 2011, Andraka et al. 2013) with fairly ambiguous results. Sea turtle CPUE (per 1,000 hooks) varies from 1.5 (C 16/0 hooks, Andraka et al. 2013), to 9.05 (C 14-16/0, Whoriskey et al. 2011), to 19 (C 14/0 Swimmer et al. 2010). These discrepancies may be due in part to sampling proximity to nesting beaches or during times of year with higher or lower turtle densities (Andraka et al. 2013), although significant uncertainty remains around the impact of Costa Rican mahi mahi fishers on local and regional turtle populations.

The Ecuadorian government is currently working on several fronts to increase circle hook usage in the mahi mahi fleet including supplying circle hooks for a J-hook exchange program, training fishers on proper handling and release of hooked or entangled turtles and exploring technologies to reduce entanglement (P. Guerrero pers. comm.). The government has recently reduced the import tariff on circle hooks, while leaving this tax in place for J-hooks, in order to ensure the widespread availability of circle hooks at competitive prices. The end goal of these activities is to mandate the use of circle hooks and other mitigation measures, once circle hooks are readily available to Ecuadorian fishers.

	Ecuador				Costa Rica	
	J-hook CPUE	C 15/0 CPUE	J-hook (No.4,5) CPUE	C 14/0 CPUE	J-hook (No. 2,3) CPUE	C 16/0 CPUE
Target species:						
Coryphaena hippurus	144.13	86.34	151.94	101.93	24.66	27.86
Sea turtles:						
Caretta caretta	0	0	0.09	0	-	-
Chelonia mydas	0.41	0.34	0.45	0	-	-
Eretmochelys imbricata	0.49	0.08	0.54	0.45	0.03	0.08
Lepidochelys olivacea	1.07	1.17	1.16	0.81	2.32	1.5

Figure 19 Sea turtle catch rates by hook type in Ecuador (J vs. C15/0 and J vs.C14/0) and Costa Rica's (J vs. C16/0) mahi mahi fishery (Andraka et al. 2013). Catch per unit effort (CPUE) rates are per 1,000 hooks.

There was a directed sea turtle fishery in Peru through much of the 1990's and evidence suggests that some harvest continued following the 1995 ban on the commercial capture of turtles (Arauz, 1999, Alfaro-Shigueto et al. 2011). A hook exchange program has been initiated by a coalition of organizations (Pro Delphinus, WWF, NFWF, NOAA), but there are currently no government mandated measures in place to reduce sea turtle bycatch (J. Alfaro-Shigueto pers. comm., A. Gonzales, pers. comm.).

PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

High Concern

While pelagic longline fisheries are widely regarded as one of the main sources of fishing mortality for turtles (Lewison and Crowder 2007), no assessment of the impacts of these fisheries from Costa Rica and Ecuador on turtle populations has been conducted. Thus, the fishery contribution from these sources is unknown. Both countries have some measures in place that have been found to be effective in reducing turtle mortality when used correctly (i.e. circle hooks – see below and Criterion 3.2). In Peru, while the fishery-specific mortality on turtle populations is also unknown, there is some indication that the artisanal longline and net fleets may be having a severe impact. There are also no management measures in place to reduce mortality.

Justification:

Sea turtle conflict with mahi mahi longliners in the Eastern Pacific is, to some extent unavoidable. These five species of sea turtle each spend some aspect of their life history off the northwest coast of South America, bringing them into contact with Ecuador, Peru and Costa Rica's mahi mahi fishing fleets (Figure 8).

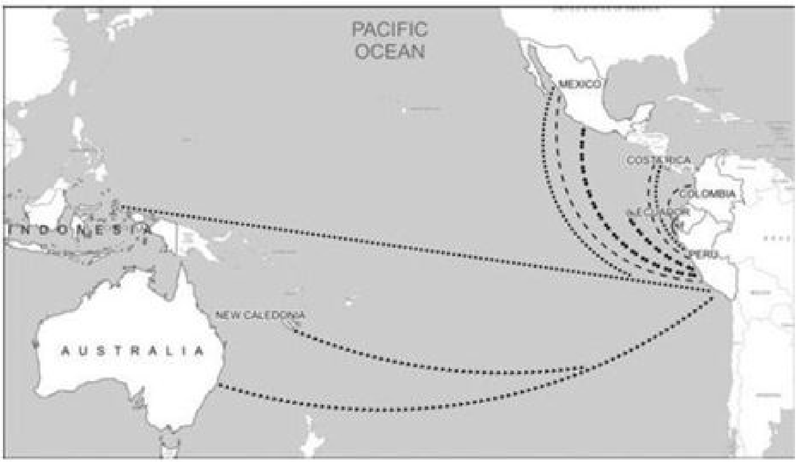

Fig. 2. Schematic view of linkages of turtles breeding stocks to Peruvian foraging grounds. Leatherback turtles (•): western and eastern Pacific rockeries (Eckert & Sarti 1997; Shillinger *et al.* 2008; Dutton *et al.* 2010). Olive ridleys (––): Colombia, Mexico and Costa Rica (Zeballos & Arias-Schreiber 2001; Velez-Zuazo & Kelez 2010). Green turtles (♦ ♦): Galapagos Islands and Mexico (Hays-Brown & Brown 1982; Velez-Zuazo & Kelez 2010). Loggerhead turtles (▶▶): Australia and New Caledonia (Alfaro-Shigueto *et al.* 2004; Boyle *et al.* 2009). Hawksbill turtles (–): Mainland Ecuador as the closest nesting rockery for the species.

Figure 20 From Alfaro-Shigueto (2011) illustrating the movement of turtle stocks throughout the Southeastern Pacific Ocean.

Numerous observer programs have found that sea turtles are frequently caught in shallow longline sets (Lewison and Crowder 2007). For example, in Costa Rica's fishery, olive ridley hooking rates sometimes exceeds CPUE rates for mahi mahi (Swimmer et al. 2011). Despite the high initial survivability of most hookings, there may be delayed mortality due to the stress of capture or the secondary effects of hooking or hook removal, which cannot be accounted for through catch observation alone (Swimmer et al. 2006). Furthermore, the presence of observers likely affects fisher behavior, with vessels carrying observers being more likely to land captured turtles and remove the hooks with relative care, rather than simply rip out the hook or cut the line with the turtles still in the water (Arauz 2000).

Estimates of fishery captures of sea turtles vary considerably. For example, in separate studies of the Costa Rican mahi mahi fishery, Whoriskey et al. (2011) and Swimmer et al. (2012) found a catch rate (turtles/mahi mahi) of 0.17 and 2.21, respectively. Although, it should be noted that the Swimmer et al. (2012) study only partially overlapped with the traditional mahi mahi season, thus one would expect lower mahi mahi catch rates, which may account for the high turtle:mahi mahi ratio. A recent study of the effects of hook type on sea turtle bycatch in the Ecuadorian and Costa Rican mahi mahi fishery showed generally low hooking rates for sea turtles in these nations (Table 1). Alfaro-Shigueto et al. 2011 estimated a mean of 1061 greens, 133 olive ridleys, 2613 loggerheads and 6 leatherbacks are caught per year in the Peruvian mahi mahi longline fishery, and concluded that interactions with Peru's artisanal longline and net fleets may be severely impacting the populations of sea turtles in the Pacific (Alfaro-Shigueto et al. 2011).

While sea turtles are regularly hooked in the southeastern Pacific mahi mahi fishery, they are usually released alive, as the hook proximity to the surface allows the turtles to continue to surface to breathe (Swimmer et al. 2006, Witzell 1999). Governments and NGOs have focused much of their bycatch mitigation efforts for the mahi mahi fishery on reducing turtle hooking and entanglements. Loggerhead, hawksbill and olive ridley turtles are most often caught via biting baited hooks (Swimmer 2006, Largarcha et al. 2005) whereas leatherback and green turtles are more likely to become entangled in lines or to be hooked in flippers (Largarcha et al. 2005, Witzell 1999).

Hook modifications are the primary means of reducing sea turtle capture. Circle hooks are generally considered to be "turtle friendly," usually resulting in lower capture rates and fewer deep hookings when

compared to J-hooks (i.e. Andraka et al. 2013, Swimmer et al. 2006, 2011). There is an effort underway to encourage fishers in this region to replace the traditional J-style hooks with circle hooks (Mug et al. 2008). Fishers in Costa Rica routinely use circle hooks (E. Villagran pers. comm., R. Arauz pers. comm.) while Ecuador is actively encouraging fishers to switch from J to circle hooks (P. Guerrero pers. comm). J-hooks are still used predominantly in Peru.

In addition to lower catch rates for turtles, these hooks have been shown to result in lower catch rates for mahi mahi when compared to J-hooks (Largarcha et al. 2005, Mug et al. 2008), although circle hooks do yield a higher quality, and hence, more valuable mahi mahi catch (R. Arauz pers. comm.). The addition of an "appendage" to the commonly used 14/0 circle hook, showed a general decrease in CPUE for all species, including a reduction in sea turtle hookings by 52% and a 23% reduction in tunas and billfish captures (Swimmer et al., 2011). Despite the benefits for sea turtles, the economic cost of lower tuna, billfish and mahi mahi (R. Arauz pers. comm.) landings may make the use of these hooks impracticable (R. Arauz, pers. comm., Andraka et al. 2013). Other hook modifications (10°offset 14/0 circle hooks, Swimmer et al. 2010), or bait modifications (blue dyed bait, Swimmer et al., 2005) have failed to measurably reduce sea turtle catch rates.

Sea turtle bycatch in Costa Rican longline fisheries has been the subject of several recent studies (i.e. Arauz 2000, Swimmer et al. 2005, 2006, 2010, 2011, Whorisky et al. 2011, Andraka et al. 2013) with fairly ambiguous results. Sea turtle CPUE (per 1,000 hooks) varies from 1.5 (C 16/0 hooks, Andraka et al. 2013), to 9.05 (C 14-16/0, Whoriskey et al. 2011), to 19 (C 14/0 Swimmer et al. 2010). These discrepancies may be due in part to sampling proximity to nesting beaches or during times of year with higher or lower turtle densities (Andraka et al. 2013), although significant uncertainty remains around the impact of Costa Rican mahi mahi fishers on local and regional turtle populations.

The Ecuadorian government is currently working on several fronts to increase circle hook usage in the mahi mahi fleet including supplying circle hooks for a J-hook exchange program, training fishers on proper handling and release of hooked or entangled turtles and exploring technologies to reduce entanglement (P. Guerrero pers. comm.). The government has recently reduced the import tariff on circle hooks, while leaving this tax in place for J-hooks, in order to ensure the widespread availability of circle hooks at competitive prices. The end goal of these activities is to mandate the use of circle hooks and other mitigation measures, once circle hooks are readily available to Ecuadorian fishers.

	Ecuador				Costa Rica	
	J-hook CPUE	C 15/0 CPUE	J-hook (No.4,5) CPUE	C 14/0 CPUE	J-hook (No. 2,3) CPUE	C 16/0 CPUE
Target species:						
Coryphaena hippurus	144.13	86.34	151.94	101.93	24.66	27.86
Sea turtles:						
Caretta caretta	0	0	0.09	0	-	-
Chelonia mydas	0.41	0.34	0.45	0	-	-
Eretmochelys imbricata	0.49	0.08	0.54	0.45	0.03	0.08
Lepidochelys olivacea	1.07	1.17	1.16	0.81	2.32	1.5

Figure 21 Sea turtle catch rates by hook type in Ecuador (J vs. C15/0 and J vs.C14/0) and Costa Rica's (J vs. C16/0) mahi mahi fishery (Andraka et al. 2013). Catch per unit effort (CPUE) rates are per 1,000 hooks.

There was a directed sea turtle fishery in Peru through much of the 1990's and evidence suggests that some harvest continued following the 1995 ban on the commercial capture of turtles (Arauz, 1999, Alfaro-Shigueto et al. 2011). A hook exchange program has been initiated by a coalition of organizations (Pro Delphinus, WWF, NFWF, NOAA), but there are currently no government mandated measures in place to reduce sea turtle bycatch (J. Alfaro-Shigueto pers. comm., A. Gonzales, pers. comm.).

Factor 2.4 - Discard Rate

COSTA RICA/EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA
PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

< 20%

Discard rates are unknown for the mahi mahi fisheries in Ecuador, Peru, Costa Rica and Guatemala. Small-scale operators typically have lower discard rates than industrial scale vessels (Kelleher 2005), because artisanal fishers are able to utilize more of the incidental catch. Kelleher (2005) assumed a discard rate of <1 to 5% for artisanal fisheries. In keeping with this standard, the discard rate for the mahi mahi fisheries in Ecuador, Peru and Costa Rica was categorized as <20%. Kelleher (2005) also found that industrial scale longliners targeting HMS, like those used in the Guatemalan mahi mahi fishery, averaged a discard rate of 28.5%, however, the majority of incidentally captured fish is consumed in the domestic market (E. Villagrán, pers. comm.) so the discard rate in this fishery is likely significantly lower.

WAVED ALBATROSS

Factor 2.1 - Inherent Vulnerability

PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

High

Waved albatrosses are long-lived and do not reproduce until 4-6 years of age (BirdLife International 2012). Chicks experience high mortality and mortality rates increase for both adults and chicks during ENSO years (Awkerman et al. 2006). Additionally, waved albatrosses practice obligate, bi-parental care (Birdlife International 2012), so the loss of one member of a breeding pair reduces the effective population size by two individuals.

Factor 2.2 - Abundance

PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

Very High Concern

Waved albatrosses are ranked as critically endangered by the World Conservation Union (IUCN 2011).

Justification:

With few exceptions, the entire breeding population of waved albatrosses resides on Isla Española in Galápagos National Park, Ecuador and forages primarily off the coasts of southern Ecuador and northern Peru (Jiménez-Uzcátegui et al. 2006, Anderson et al. 2008). Accordingly, the entirety of the wild population is vulnerable to local environmental perturbations. The total number of waved albatrosses was estimated at 34,694 adults in 2001 (Anderson et al. 2002), with observed declines in the number of breeding pairs in subsequent years (Birdlife International 2012).

Factor 2.3 - Fishing Mortality

PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

High Concern

The limited information available suggests that longline fisheries account for much of the observed mortality of adult waved albatrosses (44%) and hooking and entanglement in fishing gear poses a serious risk to the survival of this species (Jiménez-Uzcátegui et al. 2006).

Justification:

The incidental catch of a variety of sea birds with pelagic longline gear has been well documented. Birds attempting to forage on baited hooks often become hooked or entangled in the lines and ultimately drown as the gear sinks. Jahncke et al. (2001) estimate 5-13% of the pooled population of waved and Chatham Island albatrosses are caught in Peru's artisanal longline fisheries per year. In addition to the risk associated with interaction with gear, Pro Delphinus (2006) reported targeted capture and consumption of waved albatrosses, and other seabirds by Peruvian gillnet crews. While this practice may not be widespread, the estimated hunting a few hundred birds per year (Pro Delphinus 2006) can nonetheless have egregious population consequences.

Reducing adult mortality associated with fishery bycatch is crucial to waved albatross recovery (Anderson et al. 2008). Using fresh or thawed bait, blue-dyed bait, tori lines and setting hooks at night have been demonstrated to greatly reduce incidental seabird capture (Jahncke et al. 2001, Gilman et al. 2011).

Factor 2.4 - Discard Rate

PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

< 20%

Discard rates are unknown for the mahi mahi fisheries in Ecuador, Peru, Costa Rica and Guatemala. Small-scale operators typically have lower discard rates than industrial scale vessels (Kelleher 2005), because artisanal fishers are able to utilize more of the incidental catch. Kelleher (2005) assumed a discard rate of <1 to 5% for artisanal fisheries. In keeping with this standard, the discard rate for the mahi mahi fisheries in Ecuador, Peru and Costa Rica was categorized as <20%. Kelleher (2005) also found that industrial scale longliners targeting HMS, like those used in the Guatemalan mahi mahi fishery, averaged a discard rate of 28.5%, however, the majority of incidentally captured fish is consumed in the domestic market (E. Villagrán, pers. comm.) so the discard rate in this fishery is likely significantly lower.

Criterion 3: Management Effectiveness

Management is separated into management of retained species (harvest strategy) and management of non-retained species (bycatch strategy).

The final score for this criterion is the geometric mean of the two scores. The Criterion 3 rating is determined as follows:

- *Score >3.2=Green or Low Concern*
- *Score >2.2 and ≤3.2=Yellow or Moderate Concern*
- *Score ≤2.2 or either the Harvest Strategy (Factor 3.1) or Bycatch Management Strategy (Factor 3.2) is Very High Concern = Red or High Concern*

Rating is Critical if either or both of Harvest Strategy (Factor 3.1) and Bycatch Management Strategy (Factor 3.2) ratings are Critical.

Criterion 3 Summary

Region / Method	Harvest Strategy	Bycatch Strategy	Score
Costa Rica / Eastern Central Pacific / Drifting longlines / Costa Rica	1.000	2.000	Red (1.410)
Peru / Southeast Pacific / Drifting longlines / Peru	2.000	1.000	Red (1.410)

Criterion 3 Assessment

SCORING GUIDELINES

Factor 3.1 - Harvest Strategy

Seven subfactors are evaluated: Management Strategy, Recovery of Species of Concern, Scientific Research/Monitoring, Following of Scientific Advice, Enforcement of Regulations, Management Track Record, and Inclusion of Stakeholders. Each is rated as 'ineffective,' 'moderately effective,' or 'highly effective.'

- *5 (Very Low Concern)—Rated as 'highly effective' for all seven subfactors considered*
- *4 (Low Concern)—Management Strategy and Recovery of Species of Concern rated 'highly effective' and all other subfactors rated at least 'moderately effective.'*
- *3 (Moderate Concern)—All subfactors rated at least 'moderately effective.'*
- *2 (High Concern)—At minimum, meets standards for 'moderately effective' for Management Strategy and Recovery of Species of Concern, but at least one other subfactor rated 'ineffective.'*
- *1 (Very High Concern)—Management exists, but Management Strategy and/or Recovery of Species of Concern rated 'ineffective.'*
- *0 (Critical)—No management exists when there is a clear need for management (i.e., fishery catches threatened, endangered, or high concern species), OR there is a high level of Illegal, unregulated, and unreported fishing occurring.*

Factor 3.1 Summary

FACTOR 3.1 - MANAGEMENT OF FISHING IMPACTS ON RETAINED SPECIES							
Region / Method	**Strategy**	**Recovery**	**Research**	**Advice**	**Enforce**	**Track**	**Inclusion**
Costa Rica / Eastern Central Pacific / Drifting longlines / Costa Rica	Ineffective	Ineffective	Ineffective	Ineffective	Ineffective	Ineffective	Ineffective
Peru / Southeast Pacific / Drifting longlines / Peru	Moderately Effective	N/A	Ineffective	Ineffective	Ineffective	Ineffective	Ineffective

Subfactor 3.1.1 – Management Strategy and Implementation

Considerations: What type of management measures are in place? Are there appropriate management goals, and is there evidence that management goals are being met? To achieve a highly effective rating, there must be appropriate management goals, and evidence that the measures in place have been successful at maintaining/rebuilding species.

COSTA RICA / EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA

Ineffective

There is no management plan nor any mahi mahi-specific management measures in place in Costa Rica. Costa Rica suffers from a lack of sufficient fisheries enforcement, but there is research and monitoring occurring, conducted jointly by WWF and INCOPESCA (R. Arauz, pers. comm.). Although this is a positive development, the harvest strategy in Costa Rica remains a Very High Concern.

PERU / SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

Moderately Effective

There is currently no mahi mahi management plan in place in Peru, although some measures have been taken to try to reduce the impact of the Peruvian mahi mahi fleet on recruitment. The government has established a minimum size of 70cm with an allowance for 10% of the catch to be below this size (A. Gonzales, pers. comm.). In addition, a scientific study of Peru's mahi mahi fishery was carried at the behest of the World Wildlife Fund. Although the findings of this study are not publicly available, WWF is currently working with Food Certification International to develop a strategy for gaining Marine Stewardship Council (MSC) certification for the Peruvian mahi mahi fishery (S. Amoros, pers. comm.). Once the preliminary assessment is complete, it will be presented to PRODUCE, with the goal of assembling a workshop with various stakeholder groups in early 2013 to develop an action plan for the fishery (S. Amoros, pers. comm.).

Subfactor 3.1.2 – Recovery of Species of Concern

Considerations: When needed, are recovery strategies/management measures in place to rebuild overfished/threatened/ endangered species or to limit fishery's impact on these species and what is their likelihood of success? To achieve a rating of Highly Effective, rebuilding strategies that have a high likelihood of success in an appropriate timeframe must be in place when needed, as well as measures to minimize mortality for any overfished/threatened/endangered species.

COSTA RICA / EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA

Ineffective

PERU / SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

N/A

The Peruvian fishery is highly seasonal, with mahi mahi stocks most abundant from December to March (Alfaro-Shigueto et al. 2011). During this period fishery landings are dominated by mahi mahi. As the stock diminishes in April many longline fishers modify their gear and begin targeting sharks. While there is undoubtedly some overlap of the mahi mahi and shark season, where fishers are both landing mahi mahi for export and sharks for domestic consumption there are sufficient temporal and gear configuration differences to consider these two separate fisheries (Alfaro-Shigueto et al. 2011). There are no stocks of concern retained in the Peruvian mahi mahi fishery.

Subfactor 3.1.3 – Scientific Research and Monitoring

Considerations: How much and what types of data are collected to evaluate the health of the population and the fishery's impact on the species? To achieve a Highly Effective rating, population assessments must be conducted regularly and they must be robust enough to reliably determine the population status.

COSTA RICA / EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA

Ineffective

PERU / SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

Ineffective

There has been some scientific investigation into Peru's mahi mahi fishery but the results of this study are not available.

Subfactor 3.1.4 – Management Record of Following Scientific Advice

Considerations: How often (always, sometimes, rarely) do managers of the fishery follow scientific recommendations/advice (e.g. do they set catch limits at recommended levels)? A Highly Effective rating is given if managers nearly always follow scientific advice.

COSTA RICA / EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA

Ineffective

PERU / SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

Ineffective

The Instituto del Mar del Perú (IMARPE) conducts fisheries research to inform management policy. While this organization is well established throughout the coast, there is some question as to whether IMARPE has adequate resources to fulfill its mandate (A. Gonzales, pers. comm.).

Subfactor 3.1.5 – Enforcement of Management Regulations

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

COSTA RICA / EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA

Ineffective

PERU / SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

Ineffective

PRODUCE enforces fisheries laws and guidelines, as recommended by IMARPE. It is unclear as to whether its enforcement capacity is sufficient to police such a large and spatially diffuse fishery.

Subfactor 3.1.6 – Management Track Record

Considerations: Does management have a history of successfully maintaining populations at sustainable levels or a history of failing to maintain populations at sustainable levels? A Highly Effective rating is given if measures enacted by management have been shown to result in the long-term maintenance of species overtime.

COSTA RICA / EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA

Ineffective

PERU / SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

Ineffective

There is no history of active management of the Peruvian mahi mahi fishery.

Subfactor 3.1.7 – Stakeholder Inclusion

Considerations: Are stakeholders involved/included in the decision-making process? Stakeholders are individuals/groups/organizations that have an interest in the fishery or that may be affected by the management of the fishery (e.g., fishermen, conservation groups, etc.). A Highly Effective rating is given if the management process is transparent and includes stakeholder input.

COSTA RICA / EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA

Ineffective

PERU / SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

Ineffective

Unknown

Factor 3.2 - Bycatch Strategy

<u>SCORING GUIDELINES</u>

Four subfactors are evaluated: Management Strategy and Implementation, Scientific Research and Monitoring, Record of Following Scientific Advice, and Enforcement of Regulations. Each is rated as 'ineffective,' 'moderately effective,' or 'highly effective.' Unless reason exists to rate Scientific Research and Monitoring, Record of Following Scientific Advice, and Enforcement of Regulations differently, these rating are the same as in 3.1.

- *5 (Very Low Concern)—Rated as 'highly effective' for all four subfactors considered*
- *4 (Low Concern)—Management Strategy rated 'highly effective' and all other subfactors rated at least 'moderately effective.'*
- *3 (Moderate Concern)—All subfactors rated at least 'moderately effective.'*
- *2 (High Concern)—At minimum, meets standards for 'moderately effective' for Management Strategy but some other factors rated 'ineffective.'*
- *1 (Very High Concern)—Management exists, but Management Strategy rated 'ineffective.'*
- *0 (Critical)—No bycatch management even when overfished, depleted, endangered or threatened species are known to be regular components of bycatch and are substatntially impacted by the fishery*

FACTOR 3.2 - BYCATCH STRATEGY						
Region / Method	**All Kept**	**Critical**	**Strategy**	**Research**	**Advice**	**Enforce**
Costa Rica / Eastern Central Pacific / Drifting longlines / Costa Rica	No	No	Moderately Effective	Ineffective	Ineffective	Ineffective
Peru / Southeast Pacific / Drifting longlines / Peru	No	No	Ineffective	Ineffective	Ineffective	Ineffective

Subfactor 3.2.2 – Management Strategy and Implementation

Considerations: What type of management strategy/measures are in place to reduce the impacts of the fishery on bycatch species and how successful are these management measures? To achieve a Highly Effective rating, the primary bycatch species must be known and there must be clear goals and measures in place to minimize the impacts on bycatch species (e.g., catch limits, use of proven mitigation measures, etc.).

COSTA RICA / EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA

Moderately Effective

Circle hooks, as a means to mitigate turtle bycatch, are mandated by executive decree, although there is little oversight to ensure compliance; olive ridley bycatch rates remain some of the highest in the world (R. Arauz, pers. comm.).

PERU / SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

Ineffective

At present there are no guidelines in place to reduce bycatch or to encourage the recovery of species of concern.

Subfactor 3.2.3 – Scientific Research and Monitoring

Considerations: Is bycatch in the fishery recorded/documented and is there adequate monitoring of bycatch to measure fishery's impact on bycatch species? To achieve a Highly Effective rating, assessments must be conducted to determine the impact of the fishery on species of concern, and an adequate bycatch data collection program must be in place to ensure bycatch management goals are being met

COSTA RICA / EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA

Ineffective

There is no governmental monitoring program for bycatch of sensitive species for this fishery. Research and monitoring is conducted jointly by WWF and INCOPESCA (R. Arauz, pers. comm.).

PERU / SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

Ineffective

WWF has recently conducted an assessment of Peru's mahi mahi fishery but the results of this study are not yet available.

Subfactor 3.2.4 – Management Record of Following Scientific Advice

Considerations: How often (always, sometimes, rarely) do managers of the fishery follow scientific recommendations/advice (e.g., do they set catch limits at recommended levels)? A Highly Effective rating is given if managers nearly always follow scientific advice.

COSTA RICA / EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA

Ineffective

PERU / SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

Ineffective

See 3.1 Harvest Strategy above.

Subfactor 3.2.5 – Enforcement of Management Regulations

Considerations: Is there a monitoring/enforcement system in place to ensure fishermen follow management regulations and what is the level of fishermen's compliance with regulations? To achieve a Highly Effective rating, there must be consistent enforcement of regulations and verification of compliance.

COSTA RICA / EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA

Ineffective

INCOPESCA is responsible for enforcing fisheries laws, although there is some concern as to effectiveness of this agency in policing the artisanal mahi mahi fleet (R. Arauz, pers. comm.).

PERU / SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

Ineffective

See 3.1 Harvest Strategy above.

Criterion 4: Impacts on the habitat and ecosystem

This Criterion assesses the impact of the fishery on seafloor habitats, and increases that base score if there are measures in place to mitigate any impacts. The fishery's overall impact on the ecosystem and food web and the use of ecosystem-based fisheries management (EBFM) principles is also evaluated. Ecosystem Based Fisheries Management aims to consider the interconnections among species and all natural and human stressors on the environment.

The final score is the geometric mean of the impact of fishing gear on habitat score (plus the mitigation of gear impacts score) and the Ecosystem Based Fishery Management score. The Criterion 2 rating is determined as follows:

- *Score >3.2=Green or Low Concern*
- *Score >2.2 and ≤3.2=Yellow or Moderate Concern*
- *Score ≤2.2=Red or High Concern*

Rating cannot be Critical for Criterion 4.

Criterion 4 Summary

Region / Method	Gear Type and Substrate	Mitigation of Gear Impacts	EBFM	Score
Costa Rica / Eastern Central Pacific / Drifting longlines / Costa Rica	5.00: None	0.00: Not Applicable	3.00: Moderate Concern	Green (3.870)
Peru / Southeast Pacific / Drifting longlines / Peru	5.00: None	0.00: Not Applicable	3.00: Moderate Concern	Green (3.870)

Criterion 4 Assessment

SCORING GUIDELINES

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

- *5 (None) - Fishing gear does not contact the bottom*
- *4 (Very Low) - Vertical line gear*
- *3 (Low)—Gears that contacts the bottom, but is not dragged along the bottom (e.g. gillnet, bottom longline, trap) and is not fished on sensitive habitats. Bottom seine on resilient mud/sand habitats. Midwater trawl that is known to contact bottom occasionally (*
- *2 (Moderate)—Bottom dragging gears (dredge, trawl) fished on resilient mud/sand habitats. Gillnet, trap, or bottom longline fished on sensitive boulder or coral reef habitat. Bottom seine except on mud/sand*
- *1 (High)—Hydraulic clam dredge. Dredge or trawl gear fished on moderately sensitive habitats (e.g., cobble or boulder)*
- *0 (Very High)—Dredge or trawl fished on biogenic habitat, (e.g., deep-sea corals, eelgrass and maerl) Note: When multiple habitat types are commonly encountered, and/or the habitat classification is uncertain, the score will be based on the most sensitive, plausible habitat type.*

Factor 4.2 - Mitigation of Gear Impacts

- *+1 (Strong Mitigation)—Examples include large proportion of habitat protected from fishing (>50%) with gear, fishing intensity low/limited, gear specifically modified to reduce damage to seafloor and modifications* *shown to be effective at reducing damage, or an effective combination of 'moderate' mitigation measures.*

- *+0.5 (Moderate Mitigation)—20% of habitat protected from fishing with gear or other measures in place to limit fishing effort, fishing intensity, and spatial footprint of damage caused from fishing.*
- *+0.25 (Low Mitigation)—A few measures are in place (e.g., vulnerable habitats protected but other habitats not protected); there are some limits on fishing effort/intensity, but not actively being reduced*
- *0 (No Mitigation)—No effective measures are in place to limit gear impacts on habitats*

Factor 4.3 - Ecosystem-Based Fisheries Management

- *5 (Very Low Concern)—Substantial efforts have been made to protect species' ecological roles and ensure fishing practices do not have negative ecological effects (e.g., large proportion of fishery area is protected with marine reserves, and abundance is maintained at sufficient levels to provide food to predators)*
- *4 (Low Concern)—Studies are underway to assess the ecological role of species and measures are in place to protect the ecological role of any species that plays an exceptionally large role in the ecosystem. Measures are in place to minimize potentially negative ecological effect if hatchery supplementation or fish aggregating devices (FADs) are used.*
- *3 (Moderate Concern)—Fishery does not catch species that play an exceptionally large role in the ecosystem, or if it does, studies are underway to determine how to protect the ecological role of these species, OR negative ecological effects from hatchery supplementation or FADs are possible and management is not place to mitigate these impacts*
- *2 (High Concern)—Fishery catches species that play an exceptionally large role in the ecosystem and no efforts are being made to incorporate their ecological role into management.*
- *1 (Very High Concern)—Use of hatchery supplementation or fish aggregating devices (FADs) in the fishery is having serious negative ecological or genetic consequences, OR fishery has resulted in trophic cascades or other detrimental impacts to the food web.*

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

COSTA RICA / EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA
PERU / SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

None

Surface longlines do not impact the sea floor substrate.

Factor 4.2 - Mitigation of Gear Impacts

COSTA RICA / EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA
PERU / SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

Not Applicable

Factor 4.3 - Ecosystem-Based Fisheries Management

COSTA RICA / EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA
PERU / SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

Moderate Concern

Mahi mahi are considered to be a mid-trophic-level species (Polovina et al. 2009, SAFMC 2003). Removal of any component of a biological community can have cascading effects on a host of other species (Crowder et al. 2008). Meso-predators like mahi mahi undoubtedly play an important ecological role (i.e. Crooks and Soule

1999, Estes et al. 1998), however this report focuses on the effects of commercial fisheries on organisms considered to be of exceptional importance to ecosystem function and food web structure. This includes those species whose effects on ecological processes are greater than would be predicted by their biomass alone, including top predators, ecosystem engineers and important primary producers (i.e. Sergio et al. 2008, Mumby et al. 2008). Apex predators (sharks) are captured and generally retained in the mahi mahi fisheries of Costa Rica, Peru and Ecuador but do not comprise a significant proportion of the catch during the austral summer months, when the majority of mahi mahi are landed.

IATTC has recently addressed the broader ecosystem implications of some EPO fishing practices and has supported several measures to reduce the impacts of longline fishers on shark populations. Among these, are a prohibition on the retention and sale of oceanic white tip sharks (Resolution C-11-10, 2011) and the soliciting for funding to support the development of technologies to allow for the release, and post-release monitoring of billfish, sharks and rays (Resolution C-04-05, 2006). Although members of IATTC, Costa Rica, Ecuador and Peru are each bound by these guidelines, whether this concern over ecological impacts of top predator removal translates into additional conservation measures at the national scale remains to be seen.

Acknowledgements

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

Seafood Watch would like to thank Randall Arauz, Sophie Whoriskey and two anonymous reviewers for graciously reviewing this report for scientific accuracy.

Appendix A: Extra By Catch Species

OLIVE RIDLEY TURTLE

Factor 2.1 - Inherent Vulnerability

COSTA RICA/EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA
PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

High

Generally, sea turtles have low inherent resilience. These species are long lived, in some cases taking as long as 40 years to reach sexual maturity (Mortimer & Donnelly 2008), and experience high hatchling and juvenile mortality (Abreu-Grobois and Plotkin 2008; IUCN 2011).

Factor 2.2 - Abundance

COSTA RICA/EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA
PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

High Concern

Factor 2.3 - Fishing Mortality

COSTA RICA/EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA

Moderate Concern

While pelagic longline fisheries are widely regarded as one of the main sources of fishing mortality for turtles (Lewison and Crowder 2007), no assessment of the impacts of these fisheries from Costa Rica and Ecuador on turtle populations has been conducted. Thus, the fishery contribution from these sources is unknown. Both countries have some measures in place that have been found to be effective in reducing turtle mortality when used correctly (i.e. circle hooks – see below and Criterion 3.2). In Peru, while the fishery-specific mortality on turtle populations is also unknown, there is some indication that the artisanal longline and net fleets may be having a severe impact. There are also no management measures in place to reduce mortality.

Justification:

Sea turtle conflict with mahi mahi longliners in the Eastern Pacific is, to some extent unavoidable. These five species of sea turtle each spend some aspect of their life history off the northwest coast of South America, bringing them into contact with Ecuador, Peru and Costa Rica's mahi mahi fishing fleets (Figure 8).

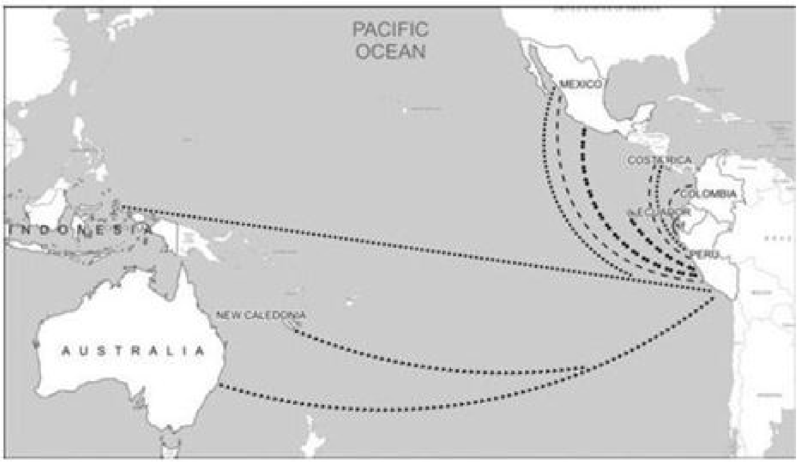

Fig. 2. Schematic view of linkages of turtles breeding stocks to Peruvian foraging grounds. Leatherback turtles (•): western and eastern Pacific rockeries (Eckert & Sarti 1997; Shillinger *et al.* 2008; Dutton *et al.* 2010). Olive ridleys (−−): Colombia, Mexico and Costa Rica (Zeballos & Arias-Schreiber 2001; Velez-Zuazo & Kelez 2010). Green turtles (♦ ♦): Galapagos Islands and Mexico (Hays-Brown & Brown 1982; Velez-Zuazo & Kelez 2010). Loggerhead turtles (▶▶): Australia and New Caledonia (Alfaro-Shigueto *et al.* 2004; Boyle *et al.* 2009). Hawksbill turtles (−): Mainland Ecuador as the closest nesting rockery for the species.

Figure 22 From Alfaro-Shigueto (2011) illustrating the movement of turtle stocks throughout the Southeastern Pacific Ocean.

Numerous observer programs have found that sea turtles are frequently caught in shallow longline sets (Lewison and Crowder 2007). For example, in Costa Rica's fishery, olive ridley hooking rates sometimes exceeds CPUE rates for mahi mahi (Swimmer et al. 2011). Despite the high initial survivability of most hookings, there may be delayed mortality due to the stress of capture or the secondary effects of hooking or hook removal, which cannot be accounted for through catch observation alone (Swimmer et al. 2006). Furthermore, the presence of observers likely affects fisher behavior, with vessels carrying observers being more likely to land captured turtles and remove the hooks with relative care, rather than simply rip out the hook or cut the line with the turtles still in the water (Arauz 2000).

Estimates of fishery captures of sea turtles vary considerably. For example, in separate studies of the Costa Rican mahi mahi fishery, Whoriskey et al. (2011) and Swimmer et al. (2012) found a catch rate (turtles/mahi mahi) of 0.17 and 2.21, respectively. Although, it should be noted that the Swimmer et al. (2012) study only partially overlapped with the traditional mahi mahi season, thus one would expect lower mahi mahi catch rates, which may account for the high turtle:mahi mahi ratio. A recent study of the effects of hook type on sea turtle bycatch in the Ecuadorian and Costa Rican mahi mahi fishery showed generally low hooking rates for sea turtles in these nations (Table 1). Alfaro-Shigueto et al. 2011 estimated a mean of 1061 greens, 133 olive ridleys, 2613 loggerheads and 6 leatherbacks are caught per year in the Peruvian mahi mahi longline fishery, and concluded that interactions with Peru's artisanal longline and net fleets may be severely impacting the populations of sea turtles in the Pacific (Alfaro-Shigueto et al. 2011).

While sea turtles are regularly hooked in the southeastern Pacific mahi mahi fishery, they are usually released alive, as the hook proximity to the surface allows the turtles to continue to surface to breathe (Swimmer et al. 2006, Witzell 1999). Governments and NGOs have focused much of their bycatch mitigation efforts for the mahi mahi fishery on reducing turtle hooking and entanglements. Loggerhead, hawksbill and olive ridley turtles are most often caught via biting baited hooks (Swimmer 2006, Largarcha et al. 2005) whereas leatherback and green turtles are more likely to become entangled in lines or to be hooked in flippers (Largarcha et al. 2005, Witzell 1999).

Hook modifications are the primary means of reducing sea turtle capture. Circle hooks are generally considered to be "turtle friendly," usually resulting in lower capture rates and fewer deep hookings when

compared to J-hooks (i.e. Andraka et al. 2013, Swimmer et al. 2006, 2011). There is an effort underway to encourage fishers in this region to replace the traditional J-style hooks with circle hooks (Mug et al. 2008). Fishers in Costa Rica routinely use circle hooks (E. Villagran pers. comm., R. Arauz pers. comm.) while Ecuador is actively encouraging fishers to switch from J to circle hooks (P. Guerrero pers. comm). J-hooks are still used predominantly in Peru.

In addition to lower catch rates for turtles, these hooks have been shown to result in lower catch rates for mahi mahi when compared to J-hooks (Largarcha et al. 2005, Mug et al. 2008), although circle hooks do yield a higher quality, and hence, more valuable mahi mahi catch (R. Arauz pers. comm.). The addition of an "appendage" to the commonly used 14/0 circle hook, showed a general decrease in CPUE for all species, including a reduction in sea turtle hookings by 52% and a 23% reduction in tunas and billfish captures (Swimmer et al., 2011). Despite the benefits for sea turtles, the economic cost of lower tuna, billfish and mahi mahi (R. Arauz pers. comm.) landings may make the use of these hooks impracticable (R. Arauz, pers. comm., Andraka et al. 2013). Other hook modifications (10°offset 14/0 circle hooks, Swimmer et al. 2010), or bait modifications (blue dyed bait, Swimmer et al., 2005) have failed to measurably reduce sea turtle catch rates.

Sea turtle bycatch in Costa Rican longline fisheries has been the subject of several recent studies (i.e. Arauz 2000, Swimmer et al. 2005, 2006, 2010, 2011, Whorisky et al. 2011, Andraka et al. 2013) with fairly ambiguous results. Sea turtle CPUE (per 1,000 hooks) varies from 1.5 (C 16/0 hooks, Andraka et al. 2013), to 9.05 (C 14-16/0, Whoriskey et al. 2011), to 19 (C 14/0 Swimmer et al. 2010). These discrepancies may be due in part to sampling proximity to nesting beaches or during times of year with higher or lower turtle densities (Andraka et al. 2013), although significant uncertainty remains around the impact of Costa Rican mahi mahi fishers on local and regional turtle populations.

The Ecuadorian government is currently working on several fronts to increase circle hook usage in the mahi mahi fleet including supplying circle hooks for a J-hook exchange program, training fishers on proper handling and release of hooked or entangled turtles and exploring technologies to reduce entanglement (P. Guerrero pers. comm.). The government has recently reduced the import tariff on circle hooks, while leaving this tax in place for J-hooks, in order to ensure the widespread availability of circle hooks at competitive prices. The end goal of these activities is to mandate the use of circle hooks and other mitigation measures, once circle hooks are readily available to Ecuadorian fishers.

	Ecuador				Costa Rica	
	J-hook CPUE	C 15/0 CPUE	J-hook (No.4,5) CPUE	C 14/0 CPUE	J-hook (No. 2,3) CPUE	C 16/0 CPUE
Target species:						
Coryphaena hippurus	144.13	86.34	151.94	101.93	24.66	27.86
Sea turtles:						
Caretta caretta	0	0	0.09	0	-	-
Chelonia mydas	0.41	0.34	0.45	0	-	-
Eretmochelys imbricata	0.49	0.08	0.54	0.45	0.03	0.08
Lepidochelys olivacea	1.07	1.17	1.16	0.81	2.32	1.5

Figure 23 Sea turtle catch rates by hook type in Ecuador (J vs. C15/0 and J vs.C14/0) and Costa Rica's (J vs. C16/0) mahi mahi fishery (Andraka et al. 2013). Catch per unit effort (CPUE) rates are per 1,000 hooks.

There was a directed sea turtle fishery in Peru through much of the 1990's and evidence suggests that some harvest continued following the 1995 ban on the commercial capture of turtles (Arauz, 1999, Alfaro-Shigueto et al. 2011). A hook exchange program has been initiated by a coalition of organizations (Pro Delphinus, WWF, NFWF, NOAA), but there are currently no government mandated measures in place to reduce sea turtle bycatch (J. Alfaro-Shigueto pers. comm., A. Gonzales, pers. comm.).

PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

High Concern

While pelagic longline fisheries are widely regarded as one of the main sources of fishing mortality for turtles (Lewison and Crowder 2007), no assessment of the impacts of these fisheries from Costa Rica and Ecuador on turtle populations has been conducted. Thus, the fishery contribution from these sources is unknown. Both countries have some measures in place that have been found to be effective in reducing turtle mortality when used correctly (i.e. circle hooks – see below and Criterion 3.2). In Peru, while the fishery-specific mortality on turtle populations is also unknown, there is some indication that the artisanal longline and net fleets may be having a severe impact. There are also no management measures in place to reduce mortality.

Justification:

Sea turtle conflict with mahi mahi longliners in the Eastern Pacific is, to some extent unavoidable. These five species of sea turtle each spend some aspect of their life history off the northwest coast of South America, bringing them into contact with Ecuador, Peru and Costa Rica's mahi mahi fishing fleets (Figure 8).

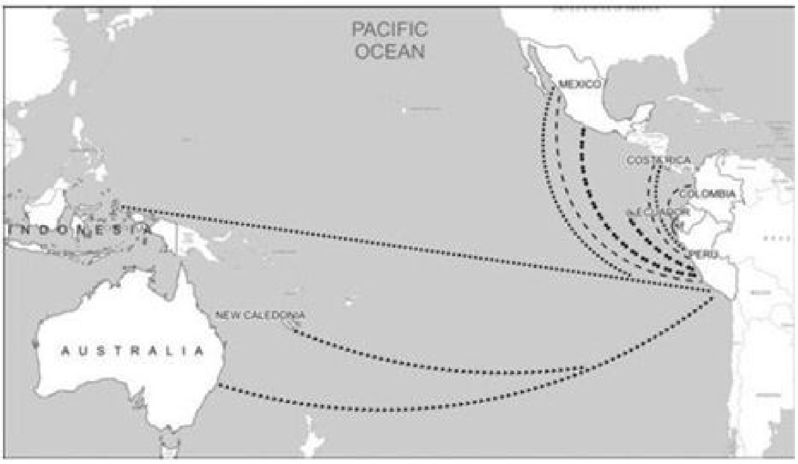

Fig. 2. Schematic view of linkages of turtles breeding stocks to Peruvian foraging grounds. Leatherback turtles (•): western and eastern Pacific rockeries (Eckert & Sarti 1997; Shillinger *et al.* 2008; Dutton *et al.* 2010). Olive ridleys (‒‒): Colombia, Mexico and Costa Rica (Zeballos & Arias-Schreiber 2001; Velez-Zuazo & Kelez 2010). Green turtles (♦ ♦): Galapagos Islands and Mexico (Hays-Brown & Brown 1982; Velez-Zuazo & Kelez 2010). Loggerhead turtles (▶▶): Australia and New Caledonia (Alfaro-Shigueto *et al.* 2004; Boyle *et al.* 2009). Hawksbill turtles (‒): Mainland Ecuador as the closest nesting rockery for the species.

Figure 24 From Alfaro-Shigueto (2011) illustrating the movement of turtle stocks throughout the Southeastern Pacific Ocean.

Numerous observer programs have found that sea turtles are frequently caught in shallow longline sets (Lewison and Crowder 2007). For example, in Costa Rica's fishery, olive ridley hooking rates sometimes exceeds CPUE rates for mahi mahi (Swimmer et al. 2011). Despite the high initial survivability of most hookings, there may be delayed mortality due to the stress of capture or the secondary effects of hooking or hook removal, which cannot be accounted for through catch observation alone (Swimmer et al. 2006). Furthermore, the presence of observers likely affects fisher behavior, with vessels carrying observers being more likely to land captured turtles and remove the hooks with relative care, rather than simply rip out the hook or cut the line with the turtles still in the water (Arauz 2000).

Estimates of fishery captures of sea turtles vary considerably. For example, in separate studies of the Costa Rican mahi mahi fishery, Whoriskey et al. (2011) and Swimmer et al. (2012) found a catch rate (turtles/mahi mahi) of 0.17 and 2.21, respectively. Although, it should be noted that the Swimmer et al. (2012) study only partially overlapped with the traditional mahi mahi season, thus one would expect lower mahi mahi catch rates, which may account for the high turtle:mahi mahi ratio. A recent study of the effects of hook type on sea turtle bycatch in the Ecuadorian and Costa Rican mahi mahi fishery showed generally low hooking rates for sea turtles in these nations (Table 1). Alfaro-Shigueto et al. 2011 estimated a mean of 1061 greens, 133 olive ridleys, 2613 loggerheads and 6 leatherbacks are caught per year in the Peruvian mahi mahi longline fishery, and concluded that interactions with Peru's artisanal longline and net fleets may be severely impacting the populations of sea turtles in the Pacific (Alfaro-Shigueto et al. 2011).

While sea turtles are regularly hooked in the southeastern Pacific mahi mahi fishery, they are usually released alive, as the hook proximity to the surface allows the turtles to continue to surface to breathe (Swimmer et al. 2006, Witzell 1999). Governments and NGOs have focused much of their bycatch mitigation efforts for the mahi mahi fishery on reducing turtle hooking and entanglements. Loggerhead, hawksbill and olive ridley turtles are most often caught via biting baited hooks (Swimmer 2006, Largarcha et al. 2005) whereas leatherback and green turtles are more likely to become entangled in lines or to be hooked in flippers (Largarcha et al. 2005, Witzell 1999).

Hook modifications are the primary means of reducing sea turtle capture. Circle hooks are generally considered to be "turtle friendly," usually resulting in lower capture rates and fewer deep hookings when compared to J-hooks (i.e. Andraka et al. 2013, Swimmer et al. 2006, 2011). There is an effort underway to encourage fishers in this region to replace the traditional J-style hooks with circle hooks (Mug et al. 2008). Fishers in Costa Rica routinely use circle hooks (E. Villagran pers. comm., R. Arauz pers. comm.) while Ecuador is actively encouraging fishers to switch from J to circle hooks (P. Guerrero pers. comm). J-hooks are still used predominantly in Peru.

In addition to lower catch rates for turtles, these hooks have been shown to result in lower catch rates for mahi mahi when compared to J-hooks (Largarcha et al. 2005, Mug et al. 2008), although circle hooks do yield a higher quality, and hence, more valuable mahi mahi catch (R. Arauz pers. comm.). The addition of an "appendage" to the commonly used 14/0 circle hook, showed a general decrease in CPUE for all species, including a reduction in sea turtle hookings by 52% and a 23% reduction in tunas and billfish captures (Swimmer et al., 2011). Despite the benefits for sea turtles, the economic cost of lower tuna, billfish and mahi mahi (R. Arauz pers. comm.) landings may make the use of these hooks impracticable (R. Arauz, pers. comm., Andraka et al. 2013). Other hook modifications (10°offset 14/0 circle hooks, Swimmer et al. 2010), or bait modifications (blue dyed bait, Swimmer et al., 2005) have failed to measurably reduce sea turtle catch rates.

Sea turtle bycatch in Costa Rican longline fisheries has been the subject of several recent studies (i.e. Arauz 2000, Swimmer et al. 2005, 2006, 2010, 2011, Whorisky et al. 2011, Andraka et al. 2013) with fairly ambiguous results. Sea turtle CPUE (per 1,000 hooks) varies from 1.5 (C 16/0 hooks, Andraka et al. 2013), to 9.05 (C 14-16/0, Whoriskey et al. 2011), to 19 (C 14/0 Swimmer et al. 2010). These discrepancies may be due in part to sampling proximity to nesting beaches or during times of year with higher or lower turtle densities (Andraka et al. 2013), although significant uncertainty remains around the impact of Costa Rican mahi mahi fishers on local and regional turtle populations.

The Ecuadorian government is currently working on several fronts to increase circle hook usage in the mahi mahi fleet including supplying circle hooks for a J-hook exchange program, training fishers on proper handling and release of hooked or entangled turtles and exploring technologies to reduce entanglement (P. Guerrero pers. comm.). The government has recently reduced the import tariff on circle hooks, while leaving this tax in place for J-hooks, in order to ensure the widespread availability of circle hooks at competitive prices. The end goal of these activities is to mandate the use of circle hooks and other mitigation measures, once circle hooks are readily available to Ecuadorian fishers.

	Ecuador				Costa Rica	
	J-hook CPUE	C 15/0 CPUE	J-hook (No.4,5) CPUE	C 14/0 CPUE	J-hook (No. 2,3) CPUE	C 16/0 CPUE
Target species:						
Coryphaena hippurus	144.13	86.34	151.94	101.93	24.66	27.86
Sea turtles:						
Caretta caretta	0	0	0.09	0	-	-
Chelonia mydas	0.41	0.34	0.45	0	-	-
Eretmochelys imbricata	0.49	0.08	0.54	0.45	0.03	0.08
Lepidochelys olivacea	1.07	1.17	1.16	0.81	2.32	1.5

Figure 25 Sea turtle catch rates by hook type in Ecuador (J vs. C15/0 and J vs.C14/0) and Costa Rica's (J vs. C16/0) mahi mahi fishery (Andraka et al. 2013). Catch per unit effort (CPUE) rates are per 1,000 hooks.

There was a directed sea turtle fishery in Peru through much of the 1990's and evidence suggests that some harvest continued following the 1995 ban on the commercial capture of turtles (Arauz, 1999, Alfaro-Shigueto et al. 2011). A hook exchange program has been initiated by a coalition of organizations (Pro Delphinus, WWF, NFWF, NOAA), but there are currently no government mandated measures in place to reduce sea turtle bycatch (J. Alfaro-Shigueto pers. comm., A. Gonzales, pers. comm.).

Factor 2.4 - Discard Rate

COSTA RICA/EASTERN CENTRAL PACIFIC, DRIFTING LONGLINES, COSTA RICA
PERU/SOUTHEAST PACIFIC, DRIFTING LONGLINES, PERU

< 20%

Discard rates are unknown for the mahi mahi fisheries in Ecuador, Peru, Costa Rica and Guatemala. Small-scale operators typically have lower discard rates than industrial scale vessels (Kelleher 2005), because artisanal fishers are able to utilize more of the incidental catch. Kelleher (2005) assumed a discard rate of <1 to 5% for artisanal fisheries. In keeping with this standard, the discard rate for the mahi mahi fisheries in Ecuador, Peru and Costa Rica was categorized as <20%. Kelleher (2005) also found that industrial scale longliners targeting HMS, like those used in the Guatemalan mahi mahi fishery, averaged a discard rate of 28.5%, however, the majority of incidentally captured fish is consumed in the domestic market (E. Villagrán, pers. comm.) so the discard rate in this fishery is likely significantly lower.