Seafood Watch
Seafood Report

MONTEREY BAY AQUARIUM®

Tako (Madako)
Common Octopus
Octopus vulgaris

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About Seafood Watch® and the Seafood Reports

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.

Disclaimer

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

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I. Scope of the Analysis and the Ensuing Recommendation

This report concentrates solely on sushi-grade imported octopus: blanched, frozen *O. vulgaris* that is sold to the United States (US) sushi industry or to certain specialty markets. That being said, there are numerous octopus species consumed in the United States, including *O. mimus, O. maya, O. aegina, O. cyanea, O. dollfusi, O. macropus* and *O. membranaceus*; this product is imported from various countries.

Sushi restaurants in the United States use *O. vulgaris* that has been sourced primarily from North Africa, Vietnam, and Spain by the Japanese octopus preparation industry. This product is blanched, prepared, and then exported (or re-exported) to the United States for consumption. As such, this report examines the North African, Spanish, and Vietnamese octopus fisheries and offers recommendations on their sustainability. While the largest exporter of octopus to the US is the Philippines (NMFS 2006), this report concentrates solely on octopus used by the US sushi industry, which is not a Philippine product as the Philippines does not export large amounts of *O. vulgaris* to Japan for processing.

Octopus fisheries occur in many countries throughout Asia, Africa and Europe, including China, Japan, Thailand, Portugal, Italy, Greece, and Senegal. There is discussion within this report on octopus production in Japan (domestic landings), Thailand, China, Portugal, Tunisia, and Senegal. However, for various reasons (which are explained in the coming pages) this report does not offer recommendations on these fisheries.

II. Executive Summary

The octopus sourced for use in sushi and sashimi by the American sushi industry is generally *Octopus vulgaris*, the common octopus[1]. However, other octopus species are sometimes sold and marketed as *O. vulgaris*. The common octopus occurs in most neritic zones throughout the world with the exception of the colder waters of the Southern Ocean, the northern Pacific, and parts of the northern Atlantic. Product is sourced by the Japanese octopus industry from numerous areas around the globe. When it reaches Japan, it is prepared for use in sushi and then re-exported. As such, it is difficult to obtain an accurate idea about the country of origin of octopus used in the sushi industry.

The primary *O. vulgaris* fishery is located off the coast of the Western Sahara zone of Morocco, and has historically been exploited by Moroccan and foreign efforts. Other countries with major *O. vulgaris* fisheries include Mauritania, Spain, Japan, and Vietnam. The combined product of these fisheries is believed to constitute the great majority of the octopus imported and served by American sushi restaurants. This report contains recommendations on the sustainability of four of the five aforementioned fisheries; the Japanese domestic fishery is excluded due to a lack of verifiable information.

The common octopus is naturally resilient to fishing pressure due to its short lifespan, quick maturation, high fecundity, and rapid growth rate. Unfortunately, many of the traditional *O. vulgaris* fishing grounds have a history of over-exploitation and mismanagement. Moreover, information is not available in English, and critical data are unavailable for certain fisheries. This lack of information poses an additional challenge for the agencies seeking to manage or rebuild these stocks. Stock status appears questionable in all of the fisheries, but Spain is likely the most stable, followed by Morocco. There is a pronounced insufficiency of reliable data from Mauritania and Vietnam where *O. vulgaris* populations may be in poor shape due to a lack of management.

The majority of common octopus is caught either using octopus pots or bottom (otter) trawls. The former tends to have very low levels of bycatch. Bottom trawling, on the other hand, can severely damage the local benthos and often has high discard rates. The Spanish pot fishery has the lowest bycatch rate of any *O. vulgaris* fisheries due to transparency and non-lethal apprehension methods; therefore, bycatch concerns in these fisheries are "low." The Vietnamese trawl fishery retains and uses entire catches regardless of their composition, which can be considered byproducts instead of bycatch. A precautionary approach dictates, however, that the definition of bycatch includes unmanaged and unaccounted-for captures even if they are used. Thus, bycatch concerns in the Vietnamese fishery are "high." The Moroccan trawl fishery and Spanish trawl fisheries have relatively the same discard rate, averaging around 40%. The Mauritanian trawl fisheries have a discard rate of 60%. As such, bycatch concerns in these fisheries are "moderate."

Bottom trawling is more destructive to the local ecosystem than pot fishing. While little is known about the long-term effects of removing the common octopus from the ecosystem, it is

[1] *O. vulgaris* refers to the '*vulgaris* species complex' as it has a wide range and is currently being debated by systematists exactly which species is *vulgaris*.

understood that repetitive bottom trawling causes major damage to targeted habitats preferred by *O. vulgaris*, which are moderately to highly vulnerable to that type of disturbance. As such, the Spanish pot fishery's effects on habitat and ecosystems is rated "moderate", resulting in less bottom damage than the trawl fisheries, which are ranked "high" for their effects on habitat and ecosystems.

Management varies between the producing countries. Morocco has a history of stock over-exploitation, but has recently revitalized its fishery management system; its effectiveness has yet to be determined. Spanish stocks seem stable and management is relatively pro-active, although increasing European demand may put more pressure on Mediterranean *O. vulgaris* populations in the future. Despite recent strides in management techniques, Vietnamese management is ineffectual. Vietnamese stocks are known to be over-exploited, but overfishing is most likely still occurring. Little is known about Mauritanian management practices, but one can infer from recent heavy increases in exploitation along with a sudden severe decline in export quantity that stock strength may be tenuous. In addition, Mauritania has recently signed a fisheries partnership agreement with the European Union (EU), which allows the stock to be further exploited.

It should be mentioned that there is a domestic *O. vulgaris* fishery in the United States, primarily in the Gulf of Mexico and off the southern extremes of the eastern seaboard. Because the amount of octopus exported from the US to Japan approaches zero, this fishery does not likely contribute to the US sushi market and is not included in this report.

Due to the rampant confusion, weak stock status, and general lack of management present in the *O. vulgaris* industry, *tako* should generally be avoided. Spanish octopus (especially pot-caught) is the preferred alternative, but identifying the country of origin of the octopus being served at a given sushi bar is nearly impossible, as all of the product passes through Japan for re-processing and thus deemed a "product of Japan" under US import law.

The combination of individual criteria results in an overall rating of "Good Alternative" for the Spanish inshore pot and offshore trawl fisheries, and "Avoid" for the Moroccan, Mauritanian, and Vietnamese fisheries. However, due to the difficulty associated with discerning the actual country of origin of octopus found in US sushi restaurants, *tako* should be avoided as a general rule. While Spanish octopus (especially pot-caught) is a preferred alternative to North African and Vietnamese octopus, it is rare that sufficient sourcing information is available to the consumer.

Table of Sustainability Ranks

	Conservation Concern			
Sustainability Criteria	**Low**	**Moderate**	**High**	**Critical**
Inherent Vulnerability	√			
Status of Stocks		√ (Spain, Morocco)	√ **(Vietnam)**	√ (Mauritania)
Nature of Bycatch	√ (Pot: Spain inshore)	√ (Bottom trawl: Morocco, Mauritania, Spain offshore)	√ (Bottom trawl: Vietnam)	
Habitat & Ecosystem Effects		√ (Pot: Spain inshore)	√ (Bottom trawl: Morocco, Mauritania, Spain offshore, Vietnam)	
Management Effectiveness		√ (Spain)		√ (Morocco, Mauritania, Vietnam)

About the Overall Seafood Recommendation:

- A seafood product is ranked **Best Choice** if three or more criteria are of Low Conservation Concern (green) and the remaining criteria are not of High or Critical Conservation Concern.
- A seafood product is ranked **Good Alternative** if the five criteria "average" to yellow (Moderate Conservation Concern) OR if the "Status of Stocks" and "Management Effectiveness" criteria are both of Moderate Conservation Concern.
- A seafood product is ranked **Avoid** if two or more criteria are of High Conservation Concern (red) OR if one or more criteria are of Critical Conservation Concern (black) in the table above.

Overall Seafood Recommendation: Spain

Best Choice | **Good Alternative** | Avoid

Overall Seafood Recommendation: Morocco, Mauritania, Vietnam

Best Choice | Good Alternative | **Avoid**

III. Introduction

Basic Biology

Octopus vulgaris is a benthic species that inhabits neritic zones occurring from the coastline to the outer edge of the continental shelf. It dwells in numerous distinct habitats, including atop rocky substrate, amongst coral reefs, and along grassy beds. It is exothermic and enters an inactive state in waters of 7°C or colder (Oosthuizen 2003; Rodriguez-Rua 2005).

The common octopus has a vast range and is found in offshore waters across much of the globe (FAO 2001; Balguerías et al. 2002) (Figure 1). Depending on its location, *O. vulgaris* is known to vary widely in numerous life history parameters. It is thought that *O. vulgaris* has a number of subspecies, but full taxonomic classification is incomplete (Oosthuizen 2003).

Figure 1. *Octopus vulgaris* distribution throughout the world's oceans. There is still much conjecture as to the distinct territorial limits of *O. vulgaris* (FAO 2001).

O. vulgaris is known to undertake seasonal migrations within its general habitat, over-wintering in deeper waters and returning to shallower areas during the summer. Two migrations seem to occur in most populations, with the first mainly consisting of mature animals and the second of juveniles. This is especially pronounced in the western Mediterranean populations (FAO 2001).

As is the case with most cephalopods, *O. vulgaris* grows quickly and has a relatively short lifespan (Rodriguez-Rua 2005). Although the common octopus seems to spawn year-round (Wodinsky 1972), there are observable spawning peaks at two distinct times during the year. For populations in the Mediterranean and the Inland Sea of Japan, the first spawning peak occurs in April/May, corresponding to octopuses undergoing inshore migration in spring. The second peak comes in October, corresponding to an autumn migration group (FAO 2001; Fernández-Rueda et al. 2007). For West African populations, the first spawning peak occurs in May/June and the second and more important peak occurs in September (FAO 2001).

Male octopuses possess a specialized hectocotylus arm, which is used to transfer sperm into the body cavity of the female. The female is able to store these spermatophores in her oviducal glands until spawning (Mangold-Wirz 1963).

During each breeding cycle, a female common octopus lays between 100,000 and 500,000 eggs (Figure 2). The female attaches these eggs to the substrate and will guard and clean them until they hatch. This generally takes about one month, during which time the female occupies herself completely with caring for the eggs, even neglecting to feed. In most cases, she dies shortly after the eggs hatch (Oosthuizen 2003).

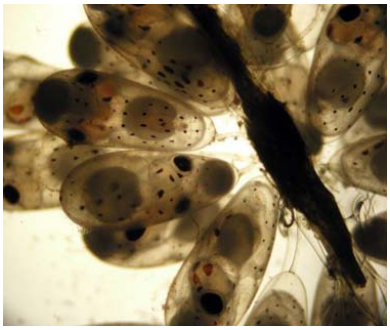


Figure 2. *O. vulgaris* eggs (Anon.)

After they hatch, the pelagic octopus larvae live within the planktonic food web for 1 to 2 months (Figure 3). These hatchlings weigh approximately 1.2 mg with a mantle length of 1.7 mm (Mangold 1997). The duration of this planktonic stage is temperature-dependent, and is known to vary from 33 – 40 days at 22 – 27˚C (Itami et al. 1963) and 50 – 60 days at 21˚C (Villanueva 1995). The larvae that survive the myriad of predators feeding on the plankton cloud enter a benthic stage, and are considered juveniles until reaching sexual maturity at 1 - 2 years of age (Figure 4).

Figures 3 and 4. Octopus in larval stage (left) and juvenile stage (right) (Sources UBC and MBL, respectively).

Availability of Science

There is a wealth of information about the biology of *O. vulgaris*. The common octopus is a very well-researched organism and many publications are available on its life history, behavior, and physiology.

Information on the basic biology of *O. vulgaris* is taken primarily from the well-known biological research of K. Mangold, and is augmented with data from the Food and Agriculture Organization of the United Nations (FAO) and the scientific observations of other researchers, including Itami, Oosthuizen, Quetglas, and Rodriguez-Rua. Data concerning stock assessment and estimates of exploitation rates are made available by the FAO as well as certain industry publications, such as Globefish and Fistenet. Some octopus fisheries, most notably in the Mediterranean, have a fair amount of scientific data that have been gathered over the past few decades. A moderate amount of information for the octopus fisheries in Morocco and Mauritania is available from the FAO Fishery Committee for the Eastern Central Atlantic and from other researchers including Gascuel, Zeller, and Balguerías. While much research has been conducted on the life history and behavior of *O. vulgaris*, there is an unfortunate lack of data in regard to stock status and fishery management in Vietnam and other Asian regions. It should be noted that in many cases there is little information available in English, and the authors of this report were thus unable to gather and synthesize information. This report adopts precautionary principles when confronted with missing information and/or questionable practices.

Market Availability

Common and market names:
Octopus is known as *tako* in sushi bars; *O. vulgaris* proper is technically known as *madako* although the term *tako* is generally used. It is exceedingly rare for octopus to be listed by species on menus in seafood establishments or in markets, although at times "baby octopus" is available. "Baby octopus" is either just that or adult octopus of a smaller species.

Seasonal availability:
Octopus is available year-round, although often in different forms. The spawning spikes that bring mature octopus into shallower waters increase the take from inshore pot fisheries, while off-season catch generally consists of deeper-water trawls that target smaller octopuses. However, this is a moot point for the American sushi industry, as the amount of octopus consistently in Japanese cold storage is able to provide the US consumer with top-quality large octopus throughout the year. Japanese purveyors have managed to keep the surplus at relatively stable levels for the last three years (Figure 5).

Figure 5. Japanese cold storage of imported and domestic octopus (Globefish 2006c).

Product forms:
Octopus is available in a myriad of forms. Live, fresh, dried, frozen, cured, salted, and brined octopus are all available to the public in seafood markets or specialty grocery stores. Restaurants with an Asian or Mediterranean theme may offer octopus, often prepared in a traditional manner. Some of this product is *O. vulgaris*, but other species are also available.

Import and export sources and statistics:
There are two distinct octopus markets in the US – one for prepared octopus (frozen, salted, in brine, etc.), and a second for fresh or live octopus. The sushi industry supports the former; most Japanese restaurants purchase prepared, blanched octopus for use in various dishes.

US sushi restaurants generally use octopus imported from Japan. It is often the case, however, that the octopus originates elsewhere – most typically from North Africa – and is sent to Japan for processing and re-export.

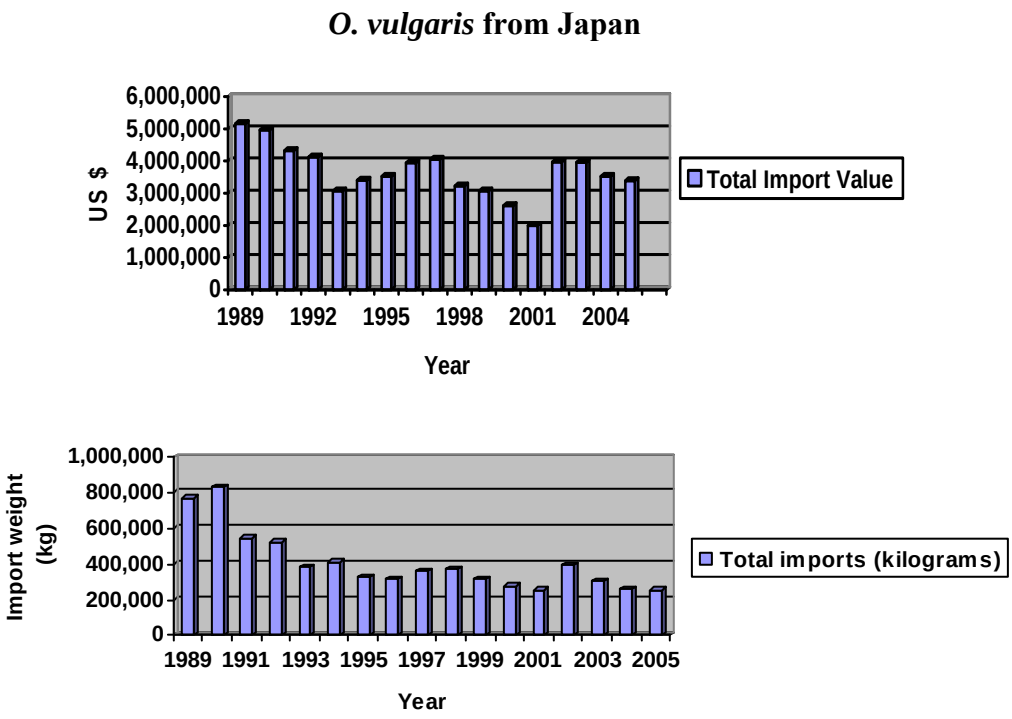
The Moroccan fishery has historically dominated the Japanese market, but a shift towards Chinese octopus began in 2002 and reached an apex in 2004, congruent with a decline in Moroccan production. As of 2004, Morocco lost its position at the top of the Japanese market, which it had held for decades (Globefish 2005b). Mauritanian exports have varied since 1998, and began increasing in 2002, surpassing Morocco in 2004 (Table 1) (Globefish 2007).

Table 1. Japanese octopus imports (Source Globefish 2007).

	1998	1999	2000	2001	2002	2003	2004	2005	2006	Jan-Apr 2006	Jan-Apr 2007
			(1000 tonnes)								
Mauritania	18.6	24.8	21.3	10.2	7.6	11.8	14.5	19.5	16.6	3.1	4.8
Morocco	36.2	52.8	72.6	58.3	43.0	21.0	5.2	8.7	8.7	5.8	4.1
China	4.3	2.7	3.4	4.0	7.5	7.2	13.1	9.9	8.2	2.3	1.9
Viet Nam	*	*	2.4	3.9	4.7	4.9	5.9	5.6	5.5	1.8	1.5
Thailand	2	2.8	4.4	3.0	4.1	3.0	1.8	3.0	1.9	0.5	0.7
Spain	7.9	7.5	7.7	3.6	3.3	1.0	1.8	2.3	4.0	0.5	0.5
Others	8.3	12.6	4.5	2.7	4.5	7.0	11.0	6.5	3.5	1.9	1.0
Total	77.3	103.2	116.3	85.7	74.7	55.9	53.3	55.5	48.4	15.9	14.5

Octopus imports from Japan have leveled off since the late 1980s, although the price continues to climb (Figures 6-8). As of 2005, prepared octopus was priced between US $13 - $14 per kilogram. This is nearly double the $6 - $8 per kilogram price of the early 1990s (NMFS 2006b)

NMFS trade data groups all prepared (or frozen) octopus together, regardless of species, method of preparation, or target market. As such, it is unknown what segment of these imports was directed towards, or purchased by, the sushi industry. It should be noted, however, that there are other major exporters of prepared or frozen octopus, most notably the Philippines, which provide product to the US at much lower prices (NMFS 2006b). While sushi establishments generally demand fish and shellfish of the highest quality, less particular customers may choose to purchase octopus from other sources.



Figures 6 and 7. Total import value in US dollars (above) and total imports in kilograms (below) of *O. vulgaris* from Japan (adapted from NMFS 2006b).

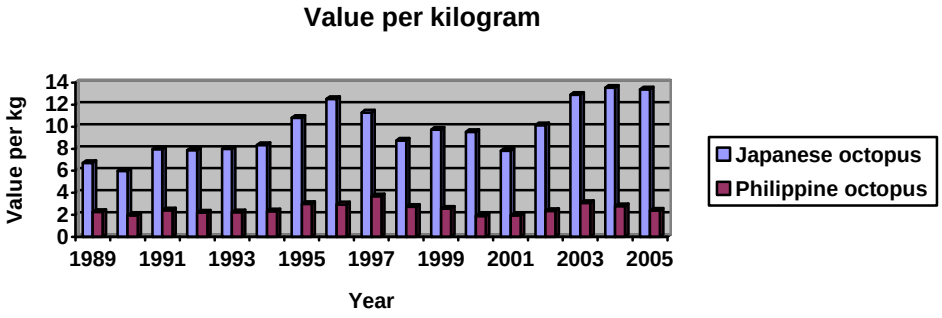


Figure 8. Comparison of value per kilogram between imported Japanese and Philippine product (adapted from NMFS 2006b).

Vietnam catches and exports a variety of species of octopus, one of which is *O. vulgaris*. Unfortunately, Vietnamese export data do not differentiate octopus by species, and thus it is difficult to tell what proportion of the Vietnamese catch is *O. vulgaris*. In 2004, a total of 23,351 mt of *Octopus spp.* were exported from Vietnam (FAO 2005b). The Vietnamese exports include marbled octopus (*Octopus dollfusi),* short arm octopus (*Octopus ocellatus),* and several other species, including *O. vulgaris*. Japan is the largest consumer of Vietnamese octopus, with a 41% share of exported product in 2004 (Fistenet 2006). While *O. vulgaris* was almost certainly

represented in these exports, its proportion within the total is unknown. Without export or catch figures, total landings of *O. vulgaris* in Vietnam remain elusive.

There is an "octopus sashimi" exported from Vietnam that may be *O. dollfusi* rather than *O. vulgaris* (Fistenet 2006). This seems to be local terminology referring to frozen skewered cut octopus meant to be consumed without further preparation. Whether or not this product is considered sushi-grade in Japan or the US is unknown.

IV. Analysis of Seafood Watch® Sustainability Criteria for Wild-caught Species

Criterion 1: Inherent Vulnerability to Fishing Pressure

The common octopus has an estimated intrinsic rate of increase of 0.18, growing quickly and reaching maturity at a relatively young age (as is the case with most cephalopods) (CephBase 2002). *O. vulgaris* is able to reproduce at the age of 1 – 2 years, by which time its average weight is over 2 kg.

Sizes and growth rates differ depending on temperature and location, and constants used to describe the growth of *O. vulgaris* may not be globally applicable. Common octopuses in the Inland Sea of Japan are known to reach about 1 kg in four months; in the western Mediterranean, the same animal may grow from 3 to about 20 cm in seventeen months (FAO 2001). Growth patterns in the western Mediterranean display octopuses with a mantle length of 6-7 cm in January growing to a mantle length of 11-12 cm by August (Quetglas et al. 1998). The maximum total length of *O. vulgaris* is thought to be 1.2 m in females and 1.3 m in males (FAO 2001). Adult animals weigh 2 - 10 kg (Mangold 1997) with sizes over 3 kg being less common (FAO 2001). In the western Mediterranean, mantle length at first maturity is about 9.5 cm in males (190 g weight) and 13.5 cm in females (FAO 2001). Along the Atlantic coast of Southern Spain, average weight at first maturity is 850 g for males and 1,250 g for females (Rodruigez-Rua et al. 2005).

Octopuses are benthic hunters and subsist mainly on a variety of bivalves and crustaceans (Smale and Buchan 1981). Larvae and juvenile octopuses are preyed upon by albacore tuna (*Thunnus alalunga*) and other pelagic predators subsisting on the plankton cloud, while adults are eaten by benthic finfishes (FAO 2001).

The von Bertalanffy growth equation for *O. vulgaris* varies by region. The northern Cape Barbas - Cape Garnett stock along the North African coast has a lower growth rate than the neighboring stock to the south off Cape Blanc, with K values of 0.47 and 0.65 respectively (FAO 1978; Hanataka 1979).

Although *O. vulgaris* only reaches the age of 3 – 5 years, its reproductive potential is high. A female common octopus is able to produce between 50,000 and 750,000 eggs during its relatively short lifespan (Mangold 1983; Oosthuizen 2003). This level of fecundity should help to maintain the population in the face of predation and fishing pressure.

The worldwide *O. vulgaris* habitat is extremely expansive, stretching from the Gulf of Mexico south to the Chilean coast and as far east as the Sea of Japan. The common octopus is thought to occur in all temperate and tropical neritic zones within these boundaries (FAO 2001). While the sheer range of the common octopus may serve to further bolster its resilience, *O. vulgaris* undertakes a yearly or semi-yearly migration from deepwater areas to inshore habitat for spawning purposes, a behavior which invites heavily targeted fishing pressure during these periods (Table 2) (FAO 2001).

Table 2. Life history characteristics of *Octopus vulgaris*.

Intrinsic Rate of Increase (r)	Age at Maturity	Growth Rate	Max Age	Max Size	Fecundity	Species Range	Special Behaviors	Sources
0.18	435 growth days	Varies according to temperature and location	5 years	10 kg	100k – 500k eggs per breeding female	From the Gulf of Mexico south to Chile and east to Japan in temperate to tropical neritic zones	Offshore to inshore migration prior to spawning; two pronounced spawning periods per year	Itami et al. 1963; Mangold 1983; Villanueva 1995; Mangold 1997; Wood 2000; FAO 2001; Cephbase 2002; Oosthuizen 2003; Rodruigez-Rua et al 2005

Synthesis

O. vulgaris is a naturally resilient organism, with high fecundity, low age at maturity, a relatively short lifespan, and rapid growth rate. Its migratory behavior and spawning spikes do impart a certain level of vulnerability, but when properly managed and exploited, the common octopus should be able to withstand a substantial amount of directed fishing pressure.

Inherent Vulnerability Rank:

Resilient Moderately Vulnerable Highly Vulnerable

Criterion 2: Status of Wild Stocks

The North African common octopus trawl fishery has historically been the largest *O. vulgaris* fishery in the world. This fishery reached a peak with a combined international catch of 135,000 tons in 1994 (FAO 1997). It is based in the waters of Morocco and Mauritania, with occasional catches from Senegalese territory. Traditionally, much of the North African common octopus catch is exported to Japan, either for local consumption or re-export (Guerra 1997).

O. vulgaris also supports other fisheries in a multitude of locations around the globe. Some of these fisheries are long-standing and targeted, while others have recently developed or only occur as non-targeted catch of other fisheries. This report will not attempt to cover global *O. vulgaris* production, but will concentrate on the major fisheries supporting the octopus demand of the US sushi industry.

Morocco (North African Northern Stock: Cape Garnett – Cape Barbas)
Morocco is generally considered to be the most important producer of *O. vulgaris* product in the world (Globefish 2006a). Most of the Moroccan octopus sourced by the American sushi industry passes through Japan for processing before reaching the US sushi market.

This fishery emerged in the 1960s with the decline of traditional finfish catches in the area, most notably sea bream (Caddy 1983; Rathjen and Voss 1987; Caddy and Rodhouse 1998). There are two distinct *O. vulgaris* populations, the first in the north on the Saharan Bank including Cape Garnett-Cape Barbas, and the second in the south off of Ras Nouadhibou (Cape Blanc). Catches of southern stocks declined in the 1980s but rebounded in the early 1990s after a 40% reduction in fishing activity (FAO 1997). The Moroccan octopus resource has historically been exploited not only by Moroccan fishermen, but by the Spanish and South Korean fishing fleets as well. A trade agreement allowing the Spanish fleet into Moroccan waters expired in 1999, but not before pressure on the *O. vulgaris* population had reached critical levels. A two-month closure and a reduction of foreign vessels were implemented in the north as management measures, but produced only dubious results. A second closure was introduced in 2001 with a further reduction of foreign vessel presence (Globefish 2006c).

In the first several years of the 21st century, the Moroccan octopus resource was known to be suffering, with total catches exceeding a 50,000 ton haul quota that did not account for the tons of octopus gutted and thrown away as inferior product (Globefish 2005a). At this point, the FAO considered these fisheries to be overfished (2005b). Quotas and a fishing moratorium for the whole fleet were imposed to help address this problem, and are having a positive effect. The resource seems to be recovering; about one-third of all octopus caught has been larger than 3 kg since the fishery reopened in early June 2006 (Globefish 2006b). As of 2006, the stock is no longer considered overfished (Globefish 2007).

In the Moroccan octopus fishery, current population abundance relative to B_{MSY} and occurrence of overfishing are unknown; however, the stock has recovered from its overfished status and abundance continues to increase. This results in a Seafood Watch® ranking of “moderate” for the stock status of Moroccan octopus.

Mauritania (North African Southern Stock: Ras Nouadhibou)

Mauritania was quick to fill the gap left in the Japanese octopus market by the reduction in Moroccan exports. Unfortunately, Mauritania has even weaker fishery management than its northern neighbor, although it does follow a similar closure system (Globefish 2005b). Like that of Morocco, the Mauritanian fishery is mainly trawl-based.

Mauritania is currently vying with Morocco to retain its title as largest supplier of *O. vulgaris* to the Japanese market (Globefish 2006c). Octopus is known to be overexploited in Mauritanian waters (CFFA 2006). Industrial trawling for *O. vulgaris* developed in the 1960s, and by the early 1980s, that stock was fully-exploited. Biomass of *O. vulgaris* has been decreasing since then and various stock assessments show that the stock is overexploited (Figure 9) (Gascuel et al. 2007). There is an estimated excessive fishing capacity of 31% in the Mauritanian octopus fishery. This is partly due to illegal fishing. Numerous European boats have been accused of declaring false catches and catching large amounts of juveniles (Pechecops and CFFA 2006).

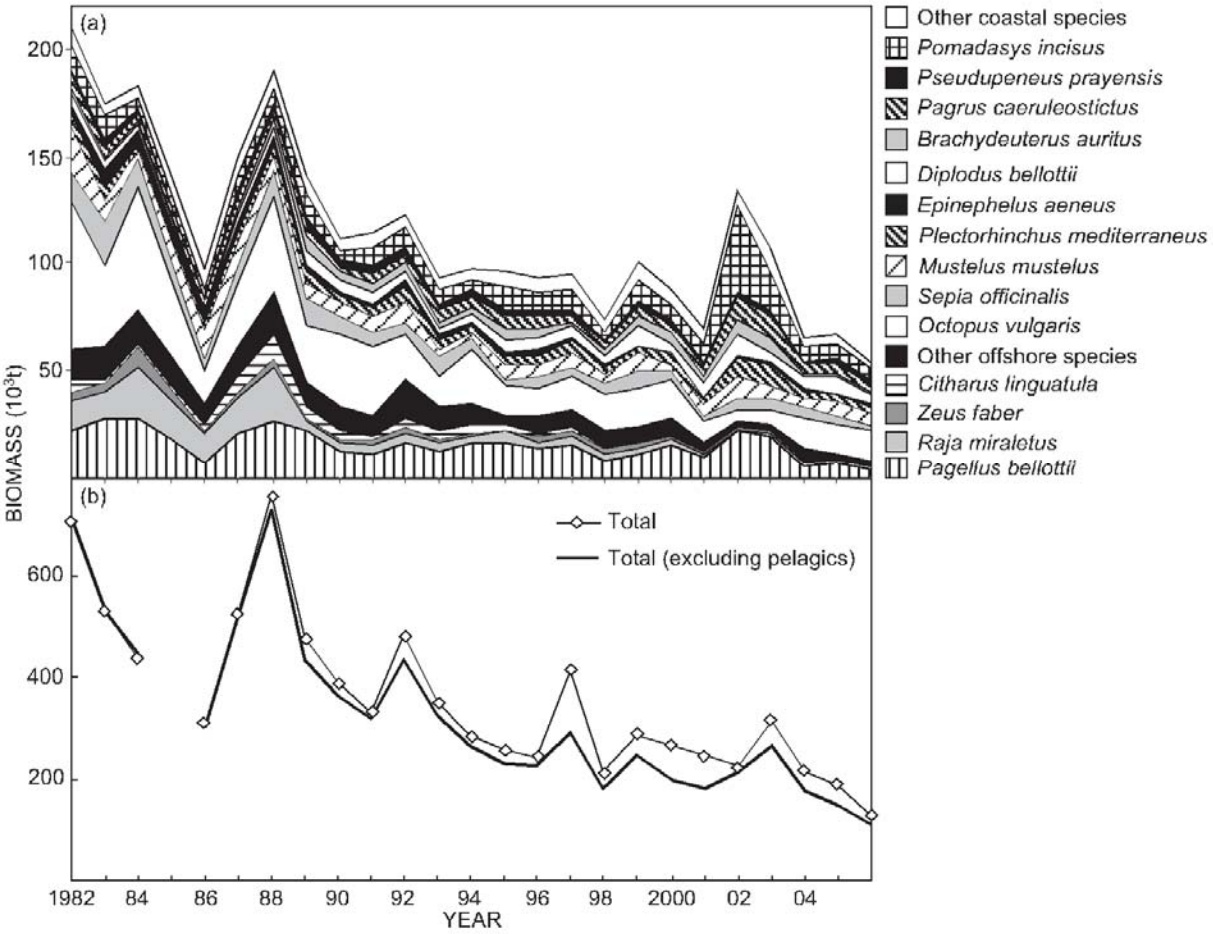


Figure 9. Trend in a) biomass for the 24 studied taxa and b) for the total biomass caught by the bottom trawl. (Gascuel et al. 2007)

This overexploitation and general lack of fishery management practices creates a troubling outlook, especially with a new agreement allowing European Union fleets (including Spanish

trawl fleets) access to octopus stocks (Pechecops and CFFA 2006). The current situation in Mauritania has forced the country to cut its exports to Japan by 25% (Globefish 2006b).

The overexploitation and likely overfishing of the stock, and the decreasing trends in stock abundance result in a Seafood Watch® ranking of "critical" for the Mauritanian octopus fishery.

Mediterranean (Spain)

Both pots and trawls are used to harvest octopus in the Mediterranean. The pot fishery is ancient, having existed for centuries, and accounts for slightly less than half of annual octopus landings in the Spanish Mediterranean (Mangold 1983; Sánchez & Obarti 1993) (Figure 10).

Figure 10. Classical Mediterranean octopus pot (Gard- Provencal.com 2006).

Pots are used in inshore waters while the trawl fishery operates farther offshore. Only large octopuses (greater than 1 kg in weight and with a mantle length exceeding 11 cm) are caught by the pot fishery (Sánchez & Obarti 1993). This fishery reaches its apex in the early winter, with 0.15 to 0.3 octopuses caught per pot (Oosthuizen 2003) (Figure 11).

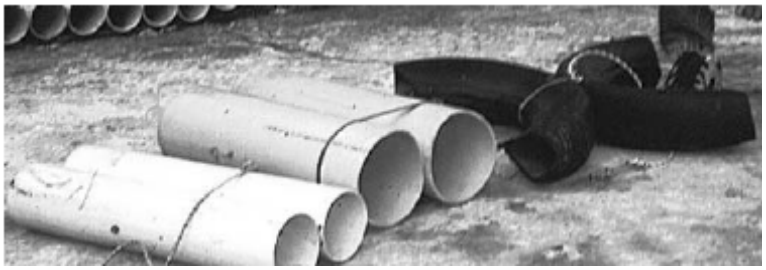


Figure 11. Modern octopus "pots", constructed from PVC piping and tires (Oosthuizen 2004).

The trawl fishery generally catches smaller animals, with even the largest octopuses much smaller than those caught by the inshore pot fishery. The CPUE for this fishery is highest in the summer when it reaches 40 kg/h (Quetglas et al. 1998). The fishery data suggest that young octopuses dwell in deeper waters, while mature octopuses migrate to shallower areas for spawning purposes. After migration, these larger animals become available to the pot fishery. The FAO considers the Mediterranean *O. vulgaris* fishery to be fully exploited (FAO 2005c).

Spain catches a large amount of octopus from the Mediterranean and in the eastern Atlantic. Spanish octopus landings climbed throughout the 1980s and into the 1990s, mainly to feed

domestic demand (Sánchez & Obarti 1993). Fishing agreements with Morocco and Mauritania give the Spanish fleet access to the octopus-rich waters of the Sahara Bank and Ras Nouadhibou. With the ability to exploit all of these areas, the Spanish catch of *O. vulgaris* increased dramatically. Spanish landings of *O. vulgaris* increased by a factor of ten throughout the second half of the 20th century, from approximately 5,000 tons in the 1950s to 20,000 tons in the 1990s (Guerra 1997). The implosion of the eastern Atlantic *O. vulgaris* fishery coincided with the interruption of Moroccan-Spanish fishing agreements and the sudden unemployment of thousands of Spanish fishermen. However, a new agreement with Morocco was signed in 2007 and the Mauritanian agreement was renewed in June 2006. In addition, Madrid has recently entered into an agreement with the government of Senegal that allows the Spanish a certain level of octopus harvesting in Senegalese waters (Globefish 2006a).

Catches of *O. vulgaris* in the Mediterranean have been at relatively unchanging levels since the 1980s, averaging 15,000 mt per year (FAO 2005c). These figures represent the combined efforts of all Mediterranean octopus harvests, including Italy, Tunisia, and other countries. Italy is a major harvester and consumer of *O. vulgaris* but exports very little, if any, octopus to Japan. Portugal and Tunisia are also sizeable figures in local octopus production, but concentrate primarily on domestic consumption and trade within the European market (Oosthuizen 2003; Globefish 2006a). Since they do not have a direct connection to the US sushi market, these two countries will be addressed only as influences that increase the pressure on the Mediterranean and Atlantic fisheries.

The combination of Seafood Watch® scientific criteria results in a rating of "moderate" for the Spanish *O. vulgaris* fishery, as population abundance relative to B_{MSY}, population abundance trends, and size/sex/age distribution of the population are unknown.

Japan

Although various octopus species are exploited in Japanese waters, *O. vulgaris* is the most common, and accounted for 90% of the total octopus catch in the 1980s (Takeda 1990). It is most often caught at depths of less than 100 m in the Seto Inland Sea through fishing methods such as trawling, pots, longlines, and angling. Pot fishing and trawling have historically been the top two methods of capture, with 49% and 27% of the total take respectively in 1980. Landings decreased from 14,166 tons in the 1960s to 6,422 tons in the 1980s (Takeda 1990). The mid-1980s saw the establishment of a five-year revitalization plan aimed at protecting and rebuilding spawning grounds and traditional nursery areas. Boulders, blocks, and smaller stones were introduced to the area to provide attractive areas for spawning females, but whether or not this intervention was successful remains unknown (Takeda 1990). Between 12,000 and 17,000 pots are laid out annually to provide shelter and protect the remaining stock (FAO 2001).

There is a marked lack of contemporary information on the Japanese octopus fishery. Data are available for the total Japanese octopus catch, but they are not differentiated by species. It is suspected that the Japanese catch of all octopuses within the entirety of the Northwest Pacific has ranged from 40,000 to 60,000 tons annually between 1980 and 2004 (FAO 2005c; FIGIS 2006), although these figures are challenged by Japanese fishery data which places the figure closer to

6,000 tons (MAFF 2006).[2] The proportion of *O. vulgaris* within this total is unknown, as is the amount taken from the *O. vulgaris* fishing grounds within the Seto Inland Sea. The FAO maintains statistical data for octopus, squid, and cuttlefish landings in of the Northwest Pacific (FAO Fishing Area 61), and Takeda's 1990 estimation of 90% of the total catch representing *O. vulgaris* may or may not pertain to the same area as that delineated by the FAO. This is an enormous stretch of ocean with a multitude of cephalopod species, and the landings of the Japanese Inland Seto Sea *O. vulgaris* fishery cannot fairly be extrapolated from these data (FAO 2005c).

This report is unable to make a sustainability recommendation on the domestic Japanese *O. vulgaris* fishery due to a general lack of information as well as the presence of conflicting and undependable data (FIGIS 2006; MAFF 2006; FAO 2005c).

China

Chinese octopus is not sourced from Chinese waters, but is in fact caught in small quantities from numerous geographic sources (Globefish 2005b). As such, it is difficult to discern which regions are being affected by Chinese operations. The Chinese fleet may be present in North Africa to some degree, probably in Senegalese or Mauritanian waters as foreign presence is still allowed in these areas.

As there is no definitive Chinese *O. vulgaris* fishery, and Chinese product is caught in any number of locations, no comprehensive assessments of targeted stocks, fishing management regime, or affected areas are available. This report does not make a recommendation on Chinese octopus.

Vietnam

The FAO considers the octopus fisheries of the western and central Pacific to be fully exploited (FAO 2005c). This includes the Vietnamese fishery (FAO 2005c; Kelleher 2005). It should be mentioned that this designation also covers the fisheries of Indonesia and the Philippines, both of which are large producers of octopus.

The particulars of the Vietnamese *O. vulgaris* fishery, such as B_{MSY}, CPUE trends, and similar scientific information, are unknown. This is the result of weak management and a general lack of landing records, stemming perhaps from the Vietnamese tradition of non-target fishing (wherein all organisms caught are retained and separated later to be used for various purposes) (FAO 2005b; Son 2006). Although figures pertaining specifically to the *O. vulgaris* fishery are unavailable, general trends in Vietnamese seafood landings display a marked decline and may indicate suffering fish and shellfish populations in the area (Son 2006). More information is available under the management section (Criterion 5) of this report.

The Vietnamese *O. vulgaris* fishery's fully-exploited status and decreasing trends in landings, coupled with the lack of information on B_{MSY}, F_{MSY} and occurrence of overfishing result in a stock status ranking of "poor" according to Seafood Watch® scientific criteria.

[2] This report is unable to explain this discrepancy aside from noting that the Japanese data only account for marketed octopus landings. It is doubtful, however, that this alone would explain the variation – a difference between approx. 6,000 tons (MAFF 2006) and approx. 60,000 tons (FAO 2005c) in 2005-2006.

Thailand

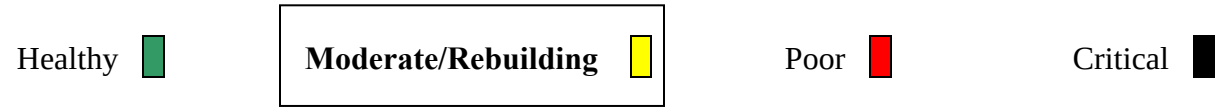
Thailand does not catch any substantial amount of *O. vulgaris*. Although it exports a large amount of octopus to Japan and to the EU, this is a combination of *Octopus membranaceous, O. dollfusi* and *Cistopus indicus*, native octopuses in Thai waters that are not used in the US sushi industry (Department of Fisheries of Thailand 2006). As such, this report does not make a recommendation on Thai octopus.

Table 3. Stock status of *Octopus vulgaris.*

Fishery	Classification Status	B/B_{MSY}	Occurrence of Overfishing	F/F_{MSY}	Abundance Trends /CPUE	Age/Size/Sex Distribution	Degree of Uncertainty in Stock Status	Sources	SFW Rank
North Africa: Northern Stock, Cape Garnett – Cape Barbas (Morocco)	Fully exploited	Unk; Exploitable biomass estimated at 75,000 tons (1997)	Unk.	Unk	Increasing trend	Mature animals inshore; juveniles in deeper water (functionally normal)	Moderate	FAO 1997; FAO 2001; FAO 2005c; Globefish 2005a,b; Globefish 2006a,b,c; Globefish 2007	Moderate
North Africa: Southern Stock -- Ras Nouadhibou (Mauritania)	Overfished	Unknown	Likely	Unk	Decreasing trend	Mature animals inshore; juveniles in deeper water (functionally normal)	High	FAO 1997; FAO 2001; FAO 2005c; Globefish 2005a,b; Globefish 2006a,b,c;	Critical
Western Mediterranean (Spain)	Fully exploited	Unk.	Overfishing not occurring	Unk.	Trends are flat; CPUE is 0.072 – 0.462 kg/pot (inshore); as high as 40 kg/h during season peak (offshore)	Mature animals inshore; juveniles in deeper water (functionally normal)	Moderate	Sánchez 1993; Quetglas et al. 1998; Oosthuizen 2003; FAO 2005c	Moderate
Vietnam	Fully exploited	Unk.	Unk.	Unk.	Decreasing trend in general landings but particulars for *O. vulgaris* are unknown	Unk.	High	FAO 2005b,c; Fistenet 2006; Kelleher 2005; Son 2006	Poor

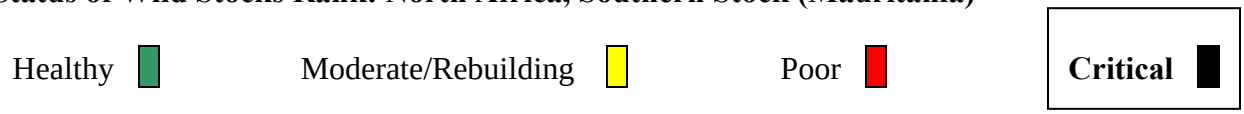
Synthesis
Stock status varies among the major *O. vulgaris* fisheries (Table 3). The Moroccan and Spanish stocks receive a stock status ranking of "moderate." Both stocks are fully exploited with unknown stock abundance and fishing mortality rates. The Vietnamese fishery also has unknown stock abundance and fishing mortality. This lack of data combined with heavy exploitation of the stock and decreasing trends in landings results in the Vietnamese stock receiving a stock status ranking of "poor." The Mauritanian stock is overfished with decreasing biomass, and overfishing is likely to be occurring; therefore, the stock is deemed to be "critical."

Status of Wild Stocks Rank: North Africa, Northern Stock (Morocco); Western Mediterranean (Spain)



Status of Wild Stocks Rank: Vietnam

Status of Wild Stocks Rank: North Africa, Southern Stock (Mauritania)



Criterion 3: Nature and Extent of Bycatch

Seafood Watch® defines sustainable wild-caught seafood as marine life captured using fishing techniques that successfully minimize the catch of unwanted and/or unmarketable species (i.e., bycatch). Bycatch is defined as species that are caught but subsequently discarded (injured or dead) for any reason. Bycatch does not include incidental catch (non-targeted catch) if it is utilized, accounted for and managed in some way.

Trawl
The octopus fisheries of North Africa are almost entirely trawl fisheries, although there is a small artisanal hook-and-line component. The vast majority of octopus sourced from the Saharan Bank and Ras Nouadhibou areas is caught by means of bottom trawling. The discard rate[3] in the Moroccan *O. vulgaris* fishery is estimated to be 45% (Kelleher 2005). The *O. vulgaris* trawl fishery in Mauritania has 60% bycatch, primarily composed of juveniles of other species (Pechecops and CFFA 2006).

[3] The term "discard rate" refers to the weighted discard rate. The weighted discard rate is derived from the set of complete records for the type of fishery and is the summed discards as a percentage of summed landings plus summed discards (Kelleher 2005).

The Mediterranean trawl fishery is a multispecies fishery, which means that although it is directed at a number of target species, total landings also include several species of "retained bycatch." In the Mediterranean trawl fishery, *O. vulgaris* represents only 8 - 40% of the total catch (Quetglas et al. 1998; Sator et al. 1998). The remainder of the catch is composed of other cephalopods, finfish, crustaceans, and echinoderms. Bycatch rates in the fishery are estimated at 20% - 50%, similar to the rates seen in Morocco (Sánchez et al. 2007).

O. vulgaris caught in Portuguese waters is generally bycatch in other finfish fisheries, even though the octopuses command three times the price of the targeted fish (Fonseca et al. 2002). Octopuses of legal size are sold for export or consumption; the problem arises when a juvenile is ensnared in the finfish nets. Although the minimum legal size for octopus is 0.75 kg, the finfish trawl mesh size generally retains octopuses much smaller than this (Oosthuizen 2003). This contributes to juvenile octopus mortality in the Mediterranean and East Atlantic fisheries.

In the Vietnam fishery, fishermen retain the total catch regardless of size or species, and use non-table species ("trash fish") for the production of fish sauce or fish meal, or as feed for aquaculture or livestock (Kelleher 2005; FAO 2005b). It is estimated that 50% – 70% percent of the landings by trawlers in this area are some sort of trash fish (FAO 2005b). The major trash fish on the Vietnamese coast are anchovy (*Stolephorus spp.*), lizard fish (*Saurida spp.*), and pony fish (*Leiognathus spp.*); the abundance of these fish is highly seasonal (FAO 2005b). Whether or not these fishers take species of special concern with their catches is unknown. Landings of trash fish in Vietnamese fisheries, including the *O. vulgaris* trawl fishery, are likely to increase (FAO 2005b). Combined with the rapidly increasing number of fish species threatened with extinction in Vietnam (FAO 2005b), a high amount of trash fish landings in the *O. vulgaris* fishery could play a part in the continuing degradation of many Vietnamese fish populations.

Because virtually all of the bycatch in the Vietnam fishery is used, it can be considered byproduct rather than waste. According to Gildberg (2002) fishery byproducts are used as material in four major categories: fertilizer, feed, food, and specialty products (e.g. biotechnical or medical applications). Today most fishery byproducts are used for agricultural feed, including aquaculture feeds.

The Food and Agricultural Organization (FAO) has published several estimates of bycatch in global marine fisheries. The report in 1994, known as the "Alverson assessment," estimated that bycatch averaged 27 million mt per year, composing 32% of the total annual production of marine capture fisheries (Alverson et al. 1994). In 1997, Clucas and James (1997) revised the estimate to 20 million mt, or 25% of annual production. The most recent estimate by Kelleher (2005) used different methods which included (among other revisions) reporting the discard rate in the Vietnamese octopus fishery to be insignificant because the entire catch is used. Accordingly, Kelleher's report considers bycatch to be non-target catch that is not utilized, and thus, Vietnam's non-target catches are considered byproducts.

Although all fish caught by Vietnam's fisheries are considered valuable byproduct, Seafood Watch® maintains a precautionary approach toward this issue. Because fisheries are impacted by all types of catches, the definition of bycatch used here includes unmanaged and

unaccounted-for captures even if they are used. This definition is particularly relevant in Vietnam, where many fish stocks are threatened with extinction.

Pot

Octopus pots have negligible discards (Kelleher 2005). Due to the nature of the fishing gear, pot fishermen are able to check the contents of their pots and release any bycatch before any mortality occurs. The transparency of pot fishing keeps bycatch to low levels within the fishery (Bjordal 2002; Oosthuizen 2004; Pechecops and CFFA 2006). Some bycatch are retained for sale or consumption, as in the trawl fishery, but to a lesser extent; therefore, they have less impact on Vietnamese fish populations than the trawl fisheries.

Table 4. Bycatch data for the *Octopus vulgaris* fishery.

Gear	Fishery	Composition of Bycatch	Population Consequences of Bycatch	Bycatch / Target Species ratio	Trend in Quality & Quantity of Bycatch	Ecosystem Effects	Sources
Bottom trawl	Morocco	Juvenile cephalopods, various finfish	Unknown	45%	Unknown	Unknown	Globefish 2005a; Kelleher 2005
Bottom trawl	Mauritania	Juvenile cephalopods, various finfish	Unknown	60%	Unknown	Unknown	Globefish 2005a; Kelleher 2005; Pechecops and CFFA 2006
Bottom trawl	Spain, offshore	Various finfish, cephalopods, etc.[4]	Unknown	Between 20% and 50%	Unknown	Unknown	Kelleher 2005; Oosthuizen 2003; Quetglas et al. 1998; Sartor et al. 1998; Sánchez et al. 2007
Bottom trawl	Vietnam	"Trash fish:" anchovy, lizard fish, pony fish	Contributing factor in driving bycatch species towards extinction	50-70% (estimation for all Vietnamese trawl fisheries)	Unknown	Ecosystem likely to be altered	Kelleher 2005; FAO 2005b
Pot	Spain, inshore	Cephalopods	Unknown	Negligible	Unknown	Unknown	Sartor et al. 1998; Oosthuizen 2003; Kellher 2005

[4] See Supplemental Information section for a full listing of cephalopod species taken in this fishery.

Synthesis
Aside from Vietnam, bycatch seems to be fairly uniform between fisheries employing like gear (Table 4). The pot fishery in Spain has little or no bycatch, while the Spanish and Moroccan trawl fisheries have similar bycatch rates (approximately 45%). No bycatch mitigation measures are in place in the Mediterranean and North African octopus fisheries. In the Vietnamese fishery, fishermen retain and use all non-target species (50-70% of all Vietnamese trawlers' catches), which can be considered byproducts instead of bycatch. This practice is thought to play a part in the continuing degradation of many Vietnamese fish stocks threatened with extinction. As such, a precautionary approach dictates that the definition of bycatch includes unmanaged and unaccounted-for captures even if they are used.

Nature of Bycatch Rank: Pot (Spain – inshore)

Low Moderate High Critical

Nature of Bycatch Rank: Bottom trawl (Morocco; Mauritania; Spain – offshore)

Low **Moderate** High Critical

Nature of Bycatch Rank: Bottom trawl (Vietnam)

Low **Moderate** **High** Critical

Criterion 4: Effect of Fishing Practices on Habitats and Ecosystems

Habitat Effects
Generally, *O. vulgaris* inhabits coral reefs or rocks in very shallow water, but it is even more abundant in many areas over sandy and muddy bottoms or sea grass beds (Katsanevakis and Verriopoulos 2004). The two main types of gear used to catch octopus, bottom trawls and octopus pots, interact with these habitats in different ways.

Bottom trawls are used in the North African (Morocco and Mauritania) *O. vulgaris* fisheries. In this area, *O. vulgaris* is most abundant on rocky and sandy bottoms shallower than 110 m, becoming scarcer with increasing depth and virtually disappearing at 200 m (Balguerías et al. 2002). Trawl fisheries employ large, weighted nets which are dragged along the seabed to ensnare benthic organisms. Bottom trawling is generally known to have a high level of habitat impact (Chuenpagdee et al. 2003; Morgan and Chuenpagdee 2003). Trawling in areas with coral reefs or rocky bottoms often results in the disruption of the benthic habitat as rocks are dislodged, stands of coral are destroyed, and local plant life is torn free by the trawl nets.

Moreover, numerous benthic animals are displaced, wounded, or killed by the trawl nets (Chuenpagdee et al. 2003; Morgan and Chuenpagdee 2003).

Conditions are slightly better in the case of the Spanish and Vietnamese trawl fisheries. According to fishery regulations in the area of the Spanish offshore fishery, trawling is restricted to deep-water sandy and muddy seabed (Mangold 1983; Quetglas et al. 1998). The Vietnamese trawl fishery occurs in a similar habitat (Duc Luong 2001). By preventing the bottom trawlers from targeting rocky substrate habitats, a portion of the potential negative impacts of bottom trawling is minimized.

The pot fishery has much less of an impact. In the case of the Spanish fishery, pots are used in shallow waters (generally 50 – 100 m) and in rocky habitats (Quetglas et al. 1998). A pot is set in octopus habitat, allowed to remain for a given period of time, and then checked to see if any octopuses have been caught. This type of octopus fishing is fairly passive and much less disruptive than bottom trawling, although pots may be dragged along the seabed during retrieval and thus may cause some amount of damage to the benthos.

Ecosystem Effects

The common octopus is an opportunistic feeder as well as the preferred prey of numerous predatory finfish (Caddy 1983). *O. vulgaris* preys on crustaceans, in addition to small finfishes, bivalves, gastropods, polychaeta, and other cephalopods (Sánchez 1993; Clarke 1996).

Given the short lifespan and high fecundity of *O. vulgaris*, it has been hypothesized that the species benefits from anthropogenic impacts reducing predatory faunal abundance (Caddy 1983; Caddy and Rodhouse 1998). In the case of the development of the Saharan Bank fishery, other factors are also thought to have played a role in the augmentation of the octopus stock (Balguerias et al. 2000; Oosthuizen 2003).

The effects of removing the common octopus from its habitat are largely unexplored.

Table 5. Habitat and ecosystem effects of the *Octopus vulgaris* fishery.

Gear Type	Effect of Fishing Gear on Habitats	Habitat Resilience to Disturbance	Geographic Extent of Fishery Effects	Evidence of Food Web Disruption	Evidence of Ecosystem Changes	Sources
Bottom trawl (Spain offshore, Vietnam)	Great damage	Moderate	Moderate	Unknown	Unknown	Caddy 1983; Mangold 1983; Oosthuizen 2003; Quetglas et al 1998; Luong 2001; Morgan and Chuenpagdee 2003
Bottom trawl (Morocco, Mauritania)	Great damage	Low	Moderate	Unknown	Unknown	Caddy 1983; Balguerías et al. 2002; Oosthuizen 2003; Morgan and Chuenpagdee 2003
Pot (Spain inshore)	Moderate damage	Low	Small	Unknown	Unknown	Caddy 1983; Oosthuizen 2003; Morgan and Chuenpagdee 2003

Synthesis

As is the case in many other fisheries, the *O. vulgaris* trawl fisheries damage the benthos by relying on a gear type that can result in severe habitat disruption (Table 5). The trawl fisheries in Morocco and Mauritania occur in rocky areas, which are known to be particularly vulnerable to bottom trawling. The Spanish and Vietnamese trawl fisheries are slightly less damaging because the fisheries occur in muddy, sandy bottom areas which are known to be more resilient to bottom trawling than rocky areas. That being said, bottom trawling still impacts all organisms that dwell in these areas – not just the high-value *O. vulgaris* (see the Appendix of this report for a full list of cephalopod species taken in the fishery). The exact amount of damage done by the Spanish inshore pot fishery is unknown, but it is thought to be much less than the fisheries employing weighted trawl nets. The long-term effects of removing substantial quantities of *O. vulgaris* remain unexplored in all major octopus fisheries.

Effect of Fishing Practices Rank: Pot (Spain inshore)

Benign | **Moderate** | Severe | Critical

Effect of Fishing Practices Rank: Bottom Trawl (Morocco, Mauritania, Spain offshore, Vietnam)

Benign | Moderate | **Severe** | Critical

Criterion 5: Effectiveness of the Management Regime

For the most part, little information is available on the assessment and management of octopus fisheries (Oosthuizen 2003). The data that do exist pertain mostly to the Mediterranean fisheries, or are not available in English. The remaining data tend to be very broad FAO data that may or may not be of use when analyzing a particular fishery, fishing ground, or management regime.

Pro-active management practices in octopus fisheries generally involve input controls such as seasonal closures, closed areas, and size or effort limitations (Caddy 1983; FAO 1997; Oosthuizen 2003). The effectiveness of these tools varies depending on enforcement, stock status, and other anthropogenic and biogenic factors.

North Africa

Morocco and Mauritania host the vast majority of the North African *O. vulgaris* fishery. These countries have had over-exploited stocks in the past (Oosthuizen 2003), but this situation may be beginning to change.

After the quota reductions paralleling the octopus fishery crash of 2001-2004, the Moroccan government was quick to reverse direction. In 2005, the Moroccan Ministry of Agriculture increased the total quota for octopus fishing from 6,500 tons to 25,000 tons, citing a "remarkable improvement in octopus reserves" due to the fishing closures (Arabic News 2005). This statement was not initially corroborated by outside sources. The Moroccan fishery seems to have benefited from the 2001 closures, and larger catches are being taken in the 2006 fishing season (Globefish 2006c). New regulations demand the release of juvenile octopus, and more stringent protection measures are in place to safeguard the stocks (Globefish 2006c). The Moroccan fishery observes a seasonal closure and a 25,000 ton total haul quota, and has also delineated closed areas (FAO 1997; Oosthuizen 2003; Arabic News 2005). If the Moroccan Ministry of Agriculture is able to maintain responsible quotas, the fishery may prove to be a success story. However, the effectiveness of these measures has not yet been demonstrated.

The status of management in Mauritania is more uncertain. Rapid expansion to fill the gap left in the Japanese market by Morocco's withdrawal during 2001 – 2005 may or may not have affected Mauritanian octopus stocks. Mauritania may not be able to enforce fishery management regulations sufficiently. Little information on Mauritanian management protocol is available, but it is possible that the recent 25% drop in exported octopus to Japan may be, in part, the result of a poorly managed and over-exploited fishery.

In addition, a six-year fisheries agreement between Mauritania and the European Union (EU) came into force on August 1, 2006. The EU will pay Mauritania 86 million euros per year in

exchange for the right to utilize Mauritania's fish resources. In addition, ship owners will contribute an estimated 22 million euros, in the event that they make use of all fishing possibilities. The 1982 United Nations Convention on the Law of the Sea (UNCLOS) stipulates that foreign fleets, such as the EU, can only have access to surplus resources not fished by the national fleet—Mauritania in this case. Mauritanian octopus is overexploited, and as such, there is no surplus resource to provide to the EU fleets. Therefore, the Mauritanian-EU fisheries partnership agreement is worrying and goes against UNCLOS (Pechecops and CFFA 2006). This agreement could have negative impacts on the Mauritanian octopus stock.

It should be mentioned that there is a growing level of *O. vulgaris* exploitation south of Mauritania, in Senegalese waters. Like Mauritania, the developing fishery in Senegal has similarly obscure regulations, although it is known that the Senegalese fishery has put in place size limitations on retained octopus (Caverivière et al. 2002). Senegal has also established a closed season similar to those observed in Morocco and Mauritania. This closure is thought to be relatively effective (Caverivière et al. 2002; FAO 1997). This fishery is not yet a major producer of *O. vulgaris* for the Japanese market, but it may become one in the near future. No recommendation for Senegalese octopus is made in this report.

Spain

Spanish management maintains monthly and yearly catch statistics, as well as general haul data (Quetglas et al. 1998). While there does not seem to be a distinct management plan or technical stock assessment on the part of the Spanish government, the FAO does maintain a level of awareness concerning Mediterranean *O. vulgaris* stocks in general and has stated that the fishery, while not overfished, is fully exploited (FAO 2005c).

The trawl and pot fisheries are differentiated by depth and habitat; trawling is generally restricted to muddy or sandy bottoms at depths of 50 – 100 m while the shallower littoral waters and rocky substrate are targeted by the pot fishery (Quetglas et al. 1998). This arrangement, while not technically a bycatch reduction plan, does serve to limit bycatch and protect rocky habitat by preventing trawlers from targeting vulnerable areas.

In addition to standard fishery-dependent data, numerous independent studies of the Spanish *O. vulgaris* fishery have been conducted (Mangold-Wirz 1963; Sánchez & Obarti 1993; Quetglas et al. 1998; Rodriguez-Rua 2005).

Since the 1980s, this fishery has produced relatively stable catches. EU regulations are beginning to tighten as well, which should serve to bolster local *O. vulgaris* populations further. One of the most substantial steps was taken on November 21, 2005 when the EU Council of Ministers adopted size-specific octopus retention regulations designed to prevent the sale of juvenile octopus in the EU (Globefish 2006a). This regulation sets the minimum weight of legal gutted octopus at 450 grams. While this is technically a response to the fishery committee for the eastern-central Atlantic (CECAF), it should serve to protect juvenile populations in the Mediterranean as well. Unfortunately, juveniles caught in bottom trawl nets will most likely continue to meet a high level of mortality, regardless of whether or not they are retained for sale.

There is a large market in Spain for undersized octopus. If this decision on the part of the EU Council of Ministers is to succeed in protecting stocks, it will have to be met by a higher level of vigilance on the part of the port control authorities as well as individual traders (Globefish 2006a).

Japan

While it is known that management agencies have made an effort to protect remaining stocks by augmenting habitat with pots and other sheltering material (Takeda 1990; FAO 2001), in general very little information about the management of the fishery is available. According to the Japanese Ministry of Agriculture, Forestry and Fisheries (MAFF), the total take of octopus by the Japanese fleet varied from 304 to 695 mt per month[5] from August 2005 to August 2006, but as mentioned earlier, the proportion of this catch that reflects the domestic *O. vulgaris* catch is unknown (2006). Without a more detailed understanding of Japanese management practices, this report cannot make a recommendation aside from urging consumers to exercise caution.

Vietnam

Vietnamese fishing protocol is managed by the Vietnam Ministry of Fisheries (VFM) and by the National Directorate of Aquatic Resources Exploitation and Protection (NADAREP), a subdivision of VFM. In 2004, the VFM and FAO collaborated to draft a national strategy for the development and management of marine fisheries for the period 2005-2015.

Vietnam has a history of heavy marine resource exploitation. The last ten years have seen a 260% increase in overall fisheries production (Son 2006). It is known that Vietnam has put unmanageable pressure on many of its marine stocks in recent years, and some areas – especially nearshore zones – are thought to be overfished (FAO 2005a). Total catch rates (for all Vietnamese landings combined, not just octopus) have declined from 1.1 tons/hp/year in 1985 to 0.3 tons/hp/year in 2003 (Son 2006). There are closed areas in Vietnam, but the regulations pertaining to fishing activities within these closures are ill-defined.

It is known that, overall, recent annual catches of all species have exceeded the previous total estimate of exploitable biomass (estimated at 582,000 tonnes/year) and that the overall productivity and profitability of the fishing fleet is decreasing (FAO 2005a; Son 2006). The proportion of this estimate referring to octopus is unknown.

The plan put forth by the 2004 VFM/FAO conference aims at revitalizing the Vietnamese fishing industry though increased regulation and more effective management tactics. It involves the establishment of a more transparent statistical system, various baseline stock assessments, the construction of training centers, and the expansion of the existing marine protected area network, among other goals (FAO 2005a). The effectiveness of this plan remains to be seen; as of this writing, the plan was undergoing approval procedures.

It is worth noting that Vietnamese fisheries have a great deal of obstacles to overcome, including a lack of technology, unidentified or non-delineated fishing grounds, a shortage of skilled labor, and a tendency to retain juvenile and non-table catch (FAO 2005b). Fishing management is poor and port infrastructure is not adequately developed to host a sustainable and transparent modern

[5] As mentioned earlier, these figures differ by an order of magnitude from the FAO catch estimates (FAO 2005c).

fishery (Son 2006). Vietnam also sees the widespread usage of destructive fishing methods, such as cyanide, dynamite, and reef net fishing, but the amount of octopus targeted by these methods is unknown (Son 2006).

Table 6. Commercial catch management measures for the *Octopus vulgaris* fishery.

Fishery	Management Jurisdictions & Agencies	Total Allowable Landings	Size Limit	Gear Restrictions	Trip Limit	Closures	Sources
North Africa: Morocco	Moroccan Ministry of Agriculture	25,000 t	> 450g	None	Unknown	Seasonal closures, some closed areas	Oosthuizen 2003; FAO 2005c; Globefish 2006a; Globefish 2006c
North Africa: Mauritania	Mauritania Ministry of Fishing and Marine Economy	Unknown	Unknown	Unknown	Unknown	Unknown	FAO 2005c; Globefish 2006b
Spain	EU Council of Ministers	Varies	>750g for trawl; >1k and >11 ml for pot	Varies with fishery	Varies	Rocky and shallow areas closed to trawling	Oosthuizen 2003; Globefish 2006a;
Vietnam	Vietnam Ministry of Fisheries	Unknown	None	None	None	Some closed areas with dubious regulatory status	FAO 2005a,b,c; Son 2006

Synthesis

Management in the *O. vulgaris* fisheries is an emerging phenomenon that is evolving at different rates in different areas (Table 6). Fishery-dependent data are collected in the Spanish *O. vulgaris* fisheries but stock status is still somewhat uncertain. Spain seems to be taking steps toward stock management; however, the management measures have not been in place long enough to evaluate their effectiveness. Given this information, management of the Spanish fisheries is considered to be "moderately effective." The Moroccan *O. vulgaris* stock has historically been overexploited, and crashed from 2001-2004. Morocco has recently taken some measures to increase the health of the stock, but it is too soon to determine the effectiveness of these measures. Mauritania is undergoing a similar crisis to that faced by Morocco during its *O. vulgaris* crash, but whether it will prompt similar protective actions remains unknown. It seems unlikely considering that Mauritania recently signed a fisheries partnership agreement with the EU, allowing them to further exploit the octopus resource. Vietnamese fisheries are heavily exploited, and need to overcome a great deal of obstacles such as a lack of technology, unidentified fishing grounds, high amounts of trash fish landings, and inadequate port

infrastructure. Vietnam does not currently have the ability to address these issues. Given this information, Seafood Watch® deems the Moroccan, Mauritian, and Vietnamese management regimes to be "critical."

Effectiveness of Management Rank: Spain

Highly Effective | **Moderately Effective** | Ineffective | Critical

Effectiveness of Management Rank: Morocco, Mauritania, Vietnam

Highly Effective | Moderately Effective | Ineffective | **Critical**

V. Overall Evaluation and Seafood Recommendation

Overall, the world's *O. vulgaris* fisheries are host to lack of information and management. Although the inherent resilience of *O. vulgaris* to fishing pressure is high, there are little robust data regarding the stock health of any of the major octopus fisheries contributing to the US sushi industry, especially those in Vietnam and Mauritania. Bycatch tends to be moderate in the trawl fisheries and low in the pot fisheries, but this latter sector is only a small fraction of the global catch, which is dominated by bottom trawl. The ecosystem and habitat effects of the fishery are not well understood beyond the generally accepted premise that bottom trawling disrupts sensitive benthic habitat. Management is moderately effective in Spain. Little is known about the overall effectiveness of the developing programs in Morocco, and management in Mauritania and Vietnam is lacking.

Due to these issues, as well as the difficulty associated with discerning the actual country of origin of octopus found in US sushi restaurants, *tako* should be avoided as a general rule. Spanish octopus (especially pot-caught) is a preferred alternative to North African (Moroccan and Mauritanian) and Vietnamese octopus, but it is rare that sufficient sourcing information is available to the consumer.

Table of Sustainability Ranks

	Conservation Concern			
Sustainability Criteria	**Low**	**Moderate**	**High**	**Critical**
Inherent Vulnerability	√			
Status of Stocks		√ (Spain, Morocco)	√ (Vietnam)	√ (Mauritania)
Nature of Bycatch	√ (Pot: Spain inshore)	√ (Bottom trawl: Morocco, Mauritania, Spain offshore)	√ (Bottom trawl: Vietnam)	
Habitat & Ecosystem Effects		√ (Pot: Spain inshore)	√ (Bottom trawl: Morocco, Mauritania, Spain offshore, Vietnam)	
Management Effectiveness		√ (Spain)		√ (Morocco, Mauritania, Vietnam)

Overall Seafood Recommendation: Spain

Best Choice | **Good Alternative** | Avoid

Overall Seafood Recommendation: Morocco, Mauritania, Vietnam

Best Choice | Good Alternative | **Avoid**

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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.

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VII. Appendix I

Composition of Spanish octopus trawl fishery (Sartor et al. 1998)
Seven species are retained almost entirely, with an average discard rate of <10%:

Eledone cirrhosa
Eledone moschata
Illex coindetti
Octopus vulgaris
Loligo vulgaris
Loligo forbesi
Sepia officinalis

Thirteen species are without commercial value and are discarded systematically:

Abralia veranyi
Ancistroteuthis lichtensteini
Bathypolypus sponsalis
Brachioteuthis riisei
Chiroteuthis verayni
Chtenopteryx sicula
Heteroteuthis dispar
Histioteuthis bonnellii
Histioteuthis reversa
Onychoteuthis banksi
Pteroctopus tetracirrhus
Rondeletiola minor
Sepiola ligulata

Eleven species are retained or discarded at varying rates (0% to 100%), depending on location and market value:

Alloteuthis media
Alloteuthis subulata
Neorossia caroli
Octopus salutii
Rossia macrosoma
Scaeurgus unicirrhus
Sepia elegans
Sepia orbignyana
Sepietta oweniana
Todarodes sagittatus
Todaropsis eblanae

VIII. Appendix II

Capture Fisheries Evaluation

Species: *Octopus vulgaris*	**Region:** *Sushi*
Analysts: *Casson Trenor & Stephanie Danner*	**Date:** *August 20, 2008*

Seafood Watch™ defines sustainable seafood as originating from sources, whether fished[6] or farmed, that can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems.

The following **guiding principles** illustrate the qualities that capture fisheries must possess to be considered sustainable by the Seafood Watch program. Species from sustainable capture fisheries:

- have a low vulnerability to fishing pressure, and hence a low probability of being overfished, because of their inherent life history characteristics;
- have stock structure and abundance sufficient to maintain or enhance long-term fishery productivity;
- are captured using techniques that minimize the catch of unwanted and/or unmarketable species;
- are captured in ways that maintain natural functional relationships among species in the ecosystem, conserves the diversity and productivity of the surrounding ecosystem, and do not result in irreversible ecosystem state changes; and
- have a management regime that implements and enforces all local, national and international laws and utilizes a precautionary approach to ensure the long-term productivity of the resource and integrity of the ecosystem.

Seafood Watch has developed a set of five sustainability **criteria,** corresponding to these guiding principles, to evaluate capture fisheries for the purpose of developing a seafood recommendation for consumers and businesses. These criteria are:

1. Inherent vulnerability to fishing pressure
2. Status of wild stocks
3. Nature and extent of discarded bycatch
4. Effect of fishing practices on habitats and ecosystems
5. Effectiveness of the management regime

Each criterion includes:

- Primary factors to evaluate and rank
- Secondary factors to evaluate and rank
- Evaluation guidelines[7] to synthesize these factors
- A resulting **rank** for that criterion

[6] "Fish" is used throughout this document to refer to finfish, shellfish and other wild-caught invertebrates.
[7] Evaluation Guidelines throughout this document reflect common combinations of primary and secondary factors that result in a given level of conservation concern. Not all possible combinations are shown – other combinations should be matched as closely as possible to the existing guidelines.

Once a rank has been assigned to each criterion, an **overall seafood recommendation** for the species in question is developed based on additional evaluation guidelines. The ranks for each criterion, and the resulting overall seafood recommendation, are summarized in a table. Criterion ranks and the overall seafood recommendation are color-coded to correspond to the categories of the Seafood Watch pocket guide:

Best Choices/Green: Consumers are strongly encouraged to purchase seafood in this category. The wild-caught species is sustainable as defined by Seafood Watch.

Good Alternatives/Yellow: Consumers are encouraged to purchase seafood in this category, as they are better choices than seafood in the Avoid category. However there are some concerns with how this species is fished and thus it does not demonstrate all of the qualities of a sustainable fishery as defined by Seafood Watch.

Avoid/Red: Consumers are encouraged to avoid seafood in this category, at least for now. Species in this category do not demonstrate enough qualities to be defined as sustainable by Seafood Watch.

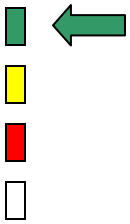
CRITERION 1: INHERENT VULNERABILITY TO FISHING PRESSURE

Guiding Principle: Sustainable wild-caught species have a low vulnerability to fishing pressure, and hence a low probability of being overfished, because of their inherent life history characteristics.

Primary Factors[8] to evaluate

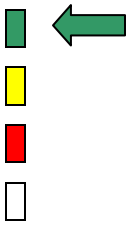
Intrinsic rate of increase ('r')

- High (> 0.16)
- Medium (0.05 - 0.16)
- Low (< 0.05)
- Unavailable/Unknown



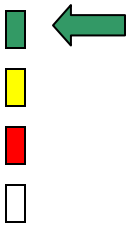
Age at 1st maturity

- Low (< 5 years)
- Medium (5 - 10 years)
- High (> 10 years)
- Unavailable/Unknown



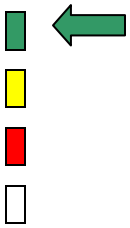
Von Bertalanffy growth coefficient ('k')

- High (> 0.16) **(Varies by region)**
- Medium (0.05 - 0.15)
- Low (< 0.05)
- Unavailable/Unknown



Maximum age

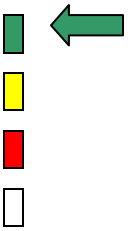
- Low (< 11 years)
- Medium (11 - 30 years)
- High (> 30 years)
- Unavailable/Unknown



[8] These primary factors and evaluation guidelines follow the recommendations of Musick et al. (2000). Marine, estuarine, and diadromous fish stocks at risk of extinction in North America (exclusive of Pacific salmonids). Fisheries 25:6-30.

Reproductive potential (fecundity)

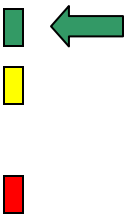
- High (> 100 inds./year)
- Moderate (10 – 100 inds./year)
- Low (< 10 inds./year)
- Unavailable/Unknown



Secondary Factors to evaluate

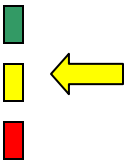
Species range

- Broad (e.g. species exists in multiple ocean basins, has multiple intermixing stocks or is highly migratory)
- Limited (e.g. species exists in one ocean basin)
- Narrow (e.g. endemism or numerous evolutionary significant units or restricted to one coastline)



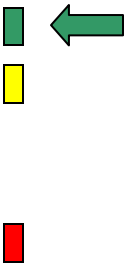
Special Behaviors or Requirements: Existence of special behaviors that increase ease or population consequences of capture (e.g. migratory bottlenecks, spawning aggregations, site fidelity, unusual attraction to gear, sequential hermaphrodites, segregation by sex, etc., OR specific and limited habitat requirements within the species' range).

- No known behaviors or requirements OR behaviors that decrease vulnerability (e.g. widely dispersed during spawning)
- Some (i.e. 1 - 2) behaviors or requirements **(spawning-related migrations)**
- Many (i.e. > 2) behaviors or requirements



Quality of Habitat: Degradation from non-fishery impacts

- Habitat is robust
- Habitat has been moderately altered by non-fishery impacts
- Habitat has been substantially compromised from non-fishery impacts and thus has reduced capacity to support this species (e.g. from dams, pollution, or coastal development)



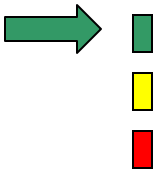
Evaluation Guidelines

1) Primary Factors
   a) If 'r' is known, use it as the basis for the rank of the Primary Factors.
   b) If 'r' is unknown, then the rank from the remaining Primary Factors (in order of importance, as listed) is the basis for the rank.

2) Secondary Factors
   a) If a majority (2 out of 3) of the Secondary Factors rank as Red, reclassify the species into the next lower rank (i.e. Green becomes Yellow, Yellow becomes Red). No other combination of Secondary Factors can modify the rank from the Primary Factors.
   b) No combination of primary and secondary factors can result in a Critical Conservation Concern for this criterion.

Conservation Concern: Inherent Vulnerability

- Low (Inherently Resilient)
- Moderate (Inherently Neutral)
- High (Inherently Vulnerable)



CRITERION 2: STATUS OF WILD STOCKS

Guiding Principle: Sustainable wild-caught species have stock structure and abundance sufficient to maintain or enhance long-term fishery productivity.

Primary Factors to evaluate

Management classification status

- Underutilized OR close to virgin biomass
- **Fully fished** (**Spain, Vietnam, Morocco)** OR recovering from overfished OR Unknown
- Recruitment or growth **overfished** (**Mauritania**), overexploited, depleted or "threatened"

Current population abundance relative to B_{MSY}

- At or above B_{MSY} (> 100%)
- Moderately Below B_{MSY} (50 – 100%) OR **Unknown** (**All)**
- Substantially below B_{MSY} (< 50%)

Occurrence of overfishing (current level of fishing mortality relative to overfishing threshold)

- Overfishing not occurring ($F_{curr}/F_{msy} < 1.0$) **(Spain)**
- **Overfishing is likely/probable** (**Mauritania, Vietnam)** OR fishing effort is increasing with poor understanding of stock status OR **Unknown** (**Morocco)**
- Overfishing occurring ($F_{curr}/F_{msy} > 1.0$)

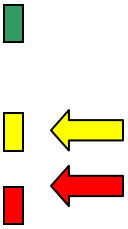
Overall degree of uncertainty in status of stock

- Low (i.e. current stock assessment and other fishery-independent data are robust OR reliable long-term fishery-dependent data available)
- Medium (i.e. only limited, fishery-dependent data on stock status are available) (**Morocco, Spain**)
- **High (i.e. little or no current fishery-dependent or independent information on stock status (Mauritania, Vietnam)** OR models/estimates broadly disputed or otherwise out-of-date)

Long-term trend (relative to species' generation time) in population abundance as measured by either fishery-independent (stock assessment) or fishery-dependent (standardized CPUE) measures

- Trend is up
- Trend is flat or variable (among areas, over time or among methods)

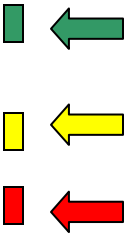
  OR **Unknown** (**Morocco, Spain**)
- Trend is down (**Vietnam, Mauritania**)



Short-term trend in population abundance as measured by either fishery-independent (stock assessment) or fishery-dependent (standardized CPUE) measures

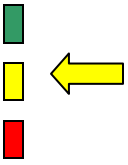
- Trend is up (**Morocco**)
- Trend is flat or variable (among areas, over time or among methods)

  OR **Unknown** (**Spain**)
- Trend is down **(Vietnam, Morocco, Mauritania)**



Current age, size or sex distribution of the stock relative to natural condition

- Distribution(s) is(are) functionally normal
- Distribution(s) unknown (**All**)
- Distribution(s) is(are) skewed



Evaluation Guidelines

A "Healthy" Stock:

1) Is underutilized (near virgin biomass)
2) Has a biomass at or above BMSY AND overfishing is not occurring AND distribution parameters are functionally normal AND stock uncertainty is not high

A "Moderate" Stock:

1) Has a biomass at 50-100% of BMSY AND overfishing is not occurring
2) Is recovering from overfishing AND short-term trend in abundance is up AND overfishing not occurring AND stock uncertainty is low
3) Has an Unknown status because the majority of primary factors are unknown.

A "Poor" Stock:

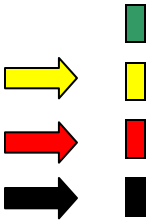
1) Is fully fished AND trend in abundance is down AND distribution parameters are skewed
2) Is overfished, overexploited or depleted AND trends in abundance and CPUE are up.
3) Overfishing is occurring AND stock is not currently overfished.

A stock is considered a **Critical Conservation Concern** and the species is ranked "Avoid**"**, regardless of other criteria, if it is:

1) Overfished, overexploited or depleted AND trend in abundance is flat or down
2) Overfished AND overfishing is occurring
3) Listed as a "threatened species" or similar proxy by national or international bodies

Conservation Concern: Status of Stocks

- Low (Stock Healthy)
- Moderate (Stock Moderate or **Unknown**) (**Spain, Morocco)**
- High (Stock Poor) (**Vietnam)**
- Stock Critical **(Mauritania)**



CRITERION 3: NATURE AND EXTENT OF DISCARDED BYCATCH[9]

Guiding Principle: A sustainable wild-caught species is captured using techniques that minimize the catch of unwanted and/or unmarketable species.

Primary Factors to evaluate

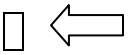
Quantity of bycatch, including any species of "special concern" (i.e. those identified as "endangered", "threatened" or "protected" under state, federal or international law)

- Quantity of bycatch is low (< 10% of targeted landings on a per number basis) AND does not regularly include species of special concern (**Spain inshore**) 
- **Quantity of bycatch is moderate (10 – 100% of targeted landings on a per number basis) AND does not regularly include species of special concern** (**Morocco, Spain offshore, Mauritania, Vietnam**) OR Unknown 
- Quantity of bycatch is high (> 100% of targeted landings on a per number basis) OR bycatch regularly includes threatened, endangered or protected species 

Population consequences of bycatch

- Low: Evidence indicates quantity of bycatch has little or no impact on population levels 
- Moderate: Conflicting evidence of population consequences of bycatch OR **Unknown** (**Morocco, Mauritania, Spain)** 
- Severe: **Evidence indicates quantity of bycatch is a contributing factor in driving one or more bycatch species toward extinction** OR is a contributing factor in limiting the recovery of a species of "special concern" **(Vietnam)** 

Trend in bycatch interaction rates (adjusting for changes in abundance of bycatch species) as a result of management measures (including fishing seasons, protected areas and gear innovations):

- Trend in bycatch interaction rates is down 
- Trend in bycatch interaction rates is flat OR **Unknown** (**Morocco, Mauritania, Vietnam, Spain offshore)** 
- Trend in bycatch interaction rates is up 
- Not applicable because quantity of bycatch is low (**Spain inshore**) 

[9] Bycatch is defined as species that are caught but subsequently discarded because they are of undesirable size, sex or species composition. Unobserved fishing mortality associated with fishing gear (e.g. animals passing through nets, breaking free of hooks or lines, ghost fishing, illegal harvest and under or misreporting) is also considered bycatch. Bycatch does not include incidental catch (non-targeted catch) if it is utilized, is accounted for, and is managed in some way.

Secondary Factor to evaluate

Evidence that the ecosystem has been or likely will be substantially altered (relative to natural variability) in response to the continued discard of the bycatch species

- Studies show no evidence of ecosystem impacts 
- Conflicting evidence of ecosystem impacts OR **Unknown**

  (Morocco, Mauritania, Spain) 
- Studies show evidence of substantial ecosystem impacts **(Vietnam)** 

Evaluation Guidelines

Bycatch is **"Minimal"** if:

1) Quantity of bycatch is <10% of targeted landings AND bycatch has little or no impact on population levels.

Bycatch is **"Moderate"** if:

1) Quantity of bycatch is 10 - 100% of targeted landings
2) Bycatch regularly includes species of "special concern" AND bycatch has little or no impact on the bycatch population levels AND the trend in bycatch interaction rates is not up.

Bycatch is "Severe" if:

1) Quantity of bycatch is > 100% of targeted landings
2) Bycatch regularly includes species of "special concern" AND evidence indicates bycatch rate is a contributing factor toward extinction or limiting recovery AND trend in bycatch is down.

Bycatch is considered a **Critical Conservation Concern** and the species is ranked "Avoid", regardless of other criteria, if:

1) Bycatch regularly includes species of special concern AND evidence indicates bycatch rate is a factor contributing to extinction or limiting recovery AND trend in bycatch interaction rates is not down.
2) Quantity of bycatch is high AND studies show evidence of substantial ecosystem impacts.

Conservation Concern: Nature and Extent of Discarded Bycatch

- Low (Bycatch Minimal) (**Spain inshore**) 
- Moderate (Bycatch Moderate) (**Morocco, Mauritania, Spain offshore**) 
- High (Bycatch Severe) **(Vietnam)** 
- Bycatch Critical 

CRITERION 4: EFFECT OF FISHING PRACTICES ON HABITATS AND ECOSYSTEMS

Guiding Principle: Capture of a sustainable wild-caught species maintains natural functional relationships among species in the ecosystem, conserves the diversity and productivity of the surrounding ecosystem, and does not result in irreversible ecosystem state changes.

Primary Habitat Factors to evaluate

Known (or inferred from other studies) effect of fishing gear on physical and biogenic habitats

- Minimal damage (i.e. pelagic longline, midwater gillnet, midwater trawl, purse seine, hook and line, or spear/harpoon)
- Moderate damage (i.e. bottom gillnet, bottom longline or **some pots/ traps**)
- Great damage (i.e. **bottom trawl** or dredge)

For specific fishery being evaluated, resilience of physical and biogenic habitats to disturbance by fishing method

- High (e.g. shallow water, sandy habitats)
- **Moderate (e.g. shallow or deep water mud bottoms, or deep water sandy habitats)** OR Unknown **(trawl – Spain offshore, Vietnam)**
- Low (e.g. shallow or deep water corals, shallow or deep water rocky bottoms) (**pot – Spain inshore; trawl – Morocco, Mauritania**)
- Not applicable because gear damage is minimal

If gear impacts are moderate or great, spatial scale of the impact

- Small scale (e.g. small, artisanal fishery or sensitive habitats are strongly protected) (**pot – Spain inshore)**
- Moderate scale (e.g. modern fishery but of limited geographic scope) (**trawl – Morocco, Mauritania, Spain offshore, Vietnam)**
- Large scale (e.g. industrialized fishery over large geographic areas)
- Not applicable because gear damage is minimal

Primary Ecosystem Factors to evaluate

Evidence that the removal of the targeted species or the removal/deployment of baitfish has or will likely substantially disrupt the food web

- The fishery and its ecosystem have been thoroughly studied, and studies show no evidence of substantial ecosystem impacts
- Conflicting evidence of ecosystem impacts OR **Unknown (All)**

- Ecosystem impacts of targeted species removal demonstrated

Evidence that the fishing method has caused or is likely to cause substantial ecosystem state changes, including alternate stable states

- The fishery and its ecosystem have been thoroughly studied, and studies show no evidence of substantial ecosystem impacts
- Conflicting evidence of ecosystem impacts OR **Unknown** (**All**)
- Ecosystem impacts from fishing method demonstrated

Evaluation Guidelines

The effect of fishing practices is **"Benign"** if:

1) Damage from gear is minimal AND resilience to disturbance is high AND neither Ecosystem Factor is red.

The effect of fishing practices is "**Moderate**" if:

1) Gear effects are moderate AND resilience to disturbance is moderate or high AND neither Ecosystem Factor is red.
2) Gear results in great damage AND resilience to disturbance is high OR impacts are small scale AND neither Ecosystem Factor is red.
3) Damage from gear is minimal and one Ecosystem factor is red.

The effect of fishing practices **is "Severe"** if:

1) Gear results in great damage AND the resilience of physical and biogenic habitats to disturbance is moderate or low.
2) Both Ecosystem Factors are red.

Habitat effects are considered a **Critical Conservation Concern** and a species receives a recommendation of "**Avoid"**, regardless of other criteria if:

- Four or more of the Habitat and Ecosystem factors rank red.

Conservation Concern: Effect of Fishing Practices on Habitats and Ecosystems

- Low (Fishing Effects Benign)
- Moderate (Fishing Effects Moderate) **(pot)**
- High (Fishing Effects Severe) (**trawl)**
- Critical Fishing Effects

CRITERION 5: EFFECTIVENESS OF THE MANAGEMENT REGIME

Guiding Principle: The management regime of a sustainable wild-caught species implements and enforces all local, national and international laws and utilizes a precautionary approach to ensure the long-term productivity of the resource and integrity of the ecosystem.

Primary Factors to evaluate

Stock Status: Management process utilizes an independent scientific stock assessment that seeks knowledge related to the status of the stock

- Stock assessment complete and robust
- Stock assessment is planned or underway but is incomplete OR stock assessment complete but out-of-date or **otherwise uncertain** (**Spain, Mauritania)**
- No stock assessment available now and none is planned in the near future (**Morocco, Vietnam)**

Scientific Monitoring: Management process involves regular collection and analysis of data with respect to the short and long-term abundance of the stock

- Regular collection and assessment of both fishery-dependent and independent data
- Regular collection of fishery-dependent data only (**Morocco, Spain inshore, Spain offshore)**
- No regular collection or analysis of data (**Mauritania, Vietnam**)

Scientific Advice: Management has a well-known track record of consistently setting or exceeding catch quotas beyond those recommended by its scientific advisors and other external scientists:

- No
- Yes
- Not enough information available to evaluate OR **not applicable because little or no scientific information is collected (All)**

Bycatch: Management implements an effective bycatch reduction plan

- Bycatch plan in place and reaching its conservation goals (deemed effective)
- Bycatch plan in place but effectiveness is not yet demonstrated or is under debate
- **No bycatch plan implemented** (**Morocco, Mauritania, Spain offshore)** or bycatch plan implemented but not meeting its conservation goals (deemed ineffective)
- Not applicable because bycatch is "low" (**Spain inshore**)

Fishing practices: Management addresses the effect of the fishing method(s) on habitats and ecosystems

- Mitigative measures in place and deemed effective
- Mitigative measures in place but effectiveness is not yet demonstrated or is under debate (**Spain offshore)**
- **No mitigative measures in place** (**Mauritania, Morocco, Vietnam**) or measures in place but deemed ineffective
- Not applicable because fishing method is moderate or benign **(Spain inshore)**

Enforcement: Management and appropriate government bodies enforce fishery regulations

- Regulations regularly enforced by independent bodies, including logbook reports, observer coverage, dockside monitoring and similar measures
- Regulations enforced by fishing industry or by voluntary/honor system (**Morocco, Spain inshore, Spain offshore)**
- Regulations not regularly and consistently enforced (**Mauritania, Vietnam**)

Management Track Record: Conservation measures enacted by management have resulted in the long-term maintenance of stock abundance and ecosystem integrity

- Management has maintained stock productivity over time OR has fully recovered the stock from an overfished condition
- Stock productivity has varied and management has responded quickly OR stock has not varied but management has not been in place long enough to evaluate its effectiveness OR **Unknown** (**Mauritania, Spain inshore, Spain offshore, Vietnam**)
- Measures have not maintained stock productivity OR **were implemented only after significant declines and stock has not yet fully recovered (Morocco)**

Evaluation Guidelines

Management is deemed to be "**Highly Effective**" if the majority of management factors are green AND the remaining factors are not red.

Management is deemed to be "**Moderately Effective**" if:

1) Management factors "average" to yellow
2) Management factors include one or two red factors

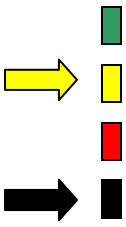
Management is deemed to be "**Ineffective**" if three individual management factors are red, including especially those for Stock Status and Bycatch.

Management is considered a **Critical Conservation Concern** and a species receives a recommendation of "**Avoid"**, regardless of other criteria if:

1) There is no management in place
2) The majority of the management factors rank red.

Conservation Concern: Effectiveness of Management

- Low (Management Highly Effective)
- Moderate (Management Moderately Effective) (**Spain**)
- High (Management Ineffective)
- Critical (Management Critically Ineffective) (**Morocco, Mauritania**, **Vietnam**)



Overall Seafood Recommendation

Overall Guiding Principle: Sustainable wild-caught seafood originates from sources that can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems.

Evaluation Guidelines

A species receives a recommendation of "**Best Choice**" if:

1) It has three or more green criteria and the remaining criteria are not red.

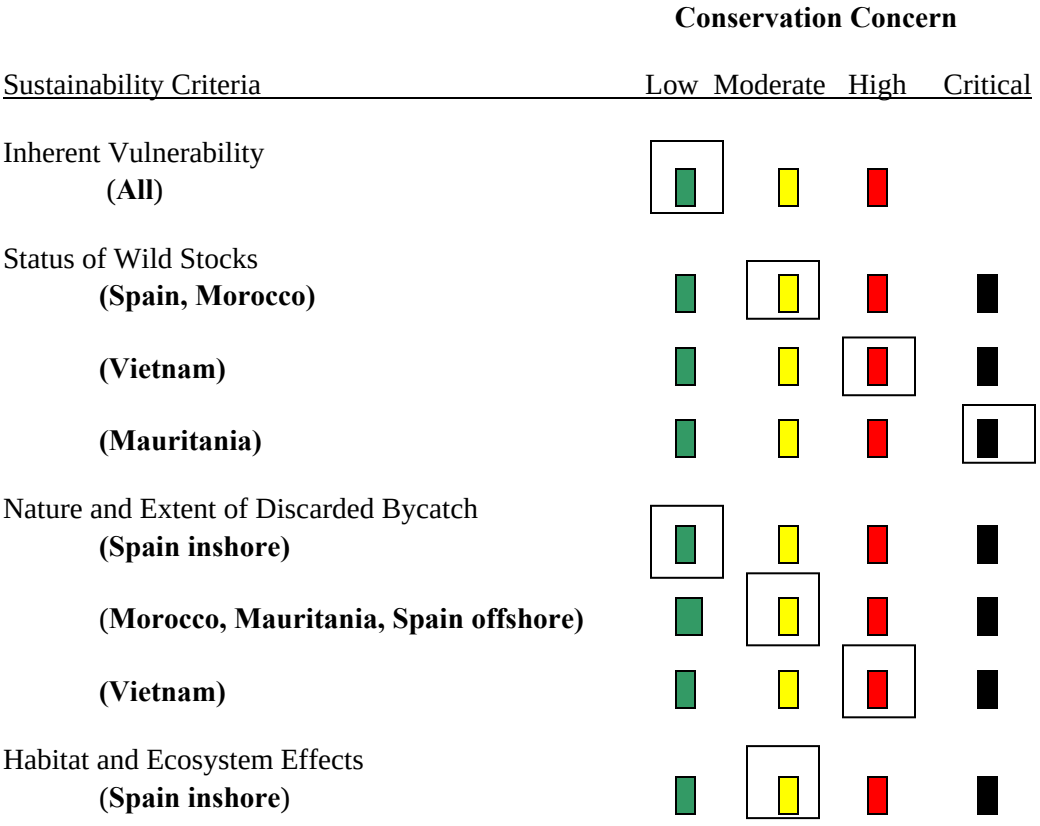
A species receives a recommendation of "**Good Alternative**" if:

1) Criteria "average" to yellow
2) There are four green criteria and one red criteria
3) Stock Status and Management criteria are both ranked yellow and remaining criteria are not red.

A species receives a recommendation of "**Avoid**" if:

1) It has a total of two or more red criteria
2) It has one or more Critical Conservation Concerns.

Summary of Criteria Ranks

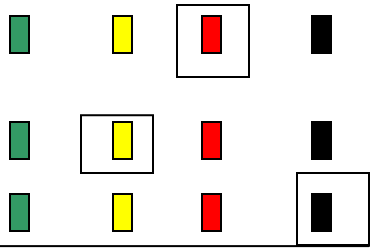


(Morocco, Mauritania, Spain offshore, Vietnam)

Effectiveness of Management

(Spain)

(Morocco, Mauritania, Vietnam)



Overall Seafood Recommendation

Best Choice

Good Alternative (Spain)

Avoid (Morocco, Mauritania, Vietnam)