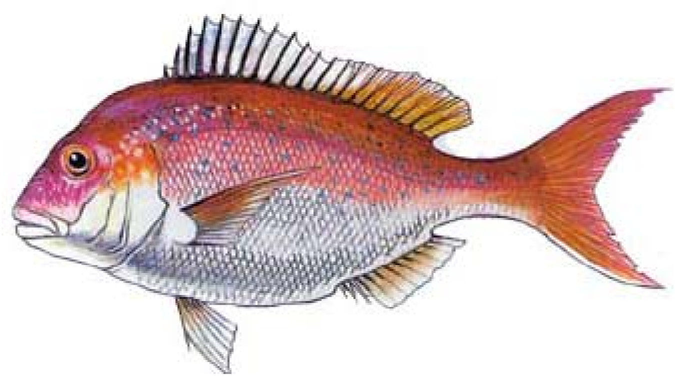
Seafood Watch

Seafood Report

MONTEREY BAY AQUARIUM®

Squirefish
"New Zealand tai snapper"
(*Pagrus auratus*)



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Final Report

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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. Executive Summary

New Zealand tai snapper (*Pagrus auratus*) is a relatively long-lived fish that inhabits the temperate and sub-tropical waters off the coasts of Australia and New Zealand. Although *P. auratus* is long lived and grows at a moderate speed, it reaches sexual maturity quickly (3–4 years) and is highly fecund. New Zealand tai snapper is restricted to the southern reaches of the Indo-Pacific basin and the neritic zones surrounding New Zealand and Australia, and it migrates from inshore to offshore at the onset of maturity. Tai snapper is a sequential hermaphrodite that aggregates prior to and during spawning. Owing to its low age at sexual maturity, this species ranks as inherently resilient to fishing pressure according to Seafood Watch® criteria.

There are six major management areas for tai snapper in New Zealand waters: East Northland/Hauraki Gulf/Bay of Plenty (SNA1), East Coast North Island (SNA2), South East Coast (SNA 3), Marlborough/Tasman (SNA7), West Coast North Island (SNA8) and Kermadec (SNA 10). Tai snapper populations in each of these management areas are managed as separate stocks, and the snapper populations in SNA1 are assessed as two separate stocks - East Northland and Hauraki Gulf/Bay of Plenty. Based on data from the 2007/2008 season, SNA1 and SNA8 are the areas of highest catch, accounting for 92% of total tai snapper catch in New Zealand. The remaining management areas (SNA3 and SNA10) contributed less than 1% of the catch in 2007/2008 and are of less commercial importance. All populations are assessed relative to the stock biomass at maximum sustainable yield (B_{MSY}), which is estimated to be about 20%–24% of unfished biomass in each region. The use of B_{MSY} as a stock target is a concern because 20% of unfished biomass is more commonly considered the threshold for overfishing. The SNA1 and SNA2 tai snapper stocks have biomass levels at or below 20% of unfished biomass and are therefore considered overfished by Seafood Watch®. The SNA8 tai snapper stocks are considered depleted by the Ministry of Fisheries, and the status of the SNA7 stock remains uncertain. Overfishing is not currently occurring in the SNA1 and SNA2 stocks as fishing mortality is below F_{MSY}, but F/F_{MSY} is unknown for SNA7 and SNA8. There is low uncertainty about the status of the SNA1 and SNA8 stocks, and uncertainty about the status of SNA7 and SNA2 stocks is moderate. The SNA7 populations are considered a moderate conservation concern according to Seafood Watch® criteria, while the SNA1, SNA2 and SNA8 stocks are a high conservation concern.

Fishing gear types used in the tai snapper fishery include beach seine, set net (bottom gillnet), bottom longline, Danish seine and bottom trawl. There is no available information on bycatch rates in the Danish seine, beach seine and set net tai snapper fisheries. Observer coverage for the bottom longline and trawl tai snapper fisheries is very low, so estimates of bycatch rates based on observer coverage do not summarize the actual rates of bycatch in these tai snapper fisheries. Overall rates of bycatch relative to targeted landings are unknown for all tai snapper fisheries because observers record only interactions with protected species and not finfish or invertebrate bycatch. It is not currently possible to estimate the quantity of sea turtle, marine mammal or seabird bycatch relative to total tai snapper landings, so the overall bycatch of these species groups in the bottom longline and trawl fisheries is unknown. The most accurate record of bycatch exists for seabirds in the bottom longline fishery with a total of 60 observed seabird captures between 2000 and 2007, including Black petrels and Buller's shearwaters (both listed as vulnerable by IUCN) in addition to flesh-footed shearwaters (listed as near threatened by IUCN).

There is no evidence of marine mammal capture in the bottom longline tai snapper fishery. Seabird and marine mammal bycatch in the inshore trawl fisheries are not well documented but are estimated to be fairly low. There was only one observed incident of sea turtle bycatch in an unidentified bottom longline fishery between 1998 and 2007, and there were no observed incidents of sea turtle bycatch in any trawl fishery between 2000 and 2007. However, given the low level of observer coverage, it is possible that substantial bycatch of rare species is occurring. Because overall bycatch rates, the extent of interactions with protected species and the population impacts of bycatch are unknown, bycatch in the New Zealand beach seine, set net, Danish seine and bottom trawl tai snapper fisheries is a moderate conservation concern according to Seafood Watch®. Because bycatch of protected seabirds regularly occurs in the bottom longline fishery—even though overall bycatch rates and the population impacts of seabird bycatch are unknown—bycatch in the tai snapper bottom longline fishery is also considered a moderate conservation concern.

Beach seines, set nets (bottom gillnets) and bottom longlines are bottom gear but are less mobile than bottom trawls or dredges and are typically used in habitats that have moderate to high resilience to disturbance. Bottom trawls and Danish seines are mobile bottom gears occasionally used on rocky bottom areas with low resilience to disturbance but primarily deployed on muddy and smooth bottom areas. Because these gear types require dragging heavy equipment across the seabed, they are considered highly damaging to bottom habitats. The impact of the tai snapper fishery on the food web and ecosystem is unknown. Because bottom trawls and Danish seines cause great damage, despite being used on a moderate spatial scale and in moderately resilient habitats, they are considered to have severe impacts on habitats and the ecosystem. Beach seines, set nets and bottom longlines are considered to have moderate impact on habitats and the ecosystem because they cause moderate damage and are used in moderately to highly resilient habitats.

Overall, management of the New Zealand tai snapper commercial fishery is moderately effective according to Seafood Watch® criteria. All of the management areas collect and analyze fishery-dependent and independent data and have completed robust stock assessments, though much of the current stock assessment information needs to be updated. The tai snapper fishery also has observer coverage and dockside monitoring in each area to enforce fishery regulations. Stock productivity has declined throughout the fishery in the past, but management has responded by reducing catch limits. Most tai snapper stocks have been in recovery since the implementation of management plans. The New Zealand government has a national plan of action in place to address seabird bycatch, the primary source of bycatch in the tai snapper fishery, but does not have effective plans to measure and address bycatch of other species. The seabird bycatch program has only been in place since late 2004 and has not yet been fully evaluated. Certain areas have been closed to reduce fishery conflicts and protect undersized snapper, but these measures do not reduce the impacts of fishing gear on habitat and are therefore only moderately effective at mitigating the habitat impacts of the bottom trawl and Danish seine fisheries.

The moderate health of the stocks, moderate bycatch concerns and moderately effective management result in a Seafood Watch® overall recommendation of **Good Alternative** for New Zealand tai snapper from the SNA7 stock, regardless of gear type. Tai snapper from the SNA1, SNA2 and SNA8 stocks caught with beach seines, set nets or bottom longlines are also deemed a

Good Alternative according to Seafood Watch® due to poor stock status, moderate bycatch, moderate habitat/ecosystem impacts and moderately effective management. Tai snapper from the SNA1, SNA2 and SNA8 stocks caught with bottom trawls or Danish seines are ranked **Avoid** due to poor stock status and severe habitat and ecosystem impacts.

Table of Sustainability Ranks

	Conservation Concern			
Sustainability Criteria	**Low**	**Moderate**	**High**	**Critical**
Inherent Vulnerability	√			
Status of Stocks		√ SNA7	√ SNA1, SNA2, SNA8	
Nature of Bycatch		√ Beach seine, Set net, Bottom longline, Danish seine, Bottom trawl		
Habitat & Ecosystem Effects		√ Beach seine, Set net, Bottom longline	√ Danish seine, Bottom trawl	
Management Effectiveness		√ SNA1, SNA2, SNA7, SNA8		

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

SNA7 – all gear; SNA1, SNA2, SNA8 – set net, beach seine and bottom longline:

Best Choice | **Good Alternative** | Avoid

SNA1, SNA2, SNA8 – bottom trawl and Danish seine:

Best Choice | Good Alternative | **Avoid**

II. Introduction

Basic biology
New Zealand tai snapper (*Pagrus auratus*) are relatively long-lived, slow-growing fish that inhabit the temperate and sub-tropical waters off the coasts of Australia and New Zealand (Figure 1). New Zealand tai snapper feed primarily on crustaceans but also include starfish, marine worms, sea urchins and small fish in their diet (FishBase 2007).

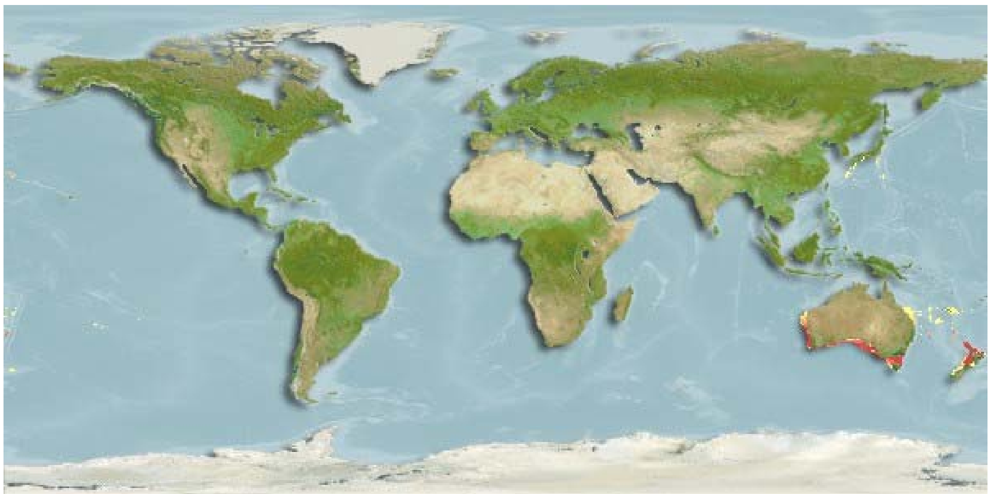

Figure 1. Global range of *P. auratus* (FishBase 2007).

The eggs of tai snapper are between 0.9 and 1.0 mm in diameter; those eggs with positive buoyancy have a higher hatching rate than those with negative buoyancy, which is generally correlated with immaturity, over-ripeness or lack of fertilization. Most tai snapper eggs hatch into 3 mm yolksac larvae about 28 hours after fertilization, although the exact time varies and is heavily dependent on water temperature (PIRSA 2000).

Larvae generally absorb the yolksac two days after hatching, and by the sixth day they absorb their oil globule as well (PIRSA 2000). The larval stage lasts anywhere from 18 to 32 days; fish spawned earlier in the season or in colder waters tend to have longer larval periods (Francis 2005).

Adult *P. auratus* can reach up to 45 lbs (20 kg) in weight and 50–70 years in age. New Zealand tai snapper are know to exhibit sequential hermaphroditism with the majority of hermaphrodites morphing from male to female in their 3rd or 4th year (FAO 2008). Older individuals, especially males, can develop excessive bone growth or thickening of the skull (know as hyperostosis) along the cranial ridge (McGrouther 2006).

Fishery information

New Zealand tai snapper have been a staple food in northern New Zealand since before the arrival of European colonizers. Over the past half century, New Zealand tai snapper have developed into one of New Zealand's most important commercial fishes (NZMF 2006) and also form one of New Zealand's most important recreational fisheries.

Overfishing of tai snapper became a significant issue in the mid-20th century, with depletion of populations throughout New Zealand's waters in the 1960s and 1970s. Commercial landings reached their peak in 1978 with a total catch of 18,000 mt (NZMF 2006). The New Zealand government has since established management measures designed to protect and rebuild tai snapper stocks (see Criterion 5: Effectiveness of the Management Regime for further information).

There are six management areas defined for New Zealand tai snapper: East Northland/Hauraki Gulf/Bay of Plenty (SNA1), West Coast North Island (SNA8), East Coast North Island (SNA2), Marlborough/Tasman (SNA7), and the minor regions SNA3 and SNA10 (Figure 2). In the 2005/2006 season, SNA1 (4,231 mt) and SNA8 (1,395 mt) accounted for 91% of the total catch while SNA2 (358 mt) and SNA7 (161 mt) contributed an additional 9% (Figure 3).

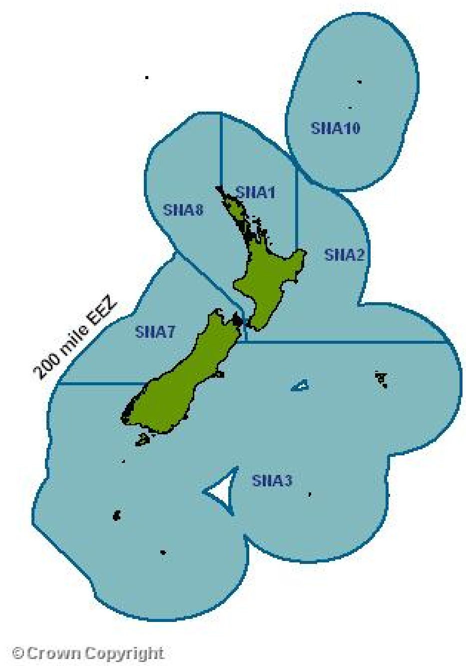

Figure 2. The division of New Zealand waters into SNA management areas (NZMF 2007b).

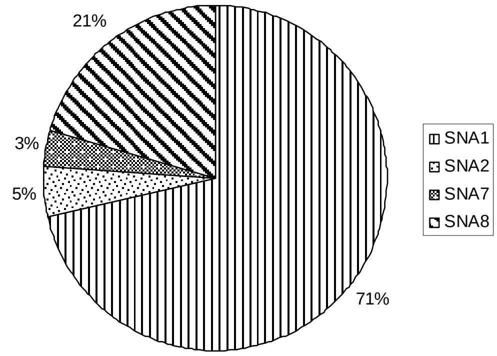

Figure 3. Relative catch of New Zealand tai snapper by management area (Data from NZMF 2007b).

Landings by gear type are only published for SNA1 between 1984 and 1998 (Table 1). Percentage of landings by gear type varied for each of the sub-stock areas, with line landings accounting for more than 50% of landings in East Northland and more than 40% of landings in Hauraki Gulf annually during this time period (Gilbert *et al.* 2000) (Table 1). Single trawls were more commonly used in the Bay of Plenty (Table 1). Estimates of landings by gear type have not been published for other management areas.

Table 1. New Zealand tai snapper catch in SNA1 from 1984 to 1998 by sub-stock and gear type (data from Gilbert *et al.* 2000).

	East Northland						Hauraki Gulf						Bay of Plenty					
Year	**Landings (mt)**	Single trawl (%)	Pair trawl (%)	Danish seine (%)	Nets (%)	Line (%)	**Landings (mt)**	Single trawl (%)	Pair trawl (%)	Danish seine (%)	Nets (%)	Line (%)	**Landings (mt)**	Single trawl (%)	Pair trawl (%)	Danish seine (%)	Nets (%)	Line (%)
1984-85	2007	6.5	36.8	3.7	2.9	50.1	3443	15.6	2.8	31.6	10.2	39.8	1354	55.6	12.8	2.8	3.1	25.6
1985-86	1563	7.3	23.6	4.9	2.8	61.4	2985	15.8	0.7	27.5	9.8	46.2	1328	46.0	10.0	1.1	3.2	39.6
1986-87	847	8.1	14.9	4.3	3.7	68.9	2333	26.7	0.5	21,5	7.4	43.9	835	51.4	10.0	1.0	3.1	34.3
1987-88	1063	7.2	17.2	3.2	4.9	67.5	3269	20.9	1.5	21.3	7.6	48.6	729	43.1	28.5	1.1	2.8	24.5
1988-89	1303	21.1	5.1	14.4	4.3	55.2	3580	27.9	0.0	14.3	7.5	47.1	910	68.2	9.2	4.8	0.7	17.1
1989-90	1521	9.6	21.6	11.9	3.5	53.4	3129	29.8	2.1	15.8	8.1	44.3	1177	49.9	10.3	18.5	1.2	20.1
1990-91	1157	11.3	13.4	13.0	4.1	58.2	3093	25.4	3.9	23.2	7.9	39.6	1065	38.9	12.6	14.8	3.7	29.9
1991-92	1151	15.7	9.5	5.1	5.6	64.1	3830	24.9	0.0	24.8	6.5	43.8	1211	28.8	18.5	23.6	3.8	25.5
1992-93	1200	15.5	17.8	2.5	4.2	59.9	3159	20.7	0.0	21.9	5.1	52.3	1065	35.3	13.5	18.4	4.0	28.9
1993-94	1261	16.2	14.4	2.3	6.1	61.1	2583	18.1	0.2	22.8	4.4	54.5	1002	28.1	15.7	19.5	6.2	30.5
1994-95	1276	11.2	13.3	1.1	8.9	65.5	2471	19.5	1.8	22.1	3.4	53.3	1082	19.9	16.0	27.6	2.9	33.6
1995-96	1494	17.4	7.3	4.1	3.7	67.4	2028	22.7	1.5	14.8	4.7	56.2	1428	37.8	12.4	17.5	3.9	28.5
1996-97	1213	15.9	7.3	3.5	6,1	67.1	1735	21.6	3.4	19.5	7.9	47.6	1176	35.5	13.7	24.7	4.3	22.2
1997-98	1033	22.5	2.6	1.8	5.0	68.2	1893	34.5	0.2	16.6	3.0	49.7	887	38.8	2.7	33.3	3.3	21.8

Scope of the analysis and the ensuing recommendation

This report offers recommendations on all major *Pagrus auratus* fisheries in New Zealand waters. These include the regions SNA1 (subdivided into SNA1a: East Northland and SNA1b:

Hauraki Gulf/Bay of Plenty), SNA2, SNA7 and SNA8 fished using beach seine, set net, bottom longline, Danish seine and bottom trawl gear. Although a fishery for *P. auratus* exists in Australia, it is not evaluated here.

Availability of Science

The data used in this report to evaluate the inherent vulnerability of New Zealand tai snapper are taken from databases maintained by FishBase and the Food and Agriculture Organization of the UN (FAO) as well as information made public by Primary Industry and Resources South Australia (PIRSA). Stock status evaluations are based on information contained in various New Zealand Ministry of Fisheries (NZMF) fishery analyses such as the work done by researchers D.J. Gilbert, J. R. McKenzie and N.M. Davies. Conclusions concerning bycatch issues are based primarily on independent research (*e.g.*, Pierre and Norden 2006) due to a lack of data from available NZMF documents. Very little information on the overall ecosystem and habitat effects of the tai snapper fisheries is available; all conclusions are based on general assumptions about the types of gear employed. Information on management techniques and overall effectiveness is taken from the work of NZMF researchers (*e.g.*, Blackwell and Gilbert 2005; Blackwell and Gilbert 2006).

Market Availability

Common and market names

Within the sushi industry and at an increasing number of grocery store seafood counters, *P. auratus* is presented as "New Zealand tai snapper". It is generally known in New Zealand as "snapper" or "tamure", the latter being the traditional Maori word for the fish (Seafriends 2007). Other names commonly used outside of New Zealand include porgy and sea bream. It should be mentioned that the Australian nomenclature of *P. auratus* is associated with the size of the fish. In Australia, *P. auratus* may be known as "cockney", "squire" or "squirefish", "pinky", "snapper" or "red bream" (Seafriends 2007). While this system has not taken hold in the United States, it may in the future as Australia is beginning to experiment with large-scale *P. auratus* aquaculture for export.

Just as the English terms "porgy" and "seabream" have ambiguous definitions in the vernacular, the Japanese word *tai* is similarly ambiguous in the sushi lexicon. *Tai* has historically referred to *Pagrus major*, or red seabream. This highly-prized reef fish is found in the western Pacific Ocean and is a traditional sushi staple in Japan. *Pagrus major* does not exist in the waters of the United States, however, and is not commonly served in US restaurants. Rather, the "tai" served in American sushi bars is sourced from a variety of alternative fisheries.

One of the substitutes for *P. major* is squirefish, which is marketed as New Zealand tai snapper. This fish is becoming popular among sushi chefs and seafood purveyors. There was some contention that the New Zealand and Australian sparids should be classified as a single species, *P. major*, however it is now universally accepted that the Australasian sparid is a separate species, *P. auratus* (Willis *et al.* 2003). This report offers a recommendation on the wild New Zealand *P. auratus* fishery.

Seasonal availability
Pagrus auratus freezes well and is available year-round.

Product forms
Pagrus auratus can be found in both sushi restaurants and fish markets, generally fresh or previously frozen. Fresh and frozen New Zealand tai snapper fillets (generally marketed as New Zealand tai snapper) are gaining popularity in grocery stores across the United States.

Import and export sources and statistics
Since 2000, the overall tonnage of exported *P. auratus* from New Zealand has declined slightly (Table 2) (NZMF 2007b). The National Marine Fisheries Service does not have import data for New Zealand tai snapper; thus, the amount imported into the US is unknown.

Table 2. Weight and value of total New Zealand tai snapper exports from 2000–2006 (NZMF 2007b).

Export Earnings							
Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
$NZ (millions)	38.9	37.4	33.7	28.8	29.0	25.9	29.0
Weight (MT)	4,600	4,100	4,300	3,800	4,166	4,144	4,176

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

Criterion 1: Inherent Vulnerability to Fishing Pressure

The intrinsic rate of population increase (r_{max}, or the rate of population growth when the population is under ideal conditions) for *P. auratus* is unknown. Estimates of the von Bertalanffy growth parameter (k) vary across the main regions subject to commercial exploitation. Tai snapper typically grows at a moderate speed with k values from different regions ranging from 0.061 to 0.160 (Table 3) (Gilbert and Sullivan 1994; Millar *et al.* 1999; NZMF unpublished data).

Table 3. von Bertalanffy growth parameter (k) by management area (figures presented in NZMF 2009).

Stock	K	Source
SNA1	0.102	Gilbert and Sullivan 1994
SNA2	0.061	NZMF unpublished data
SNA7	0.122	NZMF unpublished data
SNA8	0.160	Gilbert and Sullivan 1994

Pagrus auratus reaches sexual maturity between three and four years of age, at which point it averages about 20–28 cm in length (NZMF 2007b). Various sources have recorded the maximum age of *Pagrus auratus* as anywhere from 35 years (Fishbase 2008) to over 60 years (Francis *et al.* 1992; NZMF 2007b). Fecundity in females increases with size; sexually mature females produce approximately 297,000 eggs at 25 cm and 6,164,000 eggs at 50 cm (Crossland 1977).

Pagrus auratus is an Indo-Pacific fish that congregates primarily off the coasts of New Zealand and southern Australia. Australian and New Zealand populations are genetically distinct (Meggs and Austin 2003). Tai snapper engage in inshore-offshore migrations that depend on age and season (Francis 1995). Young snapper dwell in shallow water and sheltered areas and migrate to deeper water in the winter. Mature snapper congregate in large schools between November and December just prior to spawning and then move to their spawning grounds in the spring (NZMF 2007b). There is also evidence that tai snapper school at the mouths of estuaries while spawning (Lenanton *et al.* 1984).

Tai snapper have an annual reproductive cycle with a spawning period lasting several months. The initiation and length of spawning varies from year to year depending on sea surface temperature and photoperiod (Scott and Pankhurst 1992). Snapper spawn between October and January when the water temperature is between 16 and 21° C (Crossland 1981).

There is currently no information about habitat degradation or other quality issues related to New Zealand tai snapper.

Table 4. Life history characteristics of *Pagrus auratus.*

Species	**Intrinsic Rate of Increase**	**Age at Maturity**	**Growth Rate**	**Max Age**	**Max Size**	**Fecundity**	**Species Range**	**Special Behaviors**	**Sources**
New Zealand tai snapper *(P. auratus)*	Unquantified, but varies by stock	Low: 3-4 years	Medium: Varies by stock, ranging from 0.061 – 0.160	60+ years (NZMF 2007b)	130 cm TL	High: 297,000 at 25cm up to 6,164,000 at 50cm	Throughout Indo-Australian sub-tropical and tropical neritic zones	Inshore-offhore migrations dependent on age; aggregation prior to spawning	Crossland 1977; Fishbase 2007; NZMF 2007b

Synthesis

Although *P. auratus* is a long-lived organism, it reaches sexual maturity quickly and is highly fecund. It is restricted to the southern reaches of the Indo-Pacific basin and the neritic zones surrounding New Zealand and Australia. Tai snapper undertake an inshore-to-offshore migration corresponding with the onset of maturity. Tai snapper are sequential hermaphrodites and aggregate prior to and during spawning. Little is known about the current status of tai snapper habitat. Given a low age at maturity, Seafood Watch® considers *P. auratus* to be inherently resilient to fishing pressure.

Inherent Vulnerability Rank:

Resilient | Moderately Vulnerable | Highly Vulnerable

Criterion 2: Status of Wild Stocks

This section contains stock assessment information for the four New Zealand tai snapper fisheries management areas that account for a majority of commercial catch: East Northland/Hauraki Gulf/Bay of Plenty (SNA1, often subdivided into two sub-regions), East Coast North Island (SNA2), Marlborough/Tasman (SNA7) and West Coast North Island (SNA8). All of these stocks are ostensibly rebuilding toward B_{MSY}, but some populations remain below this level and progress in rebuilding stocks has been variable (NZMF 2006).

Stock health in all areas is monitored through tagging programs, landing records and commercial catch/effort data (NZMF 2006). While SNA1 and SNA8 are monitored closely for snapper landings—most of the commercial catch comes from these management areas,—SNA2 and SNA7 are monitored because snapper is largely taken as bycatch in these areas. The New Zealand tai snapper fisheries in SNA3 and SNA10 are minor in scope and production; little information is available concerning stock health for these areas (NZMF 2006; Weeber and Szabo 2006). Stock assessments are presented below in descending order, starting with the management region accounting for the most commercial landings. Quotas are set based on tonnage rather than mortality rates, which are not published for any stock but can be estimated based on catch and biomass estimates.

Estimates of B_{MSY} in the snapper fishery

Biomass is estimated and assessed relative to the biomass needed to produce MSY (B_{MSY}) in each management area. The value of B_{MSY} has been calculated at between 20% and 24% of unfished biomass (B_0) in each management area (NZMF 2009a). The use of this value as a target reference point is of some concern as 20% of B_0 is frequently considered an overfished threshold in other management regimes. According to New Zealand's Harvest Strategy Standard (NZMF 2008e), 20% of B_0 is defined as the default "soft limit" beyond which fisheries are considered depleted and in need of planned rebuilding. In the Standard, the Ministry of Fisheries notes that 40% of B_0 is "the default [target reference point] adopted by several national or regional fisheries management organizations," and that while alternatives to 40% of B_0 may be acceptable target reference points if justified for a particular stock, "it is becoming increasingly difficult to justify stock targets less than 30%–40% of B_0". The Ministry of Fisheries also contends that the calculation of B_{MSY} as 20% of B_0 for snapper is based on outdated assumptions from previous assessment methodologies and needs to be re-evaluated (NZMF 2008f). Nevertheless, the Ministry of Fisheries currently accepts 20% of B_0 as a stock target for snapper, and snapper stocks at or near this target are not classified as overfished. Because of the uncertainty surrounding the B_{MSY} estimates for snapper, population abundance relative to B_{MSY} is uncertain for these snapper fisheries, although estimates are available based on stock assessments.

SNA1

The area along the northeast coast of the North Island from North Cape to Cape Runaway in the Bay of Plenty has been defined as SNA1 (Figure 4). The commercial fishery in this area developed in the 19th century and expanded considerably in the 1970s with the introduction of Danish seine and trawl vessels, with catches surpassing 10,000 mt. The inception of the

Japanese *iki jime* market[1] for New Zealand tai snapper led to an increase in longlining in the 1980s. During this period, overall catch in SNA1 declined to between 6,000 and 7,000 mt. An annual total allowable commercial catch (TACC) was established in 1986 through the Quota Management System (QMS) (Gilbert *et al.* 2000). The TACC for SNA1 has been at 4,500 mt since 1998. Currently, the area is divided into three sub-stocks, namely East Northland, Hauraki Gulf and the Bay of Plenty. The latter two stocks are generally managed and assessed as a single fishery.

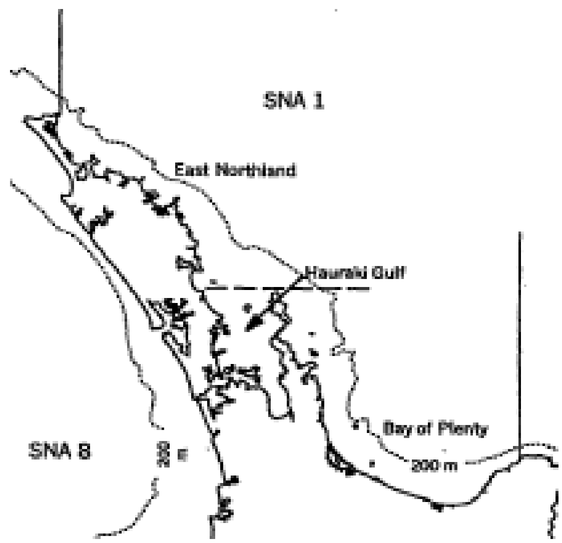

Figure 4. Map of SNA 1 divided into East Northland, Hauraki Gulf and Bay of Plenty (Figure from Gilbert *et al.* 2000).

The most recent assessments for the East Northland and Hauraki Gulf/Bay of Plenty stocks were conducted in 2000 using age-structured population models. The model performance indicators reported the probability that the current stock level would be above 2020 stock levels, the probability that 2020 stock levels would be above B_{MSY}, and the expected 2020 biomass relative to B_{MSY}. Data inputs for the analyses included catch per unit effort (CPUE) indices, tagging biomass estimates, and catch and age estimates (NZMF 2007c). At the time of the assessment, the model indicated that the East Northland stock was near B_{MSY} and had a 67% probability of exceeding B_{MSY} by 2020. Estimates for the Hauraki Gulf/Bay of Plenty stock assessment placed the stock at 80% of B_{MSY} but suggested that the stock would rebuild to B_{MSY} (with 100% probability) by the end of the 20 year model period (NZMF 2009a). Values for F and F_{MSY} were not published in the stock assessment but can be calculated from landings and biomass for F, and from MSY and B_{MSY} for F_{MSY}. Because landings are reported for SNA1 as a whole (the combined East Northland and Hauraki Gulf/Bay of Plenty stocks), F/F_{MSY} is also estimated for the combined stocks. In SNA1, F_{MSY} is approximately 0.14 and F is approximately 0.07, which yields a F/F_{MSY} ratio of about 0.5, indicating that overfishing is not occurring.

[1] *Iki jime,* or "live killing", refers to killing a fish by driving a sharp spike through its brain. It is thought that this method of killing reduces stress on the fish and thus preserves high-quality flesh, as *Iki jime* fish are generally served whole.

East Northland

The base case stock assessment for East Northland suggested that MSY for tai snapper was 2,057 mt, B_{MSY} was about 13,800 mt and 1999 biomass was 13,300 mt or 96% of B_{MSY} (NZMF 2007e). However, there is uncertainty in this estimate of B/B_{MSY} due to concerns about the estimation methods for B_{MSY} (see "Estimates of B_{MSY} in the snapper fishery" above). The value of B_{MSY} is about 21% of unfished biomass (B_0) for this stock (NZMF 2009a), so this stock with a biomass of 96% of B_{MSY} \is at 20% of B_0 (96% of 21%), which is frequently considered an overfished threshold in other management regimes, including the US. Even though the stock is not considered overfished and is classified as "unlikely" to be depleted according to the Ministry of Fisheries (NZMF 2009b), Seafood Watch® considers the stock to be overfished. Over the long term, biomass levels are expected (with a 67% probability) to trend upwards, continuing to exceed B_{MSY} by the end of the twenty-year period used in the model (Figure 5) (Gilbert *et al*. 2000; NZMF 2007c). The ratio F/F_{MSY} for the combined East Northland and Hauraki Gulf/Bay of Plenty stocks is 0.5, indicating that overfishing is not occurring. All of this suggests that the East Northland stock is recovering from overfishing. This conclusion is supported by all model scenarios, except where low natural mortality is assumed. The total allowable commercial catch (TACC) is 25% of the SNA1 total allowable catch (TAC), or 1,125 mt. For SNA1 as a whole, commercial landings have matched or only slightly exceeded the TACC since 1992 (Figure 6). Biomass estimates have exhibited a declining long-term trend and a fairly stable short-term trend of increases (Figure 5). Catch-at-age estimates for this sub-region show high catch of fish below age 12 but also show solid landings of fish on the upper end of the age distribution, including a few landings of fish over age 19. Overall, the age distribution for this stock is functionally normal (Walsh *et al.* 2008). The overall degree of uncertainty regarding the tai snapper stock in SNA1 is low.

Because the biomass of the East Northland tai snapper stock was at 20% of unfished biomass levels at its last assessment (overfished according to Seafood Watch®) and has an increasing short-term trend, this stock is considered a high conservation concern according to Seafood Watch®.

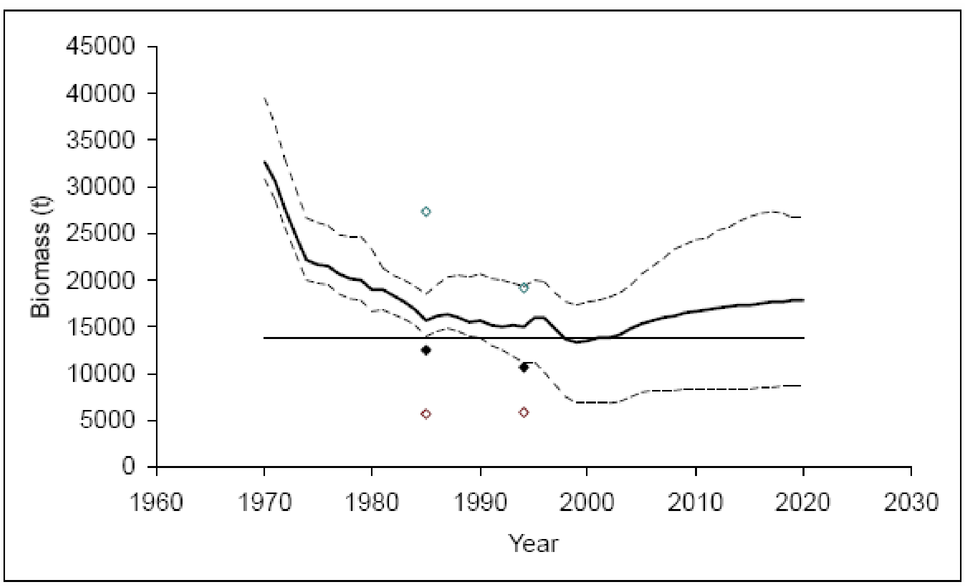

Figure 5. Biomass trajectory for East Northland snapper. Horizontal line—base case B_{MSY} estimate; solid line—base case trajectory; dashed lines—90% confidence interval (Figure from NZMF 2007e).

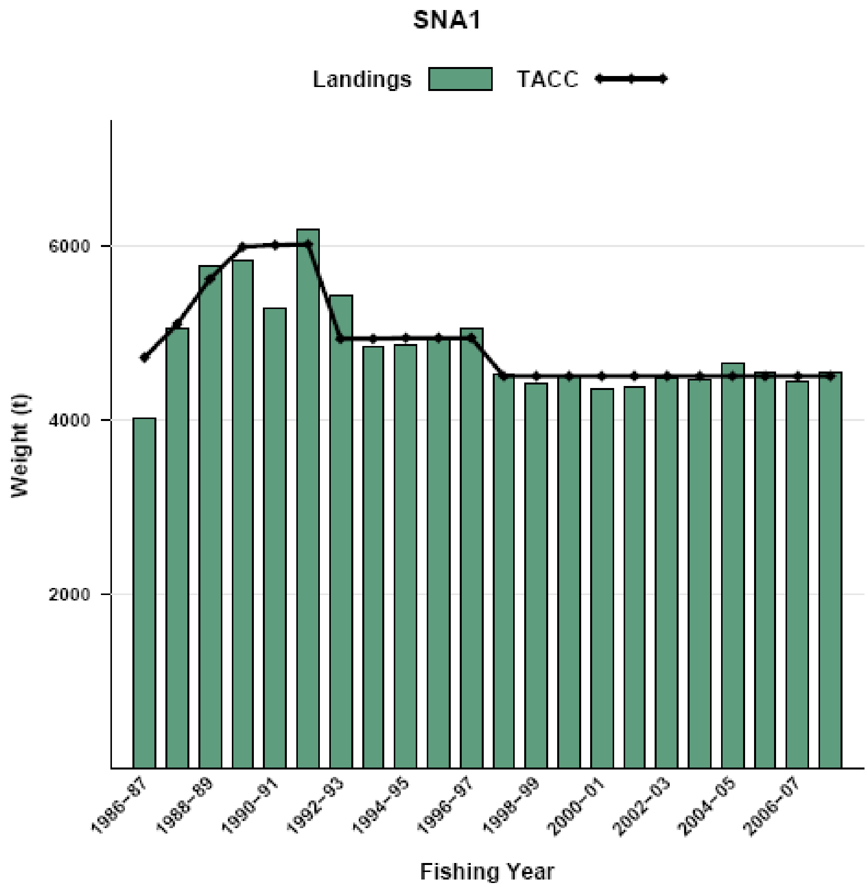

Figure 6. Historical commercial landing and TACC for SNA1 (Figure from NZMF 2009a).

Hauraki Gulf/Bay of Plenty

The base case stock assessment for Hauraki Gulf/Bay of Plenty suggested that MSY was 7,993 mt, B_{MSY} was 64,400 mt, and 1999 biomass was 51,700 mt or 80% of B_{MSY} (NZMF 2007e). However, there is uncertainty in this estimate of B/B_{MSY} due to concern about the estimation method for B_{MSY} (see "Estimates of B_{MSY} in the snapper fishery" above). The value of B_{MSY} is about 23% of unfished biomass (B_0) for this stock (NZMF 2009a) so a biomass of 80% of B_{MSY} means that the stock is at approximately 18% of B_0 (80% of 23%), which is frequently considered beyond the overfished threshold (20% of B_0) in other management regimes, including the US. Even though the stock is not considered overfished and is classified as "unlikely" to be depleted by the Ministry of Fisheries (NZMF 2009b), Seafood Watch® considers this stock to be overfished. Biomass estimates from 2000 showed a slight improvement from the previous year's estimate of 67% of B_{MSY} (Annala *et al.* 1998; Gilbert *et al.* 2000). Current recruited biomass has fallen short of projected B_{MSY} figures, but the stock is expected to increase under newly-introduced and more stringent catch limits. Projections suggest (with 100% probability) that the stock may exceed B_{MSY} by 2020; this conclusion is robust for all tested model scenarios (Gilbert *et al.* 2000; NZMF 2007c). The TACC is set to 75% of the TAC for SNA1, 3,375 mt. As with the East Northland sub-region, overfishing is not occurring, and commercial landings for the SNA1 region have matched or only slightly exceeded the TACC since 1992 (Figure 6). Biomass estimates have exhibited a variable long-term trend and an increasing short-term trend, with increases observed since the mid-1990s suggesting that the stock is recovering (Figure 7). The overall degree of uncertainty regarding the status of this stock is low.

The age distribution of commercial Bay of Plenty landings is largely weighted towards fish younger than 10 years of age. This sub-region has the fewest landings of older fish in SNA1: only 2% of landings are fish 14 years of age and older, and only a few are over 19 years of age (Walsh *et al.* 2008). The Bay of Plenty stock receives a fairly high amount of fishing pressure, and growth in older age class abundance is not anticipated to increase in the short term. The Hauraki Gulf stock has a broader catch-at-age distribution than either of the other SNA1 stocks and has the highest mean age distribution. Nonetheless, landings of fish over age 19 are still low. Overall, age distribution is functionally normal for Hauraki Gulf but skewed towards fish under age 10 in the Bay of Plenty.

Because the Hauraki Gulf/Bay of Plenty snapper stock was at about 18% of unfished biomass levels at its last assessment (overfished according to Seafood Watch®), it is considered a high conservation concern according to Seafood Watch®.

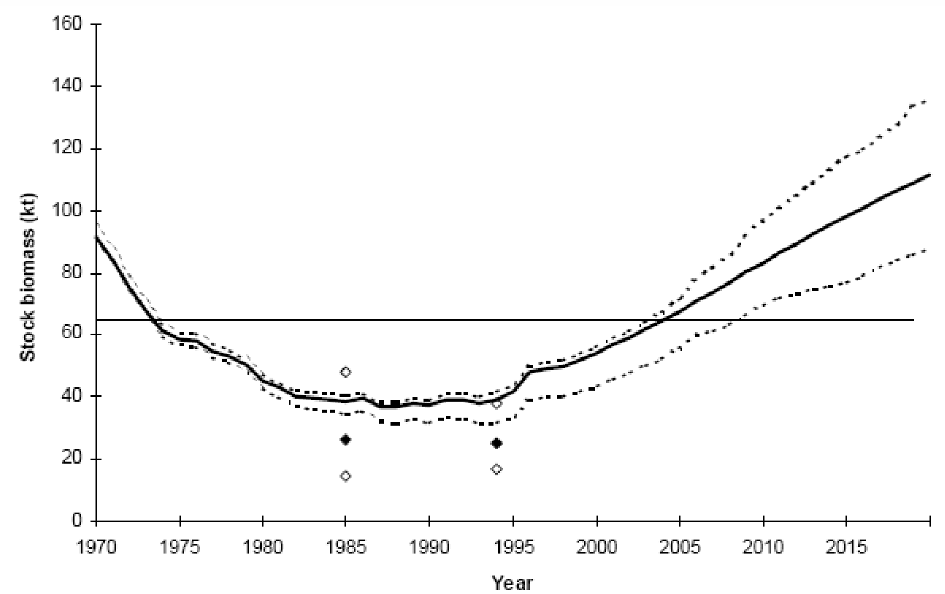

Figure 7. Biomass trajectory for Hauraki Gulf/Bay of Plenty snapper. Horizontal line—base case B_{MSY} estimate; solid line—base case trajectory; dashed lines—90% confidence interval (Figure from NZMF 2007e).

SNA8 (Auckland West/Central West)

The management region known as SNA8 covers all waters west of the North Island from the tip of North Cape southward. The current TACC for this region is 1,300 mt, which is a reduction from previous levels established in 2005 to ensure faster rebuilding of the stock (NZMF 2009a). Snapper was last assessed in this management area in 2005 using updated method-specific catch weights along with recent catch-at-age data and CPUE data (NZMF 2007e). Similar to the model for SNA1, the SNA8 assessment used an age-structured model. The Snapper Working Group defines B_{MSY} as 20% of virgin biomass (B_0), but there is some concern about this estimate and its use as a target reference point (see "Estimates of B_{MSY} in the snapper fishery" above). The most recent assessment estimated biomass at 10,800 mt and unfished biomass at 110,000 mt, assuming a recreational take of 300 mt. When recreational take was doubled to 600 mt, biomass was estimated at 11,700 mt and unfished biomass at 117,000 mt. Both models indicated that biomass at start of 2004 was about 10% of unexploited levels (with 95% confidence intervals placing this estimate between 8% and 12% of unexploited levels) (NZMF 2007e). Thus, 2004 biomass was estimated at between 39% and 60% of B_{MSY} (NZMF 2005). According to the Ministry of Fisheries, the stock is "very unlikely" to be near or above target levels and "very likely" to be depleted (NZMF 2009b).

The SNA8 tai snapper stock is rebuilding but more slowly than the government had originally predicted, and biomass estimates provided by the last assessment were well below projected levels (NZMF 2006). The primary reason for the less optimistic assessment was that the estimated natural mortality was lower than had been previously assumed (0.051–0.055 compared to 0.075 y-1), which implied a less productive population. This information prompted a TACC decrease from 1,500 mt to 1,300 mt in an effort to increase rebuilding rates (Figure 8). At the current TACC, B_{MSY} (20% B_0) should be reached in 2018 assuming either a constant recreational effort or a capped recreational catch (at either 300 mt or 600 mt per year) (NZMF 2007c; Davies *et al.* 2006). Fishing mortality is estimated to be about 0.13, but F_{MSY} cannot be estimated as MSY has not been defined for this stock. It is uncertain if overfishing is occurring, but recorded landings have exceeded the TACC since 1996. Biomass has not rebounded as predicted, suggesting that mortality rates have been in excess of rates needed to bring this stock back to B_{MSY} in the timeframe set for rebuilding. The reductions in TACC and excess landings suggest that the stock may be experiencing overfishing. The overall degree of uncertainty regarding the status of the stock is low.

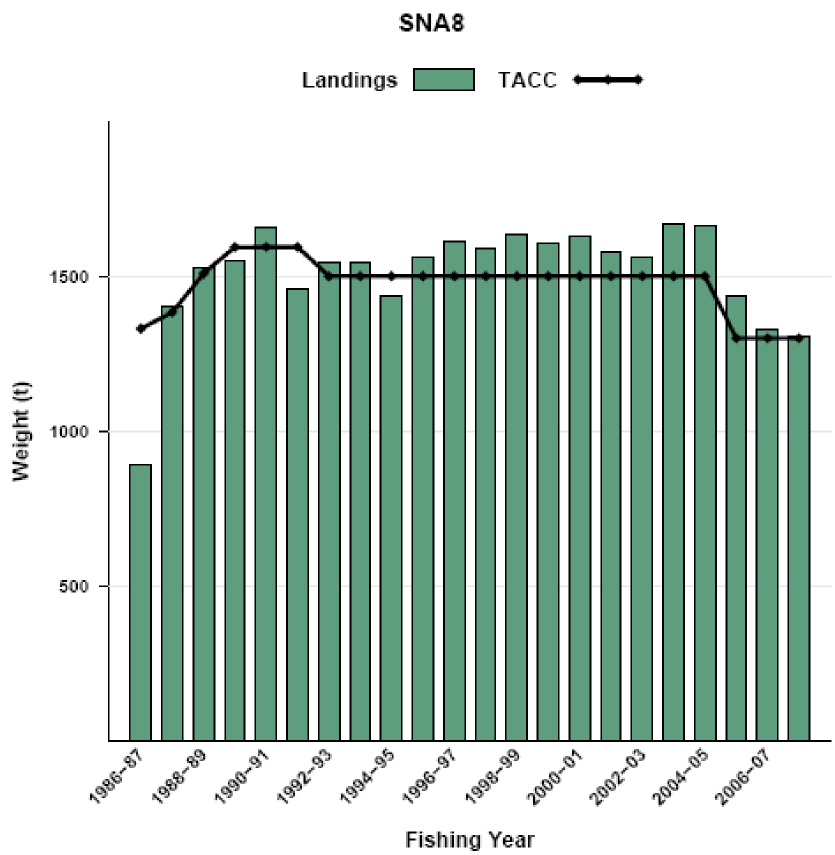

Figure 8. Historical commercial landings and TACC for SNA8 (Figure from NZMF 2009a).

Catch per unit effort data (from the 12 vessels with the highest landings) show a declining trend from 1995/96 until 2000/01 when the trend began increasing; a slight drop was also observed in 2003/04 (Figure 9) (NZMF 2007e). Estimates of stock biomass show a downward long-term trend with a very slight increasing short-term trend confirmed by absolute biomass estimates from tag-recapture studies (Figure 10) (Davies *et al.* 2006). The biomass of this stock has been estimated as similar to its size in the early 1980s, and it has been stable since 1994. Catch-at-age estimates from 1999/2000 and 2002/03 show strong recruitment in 1996 and 1998, with fish from these year classes dominating catches; fish over age of 20 were essentially absent from landings in these catch-at-age studies (Davies *et al.* 2006), suggesting that the population is skewed toward younger age classes.

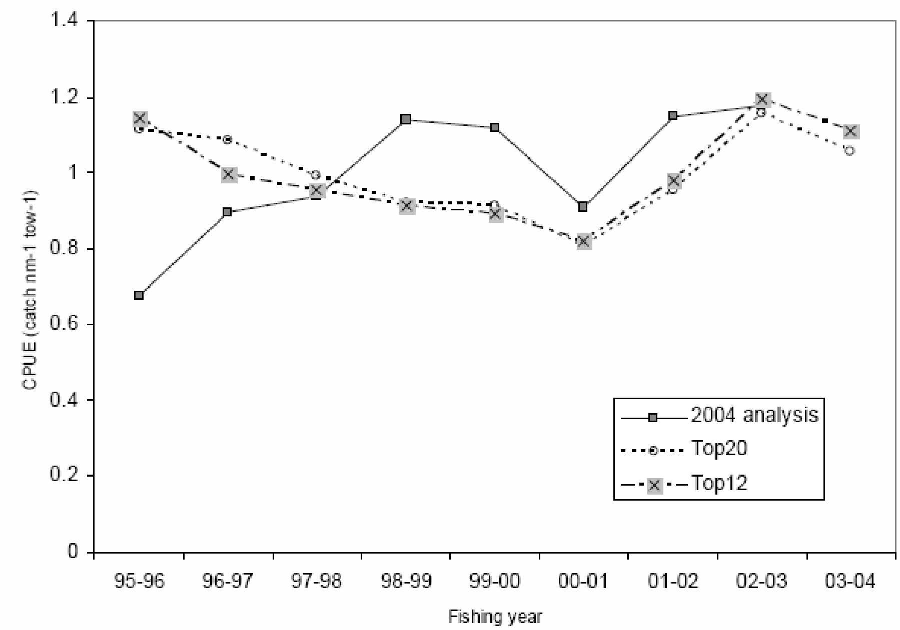

Figure 9. CPUE data from the 12 highest and 20 highest yielding vessels in SNA8, compared to the 2004 analysis (Figure from NZMF 2007e).

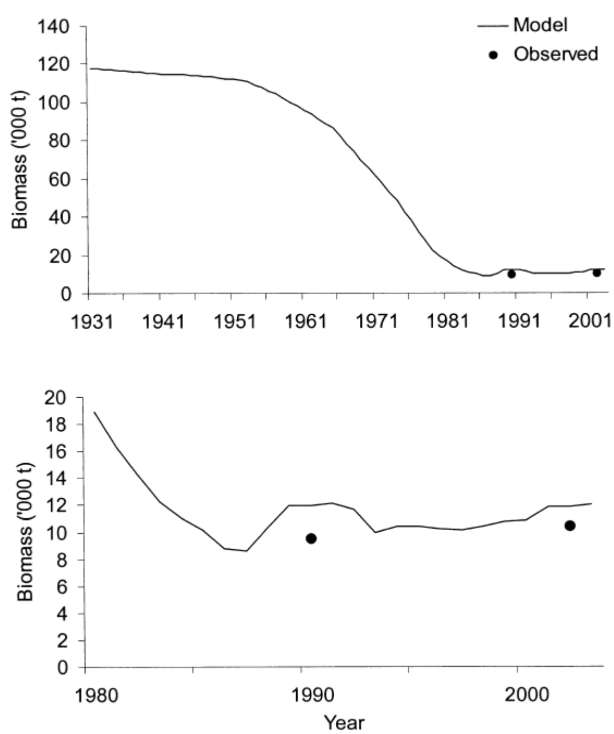

Figure 10. Biomass trajectories from 1931 to 2003 (top panel) and from 1980 to 2003 (bottom panel) showing fit with absolute estimates from the 1990 and 2002 tag-recapture studies (Figure from Davies *et al.* 2006).

Biomass of the SNA8 tai snapper stock was only 8% to 12% of unfished biomass in the latest assessment and is considered "depleted" by the Ministry of Fisheries. Overfishing

may still be occurring. The short-term trend in biomass is increasing slightly, and the TACC has recently been lowered to further reduce fishing mortality and ensure faster rebuilding of the stock. Therefore, the status of the SNA8 snapper stock is considered to be a high conservation concern according to Seafood Watch®.

SNA2

The SNA2 region encompasses the nearshore and offshore waters along the east coast of New Zealand's North Island. Tai snapper in this area are generally taken as incidental catch when the target fish are flatfish (*Rhombosolea leporine, R. plebeian, R. retiaria, R. tapirina, Pelotretis flavilatus, Peltorhamphus novaezeelandiae, Colistium guntheri or C. nudipinnis*), trevally (*Pseudocarananx dentex*), tarakihi (*Nemadactylus macropterus*) and gemfish (*Rexea solandri*) in the inshore trawl fishery, as well as occasionally when the target is hapuku/bass (*Polyprion oxygeneios*), bluenose (*Hyperoglyphe antarctica*) and school shark (*Galeorhinus galeus*) in the longline fishery (Blackwell *et al.* 2000; Gilbert and Phillips 2003).

The latest stock assessment for SNA2 was conducted in the summer of the 2001/02 fishing season and was based on a four-year population model. Although landings have exceeded the TACC in most years since 1986, model estimates suggest that this excess level of landings is sustainable (Figure 11) (Gilbert and Phillips 2003). Because no empirical biomass indices are available, however, these model estimates must be viewed cautiously (Gilbert and Phillips 2003; NZMF 2007c). In the base case scenario, the model estimates B_{2001} at 4,000 mt and B_{MSY} at 4,500 mt where MSY is set at 478 mt. Therefore, B_{2001}/B_{MSY} is approximately 0.9. Relative biomass ranged from 90% to 150% of B_{MSY} under all model scenarios (NZMF 2007e). There is uncertainty in this estimate of B/B_{MSY} due to concerns about the estimation method for B_{MSY} (see "Estimates of B_{MSY} in the snapper fishery" above). The value for B_{MSY} is about 23% of unfished biomass (B_0) for this stock (NZMF 2009a), so the stock biomass of 90% of B_{MSY} is at 20.7% of B_0 (90% of 23%), which is frequently considered the overfished threshold in other management regimes, including the US. Therefore, even though the stock is not considered overfished and is classified as "unlikely" to be depleted according to the Ministry of Fisheries (NZMF 2009b), Seafood Watch® considers the stock to be overfished. Based on model predictions, biomass trends have exhibited a long-term decline but have been increasing since about 1980 (Figure 12) (NZMF 2007e).

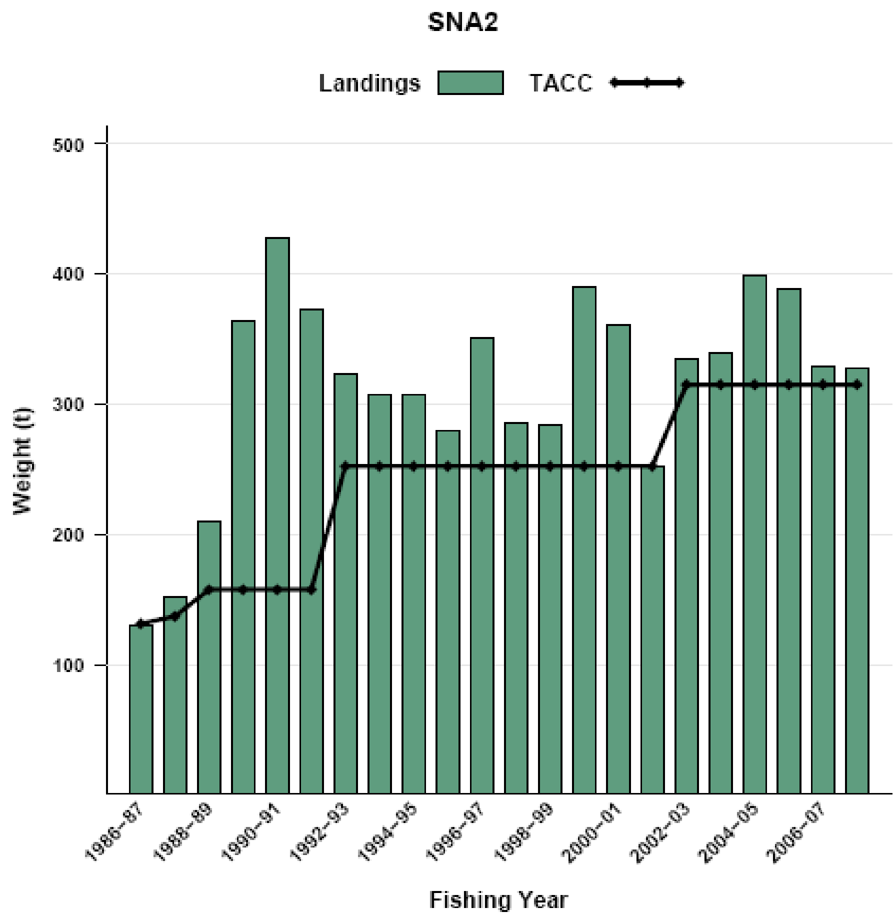

Figure 11. Historical commercial landings and TACC for SNA2 (Figure from NZMF 2009a).

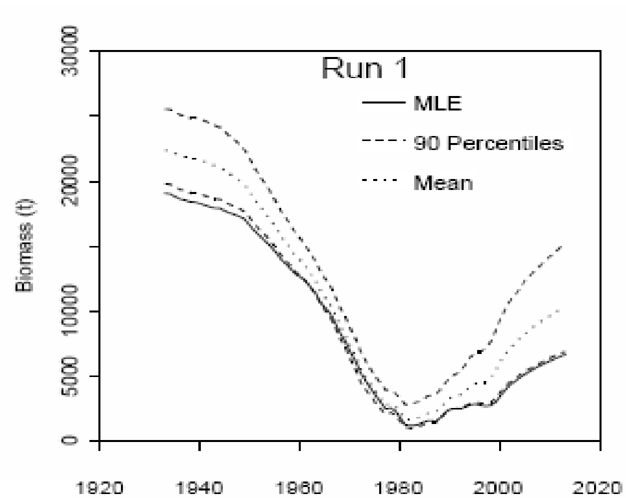

Figure 12. Projected biomass trend for SNA2 snapper for the base case scenario (Figure from NZMF 2007e).

In accordance with the optimistic view presented by the 2001/02 stock assessment, the New Zealand Ministry of Fisheries increased the TAC to its current level of 315 mt (NZMF 2006;

NZMF 2007c). The model used by Gilbert and Phillips in their assessment projected the SNA2 New Zealand tai snapper population to increase to B_{MSY} by 2006 at a catch level of 315 mt (NZMF 2007c), but the results of this speculation will not be measurable until an updated stock assessment is conducted. The base case model used in this assessment estimates MSY at 478 mt based on a theoretical B_{MSY} figure of 4,487 mt and an exploitation rate of 10.7% (Gilbert and Phillips 2003). The SNA2 stock is thought to be recovering, but the overall degree of uncertainty regarding the status of this stock is moderate. Estimates of F_{MSY} and F have not been published but can be estimated based on the model estimates of MSY, B_{MSY}, catch and biomass. Such estimates yield an F_{MSY} of 0.11 and an F of approximately 0.09, giving an F/F_{MSY} ratio of about 0.8 (NZMF 2009a). Therefore, it is unlikely that overfishing is occurring.

Catch-at-age estimates for SNA2 show that the fishery is dominated by landings of fish less than 11 years in age. The young age of fish captured from this region is also reflected in a decrease in mean fish size from 1.5 kg in 1998/99 to 0.9 kg in 2004/05 (Blackwell and Gilbert 2006).

The biomass of the SNA2 tai snapper stock at its last assessment was estimated to be 20.7% of unfished biomass levels (overfished according to Seafood Watch®) but has exhibited an increasing short-term trend. Uncertainty surrounding this stock assessment is moderate, as no biomass indices are available; results of the most recent stock assessment should be treated with caution. Accordingly, the status of the SNA2 stock is considered to be a high conservation concern according to Seafood Watch®.

SNA7 (Tasman Bay/Golden Bay)

The SNA7 region is defined as the oceanic expanse stretching from the eastern edges of the Marlborough Sounds west across the northern coast of the South Island and continuing south along the west coast of the South Island for three-quarters of its length. The majority of the catch is taken near the northern tip of the South Island (Gilbert and Phillips 2003). Landings from this region have typically been below the TACC since the inception of the Quota Management System (QMS); the TACC has been set at 200 mt since 1997 (Figure 13) (NZMF 2009a).

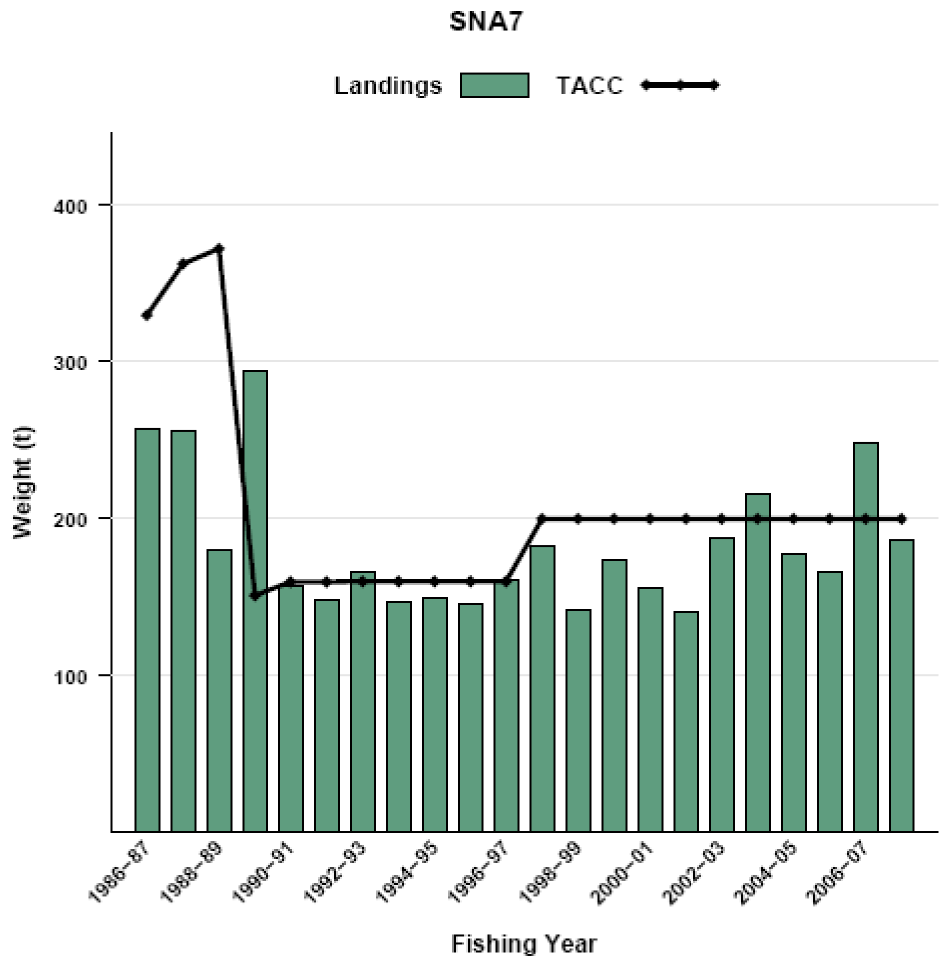

Figure 13. Historical commercial landings and TACC for SNA7 (Figure from NZMF 2009a).

The latest assessment of this stock was completed in conjunction with an assessment of the SNA2 stock in 2002 (Gilbert and Phillips 2003; NZMF 2007c). Based on two model runs (Run 1 being the base case scenario and Run 7 being a sensitivity run that used year class strength as a function of temperature), current biomass was estimated at approximately twice that of B_{MSY} (B_{2001}/B_{MSY} estimated at 2.5 for Run 1 and 2.1 for Run 7) (NZMF 2007e). The results of this assessment were rejected at the September 25, 2006 Snapper Working Group meeting, however, because they were thought to be unrealistically high (NZMF 2009a). The overall degree of uncertainty regarding the status of this stock is moderate.

Estimated biomass trends show a long-term decline with an increase since about 1980 (Figure 14) (NZMF 2007e). The base case model used in the assessment estimated MSY at 855 mt based on a theoretical B_{MSY} figure of 9,102 mt and an exploitation rate of 9.2% (Gilbert and Phillips 2003). However, there is uncertainty in the estimation methods for B_{MSY} in the snapper fishery (see "Estimates of B_{MSY} in the snapper fishery" above). In addition, because the stock assessment results were rejected, B/B_{MSY} and F/F_{MSY} remain unknown. The SNA7 tai snapper stock is not considered overfished and is classified as "unlikely" to be depleted according to the Ministry of Fisheries (NZMF 2009b). The assessment authors suggest that the stock is recovering and would continue to do so even if future catches were larger than those being taken at the time the research was conducted (Gilbert and Phillips 2003). The results of the assessment model cannot be verified, however, as there are no current biomass indices for the stock (NZMF 2007e). Nevertheless, catch-at-age data are available for recent years, and they correspond with model estimates suggesting a rebuilding stock (NZMF 2007c).

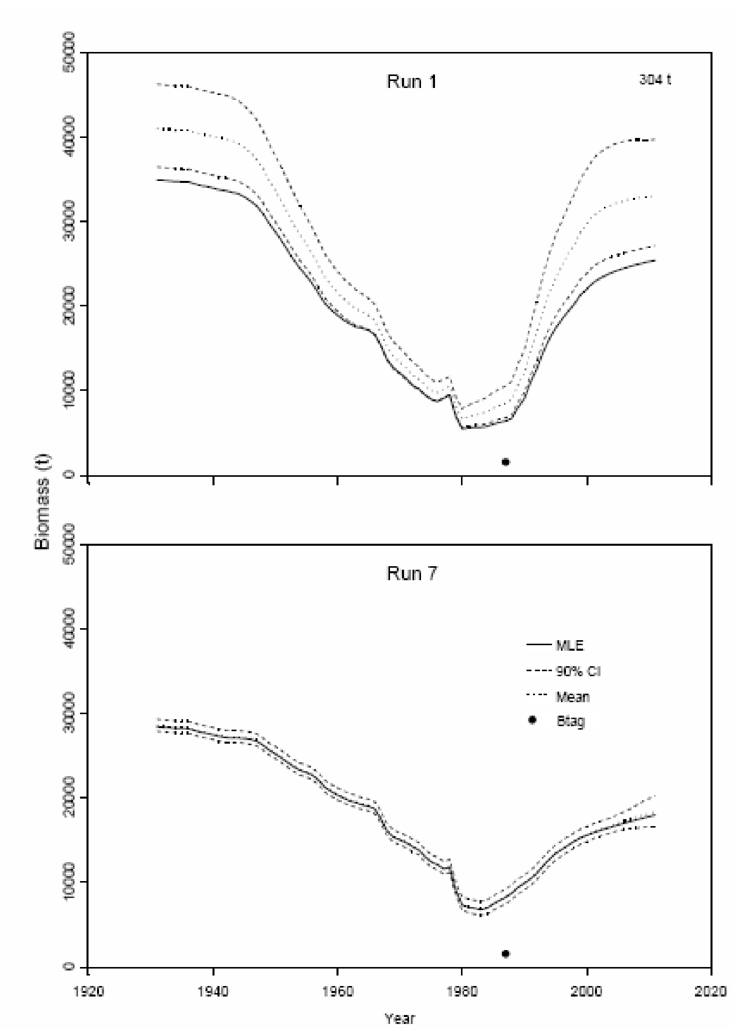

Figure 14. Biomass estimates for SNA7 from the base case scenario (Run 1) and a sensitivity run that incorporates year class strength as a function of temperature for the 2000/01 TACC (Figure from NZMF 2007e).

The 2003/04 catch-at-age estimates for SNA7 show that although the fishery was previously dominated by fish over 20 years in age, it is now dominated by several strong recent year classes. Fish from the 8, 14, 16 and 18 year-old year classes were still present in 2003/04 but are a weaker component of overall landings. The most recently measured mean weight of 1.5 kg (in contrast with the 3.0 kg mean weight measured in 2002) also shows that younger year classes were dominant in the 2003/04 season.

Biomass of the SNA7 tai snapper stock is estimated to be twice B_{MSY}, but this value has been rejected as unreasonably high because there are no reliable abundance estimates to confirm such model predictions. As a consequence, the New Zealand government deems the status of this stock to be uncertain. Accordingly, the status of the SNA7 stock is a moderate conservation concern according to Seafood Watch®.

Table 5. Stock status of *Pagrus auratus.*

Fishery	Classification Status	B/B_{MSY}	Occurrence of Overfishing	F/F_{MSY}	Abundance Trends/ CPUE	Age/Size/ Sex Distr.	Degree of Uncertainty in Stock Status	Sources	SFW Rank
SNA1: East North-land (19% of total catch)	Recovering from overfished according to NZMF but overfished according to Seafood Watch®	B_{1999}/B_{MSY} = 0.96	Overfishing is not likely occurring	0.5 (for East Northland and Hauraki Gulf/Bay of Plenty combined)	Long-term decline; short-term increase	Age distr. functionally normal	Low	Annala *et al.* 1998; Gilbert *et al.* 2000); NZMF 2006, 2007c, 2007e; Walsh *et al.* 2008	Poor
SNA1: Hauraki Gulf/ Bay of Plenty (52% of total catch)	Recovering from overfished according to NZMF but overfished according to Seafood Watch®	B_{1999}/B_{MSY} = 0.80	Overfishing is not likely occurring	0.5 (for East Northland and Hauraki Gulf/Bay of Plenty combined)	Long-term variable; short-term increase	Age skewed towards fish under age 10 for Bay of Plenty; unskewed for Hauraki Gulf	Low	Annala *et al.* 1998; Gilbert *et al.* 2000); NZMF 2006, 2007c , 2007e; Walsh *et al.* 2008	Poor
SNA 8 (21% of total catch)	Depleted	B_{2004}/B_{MSY} = 0.39 – 0.6	Likely rebuilding under current catch levels	Unknown because F_{MSY} is not estimated; F = 0.13	Long-term decline; short-term increase	Age skewed towards fish under age 10	Low	NZMF 2005, 2006, 2007c, 2007e, Davies *et al.* 2006	Poor
SNA 2 (5% of total catch)	Recovering from overfished according to NZMF but overfished according to Seafood Watch®	B_{2001}/B_{MSY} = 0.90	Likely rebuilding under current catch levels	0.8	Long-term decline; short-term increase	Age skewed towards fish under age 10	Moderate	Blackwell *et al.* 2000; Gilbert and Phillips 2003; NZMF 2002b, 2006, 2007c , 2007e	Poor

Fishery	Classification Status	B/B_{MSY}	Occurrence of Overfishing	F/F_{MSY}	Abundance Trends/ CPUE	Age/Size/ Sex Distr.	Degree of Uncertainty in Stock Status	Sources	SFW Rank
SNA 7 (3% of total catch)	Unknown	Unk; Model estimate B_{2001}/ B_{MSY} = 2.5 for Run 1, 2.1 for Run 7 but was rejected	Likely rebuilding under current catch levels	Unknown; 9.4% comm.. exploitation rate[2]	Long-term decline; short-term increase	Age skewed towards younger fish	Moderate	Gilbert and Phillips 2003; NZMF 2007c, 2007e	Moderate

Synthesis
The SNA1 and SNA2 tai snapper stocks are ranked as high conservation concerns according to Seafood Watch® because they are at or below the overfished threshold (20% of B_0) of many management regimes (including the US) and are therefore considered overfished according to Seafood Watch® despite increasing short-term trends. The SNA8 stock is depleted, with slightly increasing trends in abundance in the short-term, and its status is therefore considered poor according to Seafood Watch®. The SNA7 stock has an uncertain status and is considered a moderate conservation concern because of the uncertainty in most status metrics.

Status of Wild Stocks Rank

SNA7:

Healthy | **Moderate/Rebuilding** | Poor | Critical

SNA1, SNA2, SNA8:

Healthy | Moderate/Rebuilding | **Poor** | Critical

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.

[2] Exploitation rate is the proportion of the recruitment of vulnerable biomass caught during a certain period, usually a fishing year.

The majority of New Zealand tai snapper are targeted commercially with bottom trawl and bottom longlines, with a smaller subset of commercial landings taken using Danish seines, beach seines and set nets (Gilbert *et al.* 2000; Gilbert *et al.* 2003). Purse seines were used occasionally in SNA7 but are now banned within the fishery (NZMF 2006). Pair bottom trawls and pair Danish seines have been used since 1973 but now only account for a small portion of the annual catch (Elder 1979).

In New Zealand, many non-target finfish are retained and managed through the Individual Transferable Quota (ITQ) system (see "Criterion 5: Effectiveness of the Management Regime") and are therefore not considered bycatch according to Seafood Watch. There are several mechanisms in place for instances where fishermen do not hold individual quotas for incidentally caught species with commercial value; these mechanisms are detailed under "Criterion 5: Effectiveness of the Management Regime". In order to prevent the capture of undersized commercial species, the minimum legal mesh size is set at 125 mm for trawls, Danish seines, set nets and beach seines. There are no hook size limits, but longline fishermen are known to avoid small hooks to limit the catch of undersized fish and maximize catch of the most valuable sizes, which are 5 cm greater than the legal limit.

Non-target species with no commercial value are discarded nevertheless. These may be species with no market, species under the commercially and legally viable size limit, individuals that have been damaged due to fishing activity, or simply a lack of hold space on vessels (Anderson 2007). There is currently no published data on bycatch of non-commercially valuable species in the tai snapper fishery. The quantity of bycatch, bycatch trends and overall impacts of bycatch of non-commercially valuable species are unknown. While there is observer coverage of the New Zealand tai snapper fishery, observers are asked only to record data on landed catch and "non-fish bycatch", which specifically refers to protected species such as seabirds and marine mammals (NZMF 2008c,d).

A report published in 2009 by the New Zealand Ministry of Fisheries summarizes all observed instances of seabird, marine mammal and sea turtle bycatch in commercial trawl and longline fisheries that occurred within the New Zealand Exclusive Economic Zone between the 1998/99 and 2006/07 fishing seasons (Abraham and Thompson 2009). As these gear types account for a majority of tai snapper landings, the report represents an up-to-date and comprehensive summary of seabird, marine mammal and sea turtle bycatch in the trawl and longline tai snapper fisheries. The information presented in the report is recorded by New Zealand Ministry of Fisheries onboard observers and currently represents the best scientific information available regarding the annual rate of capture of these protected species.

There are no available data on the bycatch of finfish, seabirds, marine mammals or turtles in the Danish seine, beach seine and set net New Zealand tai snapper fisheries.

Seabirds: bycatch rates and population impacts

Seabirds are vulnerable to bottom longline fishing because they are attracted to baited hooks. Seabirds are known to dive below the surface to take baited hooks and, in certain cases, drown when they are hooked or entangled in the line (NZMF 2004). As observer coverage in the snapper bottom longline fishery is low, estimates of total bycatch are based on a relatively small amount of information.

There were a total of 60 observed seabird captures in the bottom longline fishery for tai snapper between 2000 and 2007 (Table 6) (Abraham and Thompson 2009; Pierre and Norden 2006). All bycatch incidents were observed in SNA1, and there were no observed captures in any other management areas (Figure 15). Captured seabird species include Buller's shearwaters (*Puffinus bulleri*), black petrels (*Procellaria parkinsoni*), flesh-footed shearwaters (*Puffinus carneipes*), gannets (*Morus serrator*), fluttering shearwaters (*Puffinus gavia*), pied shags (*Ogakacricirax varius*) and the grey petrels (*Procellaria cinerea*), as well as several other unidentified seabirds (Table 7) (Abraham and Thompson 2009). Buller's shearwaters and black petrels are listed as vulnerable according to IUCN, while flesh-footed shearwaters are listed as near threatened. Based on the small number of observed trips, estimates suggest an average of 550 seabird captures in the tai snapper bottom longline fishery per year, with a maximum observed bycatch rate of 5.9 captures per thousand hooks.

The tai snapper fishery accounted for between 4% and 40% of total observed seabird bycatch in the bottom longline fisheries in New Zealand between 2000 and 2007; the bluenose and ling fisheries were the other major bottom longline fisheries observed in the report (Abraham and Thompson 2009). The model used in this report suggests that the tai snapper fishery may have been responsible for as much as 90% of the estimated seabird captures in all bottom longline fisheries during the 2005/06 fishing season, though estimates for other years suggest the figure could be much lower (Abraham and Thompson 2009). The high estimated contribution of the tai snapper fishery to bottom longline seabird bycatch may a result of the low number of observed bottom longline fishing trips across all observed fisheries.

Table 6. Seabird bycatch in the snapper bottom longline fishery. Summary by year with number of hooks, number of hooks observed, percentage of hooks observed, number of observed captures, capture rate per ten thousand hooks, total estimated captures with 95% confidence intervals and percentage of hooks included in estimate.

FY	Hooks	No. hooks observed	% Obs	Observed captures	Rate	Estimated captures	% hooks included in est.
2000/01	17,336,728	44,049	0.3	26	5.9	26 (26 - 26)	0.3
2001/02	15,372,878	-	0	0		0	0
2002/03	13,722,067	-	0	0		0	0
2003/04	12,254,888	221,073	1.8	10	0.45	538 (222 - 949)	97.1
2004/05	11,531,586	265,404	2.3	12	0.45	521 (143 - 1,077)	98.3
2005/06	11,694,638	125,894	1.1	12	0.95	1,114 (178 - 2,395)	98.3
2006/07	10,344,640	63,650	0.6	0	0	0	0

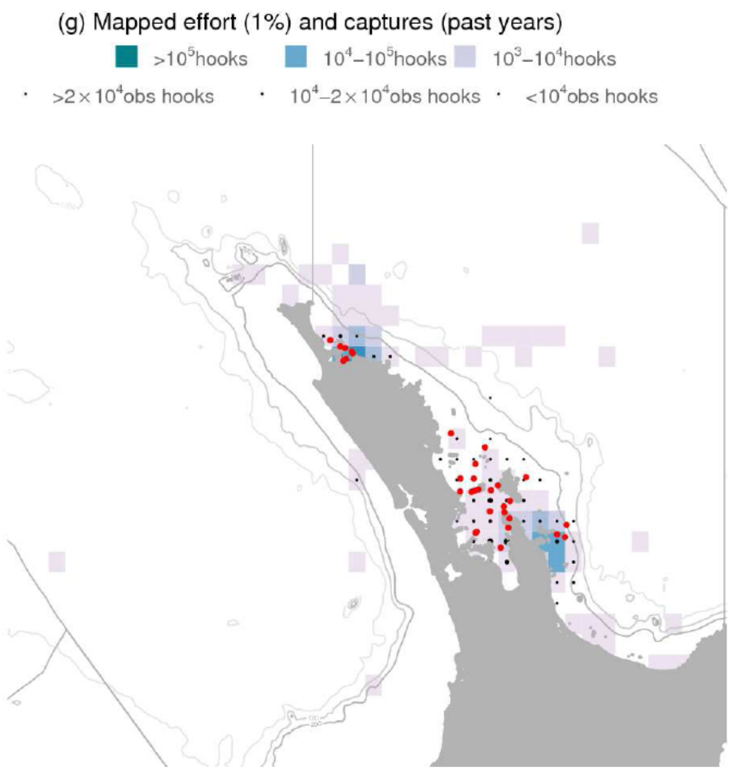

Figure 15. Effort and captures of seabirds in the snapper longline fishery, 2000 – 2006 (Figure from Abraham and Thompson 2009).

Table 7. Species caught in SNA1 with number of animals captured, dead and necropsied, breeding status in NZ, threat status according to NZ Department of Conservation and IUCN Conservation Status.

FY	Species	Captured	Dead	Necropsied	Breeding Status (NZ)	Threat Status (NZ)	Threat Status (IUCN)
2000/01	Flesh-footed shearwater	12	12	12	I	GD	NT
	Grey petrel	11	11	11	I	GD	LC
	Buller's shearwater	2	2	2	E	RR	Vun
	Fluttering shearwater	1	1	1	E	Not threatened	LC
2003/04	Flesh-footed shearwater	3	1	1	I	GD	NT
	Black petrel	2	1	1	E	GD	Vun
	Fluttering shearwater	1	1	1	E	Not threatened	LC
	Petrel (unidentified)	1	1	0			
	Seabird	1	1	0			
	Pied shag	1	1	1	E	SP	
	Gannet	1	0	0	I	Not threatened	
2004/05	Flesh-footed shearwater	9	4	4	I	GD	NT
	Seabird small	1	0	0			
	Gannet	1	0	0	I	Not threatened	
	Black petrel	1	1	1	E	GD	Vun
2005/06	Petrel (unidentified)	6	0	0			
	Buller's shearwater	4	0	0	E	RR	Vun
	Black petrel	2	2	2	E	GD	Vun

Breeding Status in NZ	**E** = Endemic, breeds only in NZ; **I** = Indigenous, breeds in NZ and elsewhere
Threat Status in NZ	Threat ranking given by the NZ Department of Conservation. **GD** = Gradual Decline; **RR** = Range Restricted; **SP** = Sparse
Threat Status (IUCN)	Threat ranking given by the World Conservation Union. **Vun** = Vulnerable; **NT** = Near Threatened; **LC** = Least Concern

Seabird bycatch in the tai snapper trawl fishery is difficult to estimate because trawl bycatch information is primarily summarized by fishery location, except in cases where seabird bycatch is high in a single species fishery (*i.e.*, the squid, scampi and hoki fisheries). The tai snapper fishery occurs in the inshore areas of New Zealand, and bycatch information for inshore fisheries includes seabird interaction records for roughly 35 inshore target species. From 2004 to 2007, inshore trawl fisheries accounted for, at most, only 4% of the annual observed seabird bycatch in all trawl fisheries and, at most, only 10% of the estimated annual seabird bycatch. These levels equate to an annual capture rate of 2.1 captures per hundred tows (calculated from the observed bycatch rate presented in Abraham and Thompson 2009), which is less than half the average annual observed capture rate for all trawl fisheries.

The impacts of incidental capture of seabirds on seabird species depends on a number of factors including species population size, population growth parameters, and the number and location of breeding colonies (NZMF 2004). It is difficult to estimate the overall impacts of fishing activities on seabird populations in New Zealand because bycatch rates are currently estimated based on limited information and because the population characteristics of a number of New Zealand seabird populations have yet to be fully described.

Seabird capture in the tai snapper bottom longline fishery appears to be following a downward trend, with seabird bycatch estimated at 5.9 captures per ten thousand hooks in the 2000/01 fishing year down to less one capture per ten thousand hooks in subsequent years (Abraham and Thompson 2009). It is important to remember, however, that these estimated rates are based on extremely low observer coverage, meaning that they could be grossly over- or underestimating actual seabird bycatch rates. The rate of seabird bycatch for the inshore trawl fishery appears to be flat, estimated between 2.91 and 4.17 captures per hundred tows between 2001 and 2007. Again, this estimate is not reflective of actual bycatch rates in the tai snapper fishery because seabird bycatch rates for trawl fisheries are reported for roughly 35 inshore target species.

Despite uncertainty about the overall impacts of fishing activity on seabird populations, the New Zealand government has made a significant effort to reduce seabird bycatch through the development of a National Plan of Action (NPOA) to reduce incidental seabird capture in fisheries. The overall goal of the plan is to ensure the long-term viability of protected seabirds by reducing incidental catch in New Zealand waters and by New Zealand flagged vessels on the high seas through the use of technology, education and economic incentives (NZMF 2004).

Current gear modifications to reduce seabird bycatch in bottom longline fisheries include: (1) use of a streamer line on vessels longer than 7 meters to scare seabirds away from bait lines during deployment, (2) restrictions on setting bottom longlines 30 minutes before nautical dawn and 30 minutes after nautical dusk, and (3) weighting all set bottom longlines along their entire length (*New Zealand Gazette*, 21 February 2008, No. 31, page 712). Bird scaring devices are also required on all trawl gear (*New Zealand Gazette*, 6 April 2006, No. 33, page 842).

Marine mammals: bycatch rate and population impacts

There were no observed incidents of marine mammal bycatch in the tai snapper bottom longline fishery reported by Abraham and Thompson (2009).

Marine mammal bycatch in trawl fisheries is summarized in the same way as seabird bycatch, with marine mammal interaction records summarized for roughly 35 inshore fisheries. From 2004 to 2007, the inshore trawl fisheries accounted for only two of the marine mammal bycatch incidents in all trawl fisheries (Abraham and Thompson 2009). For all years of the study, a very low number of tows were observed in the inshore trawl fishery (18 observed tows out of 67,295 total tows in 2004/05, 103 out of 62,056 in 2005/06 and 292 out of 59,538 in 2006/07) (Abraham and Thompson 2009).

In general, there is no information suggesting that marine mammal bycatch in the tai snapper fishery is a significant threat to any marine mammal species. The current trend in marine mammal bycatch is flat, and there is no evidence that rates of marine mammal bycatch in either the bottom longline or trawl fisheries for tai snapper will increase in the future.

Sea turtles: bycatch rate and population impacts
Between 1998 and 2007, there was only one observed capture of a green turtle (*Chelonia mydas*) in SNA8 in an unidentified bottom longline fishery (Abraham and Thompson 2009). During that period, the number of hooks observed annually ranged between 5.6 and 30%. There were no observed captures of sea turtles in the trawl fisheries for any species (Abraham and Thompson 2009).

In general, there is no information suggesting that sea turtle bycatch in the tai snapper fishery is a significant threat to any sea turtle species. The current trend in sea turtle bycatch is flat, and there is no evidence that rates of sea turtle bycatch in either the bottom longline or trawl fisheries for tai snapper will increase in the future.

Synthesis
No data are available on bycatch of finfish, seabirds, marine mammals or turtles in the Danish seine, beach seine and set net fisheries for New Zealand tai snapper.

The bottom longline and trawl fisheries account for the majority of commercial tai snapper landings. Observer coverage for these fisheries is very low, so estimates of bycatch rates based on observer coverage are not likely to accurately portray the actual rate of bycatch in the tai snapper fishery. Incidental catch of commercially valuable non-target species is accounted for, managed and used. Nevertheless, non-target species with no commercial value are typically discarded. There is currently no published data on bycatch of these non-commercially valuable species, and thus the quantity of bycatch, bycatch trends and overall impacts of bycatch of non-commercially valuable species is unknown.

Seabird bycatch in the bottom longline fishery is the best documented of all bycatch types. There were a total of 60 observed seabird captures in the bottom longline fishery between 2000 and 2007 including Black petrels and Buller's shearwaters, which are listed as vulnerable by IUCN, as well as flesh-footed shearwaters, which are listed as near threatened by IUCN. There have been no observed incidents of marine mammal capture in the bottom longline fishery. Trawl fishery bycatch information is summarized by fishery location, and the subset of information that includes the tai snapper fishery also includes observed incidents from 35 other fisheries. Seabird and marine mammal bycatch in the inshore trawl fisheries are not well observed but are estimated to be fairly low. There was only one observed incident of sea turtle bycatch in an unidentified bottom longline fishery between 1998 and 2007, and there were no observed incidents of sea turtle bycatch in any trawl fishery between 2000 and 2007.

In general, it is unknown whether the snapper fishery is directly contributing to the decline of any of the seabirds or other protected species commonly captured in the fishery.

Given the regular capture of vulnerable and near threatened seabirds, the unknown impacts of bycatch on their population levels and the unknown bycatch level of non-commercially valuable finfish species, bycatch in the bottom longline tai snapper fishery is a moderate conservation concern according to Seafood Watch ®. Bycatch in the trawl tai snapper fishery is a moderate concern according to Seafood Watch® because the quantity of bycatch and its impact on population levels is unknown, does not include species of concern and does not seem to be increasing. The Danish seine, beach seine and set net tai snapper fisheries also receive a moderate ranking because bycatch rates for these fisheries are unknown.

Nature of Bycatch Rank

Bottom longline, trawl, Danish seine, beach seine, set net:

Low	**Moderate**	High	Critical

Criterion 4: Effect of Fishing Practices on Habitats and Ecosystems

As mentioned above, a range of methods are used in the commercial fishery for New Zealand tai snapper including Danish seining, beach seining, set netting (bottom gillnetting), bottom longlining and bottom trawling (NZMF 2006).

Bottom longlining, bottom trawling and Danish seining are commonly used in the Bay of Plenty and Hauraki Gulf in SNA1, with set netting and beach seining accounting for only a small proportion of landings (Gilbert *et al.* 2000). Single trawling is predominant in the SNA2 snapper fishery (Gilbert and Phillips 2003). Pair trawling was popular until it was banned from the SNA2 fishery in the early 1970s (Blackwell *et al.* 2000). The SNA7 region is largely a single-trawl fishery, though pair trawling is legal in this region and some pair trawling does occur. There was a period during the late 1970s where substantial catches were taken by pair trawlers and purse seiners, but in the years following, most of the fleet returned to single trawling. A small portion of SNA7 landings have been taken using bottom longlines. The SNA8 region is largely a single trawl fishery with some pair trawling. Pair trawling made up a larger portion of total SNA8 landings in the past. There is currently only a very small amount of catch taken using longlines.

Habitat Impacts

Severity of gear impacts

Bottom trawls and Danish seines are mobile bottom gear known to have high impacts on habitats. Bottom trawling reduces species richness, habitat complexity and biomass of submerged aquatic vegetation while lowering the nutritive quality of sediment, reducing microbial production and increasing turbidity, which can result in hypoxia or anoxia (Morgan and Chuenpagdee 2003).

Thrush *et al.* (1998) conducted a study on disturbance of benthic habitats by commercial fishing in the Hauraki Gulf of New Zealand over a variety of habitat types from sandy, wave-exposed areas to sheltered muddy areas. The gear types studied included bottom trawling, Danish seining and scallop dredging. The study demonstrated broad-scale changes in macrobenthic communities as a result of fishing disturbance. Fishing pressure was a significant factor for the density of echinoderms, the ratio of polychaetes to mollusks, species diversity and the total number of species. Density of deposit feeders, total number of individuals and epifauna were also influenced by fishing pressure but not at a significant level (Thrush *et al.* 1998).

In general, the use of trawls and Danish seines in the tai snapper fishery involves dragging heavy gear over the seafloor. Though these gear types are typically deployed over flat, non-rocky bottom habitats that lack vertical structure, these fishing methods have been shown to damage benthic habitats nevertheless.

Bottom trawls

The environmental damage caused by bottom trawling can be substantial and irreversible (Watling and Norse 1998). The scraping action inherent in bottom trawling is highly destructive to marine habitats and has been compared to forest clear cutting in terrestrial habitats (Watling and Norse 1998). Bottom trawling has both biogenic and physical effects on the seafloor. Bottom trawls damage benthic organisms such as corals and sponges, and disturb complex habitats that provides shelter for the juveniles of commercially important fish species (Chuenpagdee *et al.* 2003). Bottom trawl nets can plow deep furrows in the seafloor, remove rock and coral, stir up sediments that smother benthic organisms, remove or harm non-target organisms and smooth out natural topography until the seafloor resembles a plowed field (Pilskaln *et al.* 1998, NRC 2002).

The degree of impact is determined by many factors, most notably: (1) the type and weight of gear used, (2) the resilience of the seabed, and (3) the amount and frequency of the disturbance. Bottom trawl disturbance of the seabed is mainly a function of bottom type (rock, sand, mud, etc.) and gear type (dredge, beam, otter trawl, etc.). Some types of trawling gear cause less damage (*e.g.*, otter trawl vs. scallop dredge) and some sediment types are more resilient to the disturbances caused by trawling. In a review of fishing effects, Collie *et al.* (2000) found that recovery rates appear to be slower in muddy and structurally complex habitats than in sandy bottom habitats. In general, organisms in stable sediments such as gravel and mud suffer more adverse effects than those in unconsolidated sediments (Collie *et al.* 2000). For soft bottom habitats, scraping the ocean bottom causes: (1) sediment re-suspension (turbidity) and smoothing, (2) removal of and/or damage to non-target species, and 3) destruction of three-dimensional habitat (Auster and Langton 1999).

In addition to impacting the habitat, bottom trawling can also impact benthic organisms and thus entire ecosystems. Emergent epifauna may be destroyed by mobile gear such as trawls (Hall 1999). Changes in both infaunal and epifaunal communities have been observed, and the effects are expected to cascade through the entire community (Barnette 2001). Bottom trawling has been shown to change the relative abundance of bottom-dwelling organisms, favoring fast-growing, opportunistic species and decreasing the abundance of slow-growing, low-fecundity species (Schwinghammer *et al.* 1998, Simboura *et al.* 1998; Wells *et al.* 2008). While overall biodiversity often decreases under heavy trawling, the bottom-trawl regime can increase the abundance of certain "desirable" organisms, such as shrimp (Simboura *et al.* 1998) or prey for commercial fish species (Engel and Kvitek 1998). Many areas are trawled several times per year, allowing no time for bottom fauna to recover to a pre-trawled condition (Watling and Norse 1998).

The effects of bottom trawling are related to sediment size (Lindholm *et al.* 2004). Hiddink *et al*. (2006) found that communities on mud or muddy sand bottoms were less severely impacted by trawling than those on sand or gravel substrates, while Collie *et al*. (2000) found that disturbance to benthic communities was more severe in gravel and muddy sand habitats than in either mud or sand habitats. However, sediment type is expected to be less important than the frequency of natural disturbance, which may be correlated with sediment type (Hiddink *et al.* 2006). Areas with muddy substrates and deeper waters are typically associated with lower rates of natural disturbance, so these areas may be more sensitive to trawling impacts than coarse sediment bottom habitats in areas prone to high rates of natural disturbance (Hiddink *et al.* 2006). While soft bottom habitats are generally less sensitive to disturbance by trawling than rocky bottoms and coral reefs, studies have found decreased habitat heterogeneity and epifaunal abundance in heavily trawled areas in both sandy bottom (Engel and Kvitek 1998) and muddy bottom habitats (Hixon and Tissot 2007; Queirós *et al.* 2006). Numerous reviews and meta-analyses document the severe effects of bottom trawling on epifaunal communities in low-disturbance muddy bottom habitats (Auster and Langton 1999, Norse and Watling 1999, Kaiser *et al*. 2002, NRC 2002, Thrush and Dayton 2002, Kaiser *et al.* 2006).

In a comprehensive review of the habitat impacts of trawling, the National Research Council (NRC 2002) noted the following possible effects of otter trawling on sandy and muddy habitats: uprooting of submerged vegetation, smothering of submerged vegetation via resuspended sediments, reduction of epifaunal coverage on sandy and muddy substrates, reduction of infaunal productivity and biodiversity, compression of sediments and alteration of the natural topography of sandy and muddy substrates (Tuck *et al.* 1998; Auster and Langton 1999; Barnette 1999; Jennings *et al.* 2000; NRC 2002). More recent studies from around the world have confirmed the findings of the NRC (2002) that otter trawling may have severe impacts in soft sediment habitats. Hiddink *et al.* (2006) found a large negative effect of beam and otter trawling on biomass production and species richness in shallow, soft-sediment habitats in the North Sea. In agreement with previous studies, they found that impacts were less severe in areas more prone to natural disturbance. Kaiser *et al.* (2006) reviewed fishing effects and recovery times for a variety of habitat types and fishing gear and found that soft sediment habitats (particularly muddy sand) were surprisingly vulnerable and exhibited a long time to recovery from trawling impacts. Otter trawls were found to have strong effects on biota in mud and muddy sand habitats. Hixon and Tissot (2007) compared trawled and untrawled areas of muddy seafloor in Oregon and found evidence for adverse effects of trawling including reduced abundance and species richness of finfish and dramatically reduced benthic invertebrate abundance. In a comparison of fishing effects along a gradient of fishing effort in the Irish Sea, Hinz *et al.* (2009) found that chronic otter trawling had a significant negative effect on benthic infauna abundance, epifauna abundance, biomass and species richness, and significantly changed community structure. Their results underscored the cumulative nature of trawling impacts, and they noted that manipulative experiments investigating the short-term effects of trawling are likely to underestimate the long-term ecological impacts of repeated trawling.

Danish seines
Danish seines, though operated quite differently from otter trawls, are thought to have similar overall impacts because of gear contact with the seafloor. The Danish seine net, which resembles a trawl net but is operated like a purse seine, is attached to a buoy and a small vessel with wire warps or towing-lines. After the buoy is set, the boat sails a half circle around a school of fish, sets the net and sails back to the buoy. The buoy is then taken aboard and the boat drags the net forward while gradually pulling together the warps, which acts to herd the fish into the net. The warps and full net are finally pulled aboard the boat using a power block. Different from bottom trawls, Danish seines have no braces to keep the net mouth open, no rock-hopping gear and no chains. During fishing, the weighted ropes used to herd the fish are in contact with the seafloor over lengths of several hundred meters, and the rope may cut into the seafloor while the seines are in use (Rose *et al.* 2000). Because Danish seines are a mobile gear fished in contact with the bottom over a large area, they are considered to have a similar impact to bottom trawls and are likely to cause great damage to seafloor habitats.

Beach seines, set nets and bottom longlines
Beach seines, set nets and bottom longlines all have moderate impacts on habitats. These are bottom gear types but are much less mobile than bottom trawls and dredges. In strong ocean currents or when being hauled out of the water, set nets (bottom gillnets) may become tangled on rocks, corals and aquatic plants, breaking or uprooting them (Morgan and Chuenpagdee 2003). In soft bottom areas, these gears can upset the nutrient content and organisms in sediments (Morgan *et al.* 2004). Bottom longlines and set nets are substantially less damaging than bottom trawls or Danish seines because they are a fixed gear. So, although they are bottom gear, bottom longlines have contact with a substantially smaller area of the seafloor than the more mobile gear types (Morgan and Chuenpagdee 2003). However, bottom longlines can entangle rocks, coral, sponges and gorgonians while being hauled in. Similarly, beach seines contact the bottom but are moved across a far smaller spatial footprint during fishing than bottom trawls or Danish seines.

Resilience of habitat
The extent of habitat impacts by fishing gear also depends on the spatial scale of the fishery and the type of habitat where fishing occurs (Morgan and Chuenpagdee 2003). The New Zealand tai snapper beach seine, bottom longline and bottom trawl fisheries occur primarily on sandy, gravelly and muddy bottom areas up to 75 m deep, which are considered to be highly to

moderately resilient habitats. Some longline fishing occurs in rocky areas, a habitat with low resilience, where lines are suspended off the sea floor to avoid snagging. A small amount of trawling also occurs in rocky areas where the bottom is relatively smooth, up to 200 m deep, which are known to have low resilience to fishing disturbance. Danish seining and set netting fisheries occur on shallow sandy, muddy habitats, which are moderately to highly resilient to fishing disturbance (Fishbase 2008; NZMF 2008a; Morgan and Chuenpagdee 2003).

Spatial extent of fishery
The New Zealand tai snapper set net fishery is very small while the other New Zealand tai snapper fisheries cover a moderate geographic scale, thus having less impact on habitats than fisheries occurring over broader geographic areas.

Ecosystem impacts
While habitat impacts have been demonstrated, it is difficult to link these effects to changes in ecosystem function (Thrush *et al.* 1998). However, tai snapper is an important predator in New Zealand's temperate reefs, and evidence from marine reserves in New Zealand suggests that heavy fishing of predators, including tai snapper, may have cascading impacts on the food web and the entire ecosystem. Babcock *et al.* (1999) found that both tai snapper and the spiny lobster *Jasus edwardsii*, both important predators of the dominant grazer *Evechinus chloroticus* (the New Zealand sea urchin), were far larger and more abundant inside the Leigh Marine Reserve and Tawharanui Marine Park than in fished areas. Predation rates on the urchin were higher and urchin abundances lower in the reserves than in the fished areas. Additionally, the primary productivity of kelp forests has increased dramatically in the Leigh Marine Reserve since its establishment. Babcock *et al.* (1999) hypothesized that fishing pressure outside the reserves has reduced predator (snapper and lobster) biomass and disrupted natural trophic cascades, leading to increased urchin grazing and decreased benthic primary productivity. These trophic effects are hypothesized to have had substantial impacts on community structure. Shears and Babcock (2003) confirmed differences in community structure between reserve and fished sites that correlated with differences in the biomass of snapper and spiny lobster. They also noted changes in mollusk populations that were hypothesized to be an indirect result of changes in urchin populations. These studies suggest that changes in the abundance of important predators such as snapper have a strong, cascading effect on food web interactions and community structure. However, the studies did not distinguish the relative impacts of fishing pressure on lobster and snapper, so the extent of the ecosystem impact from the tai snapper fishery is unclear. Additionally, while the differences between reserve sites and fished sites are consistent with top-down ecosystem impacts, these patterns are only correlative. Trophic cascades have only been noted in two of New Zealand's reserves, and it is not known whether the densities of snapper in those reserves are representative of natural densities before intensive fishing (Langlois and Ballantine 2005). Thus, it is not entirely clear whether the results can be extrapolated to determine the ecosystem effects of fishing relative to a natural state. Overall, it is likely that intensive fishing of snapper has impacts on the food web and the ecosystem, but the extent and severity of these impacts in New Zealand is not known.

Table 8. Habitat and ecosystem effects of the *Pagrus auratus* 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	SFW Rank
Beach seine	Moderate	High to moderate, shallow sandy areas, gravel, or muddy habitats	Small	Unknown	Unknown	Gilbert *et al.* 2000; Morgan and Chuenpagdee 2003; NZMF 2006	Moderate
Set net (bottom gillnet)	Moderate	High to moderate, occasionally occurs in muddy habitats	Medium	Unknown	Unknown	Gilbert *et al.* 2000; Morgan and Chuenpagdee 2003; NZMF 2006	Moderate
Bottom longline	Moderate	High to moderate, sand and gravel bottom up to 75 m Occasionally in low resilience (rocky) habitat	Medium	Unknown	Unknown	Gilbert *et al.* 2000; Gilbert and Phillips 2003; Morgan and Chuenpagdee 2003; NZMF 2006; Pierre and Nordon 2006	Moderate
Danish seine	High	High to moderate, occasionally occurs in muddy habitats	Medium	Unknown	Unknown	Gilbert *et al.* 2000; Morgan and Chuenpagdee 2003; NZMF 2006	Severe
Bottom trawl	High	High, moderate and low: up to 200m, occasionally used in rock habitats	Medium	Unknown	Unknown	Blackwell *et al.* 1999; Gilbert *et al.* 2000; Gilbert and Phillips 2003; Morgan and Chuenpagdee 2003; NZMF 2006	Severe

Synthesis

Beach seines, set nets (bottom gillnets) and bottom longlines are bottom gear types but are less mobile than bottom trawls and dredges. Also, these gear types are generally used in habitats with moderate to high resilience to disturbance (though bottom longlines are occasionally used in rocky habitats where they are suspended above the seafloor to avoid snagging). As such, these gears are deemed to have moderate impacts on habitats. Bottom trawls and Danish seines are mobile bottom gears that cause great damage to seafloor habitats and are used in highly to moderately resilient habitats over a moderate spatial scale; therefore, they are considered to have severe habitat effects. The impact of the tai snapper fishery on the food web and ecosystem are unknown, although there is some evidence that removal of tai snapper may disrupt the food web.

Effect of Fishing Practices Rank

Beach seine, set net (bottom gillnet), bottom longline:

Benign	**Moderate**	Severe	Critical

Bottom trawl and Danish seine:

Benign	Moderate	**Severe**	Critical

Criterion 5: Effectiveness of the Management Regime

The New Zealand tai snapper fishery has been host to numerous regulatory measures. A limited licensing program was employed until its discontinuance in 1963. In certain areas, severe stock depletion in the 1960s and 1970s led to the establishment of annual quotas as early as the late 1970s. The Hauraki Gulf was managed as a controlled fishery from 1983 to 1986, when it was replaced by the Quota Management System (QMS) (NZMF 2007a).

The QMS is the primary mechanism by which commercial fishing is managed in New Zealand. Almost all commercial species are divided into zones that define stocks (Lock and Leslie 2007). A Total Allowable Catch (TAC), generally equal to MSY, is set for each stock and consists of a Total Allowable Commercial Catch (TACC) and a non-commercial catch. Commercial quota holders own the right to catch a specified proportion of the TACC each year (Straker *et al.* 2002). In essence, only quota holders may take catch of a quota species; incidental catch of species other than the fishing target is not exempt from the species quota (Straker *et al.* 2002). Quotas are fully transferable, and there are comprehensive reporting requirements for fishers, fish receivers and quota holders (Straker *et al.* 2002).

Because multiple species are often landed simultaneously and because incidental catch is often landed by fishers who do not have a quota for certain species, NZMF has developed a number of mechanisms to ensure that all landings are properly recorded and to encourage fishers to stay within annual TACC limits. The Ministry attempted to develop mechanisms to encourage retention rather than dumping of incidentally captured fish while minimizing potential profits from incidentally capturing fish to ensure that overall bycatch and overfishing would remain low (Lock and Leslie 2007).

As stated under "Criterion 3: Nature and Extent of Discarded Bycatch," there is bycatch of non-target species with no commercial value in the New Zealand tai snapper fisheries. Currently, there are no data quantifying this bycatch or the impact it has on fish populations. Thus, the quantity, trends and overall impacts of bycatch of non-commercially valuable species in the New

Zealand tai snapper fisheries are unknown. There does not appear to be a plan in place to collect data on non-commercial species discards or management measures to reduce such bycatch.

Between 1986 and 2001, NZMF employed five primary mechanisms to manage catch, though as many as 20 catch balancing mechanisms were legally acceptable (Lock and Leslie 2007). During this period, it was technically illegal to capture a species without the relevant quota, so the mechanisms outlined below were enacted as a form of penalty for unintentional landings. The catch balancing mechanisms used during this time period included:

1) Surrender of catch to the Government, with extra fish being passed on to processors, and the processors paying the Government a set price for the surrendered fish;
2) Leasing or buying additional quotas from other fishers on return to port;
3) Borrowing quotas, in which a fisher could borrow small amounts (up to 10%) of a quota from the subsequent year's quota. Conversely, if a fisher took less than his annual allotted quota for a given year, up to 10% of that amount would be added to his subsequent year's quota (termed quota 'banking');
4) The Bycatch Trade-off System, in which fishers could trade quotas of one species for another according to specified ratios set by NZMF;
5) Deemed Values, in which a fisher had to pay a set price for capturing fish without relevant quota holdings.

Considerable efforts were made to streamline and simplify the catch balancing system after 2001. One substantial change is that it is no longer considered illegal for a fisher to capture QMS managed species without the relevant quota provided that the fisher holds a valid fishing permit (Lock and Leslie 2007). Only two catch balancing methods, buying additional quotas or paying a deemed value, are now considered valid, and fishers face losing their permits for the failure to balance catch (Lock and Leslie 2007). To prevent overfishing, certain stocks have limitations on the amount (calculated as a percentage) by which fishers can exceed their individually held quota amount. When this value is exceeded, then fishers are prohibited from harvesting fish or other marine species in the Quota Management Area (QMA) where the overfished threshold was exceeded, typically for the remainder of the fishing year (Lock and Leslie 2007).

The New Zealand tai snapper fishery is divided into six QMAs: SNA1, SNA2, SNA7, SNA8, SNA3 and SNA10 (the latter two are nominal and solely of bureaucratic importance). Levels for TAC and TACC generally remain in force for several years. An adjustment to TACC may be made by the Minister of Fisheries after a stock assessment suggests that more or less catch can be taken sustainably (Lock and Leslie 2007). Commercial fishers, processors and other interested parties are consulted before any quota adjustments are finalized. After a TACC change, all quota holders have their holdings (in kg) adjusted by the same proportion as the TACC adjustment. The most recent snapper TACC adjustments were SNA1 (1997/98), SNA2 (2002/03), SNA7 (1997/98) and SNA8 (2005/2006) (NZMF 2009a). For the 2005/2005 season (October–September), the total of all snapper TACs was 10,133 mt (NZMF 2006).

There is currently a movement among many recreational fishers to reduce the TAC to levels below the estimated MSY in an effort to increase the number of larger fish in the area. Although no action has yet been taken in response to these efforts, NZMF is currently investigating the issue (NZMF 2006).

The majority of fishing gear types used in the New Zealand tai snapper fishery have moderate habitat impacts, and as such, do not require any management measures to address their effects on the ecosystem. Nevertheless, a portion of the fishery continues to use bottom trawls and Danish seines. The Ministry of Fisheries has prohibited purse seining in all snapper management areas and has enacted a total ban on trawling and Danish seining in all harbors and many of the sheltered bays in SNA1 and SNA8. These closures are designed both to reduce conflict between commercial and recreational fishers and to protect the juvenile snapper that congregate in these shallower areas (NZMF 2006). The closures are not designed to protect sensitive habitats such as rocky substrate, or moderately sensitive habitats such as deep, muddy areas, from the impacts of trawling and seining on the seafloor. The closures also do not constrain the spatial footprint or reduce the intensity of those impacts. Prevention of bottom trawling and Danish seining in several areas is likely to provide some habitat protection, but the effectiveness of these closures in protecting habitat has not yet been demonstrated. Measures to mitigate the habitat impacts of bottom trawling and Danish seines are deemed moderately effective according to Seafood Watch®.

The main bycatch concern of the New Zealand government is incidental catch of seabirds in the bottom longline fishery. Current gear modifications to reduce seabird bycatch in bottom longline fisheries include: (1) use of a streamer line on vessels longer than 7 meters to scare seabirds away from bait lines during deployment, (2) restrictions on the setting of bottom longlines 30 minutes before nautical dawn and 30 minutes after nautical dusk, and (3) weighting of all set bottom longlines along their entire length (*New Zealand Gazette*, 21 February 2008, No. 31, page 712). Bird scaring devices are also required on all trawl gear (*New Zealand Gazette*, 6 April 2006, No. 33, page 842). The effectiveness of these bycatch reduction measures has not yet been demonstrated in this fishery, although streamers and bird scaring devices have proven effective in other fisheries.

In order to prevent the capture of undersized commercial species, the minimum legal mesh size is set at 125 mm for trawls, Danish seines, set nets and beach seines. There are no hook size limits, but longline fishers are known to avoid small hooks as undersized fish must be discarded and tend to reduce the catch of the most valuable sizes, which are 5 cm greater than the legal limit. While management measures are likely effective at reducing bycatch of seabirds and juveniles of commercial species, there are no measures in place to track or reduce bycatch of other species. Overall, the effectiveness of current bycatch plans has not yet been demonstrated.

Regulations in the New Zealand tai snapper fisheries are enforced by the NZMF Observer Program and the Fisheries Compliance staff, who enforce commercial and recreational regulations and target poaching (NZMF 2008b).

SNA1

Although historically the largest and most important of the New Zealand tai snapper fisheries, SNA1 has only been actively managed in recent decades. All subareas of SNA1 are managed together even though they are often defined as two (or even three) separate stocks.

A stock assessment for SNA1 is complete but out of date, as it was last conducted in 2000. The assessment concluded that stock rebuilding is proceeding according to model projections. Other methods of research are ongoing, including recreational surveys that commenced in the 2003/04 season. A tagging survey is also planned for the area.

Both SNA1 stocks (East Northland and Hauraki Gulf) experienced severe depletion in the past, but management responded by introducing the QMS and reducing TACCs, and the stocks are recovering. At the inception of the QMS in 1986, the initial quota (4,710 mt) was set substantially below current prevailing catch levels to promote stock recovery (Gilbert *et al.* 2000). The quota increased to 6,010 mt by the end of 1991, but was reduced to 4,904 mt in October of the following year. A series of minor increases brought the quota to 4,938 mt for the 1996/97 season, after which it was again reduced to 4,500 mt (Gilbert *et al.* 2000).

SNA2

The first commercial fisheries in SNA2 emerged in the early 1930s. The use of trawl gear saw landings increase to a peak of over 1,000 mt during the 1970s; trawling was subsequently banned and landings dropped to 145 mt in the 1983/84 fishing season (Blackwell *et al.* 2000; Gilbert and Phillips 2003).

Fishery-dependent and independent data is regularly collected for SNA2. A stock assessment is complete but was last conducted in 2002 and is therefore out of date.

The SNA2 stock experienced declining abundance but has been increasing since the 1980s due to reductions in the TACC. The 1986 TACC was set at 130 mt, well below the 1985/86 catch level of 177 mt, to allow the stock to rebuild. The TACC was increased to 252 mt in 1992/93 and finally increased to 315 mt in 2005. Landings have exceeded the TACC every year since then. Much of the catch is assumed to be bycatch in the inshore trawl fisheries (Gilbert and Phillips 2003).

SNA7

The SNA7 commercial New Zealand tai snapper fishery emerged in the early 20th century and developed quickly with landings reaching 500 mt in the 1940s and 1950s and climbing to over 1,000 mt between 1966 and 1979 (Mace and Sullivan 1980; Gilbert and Phillips 2003). Annual landings peaked in 1978 at an unprecedented 3,203 mt, due primarily to the unrestricted use of shallow-water purse seine and pair trawl vessels (Gilbert and Phillips 2003). Landings fell sharply in the early 1980s with an annual average of approximately 200 mt until the advent and implementation of the QMS in 1986 (Gilbert and Phillips 2003).

Fishery-dependent and independent data is regularly collected for SNA7. A stock assessment was completed in 2002 and has not been updated since. Stock abundance declined from the 1920s until the 1980s but has been increasing due to reductions in the TACC. A 1987 biomass estimate of 1,544 mt resulted in the TACC being set at 300 mt, but this was reduced to 160 mt in 1989 (Harley and Gilbert 2000; Gilbert and Phillips 2003). The TACC remained unchanged until 1998 when it was raised to 200 mt. The quota has remained steady in recent years, although the 2002 stock assessment claims that landings could be increased without hindering current rebuilding efforts (Gilbert and Phillips 2003). Landings in SNA7 have consistently been below TACC levels (Gilbert and Phillips 2003).

SNA8

The most recent quantitative stock assessment of the SNA8 stock was conducted during the 2003/04 fishing season and found populations to be rebuilding more slowly than projected. The TACC was adjusted to 1300 mt from 1500 mt to further speed recovery, but researchers do not expect the fishery to rebuild to B_{MSY} before 2018 (NZMF 2007c).

Fishery-dependent and independent data is collected for SNA8. A survey of recreational catch (projected recreational catch is incorporated into the annual TAC) was conducted for SNA8 in the summer of 2006/07 to find out more about the recreational catch in the area; results were expected in early 2008 (NZMF 2006).

Some areas in SNA8 have been closed to commercial trawling to reduce the catch of juvenile snapper. Some of the same areas are also closed to set netting to protect Maui dolphins (NZMF 2007f).

Table 9. Management measures for the commercial *Pagrus auratus* fishery.

Fishery	Management Jurisdictions & Agencies	Total Allowable Landings	Size Limit	Gear Restrictions	Trip Limit	Closures	Sources	SFW Rank
SNA1	New Zealand Ministry of Fisheries (NZMF)	Each quota holder owns a portion of the TACC in each fishery—TACCs changed periodically (Total TACC 10,133 in 2005/06)	25 cm	Purse seining is prohibited; trawling and Danish seining are prohibited in certain nearshore areas	Individual quota—no trip limit	Marine reserves closed to bulk fishing methods	Gilbert *et al.* 2000; NZMF 2006; NZMF 2007a,c,d,f	Moderately Effective
SNA2			25 cm	Purse seining is prohibited	Individual quota—no trip limit	None	Blackwell *et al.* 2000; Gilbert and Phillips 2003; NZMF 2006; NZMF 2007a,c,d,f	Moderately Effective
SNA7			25 cm	Purse seining is prohibited	Individual quota—no trip limit	None	Gilbert and Phillips 2003; NZMF 2006; NZMF 2007a,c,d,f	Moderately Effective
SNA8			25 cm	Purse seining is prohibited; trawling and Danish seining are prohibited in all harbors and certain bays	Individual quota—no trip limit	Certain areas closed to trawling and set netting	NZMF 2006; NZMF 2007a,c,d,f	Moderately Effective

Synthesis

Overall, management of the New Zealand tai snapper commercial fishery is moderately effective according to Seafood Watch® criteria. All of the management areas collect and analyze fishery-dependent and independent data, and have completed robust stock assessments, though much of the stock assessment information is out of date. The fishery also has observer coverage and dockside monitoring in each area to enforce fishery regulations. Stock productivity has declined throughout the fishery in the past, but management has responded by reducing catch limits. Most stocks have been recovering since the implementation of management plans. The New Zealand government has a national plan of action in place to address seabird bycatch, the primary source of bycatch in the snapper fishery; however, no plan currently exists to measure or reduce bycatch of other non-commercial species. The seabird bycatch program has only been in place since late 2004 and has not yet been fully evaluated. Closed areas are in place to reduce gear conflicts among fishers and to avoid juvenile snapper, but there do not appear to be serious closures in place to protect sensitive habitats from damaging gear types. Both bycatch and habitat management measures are therefore considered moderately effective.

Effectiveness of Management Rank

All management areas:

Highly Effective	**Moderately Effective**	Ineffective	Critical

V. Overall Evaluation and Seafood Recommendation

Pagrus auratus is inherently resilient to fishing pressure according to Seafood Watch® due to its low age at first maturity and high fecundity. The SNA1 and SNA2 stocks are ranked as high conservation concerns according to Seafood Watch® because biomass levels are at or below 20% of unfished levels, which is the overfished threshold in many management regimes (including the US), but exhibit short-term increasing trends. The SNA8 stock is also ranked a high conservation concern because it is currently depleted despite slight increases in abundance in recent years. The SNA7 stock is ranked a moderate concern because the stock status is uncertain.

Gear types used in the *P. auratus* fishery include Danish seine, beach seine, set net, bottom longline and bottom trawl. Bycatch in the bottom trawl and bottom longline tai snapper fisheries is a moderate concern according to Seafood Watch® because the quantity of bycatch as a percentage of target tai snapper landings is unknown, has an unknown level of impact on bycatch population levels and does not seem to be increasing based on observed information. In addition, bycatch in the bottom longline fishery includes some seabirds that are vulnerable or near threatened according to the IUCN, but there is no information suggesting that this bycatch is limiting the recovery of these species. Danish seines, beach seines and set nets also receive a moderate ranking because bycatch rates for these gear types are not well documented.

Beach seines, set nets (bottom gillnets) and bottom longlines are bottom gear but are less mobile than bottom trawls and dredges. Also, they are used in habitats that have moderate to high resilience to disturbance. Bottom trawls and Danish seines are mobile bottom gears occasionally used on rocky bottom areas, which have low resilience to disturbance, but are primarily used on muddy and smooth bottom areas, which have high to moderate resilience to disturbance. Because these gear types require the dragging of heavy equipment across the seabed, they are considered to cause great damage to the habitat. The impact of the tai snapper fishery on the food web and ecosystem are unknown. Because bottom trawls and Danish seines cause great damage, are used on a moderate spatial scale and are used in habitats with moderate to low resilience to disturbance, they are considered to have severe impacts on the habitat and ecosystem. Beach seines, set nets and bottom longlines are considered to have moderate effects on the habitat and ecosystem because they cause moderate damage and are used in moderately to highly resilient habitats.

Overall, management of the New Zealand tai snapper commercial fishery is moderately effective according to Seafood Watch® criteria. All of the management areas collect and analyze fishery-dependent and independent data, and have completed robust stock assessments, though much of the stock assessment information needs to be updated. The fishery also has observer coverage and dockside monitoring in each area to enforce fishery regulations. Stock productivity has declined throughout the fishery in the past, but management has responded by reducing catch limits; most stocks have been recovering since the implementation of management plans. A seabird bycatch plan and closed areas have been implemented in the fishery, but the bycatch mitigation strategy is considered only moderately effective because it does not address bycatch of non-commercial species other than seabirds. For the bottom trawl and Danish seine fisheries, management measures used to protect habitat are considered moderately effective because they do not offer strong protection to sensitive habitats but do protect some habitats from bottom fishing.

The moderate health of the stock, moderate bycatch concerns and moderately effective management result in a Seafood Watch® overall recommendation of **Good Alternative** for tai snapper from the SNA7 stock regardless of gear type. Tai snapper from the SNA1, SNA2 and SNA8 stocks caught with beach seines, set nets or bottom longlines are also deemed a **Good Alternative** according to Seafood Watch® due to poor stock status, moderate bycatch, moderate habitat/ecosystem impacts and moderately effective management. Tai snapper from the SNA1, SNA2 and SNA8 stocks caught with bottom trawls or Danish seines are ranked **Avoid** due to poor stock status and severe habitat and ecosystem effects.

Table of Sustainability Ranks

	Conservation Concern			
Sustainability Criteria	**Low**	**Moderate**	**High**	**Critical**
Inherent Vulnerability	√			
Status of Stocks		√ **SNA7**	√ **SNA1, SNA2, SNA8**	
Nature of Bycatch		√ **Beach seine, Set net, Bottom longline, Danish seine, Bottom trawl**		
Habitat & Ecosystem Effects		√ **Beach seine, Set net, Bottom longline**	√ **Danish seine, Bottom trawl**	
Management Effectiveness		√ **SNA1, SNA2, SNA7, SNA8**		

Overall Seafood Recommendation

SNA7 – all gear; SNA1, SNA2, SNA8 – set net, beach seine and bottom longline:

Best Choice | **Good Alternative** | Avoid

SNA1, SNA2, SNA8 – bottom trawl and Danish seine:

Best Choice | Good Alternative | **Avoid**

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VII. Appendices

Appendix I. Wild-capture fisheries evaluation

Capture Fisheries Evaluation

Species: *Chrysophrys auratus* **Region:** *Sushi*

Analyst: *Casson Trenor, Stephanie Danner, Aja Peters-Mason* **Date:** *August 3, 2010*

Seafood Watch® defines sustainable seafood as originating from sources, whether fished[3] 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[4] to synthesize these factors
- A resulting rank for that criterion

[3] "Fish" is used throughout this document to refer to finfish, shellfish and other wild-caught invertebrates.
[4] 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[5] to evaluate

Intrinsic rate of increase ('r'): **Unknown**

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

Age at 1st maturity: **3 to 4 years (NZMF 2007b)**

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

Von Bertalanffy growth coefficient ('k'): **All published values range from 0.061 to 0.16, and vary by management area (Gilbert and Sullivan 1994; NZMF unpublished data).**

- High (> 0.16)
- Medium (0.05 - 0.15)
- Low (< 0.05)
- Unavailable/Unknown

Maximum age: **Between 35 and 60 years.**

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

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[5] 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, and increases with age/size. 297,000 at 25 cm, and up to 6,164,000 at 60 cm (Crossland 1977).**

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

Secondary Factors to evaluate

Species range: **Neritic regions in the Pacific Ocean, most abundant around New Zealand and Australia.**

- 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): **Sequential hermaphrodites, spawning aggregations.**

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

Quality of Habitat: Degradation from non-fishery impacts: **Unknown**

- Habitat is robust
- Habitat has been moderately altered by non-fishery impacts/unknown
- 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 (Moderately Vulnerable)
- High (Highly 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 OR recovering from overfished OR **unknown** **SNA7**
- Recruitment or growth overfished, overexploited, **depleted** or "threatened"
  SNA8 depleted according to NZMF. SNA1, SNA2 are not depleted according to NZMF but are considered overfished according to Seafood Watch because biomass is at or below what is considered the overfished threshold in many management regimes (including the US)

Current population abundance relative to B_{MSY}: SNA1, East Northland: Moderately below B_{MSY} 2000 assessment; SNA1, Bay of Plenty/Hauraki Gulf: Moderately below B_{MSY} 2000 assessment; SNA8: substantially below B_{MSY} to moderately below B_{MSY} –going with substantially for precaution sake; SNA2: Moderately below to at B_{MSY}; SNA7: unknown

- At or above B_{MSY} (> 100%)
- Moderately Below B_{MSY} (50 – 100%) OR unknown **SNA1, 2, 7**
- Substantially below B_{MSY} (< 50%) **SNA8**

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

- Overfishing not occurring ($F_{curr}/F_{msy} < 1.0$) **SNA1, SNA2**
- Overfishing is likely/probable OR fishing effort is increasing with poor understanding of stock status OR **Unknown** **SNA7,SNA8**
- Overfishing occurring ($F_{curr}/F_{msy} > 1.0$)

Overall degree of uncertainty in status of stock: SNA1, East Northland: Low; SNA1, Bay of Plenty/Hauraki Gulf: Low; SNA8: Low; SNA2: Moderate; SNA7: Moderate.

- Low (i.e. current stock assessment and other fishery-independent data are robust OR reliable long-term fishery-dependent data available) **SNA1 & 8**
- Medium (i.e. only limited, fishery-dependent data on stock status are available) **SNA2 & 7**
- High (i.e. little or no current fishery-dependent or independent information on stock status 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: SNA1, East Northland: down; SNA1, Bay of Plenty/Hauraki Gulf: variable; SNA8, down; SNA2: down; SNA7: down.

- Trend is up
- Trend is flat or variable (among areas, over time or among methods) OR Unknown **SNA1 Bay of Plenty/Hauraki Gulf**
- Trend is down **SNA1 East Northland; SNA2; SNA7; SNA 8**

Short-term trend in population abundance as measured by either fishery-independent (stock assessment) or fishery-dependent (standardized CPUE) measures: SNA 1, East Northland: up; SNA1, Bay of Plenty/Hauraki Gulf: up; SNA8: up; SNA2: up; SNA7: Up.

- Trend is up **SNA1, 2,7 and 8**
- Trend is flat or variable (among areas, over time or among methods) OR Unknown
- Trend is down

Current age, size or sex distribution of the stock relative to natural condition: SNA 1, East Northland: Catch-at-age estimates comprised of relatively high abundances below 12 years of age, but also an appreciable number of older fish, including several over 19 years of age—overall functionally normal; SNA1, Bay of Plenty/Hauraki Gulf: Skewed towards fish under age 10 for Bay of Plenty, but functionally normal for Hauraki Gulf—overall ranking of yellow for this stock; SNA8: skewed towards fish under 10 years of age; SNA2: skewed towards fish under age 10; SNA7, skewed towards younger fish.

- Distribution(s) is(are) functionally normal **SNA1: East Northland**
- Distribution(s) unknown
- Distribution(s) is(are) skewed **SNA1: Bay of Plenty**, **SNA2, 7 & 8**

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)

  SNA7
- High (Stock Poor)

  SNA1 (East Northland and Bay of Plenty/Hauraki Gulf); SNA2; SNA 8
- Stock Critical

CRITERION 3: NATURE AND EXTENT OF DISCARDED BYCATCH[6]

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
- Quantity of bycatch is moderate (10 – 100% of targeted landings on a per number basis) AND does not regularly include species of special concern OR **Unknown all others**
- Quantity of bycatch is high (> 100% of targeted landings on a per number basis) OR **bycatch regularly includes threatened, endangered or protected species**

bottom longline

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
- 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"

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
- Trend in bycatch interaction rates is up
- Not applicable because quantity of bycatch is low

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[6] 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
- Studies show evidence of substantial ecosystem impacts

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)
- Moderate (Bycatch Moderate)
- High (Bycatch Severe)
- 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) **Beach seines, set nets, bottom longlines**
- Great damage (i.e. bottom trawl or dredge) **Danish seines, bottom trawls**

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) **Beach seines, set nets, Danish seines, set nets,**
- Low (e.g. shallow or deep water corals, shallow or deep water rocky bottoms) **Bottom longlines, Bottom trawls**
- 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) **Beach seine**
- Moderate scale (e.g. modern fishery but of limited geographic scope) **all others**
- 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

- 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
- 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) **Beach seines, set nets, bottom longlines**
- High (Fishing Effects Severe) **Danish seines, bottom trawls**
- 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
- No stock assessment available now and none is planned in the near future

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
- No regular collection or analysis of data

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

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 or bycatch plan implemented but not meeting its conservation goals (deemed ineffective)
- Not applicable because bycatch is “low”

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

  Danish seine, bottom trawl
- No mitigative measures in place or measures in place but deemed ineffective
- Not applicable because fishing method is moderate or benign

  Beach seines, set nets, bottom longlines

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
- Regulations not regularly and consistently enforced

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
- Measures have not maintained stock productivity OR were implemented only after significant declines and stock has not yet fully recovered

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)
- High (Management Ineffective)
- Critical (Management Critically Ineffective)

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

	Conservation Concern			
Sustainability Criteria	**Low**	**Moderate**	**High**	**Critical**
Inherent Vulnerability	√			
Status of Stocks		√ **SNA7**	√ **SNA1, SNA2, SNA8**	
Nature of Bycatch		√ **Beach seine, Set net, Bottom longline, Danish seine, Bottom trawl**		
Habitat & Ecosystem Effects		√ **Beach seine, Set net, Bottom longline**	√ **Danish seine, Bottom trawl**	
Management Effectiveness		√ **SNA1, SNA2, SNA7, SNA8**		

Overall Seafood Recommendation

Best Choice

Good Alternative: SNA7 – all gears; SNA 1, SNA 2, SNA8 - beach seine, set net, longline

Avoid: SNA 1, SNA 2, SNA8 bottom trawl and Danish seine