Seafood Watch
Seafood Report

MONTEREY BAY AQUARIUM®

Wild-caught Coldwater Shrimp

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Final Report
December 18, 2005

Updated July 23, 2008

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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.

Seafood Watch® and Seafood Reports are made possible through a grant from the David and Lucile Packard Foundation.

Executive Summary

Shrimp is the biggest-selling seafood on the U.S. market. Warmwater shrimp (the genus Penaeus) comprise the vast majority of this market, while coldwater (pandalid) shrimp make up only a few percent by weight in both imports and domestic landings. Virtually all coldwater shrimp is imported from Canada or caught domestically.

Pandalid shrimp are fast-growing and early-maturing, and produce several thousand young. These and other life history characteristics, such as environmental sex determination, make them inherently resistant to fishing pressure. Abundance and biomass in the Atlantic Canada northern shrimp (*Pandalus borealis*) fishery has been increasing since 1997, and catch-per-unit-effort (CPUE) trends have remained stable or above the long-term average during the same time period. In contrast, New England northern shrimp were overfished for most of the 1990s and overfishing may still be occurring, although recent trends in fishing mortality and biomass may indicate an improvement in the health of the stock. Overfishing also appears to be occurring in the Alaskan spot prawn (*Pandalus platyceros*) pot fishery. The Oregon pink shrimp (*Pandalus jordani*) and British Columbia (BC) spot prawn fisheries appear fully-fished, and the status all other coldwater shrimp fisheries are unknown.

Smaller species of coldwater shrimp, in particular northern shrimp and pink shrimp (also known as ocean shrimp), are typically caught with trawls. Bycatch reduction devices (BRDs), closed areas and seasons, and other measures have brought trawl bycatch down to levels of significantly less than 10 percent, and few endangered species (sea turtles, mammals, seabirds, etc.) are caught in these fisheries. Concern over the bycatch of groundfish species persists, however, and managers in the large fisheries (northern and Oregon pink shrimp) continue research into reducing bycatch even further. Bottom trawls typically cause considerable damage to many seabed types, including the sandy and muddy habitats preferred by the trawl fisheries' target species. The semi-pelagic trawl configuration used in the Oregon pink shrimp fishery likely significantly reduces habitat damage, and is deemed less damaging than other bottom trawl gears in use in coldwater shrimp fisheries.

The largest pandalid, the spot prawn, is now captured wholly by pot gear (except for small quantities of allowable bycatch in other shrimp fisheries). The general belief that pot fisheries have low bycatch appears to hold true for coldwater shrimp fisheries. As spot prawns are typically found in hardbottom habitat, home to fragile glass sponges and corals, the fisheries likely cause moderate habitat damage. The habitat impacts of directed pot fisheries for coonstripe shrimp off California and northern shrimp off New England are likely benign, because these species inhabit softer seafloor habitats such as sand and mud.

Like all shrimp, abundance of coldwater shrimp species varies considerably with changing environmental conditions, thus management tends to be looser with coldwater shrimp than with many finfish. Accepting the conventional wisdom that little comprehensive assessment is needed for shrimp stocks, knowledge of the condition of stocks of northern shrimp, pink shrimp off Oregon, and spot prawns off Alaska and BC are considered complete and robust. Management for these fisheries uses research survey and/or in-season monitoring to judge stock abundance, and the fisheries are comprehensively monitored and enforced. In contrast, West Coast spot prawn assessment and management is minimal. Seafood Watch® therefore deems the BC spot prawn, Atlantic Canadian northern shrimp, and Oregon pink shrimp fisheries effectively managed, and all other coldwater shrimp fisheries only moderately effectively managed.

The Oregon pink shrimp (*Pandalus jordani*) fishery, Canadian northern shrimp (*Pandalus borealis*) fishery and the Scotian shelf (*Pandalus borealis*) fishery have been certified as sustainable to the Marine Stewardship Council (MSC) standard. The MSC is an independent non-profit organization, which has developed an environmental standard for sustainable and well-managed fisheries. It uses a product label to reward environmentally responsible fishery management and practices (http://www.msc.org/).

Table of Sustainability Ranks

	Conservation Concern			
Sustainability Criteria	**Low**	**Moderate**	**High**	**Critical**
Inherent Vulnerability	√			
Status of Stocks	√ Northern shrimp, Atlantic Canada	√ All others		
Nature of Bycatch	√			
Habitat Effects	√ Northern shrimp, pot √ Coonstripe shrimp, CA, directed pot	√ Pink shrimp, OR and WA	√ Northern shrimp	
Management Effectiveness	√ Northern shrimp, Atlantic Canada √ Pink shrimp, OR √ Spot prawns, BC	√ All others		

About the Overall Seafood Recommendation:

- 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.
- 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 **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.

Overall Seafood Recommendation:

British Columbia spot prawns, California coonstripe shrimp (pot), Oregon pink shrimp:

Best Choice 🟩 Good Alternative 🟨 Avoid 🟥

All other coldwater shrimp, including U.S. spot prawns and U.S. northern shrimp:

Best Choice 🟩 **Good Alternative** 🟨 Avoid 🟥

Introduction

Though shrimp is the biggest-selling seafood on the U.S. market, coldwater shrimp make up only two or three percent by weight of shrimp imports and only 10 – 25% of domestic shrimp landings. The majority of coldwater shrimp is caught in Alaska, Oregon, Washington, and California, and imported from Canada.

General shrimp biology

Shrimps belong to the order Decapoda, a crustacean order which also includes the lobsters, true crabs, and hermit crabs. All decapods possess a full carapace or "head shield", and, eponymously, five pairs of walking legs (Fenner and Chase 1980). Their first three pairs of thoracic appendages are modified into "maxillipeds", or feeding legs (Watanabe 2001). Shrimps are distinguished from other decapods by having the front-most section of the abdomen about the same size as the rest of the sections, and by having five pairs of abdominal appendages, or pleopods, adapted for swimming (Fenner and Chase 1980).

There are more than 3,000 living species of shrimp worldwide (Watanabe 2001). Many are tiny, or inhabit niches unsuited to mass harvest (Fenner and Chase 1980). Those harvested on a commercial basis share two characteristics: they are relatively large, ranging roughly from 2 – 10 centimeters (cm) carapace length; and they school, shoal, migrate toward baited traps, or otherwise aggregate so that they are amenable to capture. Worldwide, about 40 species of shrimp meet these criteria and are harvested commercially (NMFS 1998). About ten species have been raised in captivity; for some species, such as the Pacific white shrimp, *Penaeus vannamei*, selective breeding is developing truly "domesticated" breeds of shrimp. No coldwater shrimps, however, are currently raised in aquaculture.

Most shrimps are omnivorous, catching or scavenging whatever plant or animal material is readily available. Like other arthropods, shrimps have no internal skeleton, being protected instead by a chitinous exoskeleton which must be repeatedly shed as the animal grows (Fenner and Chase 1980). The sexes in warmwater shrimp are separate, and they are free spawners. In contrast, the main commercially-important coldwater shrimps, the pandalids (Pandalus spp.), are nearly all protandrous hermaphrodites; usually all juveniles mature as males, breed as males for one or two years, and then transform and breed as females for another year or two (Fenner and Chase 1980; Idoine 2001; ADF&G 2000). The males transfer sperm to females, who may then store the sperm for some time. The females then extrude the eggs, fertilizing them as they lay them. Clutch size ranges from a few hundred eggs to about 4,000 (ADF&G 2000), which is very few compared to the tens if thousands or more eggs released by warmwater shrimps. The female pandalid attaches her fertilized eggs to her abdominal appendages, where they remain, protected by the mother and aerated by her swimming, until the larvae break free (ADF&G 2000). Newly-hatched shrimp larvae bear little resemblance to their elders; each must undergo up to 12 molts to attain final form as a juvenile shrimp.

Scientific names and shrimp vs. prawn

While there is no hard and fast rule about applying the names "shrimp" and "prawn" (L. Watling, University of Maine, pers. comm.; S. Shumway, University of Connecticut, pers.

comm.), certain scientific references state that "shrimp" refers to the infraorder Caridea, which includes the widely-harvested coldwater genera *Pandalus* and *Crangon* (Watanabe 2001). With more than 2,000 species, these so-called "true shrimp" (Watanabe 2001) are the largest group of shrimp-like decapods (Watanabe 2001). They are distinguished by the fact that small side flaps of the exoskeleton overlap on their first, second, and third abdominal segments (Watanabe 2001). Under this definition, "prawn" refers to members of the infraorder Penaeidea, which includes the peneids or tropical shrimp (Watanabe 2001). Also known as the "primitive shrimp", prawns are recognizable because their first and second anterior segments are about the same size (Watanabe 2001). However, there is vast confusion among the common names of these animals. The "spot prawn" (*Pandalus platyceros*) of the U.S. West Coast is in fact a shrimp (Watanabe 2001; NMFS 1998), and in British usage only the genus *Palaemon*, with its prominent head spine or rostrum, can be called a prawn (Fenner and Chase 1980).

In U.S. markets, "shrimp" is the default name for all these animals. "Prawn" often refers to freshwater shrimp or large saltwater shrimp. Commercially-harvested shrimp may be divided into three categories based upon their habitat: coldwater or northern species; warmwater, tropical, or southern species; and freshwater species (Batten 2001). The term "scampi" refers not to a species, but to the method of cooking large shrimp in butter and garlic (Batten 2001); likewise, when used for sushi or sashimi, coldwater species of shrimp and prawns are commonly sold as *amaebi*.

Availability of science

Because of their commercial importance, pandalid shrimp have been the subject of several international symposia and scientific meetings (Bergstrom 2000). Internationally, their stock assessment and management have also been the focus of fisheries organizations such as the International Council for the Exploration of the Seas, the North Atlantic Fisheries Organization, and the North Pacific Marine Sciences Organization.

In the U.S. and Canada, where virtually all coldwater shrimp on the U.S. market now come from, considerable research is conducted on how best to assess the health of some coldwater shrimp stocks and improve the management of fisheries that exploit them. The resources put into such work are typically dependent on the size and commercial importance of the fishery, so the quantity and quality of information varies considerably between species and area.

Product forms

Northern and pink shrimp make up the vast majority of coldwater shrimp on the U.S. market. Both species are considerably smaller than tropical shrimp. According to the Canadian Department of Agriculture:

> Coldwater shrimp have a sweet, delicate taste and are generally considered more flavourful than warmwater varieties. Live, the tail of the northern shrimp is more red than pink. Cooked, the shell is pink and the meat is an opaque white tinged with pink. The meat is firm and crisp in texture, and more moist than tropical shrimp. Once out of the shell, *P. borealis* and *P. jordani* are indistinguishable; *P. montagui* is a smaller striped shrimp that is often caught with *P. borealis*. The

montagui is a lower-value product, lacking the vibrant shell colour and crisp texture of the borealis.

These species are "often available fresh in coastal markets, but because they are fragile and relatively perishable, most shrimp is sold frozen in a variety of commercial product forms:

- frozen block whole (raw or cooked)
- frozen block peeled (raw or cooked)
- frozen IQF (Individually Quick Frozen) – raw or cooked
- canned, in brine
- smoked
- in prepared dishes such as soups, bisques and salads."[1]

Other species of coldwater shrimp are much larger. The spot prawn is the largest; sidestripe and coonstripe shrimp are of middle size (see image on front cover). Spot prawns are either quick-frozen whole at sea, sometimes for export (which accounts for approximately 90 percent of the catch in British Columbia, the biggest commercial spot prawn fishery on the Pacific coast of North America), or sold fresh. Some product is sold live in the U.S., particularly to Asian markets.

Global shrimp market

Global shrimp production has been increasing steadily since 1950 (Figure 1). Aquaculture has accounted for about 25 – 30 percent of production since the early 1990s.

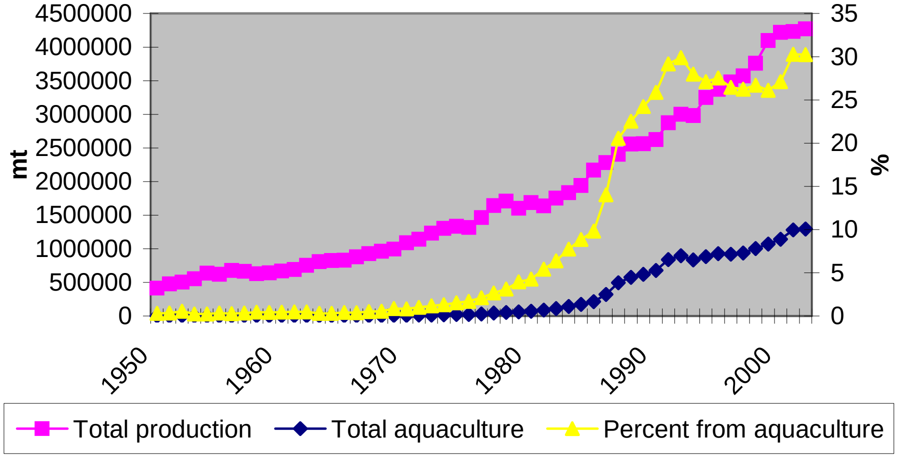

Figure 1: Global shrimp production 1950 – 2003 (FAO 2005).

The trend in increasing production is shown in both warmwater and coldwater shrimp production. Warmwater shrimp production, however, accounts for the vast majority on the global marketplace (roughly 88 percent since the early 1980s) (Figure 2).

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[1] http://atn-riae.agr.ca/seafood/shrimp-e.htm

Global coldwater shrimp production is dominated by landings of northern shrimp, *Pandalus borealis*, in the North Atlantic. This species accounted for about 80 percent of coldwater shrimp landings in the mid 1980s through 2000 (Figure 3). Landings declined in 2001, accounting for around 70 percent of total landings. Much of the remainder is comprised of other Pandalus spp., though catches of the Argentine red shrimp, *Pleoticus muelleri*, increased considerably in 2001. In addition, landings of *Crangon crangon* have been fairly stable since the early 1980s, and now account for approximately 5 percent of the total global coldwater shrimp catch (Figure 3).

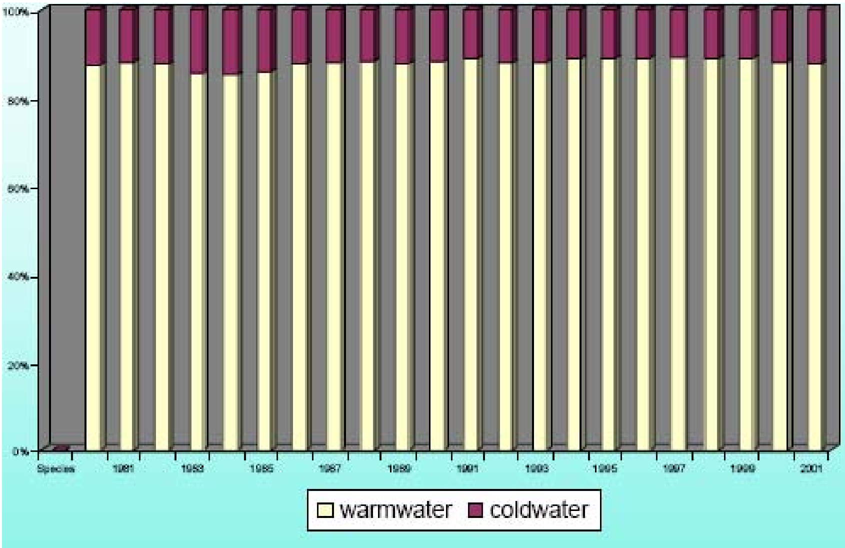

Figure 2: Relative importance of warmwater and coldwater shrimp to the global marketplace (Josupeit 2003, GLOBEFISH).

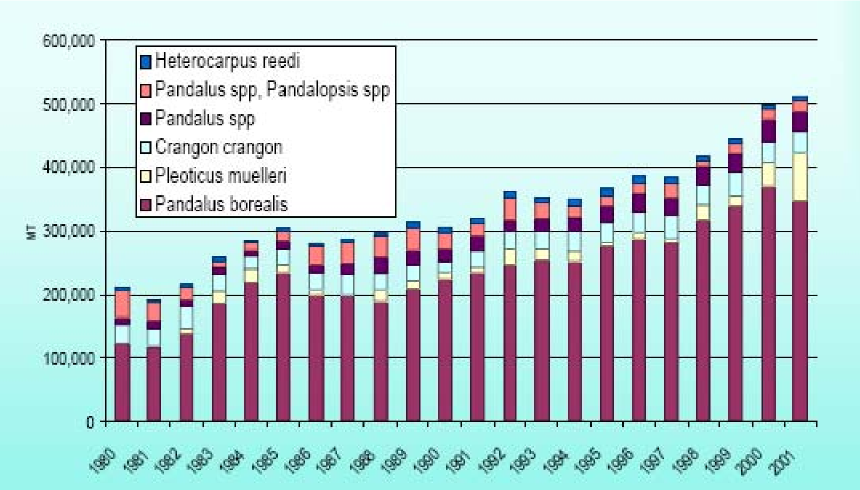

Figure 3: Global coldwater shrimp catch by species, 1980 – 2001 (Josupeit 2003).

Northern shrimp is landed almost entirely in the North Atlantic, though it is also widely distributed in the North Pacific (the Alaska population may be a subspecies, *P. borealis eous*, though this is not yet clear (FAO/FIGIS 2005). Canada, Greenland, and Norway combined account for perhaps 70 percent of landings (Figure 4). Considerable increases in landings in Canada in the late 1990s made it the largest supplier of coldwater shrimp, a crown that is still worn today (Anon 2001, Berge 2004).

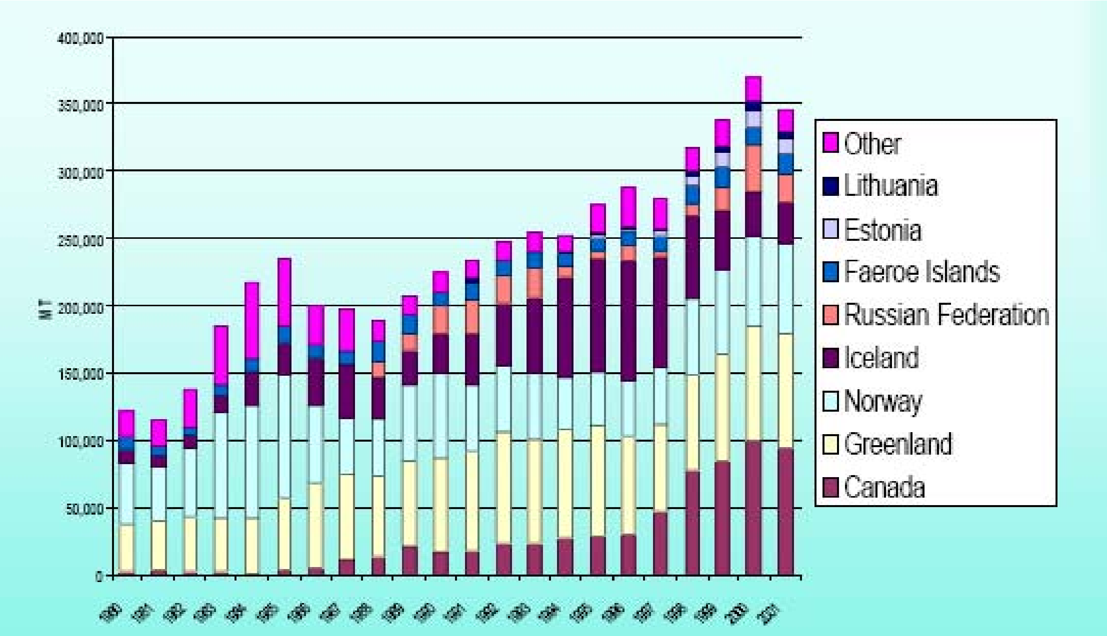

Figure 4: Global landings of northern shrimp, *Pandalus borealis*, by country, 1980 – 2000, in mt (Josupeit 2003).

U.S. domestic shrimp supply

U.S. shrimp imports have risen steadily from about 78 percent of total supply in the mid 1990s to almost 90 percent of the nearly 770 thousand metric tons (mt) of supply in 2003 (Johnson 2004). Approximately three percent of these imports are coldwater shrimp (Figure 5). In addition, domestic landings of coldwater shrimp accounted for 10 – 25 percent of all U.S.-caught shrimp over the past few years (NMFS commercial landings data 2005). Thus, around 5 percent of all shrimp on the U.S. market are coldwater shrimp.

Total U.S. shrimp supply was dominated by domestic landings in the late 1980s. Since then imports have continued to increase fairly steadily, and account for some fifty percent of supply today (Figure 6). Domestic production declined between 1989 and 1999, but total supply was held relatively stable at between 25,000 and 30,000 mt (Figure 6). U.S. landings then doubled or more between a low in 1999 and a peak in 2002, and have since declined sharply to levels similar to those in the 1990s (Figure 6). Both domestic landings and imports declined in 2003.

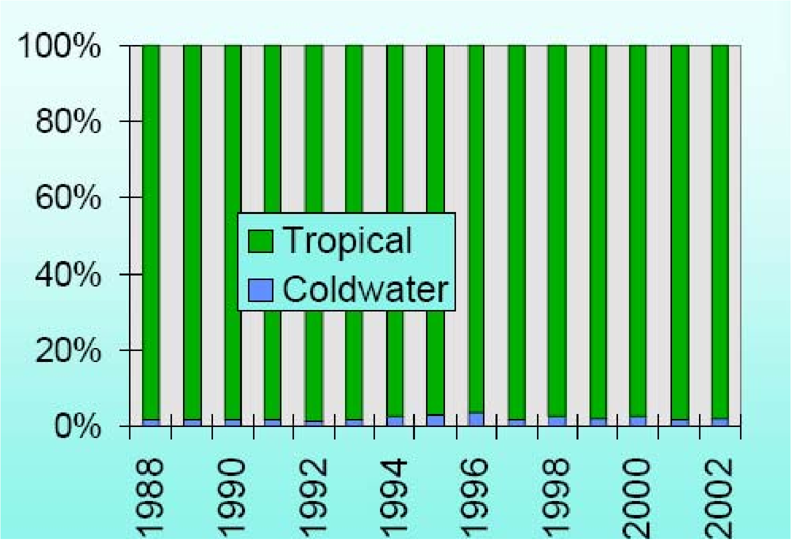

Figure 5: Relative importance of warm- and cold-water shrimp in U.S. imports, 1988 – 2002 (Josupeit 2003).

The most current domestic landings and trade data indicate that two thirds of domestic landings of coldwater shrimp are by West Coast fisheries (Figure 6). Most of the remainder is from inland brine shrimp fisheries, primarily in Utah (at least 90 percent) but also in West Coast states. Very little shrimp currently comes from New England (3 percent in 2003). Of the imports, some eighty percent are from Canada, which accounts for 51 percent of total supply. The only other major importer is Argentina (about 7 percent of imports), but imports from that country have declined considerably in the last three years (NMFS 2005) (Figure 6).

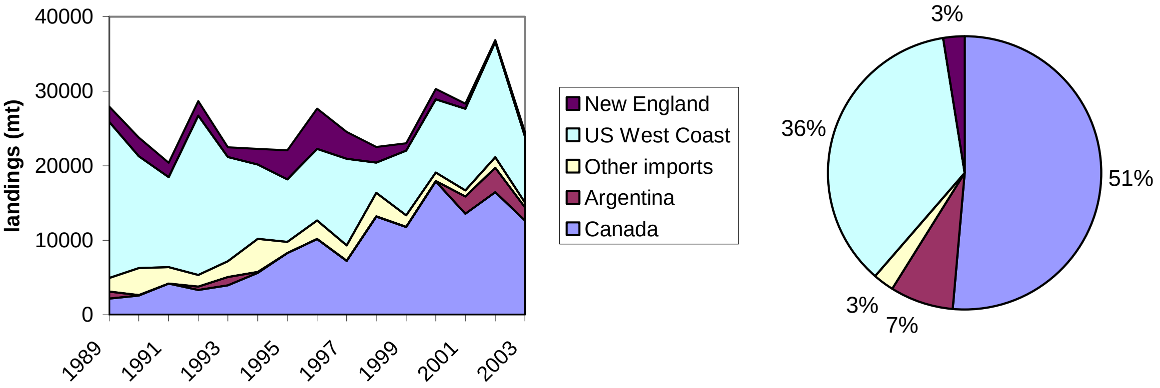

Figure 6: U.S. coldwater shrimp domestic catch and imports combined, heads-off, 1989 – 2003 trend and 2003 composition (NMFS 2005: All data are from NMFS 2005 trade and commercial landings database. NMFS import data does not specify species or even coldwater/warmwater in its imports data, so the author has selected likely coldwater shrimp sources. China is not included, but may supply some coldwater shrimp to the U.S. market).

Coldwater shrimp imports on the U.S. market

Domestic landings combined with imports from Canada represent 90 percent of the coldwater shrimp on the U.S. market (Figure 6). Pandalids make up the vast majority of coldwater shrimp caught by these two countries. The taxonomy of this genus is unclear, but approximately 20 species are currently known. They are found at all depths on the continental shelf and slope in the Northern Hemisphere. In the North Atlantic, they are found from the North Sea to the U.S. Mid-Atlantic region, including the Arctic Ocean. Only three species are found in the Atlantic, of which the northern shrimp, *P. borealis*, is by far the most abundant and widespread species (Bergstrom 2000), though *P. montagui* is important in some Canadian fisheries (DFO 2004a).

Of the 16 or 17 pandalid shrimp species found in the Pacific, eight species are found off the west coast of North America. The northern shrimp caught in Alaska and British Columbia is a subpopulation of *P. borealis*, distinct enough for some authorities to move to rename it *P. eous*. This is not yet completely accepted by the scientific community, however. This species, along with 4 other pandalid species (*P. hypsinotus*, *P. tridens*, *P. stenolepsis*, and *P. goniurus*), range from Vancouver Island to the Bering Sea (in the Northeast Pacific). The remaining three species, *P. jordani*, *P. danae*, and *P. platyceros*, are more widespread, ranging from Baja California to the Gulf of Alaska (Bergstrom 2000). The only non-pandalid landed commercially primarily for human consumption on the U.S. market is the Pacific ridgeback rock shrimp (*Sicyonia ingentis*), which is caught off the central/southern California coast (CDFG 2001).

Several non-pandalid species are also commercially important on a global scale, though beyond the scope of this report. The common or brown shrimp, *Crangon crangon*, is the target of a sizeable Mediterranean shrimp fishery (Josupeit 2003). However, there is very little shrimp on the U.S. market that is imported from Europe (NMFS 2005), and so this fishery forms only a very small percentage, if any, of the coldwater shrimp on the U.S. market. After Canada, which largely catches the same pandalids as the U.S., the second largest exporter of coldwater shrimp to the U.S. is Argentina. Production there is almost entirely of the Argentine red shrimp, *Pleoticus muelleri*. As imports from Argentina declined to close to zero in 2005 (NMFS 2005), fisheries for this species will also not be evaluated in this report.

Several other species of crangonid shrimp are caught off the west coast of North America in the bay (grass) shrimp fishery. The California bay shrimp, *C. fransicorum*, is the primary species landed in the fishery, though the blacktail bay shrimp, *C. nigricauda*, is also important (CDFG 2001). Both species are found in estuarine and nearshore waters to at least 180 feet depth. The bay shrimp fishery developed and still exists today to provide live bait for sturgeon and striped bass sport fishing, although a small percentage is reserved for human consumption (CDFG 2001). Other West Coast species landed only for bait or the aquarium trade include the ghost shrimp (*Callianassa californiensis*), the blue mud shrimp (*Upogebia pugettensis*), the red rock shrimp (*Lysmata californica*) (CDFW 2001), and the brine shrimp (*Artemia* spp.). Evaluation of these species is beyond the scope of this report.

U.S. and Canadian fisheries

Atlantic

Canada supplies roughly half of the coldwater shrimp on the U.S. market (Figure 6). Atlantic shrimp have dominated landings for at least the last 15 years, accounting for 96 – 97 percent of Canadian landings between 1999 and 2003 (FAO 2005). In contrast, New England supplies only a few percent of the total U.S. supply (Figure 6). Approximately 75 percent of Canadian production is of northern shrimp (average 2000 – 2003) (FishStat 2005). All sources combined, this species makes up perhaps 40 percent of the coldwater shrimp on the U.S. market.

Canada

The Canadian Atlantic shrimp fishery takes place off the coast of Newfoundland north to Baffin Bay, and consists of two segments (DFO 2003). The offshore component consists of 12 or 13 factory freezer trawlers (in 2003), which fish the 17 available licenses. All are purpose-built for shrimp trawling and processing, and focus on the frozen-at-sea, shell-on product, which has historically been marketed in Japan and Western Europe, but more recently in developing countries as well (DFO 2003). The inshore fleet is mainly composed of smaller vessels that fish using otter trawls, with a few using beam trawls. In addition, some experimental work is ongoing with shrimp pots. The catch is primarily processed into shell-off product on land, destined for the U.S. and Europe (DFO 2003).

Other species landed in these fisheries include the striped pink shrimp, *P. montagui*, which, although less commercially important, is fished exclusively in some areas off Canada and is caught as bycatch in the northern shrimp fisheries (DFO 2003).

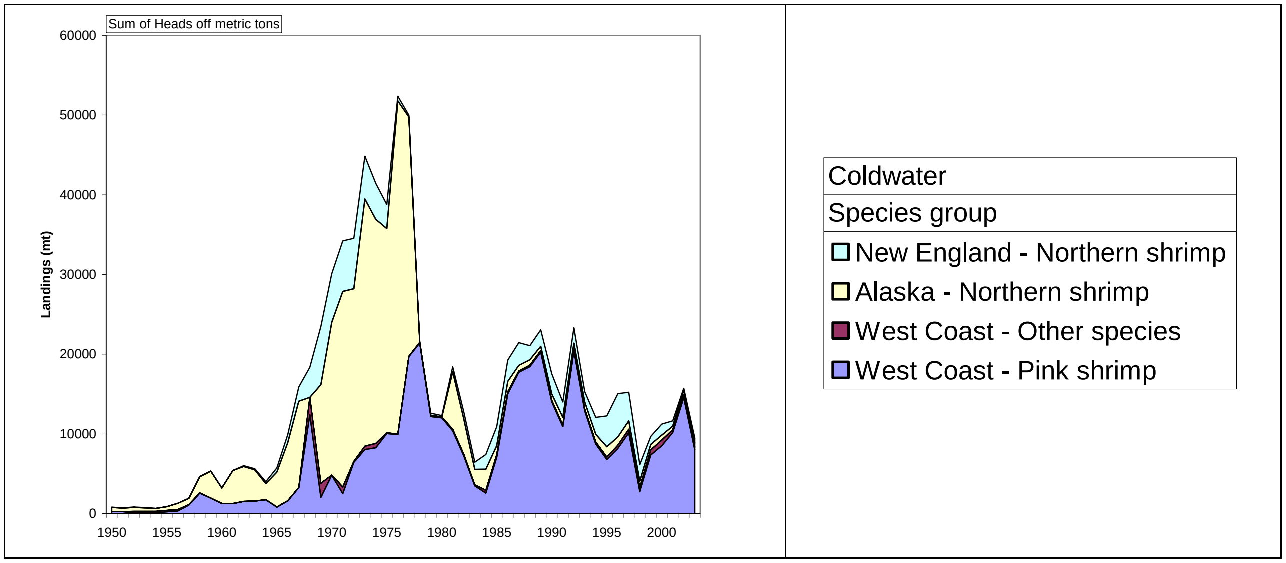

Figure 7: U.S. coldwater and northern shrimp landings, 1950 – 2003 (NMFS 2005). The large decline in Alaskan shrimp landings after 1977 has been attributed to sharp decreases in abundance of shrimp as a result of abrupt climate change (Anderson 2000).

Table 1: Coldwater and U.S. West Coast shrimp fisheries (not globally comprehensive). Bolded common names will be used in this report.

Common names U.S./Canada	Scientific name	Range	U.S./Canadian fishery location	Sources
Atlantic				
Northern shrimp, pink shrimp, great northern prawn, salad shrimp, Pacific pink shrimp (P. *eous*)	*Pandalus borealis*	Gulf of Maine to North Sea	Baffin Bay to Gulf of Maine	Bergstrom 2000, DFO 2003
Striped shrimp	*P. montagui* (*P. tridens*)	Gulf of Maine to North Sea and Barents Sea	Primarily incidental in northern shrimp fishery; small quota in Atlantic Canada	
Common shrimp, brown shrimp, shrimp (UK)	*Crangon crangon*	Northeast Atlantic (Europe and Scandinavia)	N/A	
Argentinean shrimp	*Pleoticus muelleri*	Southwest Atlantic.		
Pacific				
Northern shrimp, pink shrimp, great northern shrimp, salad shrimp, Pacific pink shrimp (*P. eous*)	*P. eous* (Pacific version of *P. borealis*)	Washington to Russia, patchy distribution off California and Japan	Davis straight off Labrador to the Gulf of Maine	Bergstrom 2000, CDFG 2001, Hannah and Jones 2003
Pink shrimp, ocean shrimp, smooth pink shrimp, ocean pink shrimp, Oregon pink shrimp	*P. jordani*	Aleutian Islands to Baja California	Vancouver Island, B.C. to Point Arguello, California	
Spot prawn, spot shrimp, spot, prawn	*P. platyceros*	Gulf of Alaska to Baja California, and off Japan	Alaska to southern California	
Pacific ridgeback prawn	*Sicyonia ingentis*	Monterey to Baja California	Santa Barbara area	
Coonstripe shrimp, humpback shrimp, king shrimp	*P. hypsinotus*	Washington to Japan	Primarily incidental in other shrimp fisheries.	
Striped shrimp	*P. montagui* (*P. tridens*)	California to Japan		
Rough patch shrimp	*P. stenolepsis*	Alaska to Washington.		
Humpy shrimp	*P. goniurus*	Washington to Northern Japan		
Dock shrimp (Oregon, Alaska, Canada), coonstripe shrimp (California)	*P. danae*	British Columbia to Baja California		
Sidestripe shrimp	*P. dispar*	North America west coast nearshore		
Generally not for human consumption				
Bay shrimp, Pacific bay shrimp, California bay shrimp, grass shrimp	*Crangon franciscorum* (primarily)	Alaska to Southern California	San Francisco area	CDFG 2001, and online sources
Red rock shrimp	*Lysmata californica*	Santa Barbara to Baja California		
Blue mud shrimp, crawfish, mud prawn, ghost shrimp, and mud shrimp	*Upogebia pugettensis*	Alaska to Baja California.		
Ghost shrimp, Pacific intertidal shrimp, crawfish, mud prawn, burrowing shrimp, red ghost shrimp, and orange mud shrimp	*Callianassa californiensis*	Alaska to Baja California.		
Brine shrimp, sea monkey, fairy shrimp	*Artemia salina, A. franciscana*	Salty lakes in Utah and West Coast states		

New England

Three quarters of shrimp landings in New England have been by Maine vessels, with the remainder (17 percent) by Massachusetts vessels. The number of vessels fishing in New England waters has fluctuated considerably, with 300 – 400 vessels in some years. Many of the participants are opportunistic, switching to shrimp trawling if price, season, and accessibility warrant the effort (ASMFC 2004). In 2004, the fleet consisted of lobster vessels that re-rigged for shrimp and a range of trawler vessels from 12 – 24 meters (m) in length. The otter trawl is the primary gear used, and is typically chain- or roller-rigged, depending on area and substrate.

There is also a small pot fishery in mid-Maine that accounts for about 5 percent of the total catch. The pots target only female shrimp once they migrate onshore. Most shrimp pot fishers also fish for lobster at other times of the year (ASMFC 2004).

Pacific

Pacific shrimp fisheries off the U.S. and British Columbia reflect the greater diversity of coldwater species available in commercially viable abundance in the Northeast Pacific compared to the Northwest Atlantic. Shrimp fisheries occur off the entire west coast from Southern California to the Aleutians, but the target species and gears used vary between and within states.

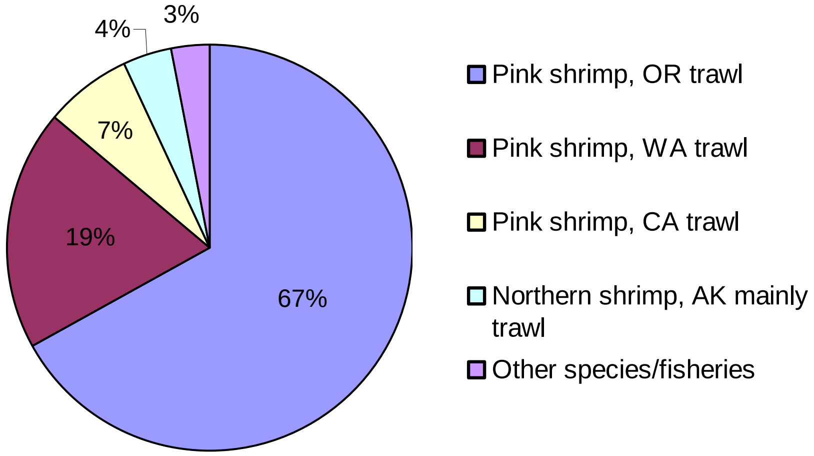

Figure 8: U.S. West Coast shrimp and prawn landings, 2000 – 2003 combined (including Alaska). Pink shrimp is *P. jordani*, northern shrimp is *P. eous*. Other species/fisheries include spot prawns, coonstripe shrimp, ridgeback prawns, and some bait shrimp and unidentified shrimp (NMFS 2005).

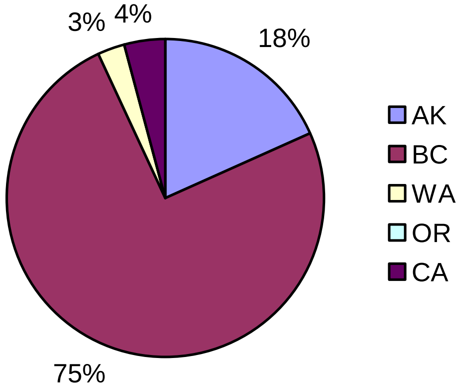

Figure 9: Spot prawn landings, 2004. Total combined landings were 2364 mt; less than 1 percent was landed in Oregon. 5% of pot landings in BC were assumed not spot prawns and omitted from the figure. Note that landings do not equate to availability in the U.S. market. Most prawns caught in Alaska (AK) are exported to Asia, with only a small limited live market in AK. In addition, 90% of BC spot prawns are also exported to Asia, but some do reach the U.S. As that fishery is at least an order of magnitude larger than West Coast fisheries, BC prawns may be in relative abundance on the U.S. market. Data are from ADFG, DFO, WDFW, ODFW, and CDFG.

Alaska

Five pandalid species of commercial importance (see cover photo) are found off Alaska, and are variously harvested in both trawl and pot fisheries. Northern shrimp generally comprise more than 80 percent of the landings from Alaskan trawl fisheries, though humpy and sidestripe shrimp are also targeted in some areas in Alaska. Shrimp pot fisheries primarily target spot prawns but also land coonstripe shrimp.

The beam trawl and trap fisheries in Southeast Alaska account for the vast majority of shrimp landed in Alaska. The proportion from each varies from year to year, but in 2003 over 90 percent of all Alaskan shrimp landings were from these two fisheries, divided roughly equally by weight (ADF&G landings data 1997 – 2003). Landings from the trawl fishery in Prince William Sound vary considerably from year to year, but have not comprised more than about 5 percent of landings since 1998. In more recent years, if any fishery existed at all, so few vessels were involved that landings data are confidential under privacy laws (ADF&G landings data, 1997 – 2003). Geographically between the Southeast fisheries and the Prince William Sound fishery is a small pot fishery off Yakutat. In addition, some shrimp were landed from the Bering Sea in 2000 – 2001, but that fishery has now closed due to insufficient information on shrimp stock abundance and distribution (ADF&G 2003). However, with the large quantities of pink and northern shrimp coming into the U.S. from Canada and Oregon fisheries, marketing pink shrimp has been a challenge. As a result, the only major Alaska processor (in St. Petersburg) has closed, so Alaskan northern shrimp are not likely to be available in the near future (G. Bishop, ADF&G, pers. comm.).

The only commercially viable shrimp pot fishery in Alaska is in the Southeast Region (Love and Bishop 2005). It is by far the most valuable of the shrimp fisheries in Alaska, with ex-vessel values typically an order of magnitude higher than the shrimp trawl fishery (ADF&G landings data, 1997 – 2003). This fishery primarily targets spot prawns (*P. platyceros*) but also lands smaller quantities of the coonstripe shrimp (*P. hypsinotus*) (about 5 percent of total landings in this fishery in the 2003 – 2004 season) (ADF&G 2004). Large catcher-processor vessels that flash freeze shrimp whole primarily for export to Japan account for the majority of the shrimp catch in Alaska. There is also a very limited live market (Love and Bishop 2005).

British Columbia

The ranges of northern and more southerly Northeast Pacific species overlap in the waters off British Columbia. Consequently, fisheries target the same five species found in Alaskan waters, as well as the pink shrimp (*P. jordani*) and the dock shrimp (*P. danae*) (DFO 1999a). Both trawl and trap gears are used. Over 75 percent of the trawl vessels use beam trawls (DFO 2001). Over 90 percent of the shrimp landed by the trawl fishery is northern/pink shrimp (both *P. eous* and *P. jordani*); sidestripe shrimp comprises the remainder (DFO 2001). Landings of these species by trap gear are not significant (DFO 2005a). Coonstripe shrimp are landed both by trawl and trap gear. The west coast of Vancouver Island has historically been the predominant shrimp trawling ground in British Columbia, with 80 – 90 percent of BC's landings taken in the offshore areas (DFO 1999a). Shrimp from the West Coast fishery account for approximately 3 percent of Canadian landings; the rest come from the northern shrimp fishery (*P. eous* and *P. montagui*) in the Atlantic (FAO 2005).

BC has the biggest fishery for spot prawns off the Pacific coast of North America, largely because there is a huge amount of appropriate habitat there available for this species (L. Wargo, WDFW, pers. comm.). Spot prawns are landed almost entirely (98 percent) by trap gear (Boutillier 2000). Roughly 90 percent of this shrimp is exported to Japan for sushi, and the majority of the rest is sold live or fresh in BC[2], but some does enter the U.S. (M. Kattilakoski, DFO, pers. comm.).

U.S. West Coast

Shrimp landings on the U.S. West Coast are dominated by trawl fisheries for pink shrimp (*P. jordani*) (Figure 8), though several other species are targeted in various fisheries, including spot prawns, coonstripe shrimp, and ridgeback prawns.

Washington

Trawling and trapping occurs for shrimp in both Puget Sound and off the Washington coast (primarily off the central and southern coast) (D. Steritt, WDFW, pers. comm.). According to NMFS landings data, trawl-caught pink shrimp account for the vast majority (95 percent in 2001 – 2003) (NMFS 2005). Although undifferentiated in the landings data, "pink shrimp" are mostly *P. jordani* in the coastal fishery, and a mix of *P. jordani* and P. *eous* in the Puget Sound fishery (L. Wargo, WDFW, pers. comm.). As the coastal otter trawl fishery generally accounts for more than 90 percent of the entire state's pink shrimp landings (based on WDFW website[3], and NMFS 2005), the majority are probably *P. jordani*.

The two directed shrimp fisheries carried out off the coast are the otter trawl fishery for pink shrimp, and the experimental longline pot fishery for spot prawns. Species other than these can

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[2] http://www.bcseafoodonline.com/files/spot_prawn.html

[3] http://wdfw.wa.gov/fish/shelfish/shrimp/comm/index.html

only be taken incidentally (Washington State regulations[4]). Of the approximately 125 licenses for the coastal trawl fishery, only 30 have been actively fished in recent years, and only 15 take the bulk of the catch (L. Wargo, pers. comm.).

The coastal spot prawn fishery was initiated in 1999 as an experimental fishery. That year, 15 vessels took part in the fishery; 10 pot vessels and 5 trawlers. Trawling was gradually phased out of the fishery, leaving only 13 pot vessels in 2004. Though the fishery had an experimental status only for an initial five years, that status was recently extended (the main effect being that permits are not transferable or inheritable) (L. Wargo, pers. comm.).

Beam trawlers in Puget Sound primarily target pink shrimp, but also catch dock, humpy, sidestripe, and coonstripe shrimp. Trawlers do not target and are prohibited from landing spot prawn. The pot shrimp fishery focuses on spot prawn, but also catches some dock, humpy, and coonstripe shrimp (D. Steritt, pers. comm.).

Oregon

The vast majority of shrimp landed in Oregon is from the trawl fishery for *P. jordani* (called pink shrimp in Oregon and ocean shrimp in Washington, California, and BC) (NMFS 2005) (Figure 8). This is the largest shrimp or prawn fishery on the U.S. West Coast (in terms of landings), including Canada and Alaska. Forty-four vessels landed pink shrimp in Oregon in 2004 (ODFW 2005a). Most are double-rigged, using two high-rise trawls (ODFW 2000).

The other two fisheries in Oregon waters are the spot prawn and coonstripe/sidestripe pot fisheries. Little information is available for these fisheries other than landings data and number of permits (J. McCrae, ODFW, pers. comm.). Both have been managed under the Oregon Department of Fish and Wildlife's (ODFW's) Developmental Fisheries Program since the program's inception in 1995. The purpose of the program is to limit effort in developing fisheries until such time as proper management measures can be put into place. In the case of the shrimp pot fisheries, there has not been enough fishing effort to justify removing from the program. For example, although ten permits are allowed for the spot prawn fishery, only a few vessels actually landed any prawns in 2004. Only 2,096 pounds (lbs) were landed in 2004, two orders of magnitude less than landed in California or Washington (landings data from K. Barsky—CA), J. McCrae—OR, and L. Wargo—WA). There are also only a couple of vessels fishing consistently for coonstripe and sidestripe shrimp (J. McCrae, pers. comm.).

California

As of 2004, the majority of shrimp landed in California were pink shrimp from the trawl fishery. Permits for the fishery have declined from over 250 in the mid 1990s to less than 50 in 2005 (CDFG Commercial Fishing Licenses data[5]). Landings have declined considerably from the 10 – 20 million lbs between the late 1980s and late 1990s to perhaps 2 million lbs in 1998. Thereafter, landings increased again to roughly 4 million lbs in 1999 (CDFG 2001), and back down to 2 million lbs in 2004 (K. Barsky, CDFG, pers. comm.). In addition, the last processor buying pink shrimp closed in 2004/2005 as a result of wastewater and water quality problems. As pink shrimp must be processed before they reach market, and transferring California-caught

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[4] http://www.leg.wa.gov/WAC/index.cfm?section=220-52-050&fuseaction=section

[5] http://www.dfg.ca.gov/licensing/pdffiles/cf_items_10yr.pdf

shrimp to Oregon processors is not economically viable, the final processor closure effectively shut down the Californian pink shrimp fishery altogether. The decline of this fishery is largely a result of competition with other shrimp fisheries rather than a decline in abundance of shrimp (K. Barsky, pers. comm.).

Ridgeback prawns are the second most landed species in California, though landings have been generally an order of magnitude lower than for pink shrimp (CDFG 2001). The fishery is centered off Santa Barbara, California and consists of 30 – 35 single-rigged trawlers (with perhaps a few double-rigged vessels). Traditionally, a number of vessels targeted both ridgeback and spot prawns, depending on season and closures. However, directed trawling for spot prawns off California is now prohibited, though ridgeback shrimp trawl fishermen have a small quota for spot prawns. Pink shrimp fishermen are prohibited from landing spot prawns. Thus, nearly all spot prawns are caught by trap, mostly from off southern California. The directed coonstripe fishery off Crescent City, California is also trap only, though the species is also often caught incidentally in the pink shrimp trawl fishery (CDFG 2001). Spot prawns are nearly always sold live (95 percent) and coonstripe shrimp are primarily landed live. Ridgeback prawns are usually sold fresh and whole, though in some years a third or more are sold live (CDFG 2001).

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

Criterion 1: Inherent Vulnerability to Fishing Pressure

Bergstrom (2000) and Cadrin et al. (2004) provide overviews of pandalid shrimp biology as it relates to fisheries; much of the following information is from those accounts.

Growth in pandalid shrimp is a discontinuous process associated with molting of the exoskeleton; the number of molts that an animal goes through in a year varies by age and life stage. There is thus no easy way to measure directly the age of a shrimp (or any crustacean), providing a challenge to conventional age-based assessment (Cadrin et al. 2004). Generally, pandalid shrimp live for 4 – 5 years, though some species in some regions are known to reach 7 or more years of age (Bergstrom 2000).

With the exception of one species, *P. propinquus*, the pandalids are all protandrous hermaphrodites. They typically spawn first as males and then go through transition to females (Bergstrom 2000). The adaptive value of protandry and the factors that determine sex change are unclear (Koeller et al. 2000a). Charnov et al. (1978) found that pink shrimp (*P. jordani*) off Oregon and Northern California actively alters the age at which it changes sex in response to changes in the relative proportion of males and females in the population. As the proportion of older breeders, and therefore reproductive capacity, decreases, shrimp populations compensate by eliminating the male phase for part of the population (Koeller et al 2000a).

A change in the gender makeup of the population can happen through the presence of a strong year class or when older year classes have been overfished (Cadrin et al. 2004). For example, the Oregon pink shrimp (*P. jordani*) fishery originally exploited three year classes of shrimp. As the age structure of the population shifted to younger shrimp due to fishing pressure in the 1970s, the abundance of primary females (first time female breeders) increased. Since then, the fishery almost entirely targeted (and still targets) age 1+ shrimp (a single year class) composed of nearly 50 percent primary females (Hannah 1999; Cadrin et al 2004). This ability in some species to accelerate sex change and growth rates in response to fishing pressure was initially thought to make the species very resistant to overfishing, but studies on the pink shrimp fishery in the late 1990s by Hannah (1999) suggested otherwise (Cadrin 2000). With further study, that author now believes he misinterpreted the data (Hannah, ODFW, pers. comm.), highlighting the uncertainties in understanding the determinants of sex change in these populations and their implications for management. Koeller et al. (2000) further suggest that although density-dependent sex change occurs in the northern shrimp (*P. borealis*), the phenomenon could be equally indicative of a healthy or a declining stock.

Some pandalids form dense seasonal aggregations (Balsiger 1981), which are dependent upon environmental factors. For example, environmental conditions such as wind stress, tidal current speed, sea surface temperature, salinity, and hours of bright sunshine significantly correlate with short term catch-per-unit-effort (CPUE) in the pink shrimp (*P. jordani*) fishery (Perry et al 1999). At least some species also show seasonal migration and gender segregation. For example, the northern shrimp fishery off New England primarily targets the large female shrimp as they migrate inshore during winter months, leaving the males and younger females offshore (D. Schick, MEDNR, pers. comm.).

A brief summary of the biology, life history and distribution of the major shrimp stocks of importance to the U.S. market follows.

Northern shrimp, *P. borealis*

Northern shrimp are the primary coldwater shrimp resource in the North Atlantic. They are also found in the North Pacific, though some experts consider northern shrimp in the North Pacific to be a different subspecies. In the Northwest Atlantic northern shrimp are found from Davis Strait (in between Baffin Island, Canada and Greenland), south to the Gulf of Maine (DFO 2003). Within this range, separate stocks have not been clearly defined (DFO 2003), although northern shrimp in the Gulf of Maine appear to be of a single stock (Clark and Anthony 1981) concentrated in the southwest region of the Gulf (Clark et al. 1999).

Gulf of Maine northern shrimp mature first as males at roughly 2 ½ years of age and then transform to females at roughly 3 ½ years of age. They spawn in offshore waters beginning in late July, and by early fall most adult females extrude their eggs onto their abdomens. Egg-bearing females move inshore in late autumn and winter, where the eggs hatch. Juveniles remain in coastal waters for a year or more before migrating to deeper offshore waters, where they mature as males. Some females may survive to repeat the spawning process in succeeding years. The species exhibits density-dependent sex change, and produces primary females (ASMFC 2004 and references therein).

West Coast pink shrimp, *P. jordani*

Pink shrimp range from Unalaska in the Aleutian Islands to off San Diego, California. Concentrations of pink shrimp generally remain in well-defined beds from year to year. The species appears to exhibit little horizontal migration and adults from the different beds probably intermingle only rarely. However, studies indicate no genetic differences between pink shrimp across their entire range, likely indicating genetic mixing through larval disbursement (CDFG 2001).

Pink shrimp generally spend the first year and a half of life as males, but adjust their sex ratio to fluctuating age distributions. Mating takes place during September and October, and fertilization takes place when the females begin extruding eggs in October. Females usually carry between 800 and 4,000 eggs (ODFW 2000; Bob Hannah, ODFW, pers. comm.). Larvae hatch in March and April. The larval period lasts 2½ to three months, and developing juvenile shrimp move into successively deeper waters (Rothlisberg and Hannah 1983). Growth rates vary by region, season, sex, and year class. The species exhibits density-dependent sex change, and there is evidence that the growth rate of Oregon pink shrimp has increased as fishing pressure has increased (Hannah and Jones 1991).

West coast spot prawn, *P. platyceros*

Spot prawns range from Alaska to San Diego, California (PFMC 2004). They are distributed very patchily and may be fairly sedentary in suitable habitat (Kimker et al. 1996). The stock structure of spot prawns is largely unknown, but is certainly related to larval drift. Early studies indicated that larval settlement occurs after at least 3 months in the water column (Boutillier and Bond 1999), but as-yet-unpublished research at the University of Washington suggests that they settle much sooner, at around 10 – 25 days (N. Lowry, UW, pers. comm.). Thus, there may not be as much genetic transfer between areas of high abundance as previously thought, which leads to an increased necessity of managing at a fairly small spatial scale. Lowry (pers. comm.) suggests that this is already happening in most areas.

Spot prawns live from 4 to 6 years, and longevity probably increases with latitude. Alaskan spot prawns have been known to reach 7 years of age (Kimker et al. 1996; Gretchen Bishop, ADFG, pers. comm.). Sexual maturity is generally reached during the third year, and the change into females begins in the fourth year. Each individual may mate multiple times, both as a male and as a female (G. Bishop, pers. comm.). Spawning occurs once each year, typically in late summer or early autumn. Females carry eggs for a period of four to five months before they hatch. Spot prawns produce a few thousand eggs. Eggs hatch over a 10-day period that is typically complete by April (PFMC 2004). Spot prawns do not have primary females (R. Hannah, ODFW, pers. comm.), but preliminary observations in Alaskan waters indicate considerable variability in the size at which shrimp transition into females, suggesting the species does exhibit environmental sex determination (G. Bishop, pers. comm.).

West Coast ridgeback prawn, *S. ingentis*

The ridgeback prawn is the only non-pandalid landed in large numbers for human consumption in the U.S. Ridgeback prawns occur from Monterey, California to Cedros Island, Baja California. They are relatively sessile and little or no intermixing occurs between the main pockets of abundance in the Santa Barbara Channel, Santa Monica Bay, and off Oceanside (CDFG 2001).

In contrast to the pandalids, ridgeback prawns have separate sexes and free-spawn instead of carrying eggs. For this reason the number of eggs they produce is far higher, at around 86,000 per female. Most spawn during their second year, although some spawn as early as their first year. Following spawning, both sexes undergo molting. Their maximum age is roughly the same as the pandalids, at around 5 years (PFMC 2004; CDFG 2001).

Synthesis
Some coldwater shrimp show behaviors that increase their resistance to fishing pressure, such as environmental sex determination, and some show behaviors which would likely increase their vulnerability to fishing pressure, including forming spawning aggregations, exhibiting site fidelity, being sequential hermaphrodites, and segregating by sex. Thus some shrimp species are likely more vulnerable to fishing pressure than others. All, however, are fast-growing, have a short longevity, and have high reproductive fecundity. For these reasons, coldwater shrimp are deemed resilient to fishing pressure.

Inherent Vulnerability Rank:

All coldwater shrimp species:

Resilient 🟩 Moderately Vulnerable 🟨 Highly Vulnerable 🟥

Criterion 2: Status of Wild Stocks

Assessments of coldwater shrimp stocks generally consist of monitoring population changes using catch rate series and in some cases research surveys. These efforts provide general information on population structure and recruitment, significant changes in which are used to identify when a change in quota or effort is needed. Biological reference points and formal yield projections are rare. Koeller et al. (2000) note that this approach to assessment evolved because of:

1) Uncertainties in ageing and establishing year-class strengths;
2) Highly selective gear and large stock areas;
3) Difficulty in demonstrating stock/recruitment relationships on which to base biological reference points;
4) The thinking that recruitment is largely environmentally driven; and
5) The belief that shrimp stocks are inherently resilient to overfishing.

Koeller et al. (2000) also note that this method appears to have generally worked fairly well, as stock collapses have been rare compared with the highly parameterized stock assessments and management regimes used for many finfish stocks.

However, it has been demonstrated that fisheries can cause major declines in shrimp stocks. For example, the New England northern shrimp fishery collapsed in the mid 1970s as a result of offshore, year-round fishing in the late 1960s. After recovering under low to moderate levels of fishing pressure, landings and mortality increased again sharply in the mid 1990s and abundance and recruitment once again declined (Clark and Cadrin 2000). In addition, fisheries can induce changes in shrimp population structure (Hannah and Jones 1991). In an analysis of catch and effort statistics and catch sampling data of pink shrimp from 1966 – 1988, Hannah and Jones

(1991) demonstrated increases in growth rate, a decline in maximum age, earlier maturation, and earlier sex change from female to male, at least in part due to increased trawling effort in the fishery (Hannah and Jones 1991; ODFW 2000; CDFG 2001).

Atlantic

Canada

Northern shrimp are found off Atlantic North America from the Gulf of Maine to Davis Strait, typically on soft, muddy sediment in waters from 1 – 6°C. Within this range, separate stocks have not been clearly defined. In Canadian waters, shrimp are assessed and managed through Shrimp Fishing Areas (SFAs), presently delineated by observed differences in shrimp growth and maturation rates (DFO 2003). Each area is managed through a total allowable catch (TAC) that is adjusted based on observed changes in the status of the stock in that area. Monitoring and assessment varies between areas and years, but broadly includes log records, observer data, and multispecies bottom trawl surveys to track fishing effort and distribution and size/age/sex catch composition.

Canadian Atlantic shrimp landings are primarily from southern waters, from northern Newfoundland to southern Labrador (SFA6, accounting for about 50 percent in 2003) and the estuary and Gulf of St Lawrence (25 – 30 percent in 2003). A small amount of shrimp are also landed from waters off eastern Nova Scotia. The latest shrimp assessments for these areas (2005) used both CPUE and research survey data. In SFA6, landings are near the all time high, CPUE for large vessels is above the long-term average, and CPUE for small vessels has remained stable since 1998. Fishery-independent data indicate increases in abundance and biomass over the 1997 – 2001 period, which have since remained high. Overall, recent catches in SFA6 have “had no observable impact on shrimp abundance and biomass” (DFO 2005b). Similar conclusions were drawn for the estuary and Gulf of St Lawrence stocks, with high CPUE and research survey indices (DFO 2005c). CPUE rates and biomass for the eastern Nova Scotia fishery are currently the highest on record (DFO 2004A). The exploitation rate in these areas is at low levels.

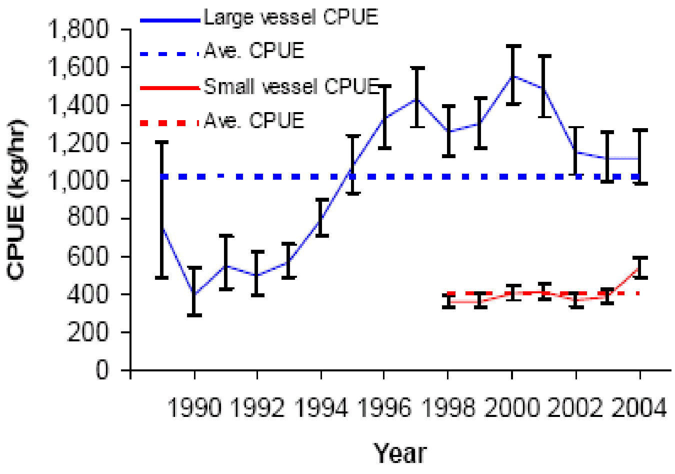

Figure 10: CPUE for large and small vessels in the region accounting for the largest commercial catch in 2003 (SFA 6). Error bars indicate 95% confidence intervals for point estimates (DFO 2005b).

The remainder of the catch is from coastal areas north of southern Labrador to Davis Strait. CPUE in these areas has stabilized above, or fluctuated around, the long-term average since the late 1990s. However, recent research surveys have been carried out only in some parts of the southernmost area (SFA 5), and not at all in more northern areas (SFA 2 and 3). Thus the current status of stocks in these areas remains uncertain. In addition, CPUE data may not reflect stock status in the northernmost areas due to the overlapping ranges of *P. borealis* and *P. montagui* in and around the Hudson Strait (SFA2 and 3). No shrimp-related research surveys have been carried out in these areas since the late 1970s (DFO 2003).

New England

Stock assessments of the U.S. northern shrimp stocks are carried out by the Atlantic States Marine Fisheries Commission (ASMFC) Northern Shrimp Technical Committee (NSTC). They are generally carried out annually (no stock assessment in 2001), and are based on fisheries-dependent and research survey data.

In their 1999 and 2000 reports to Congress, the National Marine Fisheries Service (NMFS) stated that the stock was neither overfished nor that overfishing was occurring, but that the stocks were approaching an overfished condition (NMFS 1999 – 2004). In 2001, overfishing was occurring, but whether the stock was overfished was unknown because a biomass threshold had not been defined. The same conclusions were given in both the 2002 and 2003 reports to Congress (NMFS 1999 – 2004). However, the 2001 – 2003 NSTC stock assessment report concluded that the stock was in poor condition, and strongly recommended that there be no fishing for northern shrimp during the next year (2002 – 2004) (ASMFC/NTSC 2001 – 2004). Nevertheless, fishing mortality increased over the next two years (Figure 11).

Amendment 1 to the Northern Shrimp Fishery Management Plan (FMP) was issued in October 2004, and provides a biomass threshold of 9,000 mt. If stock biomass is below this threshold, the stock is considered overfished. Using this threshold, the stock would have been considered overfished between 1998 and 2004 (ASMFC/NTSC 2005)6. However, biomass started increasing in 2003, and by 2005 was at an estimated 13,400 mt (8,500 mt in 2004), taking the stock out of an overfished condition (Figure 11). Biomass continued to increase in 2006, more than doubling, to 28,000 mt (ASMFC/NTSC 2005).

In addition, Amendment 1 established an overfishing threshold of F = 0.22, based on the period between 1985 and 1994 when abundance was “stable” (ASMFC 2004). From 1994 through 2000, fishing mortality was far higher than this target, thus overfishing was occurring. Fishing mortality dropped below the target in 2002 and 2003, and returned to close to the threshold in 2003 and 2004 (F=0.20 and 0.19, respectively)(ASMFC/NTSC 2005).

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[6] The latest assessment provides estimates of biomass and fishing mortality using both Collie-Sissenwine (CSA) and surplus production model analyses, which provide significantly different results in some cases. As the assessors make their recommendations based on the CSA, this report will do the same.

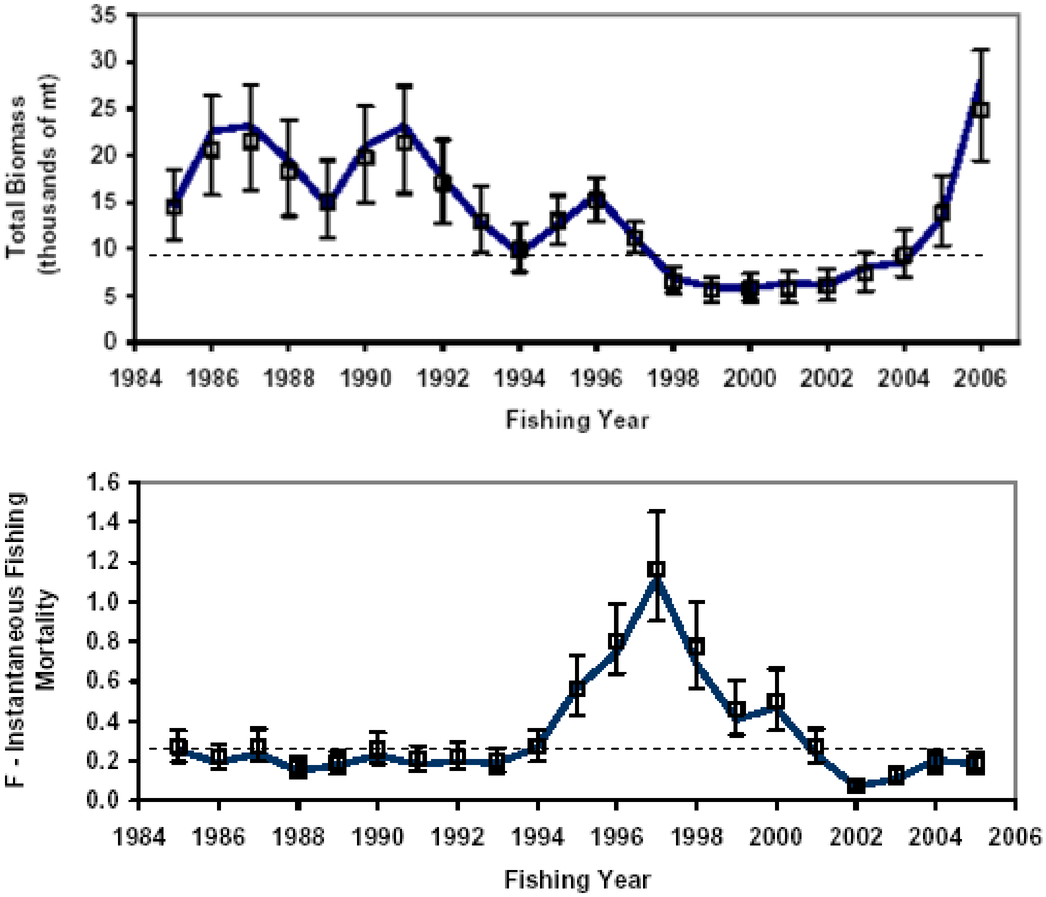

Figure 11: Fishing mortality and biomass of Gulf of Maine northern shrimp, least squares estimates, bootstrapped means, and 80% confidence intervals, and overfished (9,000 mt) and overfishing (F=0.22) thresholds (dashed lines) (ASMFC 2005).

Pacific

Alaska

The Southeast Alaska trawl and trap fisheries account for the vast majority of shrimp landed in Alaska. The proportion from each varies from year to year, but in 2003 over 90 percent of all shrimp landings were from these two fisheries, divided roughly equally by weight (ADF&G landings 1997 – 2003[7]). The trawl fishery primarily lands northern shrimp (*P. borealis eous*); the pot fishery primarily lands spot prawns.

In 2002, the beam trawl fishery stock assessment program was "still in its infancy" (Love and Bishop 2002). No fishery dependent surveys had been carried out at that time, though dockside sampling had been conducted since 1986 and onboard sampling was initiated in 2002 (Love and Bishop 2002). This information was not considered to be enough to make stock assessments or effect management decisions in a timely fashion, but did allow for general qualitative conclusions about stock strength as detailed below (Love and Bishop 2002). As of this writing,

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[7] http://www.cf.adfg.state.ak.us/geninfo/shellfsh/shelhome.php

the assessment program has not changed (G. Bishop, pers. comm.).

The Southeast Alaska pot shrimp fishery is divided into 19 management districts. Guideline Harvest Ranges (GHRs) have been established for all districts with a fairly consistent harvest history, the upper end of which is generally based upon the average harvest levels for five fishing seasons (1990/91 through 1994/95). Target harvests or Guideline Harvest Levels (GHLs) are then decided based on the GHR for the area and research surveys each year. Those with low or intermittent catches have an arbitrary 20,000-lb Guideline Harvest Limit (GHL). Each district is closed to shrimp pot fishing once the GHLs have been reached, or when the current season ends. GHLs are for coonstripe shrimp in two districts, spot and coonstripe shrimp in one, and the rest for spot prawn only (ADF&G 2004).

An annual pre-season research survey program to gather information for stock assessment purposes has been in place since 1996. It is carried out in the four districts with the highest commercial catches in each region. In two districts a post season survey has been completed in more recent years. Summaries of bycatch species prevalence, CPUE (for survey pots) by weight and number, trends in mean carapace length, length/weight relationship, and size at maturity have recently been completed for the years 1996 – 2003 (Love and Bishop 2005). While, by the authors' admission, increases in sample size are needed to be more certain of estimates and trends, these summaries provide the best assessment of the stock to date.

Catches from the district with the largest commercial fishery (in terms of harvested pounds) indicate a loss of large size classes, declines in average carapace length and declines in the size at which 50 percent of the female population is mature. A similar, if less clear, trend was also found in the second most commercially important district. Thus, although no biological reference points have been set for the fishery, both recruitment and growth overfishing may be happening in the most exploited areas (Love and Bishop 2005). Less exploited areas appear to have more stable populations, though slight declines in size of shrimp is still evident.

British Columbia

In 1997, faced with major increases in effort and yield in the shrimp trawl fishery, a management regime was implemented that divided up the coast into management areas and began the collection of fishery independent abundance data. Since then, stock assessment has been carried out using both logbook and research survey data, including an at-sea observer catch program and trawl surveys (DFO 2001).

The first assessment was carried out in 1999, and concluded that the status of the stocks was unknown (DFO 1999a). The primary recommendation was that until a relationship between biomass indices and shrimp abundance was established, in-season surveys should be used to indicate whether an area can sustain more or less effort than a ceiling set at the beginning of the year. To that purpose, fishery-independent shrimp trawl surveys are carried out in selected priority Shrimp Management Areas (SMAs) each year (surveys had been carried out in some areas since 1973).

In 2004, in the areas where shrimp are most abundant (off the west coast of Vancouver Island) biomass has declined from the record highs in 2001 (DFO 2004b) (Figure 11). In some areas, pink shrimp (*P. jordani*) biomass was the lowest on record since surveys began in 1996; in others, biomass remained above the lowest levels on record (DFO 2005a).

The biomass of sidestripe shrimp also decreased to close to 1998 levels (Figure 11). The biomass of sidestripe shrimp is still at least an order of magnitude lower than that of pink shrimp. The multispecies nature of the fishery combined with evidence that considerable numbers of sidestripe shrimp were being landed as pink shrimp, led to separate quotas for sidestripe shrimp being implemented in 2001/2002. The quota has not been reached since that time (DFO 2004b).

According to the Department of Fisheries and Oceans, Canada (DFO), there is no reason for concern over these declines as effort in the fishery is very low (DFO 2005a). However, it is unclear what the future of shrimp stock assessment is as the industry now contends they can no longer pay for it due to dramatic decreases in the price of shrimp (DFO 2005a). A 2004 study commissioned by the DFO concluded that stock assessment based on historical CPUE data alone would not be enough to ensure the sustainability of the shrimp stocks and the industry that depends upon them (Rutherford et al. 2004).

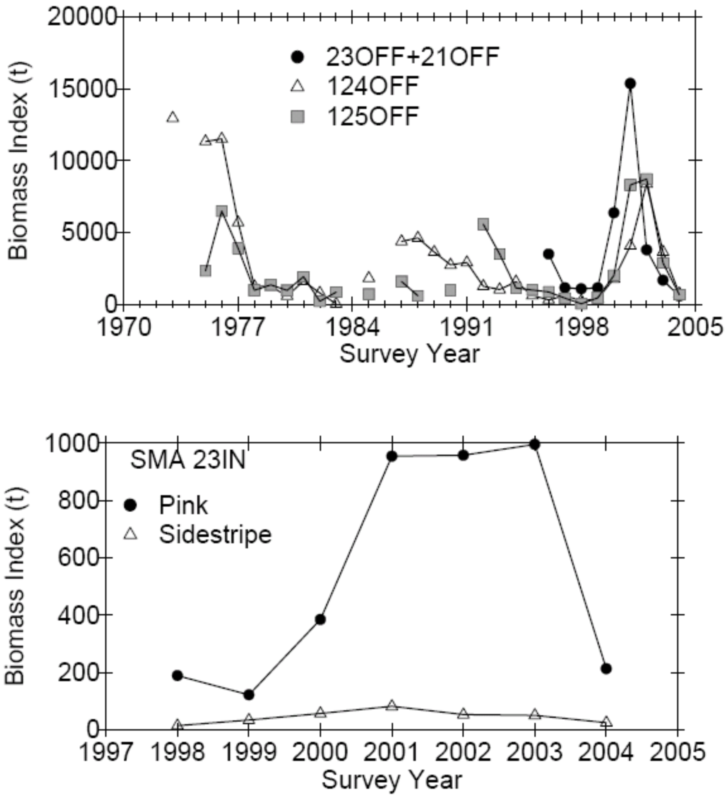

Figure 12: Trend in smooth pink shrimp (P. jordani) (top chart) and pink and sidestripe shrimp (bottom chart) biomass in several different management areas off the west coast of Vancouver Island (DFO 2004b).

The spot prawn pot fishery also relies on in-season stock assessment and management (DFO 2005d). Although the latest stock report published by the DFO was in 1999 (DFO 1999b), summary updates are included in the annual FMP reviews for the fishery (the latest FMP is for the 2005 – 2006 season). There are no pre-season fishery-independent surveys and no estimate of total biomass. The stocks are considered fully exploited, and all fisheries (commercial, recreational, and First Nation) are considered fully sustainable (DFO 2005d).

The in-season assessments are implemented through a spawner index system, in which the commercial fishery is closed once the number of females caught per trap reaches a minimum monthly spawner threshold. The series of monthly indices generated from this program, which has been in place since 1979, serve as biological reference points and are grounded in assessment indices of the average number of female spot prawns per trap in March (the month in which the eggs hatch). Standardized trap sampling is carried out by 12 at-sea observers, who take samples throughout the commercial fishing season in areas of the coast where fishing occurs (Mormorunni 2001; M. Kattilakoski, pers. comm. 2005). The spot prawn fisheries in BC and Hood Canal off Washington State are the only areas that use such index systems (Lowry 2005).

U.S. West Coast

According to the Pacific Fishery Management Council (PFMC), estimates of the abundance of the main commercial shrimp species on the U.S. West Coast are not available. This includes pink shrimp, northern shrimp, ridgeback prawns, and spot prawns (PFMC 2004). Each state has different levels of research and monitoring, however, and is documented individually below.

Washington

Management of Washington State shrimp fisheries is fragmented. Hood Canal (part of Puget Sound), Puget Sound, and offshore fisheries are each managed differently. Washington tribes have a treaty right to take half of the catch each year in each of these areas (B. McLaughlin, WDFW, pers. comm.).

Hood Canal is the only U.S. spot prawn fishery to have an indexing system in place to measure abundance (Lowry 2005). The state commercial fishery has been closed since 1992. However, there is still a tribe commercial fishery and a state recreational fishery. The tribe commercial shrimpers sell their product to many of the same buyers as state shrimpers (D. Sterritt, WDFW, pers. comm.).

Washington State pink shrimp trawl vessels are not required to carry logbooks, nor is there dockside monitoring (except for some enforcement activities) or a research survey program in place. Thus, there is no stock assessment for pink shrimp or spot prawn in the coastal fisheries or in Puget Sound (L. Wargo, pers. comm.), and thus stock status is unknown[8]. Based on assessments of Oregon fisheries and stable or increasing landings in Washington fisheries since the 1990s, pink shrimp abundance off Washington is assumed stable (L. Wargo, pers. comm.).

The coastal long-line trap fishery for spot prawns has had mandatory logbooks since 1999 and a dockside monitoring program since 2002. The fishery is relatively young (very little harvest before 1992), and with no fishery-independent data collection not enough data is yet available for stock assessments. Stock status is therefore unknown, though effort is low enough in the fishery for managers to consider it unlikely to be subject to overfishing or overfished (L. Wargo,

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[8] http://wdfw.wa.gov/fish/shelfish/shrimp/comm./index.html

pers. comm.).

Fishery management plans are drawn up annually for the Puget Sound spot prawn fishery, for which the only gear allowed is pots (Mormorunni 2001). In the latest, the assessors concede that the biological knowledge of the spot prawn populations in Washington waters is limited. Nonetheless, as the current fishery is still fairly small, managers view it as sustainable (Mormorunni 2001).

Oregon

Oregon's pink shrimp fishery is the largest U.S. coldwater shrimp fishery, by landings. Perhaps as a result, more data are collected on this species than in other U.S. West Coast states. Fishery-dependent data, particularly logbook data, are the primary source of information on the distribution and abundance of pink shrimp off Oregon. Such data have been used to demonstrate that the geographic stock area of pink shrimp expands and contracts roughly proportionally to shrimp recruitment (Hannah 1995). Research cruises and market sampling provide additional data on distribution, abundance, and the likely age structure of the stock. Research cruises are also carried out for other purposes, such as testing the efficacy of different bycatch reduction devices (BRDs) (ODFW 1996 and 2003). The primary objective of the 2004 research cruise was to test the viability of logbook data in providing an accurate picture of the spatial structure of shrimp abundance (ODFW 2005a). The data indicated that analyses of logbook data may underestimate the geographic area and abundance of shrimp in years with high commercial CPUE, as fishers tend to target specific areas of high abundance.

The shrimp population began to show signs of being "fished down" in the late 1970s. Age composition of the catch changed from the roughly equal balance of ages 1 – 3 in the 1950s and 1960s to predominantly age 1 shrimp in the late 1970s. Average CPUE and size of shrimp landed declined at this time, though the latter only somewhat (ODFW 2000). Catch age composition, shrimp size, and CPUE have remained at the late 1970s levels, though with considerable interannual variation (ODFW 2000; ODFW 2005b). Researchers at the ODFW suggested that there may be evidence of the stocks being overfished in the late 1990s (ODFW 2000). However, these conclusions have more recently been questioned by the same authors, based on a lack of data on larval and adult transport and consequently uncertain stock and recruitment indices. For example, it is unknown whether there are regular infusions of shrimp into Oregon waters from Washington and British Columbia, or from California waters during ENSO (El Nino Southern Oscillation) years. Thus, there is no evidence of overfishing (R. Hannah, pers. comm.).

Other coldwater shrimp fisheries in Oregon, including the spot prawn fishery, are managed under the Oregon Department of Fish and Wildlife's (ODFW's) Developmental Fisheries Program. Though logbooks are required, no information on stock abundance or status exists on these fisheries. Only a handful of vessels consistently take part in the fishery (J. McCrae, pers. comm.).

California

Spot prawns are the target of the most valuable shrimp/prawn fishery in California. As in other states, there is little information on spot prawn abundance or relationship among stocks (PFMC

2004). Although surveys have been done in the past to gather information on range and distribution (1960s and 1980s) (CDFG 2001), no survey work has been done to date for the purpose of estimating abundance (K. Barsky, pers. comm.). According to the PFMC, landing statistics and fisher's local knowledge are the primary sources of information about the status of spot prawns (PFMC 2004). Although logbooks are mandatory in the fishery, there had not been a recent CPUE trend calculated for the fishery as of the writing of this report (K. Barsky, pers. comm.).

The PFMC notes that there are no population estimates for ridgeback prawns either (PFMC 2004). Logs have been required since 1986, and show a steady increase in CPUE and fishing effort from 1992 to 1999, followed by a sharp decline in landings in 2001 (CDFG 2001; PFMC 2004) and the lowest landings since the inception of the fishery in 2004 (K. Barsky, unpublished). It is unknown whether the increases in landings were a result of environmental or regulatory changes (CDFG 2001).

Synthesis

Abundance and biomass in the Atlantic Canada northern shrimp (*Pandalus borealis*) fishery has been increasing since 1997, and catch-per-unit-effort (CPUE) trends have remained stable or above the long-term average during the same time period. These stocks are therefore deemed healthy by Seafood Watch. In contrast, New England northern shrimp were being overfished for most of the 1990s, and biomass has only recently risen above the overfished threshold following a curtailment of fishing mortality. If biomass and fishing mortality trends are maintained, this stock will also be deemed healthy, but remains a moderate concern at present. Overfishing also appears to be occurring in the Alaskan spot prawn (*Pandalus platyceros*) pot fishery, which is a serious concern. The Oregon pink shrimp (*Pandalus jordani*) and British Columbia (BC) spot prawn fisheries appear fully-fished, and the status all other coldwater shrimp fisheries is unknown. The status of these stocks is therefore deemed of moderate concern.

The specific factors and guidelines used by Seafood Watch to evaluate stock status are detailed in Appendix 2.

Status of Wild Stocks Rank:

Eastern Canada northern shrimp:

Healthy 🟩 Moderate 🟨 Poor 🟥 Critical ⬛

Alaskan spot prawns:

Healthy 🟩 Moderate 🟨 **Poor** 🟥 Critical ⬛

All other coldwater shrimp, including New England northern shrimp:

Healthy 🟩 **Moderate** 🟨 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/or managed in some way.

On the Atlantic coast of the U.S. and Canada, otter trawls are the primary gear used by fishermen targeting northern shrimp, although there is a small pot fishery in New England. On the Pacific, beam trawls are the primary gear used to catch northern shrimp in Alaska (also sidestripe shrimp) and Puget Sound, while otter trawls are used to catch northern shrimp in British Columbia and pink shrimp in offshore Washington waters and off Oregon and California. Other small species, such as sidestripe shrimp and humpy shrimp, are generally caught incidentally in pink shrimp and northern prawn trawl fisheries, while coonstripe shrimp are landed both with pots and trawls. Spot prawns are now caught only with pots across their range (except for a tiny percentage in British Columbia and a small incidental allowance in California, both by trawls). Ridgeback shrimp off California are caught with trawls.

Atlantic

Canada

Amid concerns over the bycatch of groundfish species by the small meshed nets used in shrimp trawls, the Nordmore grate was introduced into the Canadian northern shrimp fishery in 1993. This device allows larger fish to escape through an opening in the top of the net, while still capturing all smaller fish, including shrimp, in the codend. Their use was made mandatory for the entire industry in 1997. With their use, the DFO says that groundfish mortality in Canadian shrimp fisheries has been considerably reduced, and virtually eliminated in particularly sensitive groundfish areas (DFO 2003).

The inshore and offshore shrimping industries both have observer programs to independently document what is being caught and discarded, all landings are dockside monitored, and all fishers must keep and submit logbooks. The offshore fleet has 100 percent observer coverage, the inshore fleet a target of 10 percent (although coverage in practice varied from 1.9 percent in 2003 to 5.9 percent in 2004) (Dave Orr, DFO, pers. comm.). All programs are funded by the industry. In addition, if a set upper limit of groundfish bycatch per haul is breached, the vessel is obligated to move from that area before resuming fishing (DFO 2003).

The DFO is confident that Atlantic cod (*Gadus morhua*), American plaice (*Hippoglossoides platessoides*), redfish (*Sebastes* spp.), and Greenland halibut (*Rheinhardtius hippoglossoides*) account for 90 percent of the bycatch (Orr, pers. comm.). The estimated combined bycatch of these four species accounted for less than 1 percent of landings by weight in 2001 – 2004 (90 percent of which was Greenland halibut) for both the offshore and inshore shrimp fisheries (Orr et al. 2004). While juvenile fish make up a large portion of the bycatch (especially of Greenland halibut) (Orr et al. 2004), bycatch is presumably considerably far less as a percentage of total catch when measured in terms of numbers.

However, even low bycatch can be a concern if the biomass of the bycatch species is low, as is the case with certain groundfish species caught in shrimp trawls. For example, the biomass of Atlantic cod on the Scotian Shelf is believed to be approximately 4 percent of original biomass (Rosenberg et al. 2005), and the species is now considered at Risk under the Canadian Organization on the Status of Endangered Wildlife in Canada (COSEWIC) (Dave Kulka, DFO, pers. comm.). In addition, redfish and two species of wolffish are already protected under Canada's Species at Risk Act (DFO 2003; Kulka, pers. comm.). So, while bycatch of Atlantic cod and redfish in the shrimp fishery accounts for less than 0.1 percent of current trawlable biomass of those species (Orr et al. 2004), research is ongoing to try to reduce bycatch even further, through the potential of using grates with smaller mesh, for example (DFO 2003).

No sea turtles have been observed caught in the 255,000 shrimping sets observed since 1980. Canadian waters are at the fringe of the leatherback turtle range in the North Atlantic, and beyond the range of all other turtles (Kulka, pers. comm.). There are only a few records of cetaceans being caught in shrimp trawls in Atlantic Canadian waters, and none from Canadian vessels. No analysis has been done on shrimp effort data to estimate total bycatch of mammals, and it is not clear to the DFO why there are no records from Newfoundland vessels (Jack Lawson, DFO, pers. comm.). No seabirds designated at risk of extinction are caught in this fishery; other seabirds are caught only rarely (Kulka, pers. comm.).

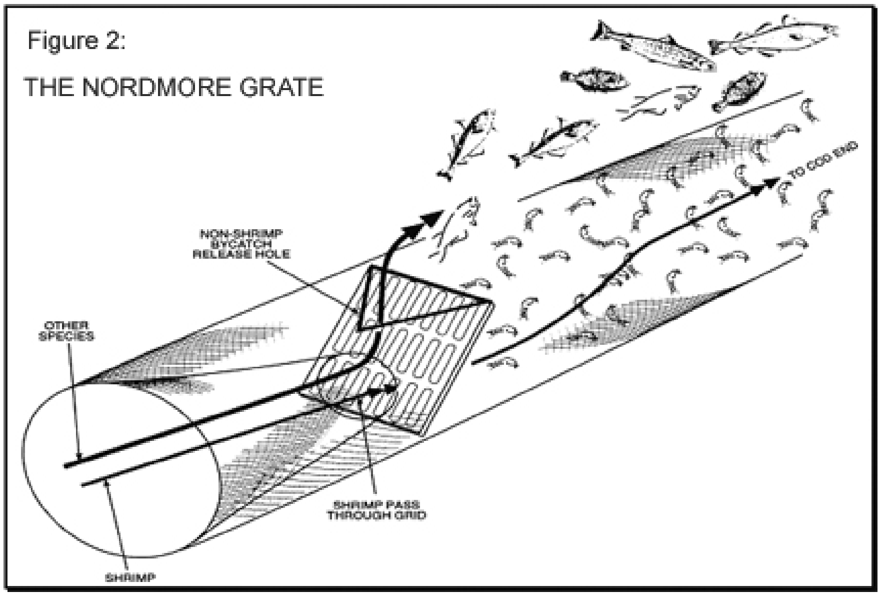

Figure 13: Illustration of a Nordmore grate (DFO 2003).

U.S. Atlantic

No official data on bycatch rate is available for the northern shrimp fishery in the U.S., but experts estimate that about 1 percent of the catch is bycatch (D. Schick, pers. comm.). This remarkably low rate is the result of a number of changes in the fishery since the 1980s to try and reduce the effects of other fisheries on declining groundfish populations (ASFMC 2004).

First, the fishery largely targets large females which migrate inshore in the winter (Clark and

Cadrin 2000). Studies have indicated that many (though not all) species of groundfish do the opposite, migrating offshore during winter months (Schick and Brown 1993, 1995; Schick, pers. comm.). Thus, the stock being fished is largely monospecific. However, larger vessels also fish offshore if abundance inshore is poor, for example due to low rates of migration. Large vessels also sometimes continue fishing into the spring if shrimp abundance is high, but this has not been the case for several years. The winter fishery always accounts for the majority of the landings (at least 80 percent in years where the season is extended). However, concerns do still remain over the higher levels of juvenile and adult groundfish bycatch in the offshore fishery (ASFMC 2004).

In addition, each U.S. vessel is required to use at least one Nordmore grate. Experiments have shown that such configurations allow over 95 percent of finfish to escape, while still keeping 95 percent of the shrimp (Kenney et al. 1992). The grate was made mandatory in the fishery in December 1992, with exceptions for the fishery operating in Maine state waters from January through March, which were dropped in 1994. However, later examinations of male shrimp length frequency indicated that the single Nordmore grid may have increased the retention rate of shrimp smaller than the controls set out in the minimum mesh size regulations. For this reason, a double Nordmore grate system was approved for voluntary use in the fishery in 1999, and has resulted in less bycatch of small shrimp and finfish (ASFMC 2004). Concerns that the double grate may be unsafe for crews on some vessels prevent it from being made mandatory, but experiments are underway to invent a compound system.

The ASMFC accepts that the trawls and traps used in the fishery have the potential to interact with sea turtles and seabirds (ASMFC 2004). However, no marine mammals (including baleen whales), sea turtles, or seabirds are known to have been entangled or caught in the fishery. According to Amendment 1 of the ASMFC FMP, there "are no known existing or proposed federal mammal, sea turtle, or seabird regulations or actions pertaining to the northern shrimp trawl fishery." The amendment also states that seabird interactions are unquantified but not considered significant, particularly for endangered or threatened birds. However, it contains little more regarding sea turtles and mammals caught in this fishery, and the fishery itself was last observed in 1997. For this reason, Amendment 1 implements several important programs for better monitoring bycatch of protected species, including an at-sea observer program, and analysis of strandings, entanglements, logbook data and port sampling (ASMFC 2004).

No bycatch studies have been undertaken in the shrimp pot fishery in the Gulf of Maine. Pot fisheries are generally considered to have low levels of bycatch (Barnette 2001; Chuenpagdee et al. 2003). However, entanglement of endangered large baleen whales is a serious concern in the Gulf of Maine lobster pot fishery. In particular, that fishery is undoubtedly a factor limiting the recovery or even contributing to the decline of endangered humpback and northern right whales (see Seafood Watch® American Lobster report). Thus, although no large whales have been observed entangled in shrimp pot gear (D. Schick, pers. comm.), it is potentially a concern in this fishery as well. It is less of a concern, however, as the fishery operates on a far smaller scale than the lobster fishery. In addition, efforts are underway in the Gulf of Maine to reduce interactions with whales and all fixed gear types, through the use of breakaway gear and large closures around whale sightings. These measures have not yet been implemented in the shrimp fishery (D. Schick, pers. comm.).

Pacific

Alaska

As part of their annual preseason surveys, the Alaska Department of Fish and Game (ADF&G) collects information on catch composition in the Southeast Alaska pot fishery for spot prawns and coonstripe shrimp. Bycatch appears to vary considerably from area to area and year to year, but the overall bycatch rate for each of the four districts for which surveys were carried out (including both pre-season and post-season surveys) was roughly 10 percent for 1996 – 2003 (calculated from tables 2, 3, and 4 in Love and Bishop 2005). For the district which typically lands the most shrimp, the percentage of bycatch was an order of magnitude lower (roughly 1.3 percent) in 2003 (the latest year for which data are available), largely because far less northern pink shrimp (*P. borealis/eous*) were caught in that district than other shrimp species (in any year). In both the 2003 and combined 1996 – 2003 data, invertebrates, mainly squat lobster (*Munida quadrispina*) and several species of crab, mollusks, and echinoderms, made up over 90 percent of the bycatch. Of finfish bycatch, sculpin, walleye pollock, quillback rockfish, sablefish, and Pacific cod made up the majority. Four species of rockfish were caught as bycatch: quillback (*Sebastes maliger*), redbanded (*S. babcocki*), yelloweye (*S. ruberrimus*), and redstripe (*S. proriger*) (Love and Bishop 2005).

Beam trawls in the Southeast Alaska shrimp fishery are typically dragged fairly slowly. At slow speeds, fish exclusion devices such as the Nordmore grate impair the way the net flies behind the beam, and so are not used. All beam trawls in Alaska have an excluder panel that extends across the lower portion of the net that serves two purposes. First, it prevents large fish and crabs from entering the trawl, thus reducing bycatch; second, it allows for quick dumping of larger bycatch, increasing the likelihood of bycatch survival. A qualitative estimate of bycatch based on the few trips that were independently observed prior to 2002 suggested a bycatch rate of less than 5 percent by weight (D. Love, ADF&G, pers. comm.). In 2003, bycatch limits of 1 percent rockfish and 10 percent spot prawn or coonstripe shrimp by weight were placed on shrimp beam trawlers. This bycatch can be landed and sold, but must be weighed and recorded beforehand. Any bycatch "overage" (i.e., more than 1 percent rockfish and 10 percent spot prawn and coonstripe shrimp by total landings weight) must be recorded as such and proceeds from selling it must be surrendered to the state (Alaska State regulations[9], ADF&G commercial fisheries news release, April 14, 2005[10]).

British Columbia

An at-sea observer program has been in place for the BC shrimp trawl fishery since 1997 (DFO 2005). An analysis of the data from 1997 – 1999 was conducted in 2000 (Olsen et al. 2000). At that time, most of the otter trawl fleet was using BRDs, while the majority of the beam trawl fleet was not. The study showed considerable variation in bycatch composition and rates between areas, years, and gears. Generally speaking, beam trawls caught considerably more bycatch than otter trawls, which the authors attributed to the much higher proportion of otter trawl vessels using BRDs. Considerable decreases in bycatch were found for those vessels, both beam and otter trawlers, using BRDs (Olsen et al. 2000). In some areas, all otter trawls sampled were using BRDs, and so can be compared with the current fishery (the use of grate or excluder net

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[9] 5 AAC 31.116. Shrimp beam trawl guideline harvest ranges and bycatch limits for Registration Area A.

[10] http://documents.cf1.adfg.state.ak.us/SubtopicContents.po?ERA=Current&TOPIC=10&SUBTOPIC=shp

BRDs were made mandatory on all otter and beam trawls in 2000). In these areas, the estimated bycatch as a percentage of the reported catch was typically between 0 and 22 percent by weight, depending on area. When differences in reported catch are taken into account, the bycatch rate over all years and areas (only for those areas with 100 percent BRD use), is about 10 percent by weight for otter trawls. The same rate expressed in term of numbers is likely much smaller, as most of the bycatch species (typically dogfish, skates, and finfish, but also other invertebrates) are larger animals. A similar calculation cannot be made for beam trawls because in no area were all vessels using BRDs (Olsen et al. 2000).

The biggest current bycatch concern in the trawl fishery is that of eulachon (*Thaleichthys pacificus*) (DFO 2004A). There is currently only a small, discrete directed state fishery for this species, but it is an important recreational and First Nations commercial species (DFO 2005e). Bycatch of rockfish is also a concern. In addition to the mandatory use of BRDs and the at-sea observer program, the DFO has implemented bycatch "action levels" and closed areas in an effort to further reduce bycatch of these and other species in the fishery (DFO 2005a).

An at-sea observer program for the commercial spot prawn fishery documents bycatch of rockfish. The DFO estimates that for every 300 pots set in a single day, one inshore rockfish will be caught (DFO 2005d). In terms of numbers or weight, the bycatch rate of rockfish in this fishery is thus very low, though still of concern to the DFO as the fishery itself is fairly large.

Washington

No empirical data exists on bycatch in the Washington State shrimp/prawn fisheries (Lorna Wargo, pers. comm.; D. Steritt, pers. comm.). Anecdotal information from preliminary catch composition surveys suggest that bycatch in the offshore (outside of Puget Sound) spot prawn pot fishery is very low, and mainly consists of urchins (L. Wargo, WDFW, pers. comm.). This information is consistent with data from the pot fishery in Alaska.

To ensure consistency with regulations in the entire West Coast groundfish fishery, the Washington trawl fleet uses mandatory bycatch reduction devices to reduce bycatch of rockfish (L. Wargo, WDFW, pers. comm.). The majority of vessels are rigged with the same gear as vessels in the Oregon pink shrimp fishery (see below).

Oregon

Vessels in the Oregon pink shrimp fishery are typically double-rigged with high-rise box trawls. In this semi-pelagic configuration, the net itself is elevated 12 to 30 inches above the seabed, while the two trawl doors and a short roller section in the center of the mouth of the net are in contact with the seafloor (Hannah and Jones 2003; Hannah, pers. comm.). Hannah and Jones (2000) demonstrated that this configuration catches far fewer finfish (47 – 84 percent depending on species) than the traditionally-used trawl with tickler chain. In addition, grates or soft-panel BRDs have been required on all vessels in the fishery since 2003 (ODFW 2005b).

According to the Oregon Trawl Commission, bycatch in the fishery is currently at about 0.7 – 2.5 percent of total catch (B. Pettinger, Oregon Trawl Commission, pers. comm.). The most recent research cruise (June 2005) recorded bycatch levels of 5.6 percent of the catch (6 percent of the target catch) for grates currently in use (Hannah, pers. comm.). This number is thought to be higher than for the fishery as a whole and over the whole season (Hannah, pers. comm.).

The continued catch of juvenile rockfish (Hannah and Jones 2005) is of concern. An observer program is in place to measure bycatch and also record what BRDs are being used, in attempts to reduce bycatch even further (ODFW 2005b). For example, the June 2005 cruise found that decreasing the size of the grate spacing from 1.25" to 0.75" will reduce bycatch levels to around 2 percent, and reduce juvenile rockfish bycatch by 94 percent. These findings will be made known in the Oregon Department of Fish and Game's 2006 newsletter, which will probably cause some component of the fleet to reduce grate spacing size to 1" or below (Hannah, pers. comm.).

There are no sea turtles or mammals caught in the Oregon pink shrimp fishery (Hannah, pers. comm.).

California

Amid concerns over the amount of bycatch in the California spot prawn trawl fishery, the California Department of Fish and Game (CDFG) implemented on-board observer programs in 2000 – 2001 for both the trawl and trap fisheries (Reilly and Geibel 2002, unpublished). In Northern California, the ratio of finfish bycatch to spot prawns was 7.5 to 1 by weight; the ratio of rockfish bycatch alone to spot prawns was 2.1 to 1. In Southern California, the ratio was 17.7 to 1 for all finfish and 1.5 to 1 for rockfish only. The total bycatch to spot prawn ratio, including invertebrates, was 8.8 and 20.6 to 1 by weight, for northern and southern fisheries, respectively.

Finfish bycatch in the trap fisheries was far less than in the trawl fisheries. The ratio of finfish bycatch to spot prawns was 0.15 and 0.22 by weight, for northern and southern fisheries, respectively, and the ratio of rockfish bycatch to spot prawns was 0.04 and 0.07, for northern and southern fisheries, respectively. The overall ratios of bycatch to spot prawns in traps was 2 to 1 for the northern fishery and 1 to 1 for the southern fishery, reflecting proportionally higher bycatch of invertebrates in traps than in the trawl fishery. Observers noted that most of the invertebrate bycatch and many of the finfish other than rockfishes could be released alive (Reilly and Geibel 2002, unpublished). A tally of organisms was not taken during this study, so an estimate of bycatch to target catch ratio by number cannot be calculated (P. Reilly, pers. comm.).

Trawling for spot prawns in California waters was phased out in 2003. California was the last state on the west coast to do so (K. Barsky, pers. comm.). Trawling for ridgeback prawns continues, however, and although a bycatch study was recently carried out on the fishery, the data are not yet publicly available (K. Barsky, pers. comm.).

No specific bycatch studies have been carried out on the directed pot fishery for coonstripe shrimp off Crescent City, California.

Synthesis

Bycatch is a far less serious concern in U.S. and Canadian coldwater shrimp fisheries than in warmwater shrimp fisheries. A mixture of seasonal regulation and technological fixes has brought bycatch rates down to less than 5 percent of the catch in the Canada, New England, and Oregon pink shrimp fisheries. Similar regulations are also in place for the other U.S. and

Canadian coldwater shrimp trawl fisheries, and so bycatch is likely equally low in those fisheries. Concerns remain, however, over the bycatch of juvenile groundfish in some fisheries, especially as some of these are now legally protected (e.g., redfish, wolffish, and cod bycatch in the Canada northern shrimp fisheries). These concerns are recognized and research is ongoing to try to reduce bycatch even further.

No marine mammals (including large baleen whales), seabirds, or sea turtles have been observed caught in coldwater shrimp fisheries in Canada and the U.S. The Canada Atlantic, British Columbia, and Oregon shrimp trawl fisheries have comprehensive observer programs in place to monitor bycatch. The New England fishery, however, has not had an observer program in place since 1997, a concern that has been addressed in Amendment 1 to the ASMFC FMP (2004).

Trap fisheries are generally considered to have low rates of bycatch. The bycatch rate as a percentage of target catch in the Southeast Alaska shrimp pot fishery is 10 percent or lower in terms of numbers. Bycatch rates in the BC and Washington pot fisheries also appear to be low. A study of the Californian pot fishery found higher levels of bycatch in terms of weight, but no tally of the number of species was carried out. In addition, bycatch in pot fisheries for coldwater shrimp generally consists of invertebrates that are released alive (although post release mortality is not known).

Nature of Bycatch Rank:

All coldwater shrimp fisheries:

[✓ **Low** 🟩] Moderate 🟨 High 🟥 Critical ⬛

Criterion 4: Effect of Fishing Practices on Habitats and Ecosystems

Effect of fishing gear on physical and biogenic habitats

Trawls

Much of the following background information on habitat impacts of trawling is extracted from the Seafood Watch® report on silver hake.

Numerous studies (Watling and Norse 1998; Auster and Langton 1999; NRC 2002; Collie 2000) have documented and summarized the effects of mobile tending gear, such as bottom trawls, on seafloor habitats, and have consistently recognized bottom trawls, including otter trawls, as some of the most damaging gear types in use. In a review of 22 studies of mobile gear on the structural components of habitat such as sand waves, emergent epifauna, sponges, and corals, Auster and Langton (1999) found similar impacts across a wide geographic range. These impacts were categorized as: 1) directly removing epifauna or damaging epifauna and leading to mortality; 2) smoothing sedimentary bedforms and reducing bottom roughness; and 3) removing taxa that produce structure (such as burrows and pits).

The National Research Council noted that the effects of mobile bottomfishing gear on benthic habitats depend on the susceptibility of the habitat and on the type of gear used. They highlighted several generalities gleaned from various reviews of impact studies: 1) trawling and dredging reduce habitat complexity by crushing, burying, or exposing marine flora and fauna; 2) repeated trawling and dredging results in discernable changes in benthic communities, shifting them from dominance by species with relatively large adult body size, towards dominance by abundances of small-bodied organisms, and species richness can decline; 3) bottom trawling reduces the productivity of benthic habitats because of an overall loss of biomass; and 4) fauna that live in low natural disturbance regimes are generally more vulnerable to fishing gear disturbance (NRC 2002). Other reviews confirm that impacts of bottom trawls on habitat generally include alteration of physical structure, suspension of sediment, modifications of water and sediment chemistry, changes to the benthic community, and a reduction in habitat complexity (NEFMC 2003; NRC 2002).

A Gear Effect Evaluation incorporated into Amendment 13 of the New England Groundfish FMP, based on a gear effects workshop sponsored by NMFS and the New England and Mid-Atlantic Fishery Management Councils, concluded that the combined effect of otter trawls, scallop dredges, and clam dredges was considerably higher in gravel and other hard bottom habitats than in sand and mud habitats (Northeast Region Essential Fish Habitat Steering Committee 2002). Structurally complex habitat is more greatly affected than less complex habitat (Auster and Langton 1999).

Most U.S. and Canadian coldwater shrimp fisheries use otter trawls. Configuration varies between fisheries, and so variation in the intensity of the impact to the seafloor may vary too. The Canada (D. Orr, DFO, pers. comm.) and New England (D. Schick, pers. comm.) trawl fisheries for northern shrimp use otter trawls similar to those used by the groundfish fishery. In this configuration, although the net itself may be suspended several inches or more above the seafloor (28 or more inches in the Atlantic Canada northern shrimp fishery), heavy rockhopper or roller gear are used to protect the gear from rough hard-bottom habitat. In Atlantic Canada, the rollers/rockhoppers are between 14 – 16 inches for the small-boat fishery that supplies the U.S. market, and far larger (40+ inches) for the large vessels supplying the European/ Scandinavian markets (Gerry Brothers, DFO, pers. comm.). In New England, the groundgear used is smaller than for the groundfish fisheries (Dan Schick, pers. comm.), but there has been a trend in recent years towards the use of heavier, larger rollers and/or rockhoppers (ASMFC 2004).

In contrast, the Oregon pink shrimp fishery typically uses vessels double-rigged with high-rise box trawls. In this semi-pelagic configuration, the net itself is elevated 12 to 30 inches above the seabed, while the two trawl doors and a short roller section in the center of the mouth of the net are in contact with the seafloor (Hannah and Jones 2003; R. Hannah pers. comm.). The Washington pink shrimp fishery primarily uses this same gear (L. Wargo, pers. comm.).

Otter trawls are banned from use in Southeast Alaska (Love 2002a) and Puget Sound (D. Sterritt, pers.comm.); these fisheries use beam trawls instead. Beam trawls are generally smaller and simpler than otter trawls, require smaller, less powerful vessels to haul, and can only be operated effectively over level bottoms like mud, sand, and gravel (D. Love, ADF&G, pers. comm.).

Traps

It is generally accepted that pots and traps have relatively little impact on the seafloor (Chuenpagdee et al. 2003; PFMC 2004[11]). However, impacts are not completely benign, especially in cases where the gear is being used in coral or hardbottom areas (Barnette 2001), as is the case in spot prawn traps.

Studies on warmwater trap fisheries document physical damage to structure-forming organisms, particularly through breaking branching corals and gorgonians, which may lead to reduced growth rates and death of these organisms (Barnette 2001 and references therein). Damage is inflicted where the pots or traps rest directly on the corals, but also during hauling if the gear is not hauled directly up, and instead is dragged for some distance over the seabed. The latter is likely where several or many pots are strung along a line, as is the case with the spot prawn fishery (vessels are limited to 300 – 500 pots in California, and 500 per permit in Washington—PFMC 2004), and the California fishery for coonstripe shrimp (20 – 30 pots per line—PFMC 2004). The dragging action of the connecting line (the trotline) can itself cause damage, potentially shearing corals and other structural organisms off at their base. The area swept by trotlines during recovery is orders of magnitude higher than the cumulative area of the traps themselves (Appledorn et al. 2000).

In Alaska, there is evidence that shrimp pots do adversely affect habitat, though the magnitude and biological significance of their effects is unknown. The annual research surveys in the most heavily exploited areas in Alaska have found shrimp pots frequently littered with glass sponge debris (Love and Bishop 2005). Hardbottom areas in which spot prawn pot fishing occurs also provide a solid substrate for other structurally complex organisms such as corals and gorgonians. Once damaged, recovery of such organisms may take decades or longer (Roberts and Hirshfield 2004). There is also likely some variation in how pots and traps are hauled in. Anecdotal evidence gathered through conversations with agency experts during the research for this report suggests that spot prawn trappers generally try and move from one end of the line to the other, thus vertically pulling up each pot or trap. Their ability to do this, however, is dependent at least somewhat on the weather and fishing conditions—the practice is much more difficult in stormy weather and rough seas.

Resilience of physical and biogenic habitats to disturbance by fishing method

The distribution of shrimp (and other continental shelf organisms) is likely defined by several parameters, including exposure to waves and currents, sediment type, temperature, salinity and light, as well as various biological factors (Bergstrom 1980). While it is beyond the scope of this report to detail the fine scale distribution of shrimp, several of these environmental factors affect the likely impacts of fishing on the seabed. Of particular importance are sediment type and the exposure of the seabed to strong currents, waves, and other physical forces, which is at least partly a function of depth.

There have been few experimental studies on habitat preferences or depth distribution in pandalids (Bergstrom 2000); most information is based on data from commercial fisheries. Most shrimp fisheries off North America catch shrimp at between 50 and 300 m depths. The most commercially important coldwater shrimp are generally fished on muddy-silty substrata. The

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[11] http://www.pcouncil.org/groundfish/gfefheis/chp4envcon.pdf

pink shrimp, *P jordani*, is most abundant between 90 and 200 m on green mud, or on mixed sand or mud bottoms (Bergstrom 2000). Both *P. borealis* and *P. eous* are found in exploitable densities between 50 and 500 m. There also appears to be a correlation between high organic content of the substrate and high abundance of *P. borealis* (Bergstrom 2000; ASMFC 2004). The same is true for most of the secondary target or incidentally caught species. The humpy shrimp, *P. goniurus*, primarily occurs from the subtidal zone down to about 125 m on mud or coarse sand, although it is also found in deeper waters and on more gravelly habitat; *P. hypsinotus* is found in the same depth range on sandy and muddy bottoms; *P. stenolepis* is typically found on mud bottoms at depths of 40 to 250 m, though the species is also found in rocky crevices in much shallower water with strong currents (Bergstrom 2000); and the ridgeback prawn, *Sicyonia ingentis*, also occurs on sandy and green mud substrates (CDFG 2001).

Other species occur more commonly in coarser habitat. Adult *P. montagui* are typically found on a wide range of substrates from sand and mud to gravel and rocks, but appear to show a preference for harder bottoms. The species is commonly caught between 20 and 100 m, though the species' depth range is considerably wider. Only one pandalid, *P. danae*, is caught regularly at less than about 50 m. It is most commonly found on coarse sand, gravel, and stones in fast-moving currents from intertidal depths down to about 80 m (Bergstrom 2000 and references therein; CDFG 2001).

Table 2: Habitat preferences of coldwater shrimp landed in U.S. and Canadian fisheries.

Species	Scientific name	Main adult fishing depth (ft, unless specified)	Substrate preference	References
Atlantic				
Northern shrimp	*Pandalus borealis*	50-500	Mud-silt	Bergstrom 2000
Pacific				
Northern shrimp	*P. eous*	50-500	Mud-silt	Bergstrom 2000; CDFG 2001; PFMC 2004; Hannah; Jones 2003
Ocean shrimp	*P. jordani*	120-240 m	Mud-silt	
Spot prawn	*P. platyceros*	70-140	On or near rocky areas, hardbottom habitat, glass sponges	
Ridgeback prawn	*Sicyonia ingentis*	<145 to >525 (depth range)	Sand, shell, and green mud	
Sidestripe shrimp	*P. dispar*	50-700 (depth range)	Soft mud	
Dock shrimp	*P. danae*	20-80	Coarse sand, gravel and stones, fairly strong currents	
Coonstripe shrimp	*P. hypsinotus*	80-400	Sandy-muddy	
Humpy shrimp	*P. goniurus*	20-120	Mud and sand	

The species most associated with hard bottom habitat is the spot prawn, *P. platyceros*, the adults of which appear to have a wide depth distribution, but are most commonly found on or near rocky habitat at 70 – 90 m depth (Bergstrom 2000). The PFMC states that the species inhabits "rocky or hard bottoms including coral reefs, glass sponge reefs, and the edges of marine canyons" (PFMC 2004).

Spatial scale of the impact

Coldwater shrimp are fished the world over. Fisheries exist for pandalids across the whole known distribution of the genus (Balsiger 1981). The largest fishery is for *P. borealis* on both sides of the North Atlantic, but large fisheries occur off the west coast of North America (*P. jordani*) and across the entire North Pacific (*P. eous*) (Bergstrom 2000). A large number of nations, including Canada, Iceland, Greenland, Norway, Germany, Russia and other former Soviet states, France, Spain, U.S.A, Japan, Korea, United Kingdom (UK), and the Faeroe Islands, participate in the exploitation of pandalids (Bergstrom 2000). These fisheries are typically carried out with trawl gear. The main trap-caught coldwater prawn of importance to the U.S. market is the spot prawn, which is fished across its entire range from Alaska to Baja California.

When compared to the groundfish fisheries in the U.S., however, the shrimp trawl fisheries are relatively small (Table 3).

Table 3: Approximate number of trawl vessels involved in U.S. coldwater shrimp and groundfish fisheries, by region (NRC 2002, based on various references between 1996 and 2001).

Region	Shrimp	Groundfish
New England	175	748
Pacific	218	397
Alaska	25	202

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

Several studies have documented changes in community structure as a result of large-scale fishing, leading to concerns that intensive fishing will lead to imbalances in ecosystem function with ramifications for community structure (Fogarty and Murawski 1998; Jennings and Kaiser 1998). In the case of coldwater shrimp fisheries, no ecosystem studies have been carried out. It is generally accepted, however, that recruitment in pandalids is largely environmentally driven, and therefore abundance varies considerably even under natural conditions. The ecosystem of which the shrimp populations are part have evolved in concert with the shrimp, and so are presumably well adapted to large changes in shrimp abundance.

Many marine species prey on pandalid shrimp. In the Atlantic, *P. borealis* is a major component of various finfish diets, including Atlantic cod and other gadoids, eelpouts, silver hake, hagfish, and Greenland halibut (Shumway et al. 1985). In the Pacific, Pacific cod, arrowtooth flounder, Pacific halibut, yellowfin sole, and Alaska pollock are major predators of *P. borealis*/*eous* (Shumway et al. 1985). Principal predators of *P. jordani* include Pacific hake, sablefish, arrowtooth flounder, spiny dogfish and skates (Bergstrom 2000). Several of these fish may contribute considerably to the natural mortality of pandalids, such as Pacific hake on *P. jordani* (Hannah 1995). Several authors have suggested that the collapse of Atlantic cod populations off Canada and in the Barents Sea may have led to an increase in biomass of *P. borealis*, but results of studies to date are equivocal (Berenboim et al. 2000; Lilly et al. 2000; Worm and Myers 2003; Frank et al. 2005). Nonetheless, predation pressure is certainly important in determining abundance of pandalid populations in at least some areas and some species (Hannah 1995;

Koeller 2000), and the consequences to those predators of removing substantial portions of their prey through fishing is of possible concern. However, these fish may also simply be opportunistically feeding on shrimp, perhaps when the shrimp are in high abundance or other prey is in low abundance. For example, Pacific hake, a possible determining factor in determining abundance of *P. jordani*, primarily feed on euphausiids rather than shrimp (Hannah 1995).

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

That trawling causes immediate and considerable damage to benthic communities is well documented (see previous section). In its recent review of the impacts of trawling, the National Research Council concluded that intensively trawled areas are likely to remain permanently altered, inhabited by fauna adapted to frequent physical disturbances (NRC 2002). In addition, the effects of mobile fishing gear are cumulative and repeated trawling can exceed a threshold and result in observable, long-term ecological effects, even in shallow, high-energy areas. Most studies focus on acute effects, which fail to document long-term changes from fishing activities (NRC 2002). No specific studies on the ecosystem impacts of removing large quantities of coldwater shrimp have been conducted.

Synthesis

The vast majority of coldwater shrimp on the U.S. market are small species caught by bottom trawl, mainly pink shrimp (*P. jordani*) and northern shrimp (*P. borealis/ P. borealis eous*). These species live primarily in sandy or muddy habitat, habitat types that are relatively resilient to fishing disturbance. However, the heavy gear used in the Atlantic Canada and New England fisheries suggests that at least some fishing does still occur in hardbottom and complex habitat areas. In contrast, the trawl configurations used to catch pink shrimp off Oregon and Washington are designed to fish a foot or more off the surface of the seabed (though the trawl doors and some groundgear/tickler chains do still touch the seabed). Thus, although no specific studies have been carried out on the impacts of these types of gears on the seafloor, they must be considerably less damaging to seafloor habitat than the heavy gear used on the East Coast.

Cold water shrimp pot fisheries catch a variety of species, but the primary target is spot prawns. All else being equal, these gears are generally recognized as being less damaging to habitat than bottom trawls. However, spot prawns, the primary target of shrimp pot fisheries in the Northeast Pacific, inhabit rocky and hardbottom habitat with complex structure, forming organisms such as glass sponges and corals, which are particularly sensitive to disturbance and may not recover for years or even decades. In contrast, the directed pot fisheries for coonstripe shrimp off Crescent City, California and northern shrimp off New England target species that typically live on sandy-muddy habitat, which is more resilient to disturbance by fishing.

Overall, coldwater shrimp pot fisheries for coonstripe shrimp off California and northern shrimp off New England are deemed benign in their habitat impacts; shrimp pot and trawl fisheries for pink shrimp (Oregon) and ridgeback prawns are deemed to cause moderate habitat damage; and all other trawl fisheries are deemed to cause severe habitat damage. The ecosystem effects of other coldwater shrimp fisheries are unknown.

Effect of Fishing Practices Rank:

California coonstripe shrimp and New England northern shrimp pot fisheries:

Benign 🟩 Moderate 🟨 Severe 🟥 Critical ⬛

Other pot/trap fisheries, including spot prawns; Oregon and Washington pink shrimp, trawl fisheries:

Benign 🟩 **Moderate 🟨** Severe 🟥 Critical ⬛

Other trawl fisheries:

Benign 🟩 Moderate 🟨 **Severe 🟥** Critical ⬛

Criterion 5: Effectiveness of the Management Regime

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

As noted previously, assessments of coldwater shrimp stocks generally consist of monitoring population changes using catch rate series and in some cases research surveys. These efforts provide general information on population structure and recruitment, significant changes in which are used to identify when a change in quota or effort is needed.

Stock assessments for the major stocks of northern shrimp targeted by both the Canadian and U.S. fisheries are generally carried out annually (no stock assessment in 2001), using both fisheries-dependent and independent data. Off the West Coast, assessment of the BC and Oregon trawl fisheries for *P. jordani* and *P. borealis*/*eous* is carried out with both fisheries-dependent and independent research. However, Washington State does not have logbook or survey programs for the trawl fishery, which may undermine Oregon's attempts at accurate stock assessment. Washington State looks to data gathered through Oregon's assessment process for information on the status of the pink shrimp stock as a whole, which is assumed to be the same stock (at least genetically). Washington State does have a logbook program and dockside monitoring of the coastal spot prawn fishery.

The ADF&G carries out pre-season (and some post season) stock assessments of the stocks targeted by the Southeast Alaska shrimp pot fishery (primarily spot prawns), but no assessment is conducted for the beam trawl fishery. The DFO carries out in-season stock assessments of the spot prawn fishery, with no pre-season fishery-independent surveys or estimates of total biomass. No fisheries-independent abundance surveys of spot prawns are carried out by West Coast states. California also does not carry out research surveys of ridgeback prawn stocks.

Accepting the conventional wisdom that little comprehensive assessment is needed for shrimp stocks, stock assessments for northern shrimp, Oregon's pink shrimp fishery, and the Alaska and BC spot prawn fisheries are deemed complete and robust. Stock assessments for all other coldwater shrimp fisheries are deemed incomplete or otherwise uncertain.

Scientific Monitoring: Management process involves regular collection and analysis of data with respect to the short and long-term abundance of the stock
Only management of the U.S. and Canadian northern shrimp fisheries, the Oregon pink shrimp fishery, and the Alaska and BC spot prawn fisheries involves the regular collection and assessment of both fishery-dependent and independent data. Data collection in other coldwater shrimp and prawn fisheries is less complete.

Scientific Advice: Management has a well-known track record of consistently setting catch quotas beyond those recommended by its scientific advisors and other external scientists
The ASMFC is well documented for not following the advice of its scientific advisors (the Northern Shrimp Technical Committee) for the Gulf of Maine northern shrimp fishery. In 1998, the NSTC recommended that the fishery be temporally restricted to February and March and in 1999 to just 40 days in those 2 months. In both cases the trawl season was left open from mid-December to late May, with approximately 15 – 20 days of closure spread out over those 5 months (Clark and Cadrin 2000). In 2001 – 2003, the NSTC strongly recommended the fishery be closed during the next year (2002 – 2004) (ASMFC 2003). Nevertheless, fishing mortality increased over the next two years. For all other coldwater shrimp fisheries, there is not enough information available to evaluate management's track record with scientific advice.

Bycatch: Management implements an effective bycatch reduction plan
All the major trawl fisheries for coldwater shrimp in the U.S. and Canada have plans in place to reduce bycatch. Both countries' northern shrimp fisheries have mandatory Nordmore grate requirements. The Oregon and Washington pink shrimp fisheries have mandatory grate or soft BRD requirements. These and other measures such as seasonal closures and trawl modifications have reduced bycatch to less than 5 percent of the total catch, and so are deemed effective. Trap fisheries have inherently low bycatch and so are not considered in this factor.

Fishing practices: Management addresses the effect of the fishing method(s) on habitats and ecosystems
U.S. and Canadian coldwater shrimp trawls are usually similar to the gears used by groundfish fishermen and are typically bound by the same rules as those gears with respect to area closures and roller size. As a result of management measures to reduce bycatch, the Oregon and Washington shrimp trawl fisheries use semi-pelagic trawls which reduce bycatch and may reduce habitat damage. However, no studies have been carried out on the impacts of coldwater shrimp trawls specifically, so the effectiveness of mitigative measures has not yet been demonstrated. Trap fisheries likely only cause low to moderate damage and so are not considered in this factor.

Enforcement: Management and appropriate government bodies enforce fishery regulations
The Canadian fishery for northern shrimp, and the Alaska, British Columbia, and Oregon trawl fisheries for pink/northern shrimp are well regulated and enforced through the use of logbooks, observer coverage, and dockside monitoring. Amendment 1 to the Northern Shrimp FMP (2004) for the U.S. fishery implemented an at-sea observer program, logbook program, and dockside monitoring. The British Columbia spot prawn fishery has an at-sea observer program, and enforcement is funded at least partly by the industry. Enforcement in these fisheries is thus deemed

effective.

Logbooks are mandatory in California and Oregon shrimp fisheries, but Washington vessels are not required to carry them. The 2004 Southeast Alaska pot shrimp FMP implemented a voluntary logbook scheme for the catcher-processor fleet. There is some dockside catch monitoring of both Washington and Alaska pot vessels. Enforcement in these fisheries is thus deemed less effective.

Management Track Record: Conservation measures enacted by management have resulted in the long-term maintenance of stock abundance and ecosystem integrity
Stock productivity is not only a function of the effectiveness of the management regime, and this is particularly the case with fast-growing species such as shrimp and prawns. It is believed that changes in environmental conditions have a greater impact on recruitment than changing fishing pressure; thus, it is often difficult to evaluate whether declines in biomass are attributable to poor management.

However, there is evidence that declines in New England-caught shrimp are a result of several consecutive years of overfishing and therefore a lack of management. The Gulf of Maine northern shrimp stock has shown two major declines in biomass since the 1960s. The fishery collapsed in the mid-1970s, recovered under restrictive management, and declined quickly again in the 1990s to an overfished condition in the early 2000s. Both the 1970s collapse and the 1990s decline occurred after fishing pressure on the stocks sharply increased (Clark and Cadrin 2000). Additionally, during these periods the ASMFC did not follow the recommendations of the Northern Shrimp Technical Committee (see Scientific Advice factor above). Despite this, however, the stocks do appear to have recovered from an overfished condition (although only very recently). In contrast, management has probably helped maintain stock productivity in the Atlantic Canada northern shrimp fishery, the Oregon pink shrimp fishery, and the BC spot prawn fishery.

Synthesis

Like all shrimp, abundance of coldwater shrimp species varies considerably with changing environmental conditions, thus management tends to be looser with coldwater shrimp than with many finfish. Accepting the conventional wisdom that little comprehensive assessment is needed for shrimp stocks, knowledge of the condition of stocks of northern shrimp, pink shrimp off Oregon, and spot prawns off Alaska and BC are considered complete and robust. Management for these fisheries uses research survey and/or in-season monitoring to judge stock abundance, and the fisheries are comprehensively monitored and enforced. In contrast, West Coast spot prawn assessment and management is minimal. Seafood Watch® therefore deems the BC spot prawn, Atlantic Canadian northern shrimp, and Oregon pink shrimp fisheries effectively managed, and all other coldwater shrimp fisheries only moderately effectively managed.

The specific factors used to evaluate the effectiveness of management are detailed for coldwater shrimp in Appendix 5.

Effectiveness of Management Rank:

Canada northern shrimp, Oregon pink shrimp, and British Columbia spot prawn fisheries:

Highly Effective 🟩 Moderately Effective 🟨 Ineffective 🟥 Critical ⬛

All other coldwater shrimp fisheries:

Highly Effective 🟩 **Moderately Effective** 🟨 Ineffective 🟥 Critical ⬛

Overall Seafood Recommendation

Pandalid shrimp are fast-growing and early-maturing, and produce several thousand young. These and other life history characteristics, such as environmental sex determination, make them inherently resistant to fishing pressure. Abundance and biomass in the Atlantic Canada northern shrimp (*Pandalus borealis*) fishery has been increasing since 1997, and catch-per-unit-effort (CPUE) trends have remained stable or above the long-term average during the same time period. In contrast, New England northern shrimp were being overfished for most of the 1990s, and biomass has only recently risen above the overfished threshold following a curtailment of fishing mortality. Overfishing appears to be occurring in the Alaskan spot prawn (*Pandalus platyceros*) pot fishery. The Oregon pink shrimp (*Pandalus jordani*) and British Columbia (BC) spot prawn fisheries appear fully-fished, and the status all other coldwater shrimp fisheries is unknown.

Smaller species of coldwater shrimp, in particular northern shrimp and pink shrimp (also known as ocean shrimp), are typically caught with trawls. Bycatch reduction devices (BRDs), closed areas and seasons, and other measures have brought trawl bycatch down to levels of significantly less than 10 percent, and few endangered species (sea turtles, mammals, seabirds, etc.) are caught in these fisheries. Concern over the bycatch of groundfish species persists, however, and managers in the large fisheries (northern and Oregon pink shrimp) continue research into reducing bycatch even further. Bottom trawls typically cause considerable damage to many seabed types, including the sandy and muddy habitats preferred by the trawl fisheries' target species. The semi-pelagic trawl configuration used in the Oregon pink shrimp fishery likely significantly reduces habitat damage, and is deemed less damaging than other bottom trawl gears in use in coldwater shrimp fisheries.

The largest pandalid, the spot prawn, is now captured wholly by pot gear (except for small quantities of allowable bycatch in other shrimp fisheries). The general belief that pot fisheries have low bycatch appears to hold true for coldwater shrimp fisheries. As spot prawns are typically found in hardbottom habitat, home to fragile glass sponges and corals, the fisheries likely cause moderate habitat damage. The habitat impacts of directed pot fisheries for coonstripe shrimp off California and northern shrimp off New England are likely benign, because these species inhabit softer seafloor habitats such as sand and mud.

Like all shrimp, abundance of coldwater shrimp species varies considerably with changing environmental conditions, thus management tends to be looser with coldwater shrimp than with many finfish. Accepting the conventional wisdom that little comprehensive assessment is needed for shrimp stocks, knowledge of the condition of stocks of northern shrimp, pink shrimp off Oregon, and spot prawns off Alaska and BC are considered complete and robust. Management for these fisheries uses research survey and/or in-season monitoring to judge stock abundance, and the fisheries are comprehensively monitored and enforced. In contrast, West Coast spot prawn assessment and management is minimal.

The Oregon pink shrimp fishery has been certified as sustainable to the Marine Stewardship Council (MSC) standard. The MSC is an independent non-profit organization, which has developed an environmental standard for sustainable and well-managed fisheries. It uses a product label to reward environmentally responsible fishery management and practices (http://www.msc.org/).

Table 4: Summary of criterion rankings and overall Seafood Watch® sustainability recommendation for coldwater shrimp, including relative importance of different fisheries to the U.S. market (*2003: based on Figure 6 and Figure 8; data for spot prawns is for 2004, see Figure 9; does not equal 100% as other imports are excluded).

Species	**Region**	**Conservation Concern**					**Overall Recommen.**	**Percentage of U.S. market***	
		Inherent vuln.	**Stock status**	**Bycatch**	**Habitat/ Ecosystem**	**Manage-ment**		**All coldwater shrimp**	**Species**
Northern shrimp, Atlantic (nearly all *P. borealis*)	Canada	Low	Low	Low	High	Low	**Good Alt.**	53	95
	New England, trawl	Low	Mod.	Low	High	Mod.	**Good Alt.**		5 (approx. 90% by trawl)
	New England, pot	Low	Mod.	Low	Low	Mod.	**Good Alt.**		
Northern shrimp/pink shrimp, Pacific (Washington and BC catch a mixture of *P. jordani* and *P. borealis eous*)	AK	Low	Mod.	Low	High	Mod.	**Good Alt.**	37	<1
	BC	Low	Mod.	Low	High	Mod.	**Good Alt.**		2
	WA	Low	Mod.	Low	Mod.	Mod.	**Good Alt.**		24
	OR	Low	Mod.	Low	Mod.	Low	**Best Choice**		74
	CA	Low	Mod.	Low	Mod.	Mod.	**Good Alt.**		<1
Spot prawn	AK	Low	High	Low	Mod.	Mod.	**Good Alt.**	<3	Mainly for export, small live market in AK
	BC	Low	Mod.	Low	Mod.	Low	**Best Choice**		90% to Asia, some to US
	WA	Low	Mod.	Low	Mod.	Mod.	**Good Alt.**		40% from WA, 60% from CA, <1% from OR in 2004
	OR	Low	Mod.	Low	Mod.	Mod.	**Good Alt.**		
	CA	Low	Mod.	Low	Mod.	Mod.	**Good Alt.**		
Ridgeback prawn	CA	Low	Mod.	Mod.	Mod.	Mod.	**Good Alt.**		
Coonstripe	CA	Low	Mod.	Low	Low	Mod.	**Best Choice**		Majority from directed CA pot fishery
	Other pot	Low	Mod.	Low	Mod.	Mod.	**Good Alt.**		
	Trawl	Low	Mod.	Low	High	Mod.	**Good Alt.**		
Others	Pot (Other than CA coonstripe and New England)	Low	Mod.	Low	Mod.	Mod.	**Good Alt.**		Minimal
	Trawl (Coonstripe, sidestripe, humpy, dock)	Low	Mod.	Low	High	Mod.	**Good Alt.**		

Table of Sustainability Ranks

	Conservation Concern			
Sustainability Criteria	**Low**	**Moderate**	**High**	**Critical**
Inherent Vulnerability	√			
Status of Stocks	√ Northern shrimp, Atlantic Canada	√ All others		
Nature of Bycatch	√			
Habitat Effects	√ Northern shrimp, pot √ Coonstripe shrimp, CA, directed pot	√ Pink shrimp, OR and WA	√ Northern shrimp	
Management Effectiveness	√ Northern shrimp, Atlantic Canada √ Pink shrimp, OR √ Spot prawns, BC	√ All others		

Overall Seafood Recommendation:

- 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.
- 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 **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.

British Columbia spot prawns, California coonstripe shrimp (pot), Oregon pink shrimp:

[✓ **Best Choice** 🟩] Good Alternative 🟨 Avoid 🟥

All other coldwater shrimp, including U.S. spot prawns and U.S. northern shrimp:

Best Choice 🟩 [✓ **Good Alternative** 🟨] Avoid 🟥

Acknowledgements

Seafood Watch® is indebted to the following experts for their technical review of relevant parts of this document for scientific accuracy and clarity: Dr. Dave Orr (DFO, Newfoundland and Labrador Region), Ms. Lorna Wargo (WDFW Region 6), Dr. Mike Kattilakoski (DFO Pacific), Dr. Robert Hannah (ODFW), Dr. Gretchen Bishop (ADFG Region 1), and Dr. Kristine Barsky (CDFG).

Scientific review does not constitute an endorsement of Seafood Watch on the part of the reviewing scientists; the Seafood Watch staff is solely responsible for the conclusions reached in this report.

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Appendix 1: Inherent Vulnerability to Fishing Pressure

Primary Factors to evaluate

Intrinsic rate of increase (‘r’)
- High (> 0.16) 🟩
- Medium (0.05 - 0.16) 🟨
- Low (< 0.05) 🟥
- Unavailable/Unknown [✓ ☐]

Age at 1st maturity
- Low (< 5 years) [✓ 🟩]
- Medium (5 - 10 years) 🟨
- High (> 10 years) 🟥
- Unavailable/Unknown ☐

Von Bertalanfy growth coefficient (‘k’)
- High (> 0.16) 🟩
- Medium (0.05 - 0.15) 🟨
- Low (< 0.05) 🟥
- Unavailable/Unknown [✓ ☐]

Maximum age
- Low (< 11 years) [✓ 🟩]
- Medium (11 - 30 years) 🟨
- High (> 30 years) 🟥
- Unavailable/Unknown ☐

Reproductive potential (fecundity)
- High (> 100 inds./year) [✓ 🟩]
- Moderate (10 – 100 inds./year) 🟨
- Low (< 10 inds./year) 🟥
- Unavailable/Unknown ☐

Secondary Factors to evaluate

Species range

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

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

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

Quality of Habitat: Degradation from non-fishery impacts

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

Evaluation Guidelines

1) Primary Factors
   a) If 'r' is known, use it as the basis for the rank of the Primary Factors.

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

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

Appendix 2: Status of Wild Stocks

Primary Factors to evaluate

Management classification status

- Underutilized OR close to virgin biomass 🟩
- Fully fished OR recovering from overfished OR unknown [✓ 🟨] All
- Recruitment or growth overfished, overexploited, depleted or "threatened" 🟥

Current population abundance relative to B_{MSY}

- At or above B_{MSY} (> 100%) 🟩
- Below B_{MSY} (50 – 100%) OR unknown [✓ 🟨] All others
- Substantially below B_{MSY} (e.g. < 50%) [✓ 🟥] BC Northern/pink

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

- Overfishing not occurring ($F_{curr}/F_{msy} < 1.0$) 🟩
- Overfishing is likely/probable OR fishing effort is increasing with poor understanding of stock status OR Unknown [✓ 🟨] All others
- Overfishing occurring ($F_{curr}/F_{msy} > 1.0$) [✓ 🟥] AK spot

Overall degree of uncertainty in status of stock

- Low (i.e. current stock assessment and other fishery-independent data are robust OR reliable long-term fishery-dependent data available) [✓ 🟩] Northern (Atlantic), OR pink, BC spot
- Medium (i.e. only limited, fishery-dependent data on stock status are available) [✓ 🟨] AK spot
- High (i.e. little or no current fishery-dependent or independent information on stock status OR models/estimates broadly disputed or out-of-date) [✓ 🟥] All others, inc AK Northern

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

- Trend is up 🟩
- Trend is flat or variable (among areas, over time or among methods) OR Unknown [✓ 🟨] All
- Trend is down 🟥

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

- Trend is up [✓ 🟩] Northern (US Atl)

- Trend is flat or variable (among areas, over time or among methods) OR Unknown — 🟨 All others
- Trend is down — 🟥 BC Northern/pink

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

- Distribution(s) is(are) functionally normal — 🟩 Atl/Pac Northern/pink (not AK, CA)
- Distribution(s) unknown — 🟨 All others
- Distribution(s) is(are) skewed — 🟥 AK spot

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

Appendix 3: Nature and Extent of Bycatch

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 🟨
- Quantity of bycatch is high (> 100% of targeted landings on a per number basis) OR bycatch regularly includes threatened, endangered or protected species 🟥

Population consequences of bycatch

- Low: Evidence indicates quantity of bycatch has little or no impact on population levels 🟩
- Moderate: Conflicting evidence of population consequences of bycatch OR Unknown [✓ 🟨]
- 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 bycatch is low [✓ ☐]

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 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 its 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 ecosystem impacts.

Appendix 4: Effect of Fishing Practices on Habitats and Ecosystems

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) [✓ 🟨] OR pink trawls, all pots
- Great damage (i.e. bottom trawl or dredge) [✓ 🟥] All other 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) [✓ 🟨] All others
- Low (e.g. shallow or deep water corals, shallow or deep water rocky bottoms) [✓ 🟥] Spot prawns
- 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) 🟩
- Moderate scale (e.g. modern fishery but of limited geographic scope) [✓ 🟨]
- Large scale (e.g. industrialized fishery over large 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 both Ecosystem Factors are not red.

The effect of fishing practices is "Moderate" if:
1) Gear effects are moderate AND resilience to disturbance is moderate or high AND both Ecosystem Factors are not red.
2) Gear results in great damage AND resilience to disturbance is high OR impacts are small scale AND both Ecosystem Factors are not 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) One or more 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.

Appendix 5: Effectiveness of the Management Regime

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 [✓ 🟩] Atl Northern, OR pink, BC/AK spot
- Stock assessment is planned or underway but is incomplete OR stock assessment complete but out-of-date or otherwise uncertain [✓ 🟨] All others
- 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 [✓ 🟩] Atl Northern, OR pink, BC/AK spot
- Regular collection of fishery-dependent data only [✓ 🟨] All others
- No regular collection or analysis of data 🟥

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

- No 🟩
- Yes [✓ 🟥] US Atl Northern
- Not enough information available to evaluate OR not applicable because little or no scientific information is collected [✓ ☐] All others

Bycatch: Management implements an effective bycatch reduction plan

- Bycatch plan in place and reaching its conservation goals (deemed effective) [✓ 🟩] All others
- 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” [✓ ☐] All pots

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 [✓ 🟨] Trawls

- No mitigative measures in place or measures in place but deemed ineffective 🟥
- Not applicable because fishing method is moderate or benign [✓ ☐] Pots

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 [✓ 🟩] Atl Northern, OR pink, BC/AK spot
- Regulations enforced by fishing industry or by voluntary/honor system [✓ 🟨] All others
- 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 [✓ 🟩] Atl Can North., OR pink, BC spot
- Stock productivity has varied but management has responded quickly OR stock has not varied but management has not been in place long enough to evaluate its effectiveness OR unknown [✓ 🟨] All others
- 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, 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.