Review of the California Trawl Fishery for Pacific Ocean Shrimp, *Pandalus jordani*, from 1992 to 2007

ADAM J. FRIMODIG, MICHELLE C. HORECZKO, MICHAEL W. PRALL,
TOM J. MASON, BRIAN C. OWENS, and STEPHEN P. WERTZ

Introduction

The Pacific ocean shrimp, *Pandalus jordani*, usually referred to as pink shrimp, is a commercially important pandalid shrimp species harvested with bottom-trawl gear off the Pacific coast of the United States and Canada. They are sold as cocktail or salad shrimp, after being machine cooked, peeled, and frozen (Fig. 1). The pink shrimp trawl fishery has been an important component of many coastal community economies in California for over 50 years, although production has decreased sharply in recent years.

Adam J. Frimodig and Michael W. Prall are with the California Department of Fish and Game, Marine Region, 619 2nd Street, Eureka, CA 95501. Michelle C. Horeczko, Tom J. Mason, Brian C. Owens, and Stephen P. Wertz are with the California Department of Fish and Game, Marine Region, 4665 Lampson Avenue, Suite C, Los Alamitos, CA 90720 (corresponding author: AFrimodig@dfg.ca.gov).

ABSTRACT—The commercial bottom trawl fishery for Pacific ocean shrimp, Pandalus jordani*, or pink shrimp, operates mostly off the west coast of the contiguous United States. The California portion of the fishery has not been thoroughly documented or reviewed since the 1991 fishing season, despite its fluctuating more during the last 16 years (1992–2007) than at any other period in its 56-year history. We used fishery-dependent data, California Department of Fish and Game commercial landing receipts and logbook data, to analyze trends and review the California pink shrimp trawl fishery from 1992 to 2007. In particular, we focus on the most recent years of the fishery (2001–07) to highlight the gear developments and key management measures implemented in the fishery. The fishery is primarily driven by market conditions and is highly regulated by both state and Federal management agencies. Several key regulatory measures implemented during this decade have had significant effects on the fishery. For example, the requirement of a Bycatch Reduction Device on trawl nets targeting pink shrimp was approved in 2001 and has greatly reduced levels of finfish bycatch. Fishery production has declined, particularly in recent years, and may be attributed to decreased market prices, followed by reduced fishermen participation; both of which are related to changes in the processing sector and demand for the product.*

The pink shrimp fishery operating in ocean waters off California is managed by the California Department of Fish and Game (CDFG), under the California Fish and Game Commission (CFGC). However, because groundfish are taken as bycatch in this fishery, it is considered a non-groundfish trawl fishery under the U.S. Pacific Groundfish Fishery Management Plan. The Federal management regulations for this fishery include groundfish trip limits, seasons, gear restrictions, and area restrictions protecting groundfish Essential Fish Habitat (Code of Federal Regulations, 2008). Historically, the CDFG conducted research on the pink shrimp fishery, including cruise surveys, development of population models, and a dockside biological market sampling program. The CDFG cruise surveys were used to estimate shrimp population sizes, mortality rates, and growth rates from 1959 to 1968, but they were discontinued because they were too expensive (Gotshall, 1972; PFMC[1]).

Population models were developed by CDFG statisticians to estimate recruitment, spawning stock abundance, and set the catch quotas from 1969 to 1976. However, the models were subsequently dropped because the exploitation rate for age-1 shrimp, which typically constitute most of the spawning stock, was determined to be low and therefore able to be managed without a quota (Geibel and Heimann, 1976; PFMC[1]). Population models were also found to have inaccuracies due to the variable recruitment, growth, and natural mortality rates associated with pink shrimp (Hannah, 1999). The dockside biological market sampling program provided data on pink shrimp size, sex, age composition, and the count-per-pound, but this program ceased in 1992 due to a lack of available staff and resources.

Essential fishery information on the California pink shrimp fishery was consistently collected from the 1960's through the 1980's. In addition, a fishery management plan was drafted for the pink shrimp fishery off Washington, Oregon, and California in 1981 because of concerns about an increase in fishing effort coupled with a coastwide decline in catch per unit of effort (CPUE) for pink shrimp (PFMC[1]). However, the Pacific Fishery Management Council (PFMC) did not adopt the plan and deferred management of the fishery to

[1]PFMC. 1981. Discussion draft fishery management plan for the pink shrimp fishery off Washington, Oregon and California. Pac. Fish. Manage. Counc., Portland, Oreg., 169 p.

the U.S. west coast states which had historically worked collaboratively to minimize interstate conflicts and resource issues (PFMC[1]; MSC[2]).

Reports on the trends and status of the California pink shrimp fishery were also published on nearly an annual basis by CDFG from 1959 to 1992 and California Cooperative Oceanic Fisheries Investigations Reports from 1984 to 1992. The Pacific States Marine Fisheries Commission (PSMFC) published just six brief summaries of the California pink shrimp fishery (1992–95; 1999–2000). Aside from these six brief PSMFC annual summaries, only two status reports or other published documents have been written on the California pink shrimp fishery since the 1991 fishing season (Collier and Hannah, 2001; Frimodig et al., 2008). Since 1992, there have been extreme fluctuations in annual landings, as well as innovative gear developments and key management measures implemented; all have had substantial impacts on the current fishery. Therefore, the objective of this paper is to analyze trends and review the California pink shrimp trawl fishery during the 16-year period from 1992 to 2007, with an emphasis on the most recent years of the fishery.

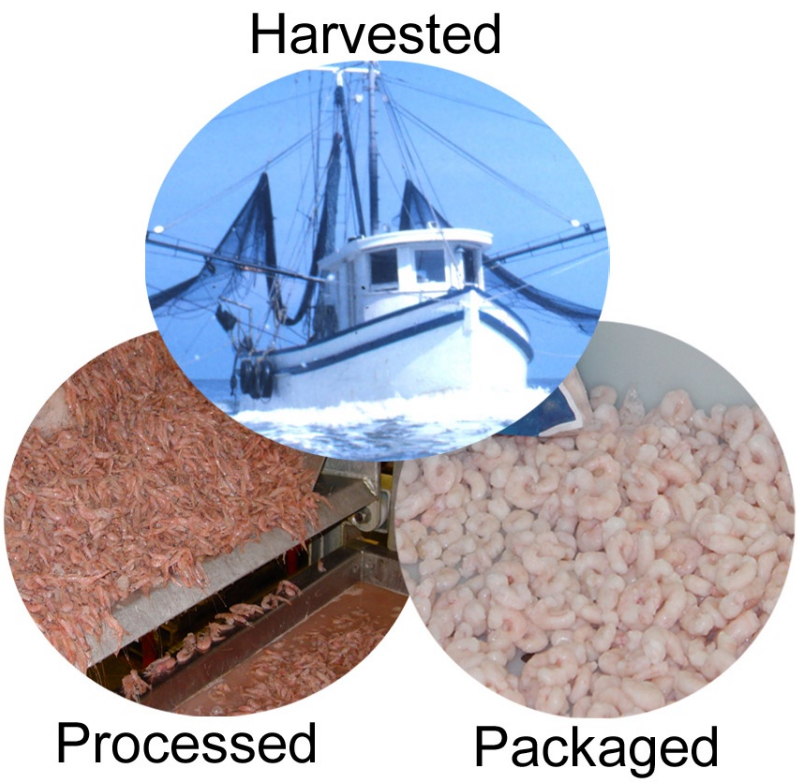

Figure 1.—Pink shrimp are harvested off the Pacific coast of the U.S., cooked, peeled and processed, and sold as salad shrimp, or cocktail shrimp. Credit: Pink shrimp photographs were taken by Adam Frimodig, CDFG, courtesy of Pacific Choice Seafoods; vessel photograph was taken by NOAA.

Biological Characteristics

Pink shrimp range from the Aleutian Islands in Alaska to San Diego, California, and the center of distribution occurs off the Oregon coast (Dahlstrom, 1970; PFMC[1]). Commercial quantities are generally confined each year to well-defined locations, or beds, from Queen Charlotte Sound, British Columbia, to Point Arguello, California (Dahlstrom, 1970; PFMC[1]). Off the California coast, pink shrimp are most abundant in the same general beds from year to year (Fig 2). These beds are primarily soft-bottom habitats characterized by green mud or muddy-sand at depths between 90 and 200 m (Dahlstrom, 1970; Bergstrom, 2000; PFMC[1]).

From 2000 to 2007, logbook data for all trips targeting pink shrimp off California indicate that the average fishing depth was 158 m, and ranged from 47 to 360 m. The largest bed extends from the Eureka area to the Oregon border. Several beds are located between False Cape and Point Reyes, and another bed is found near Morro Bay (Fig. 2). Commercial quantities of pink shrimp also occur infrequently in the Santa Barbara Channel between Point Conception and Pitas Point (Fig. 2).

Pink shrimp are protandric hermaphrodites, generally functioning as males for the first year and a half of their life before developing into terminal females (Butler, 1964), although the age at which individuals change sex can vary from year to year in response to the population structure (Hannah and Jones, 1991; Charnov and Hannah, 2002). Spawning typically takes place during September and October (Dahlstrom, 1970). Pandalid shrimp have external fertilization, and females carry fertilized eggs on their pleopods until they hatch (Balsiger, 1981; PFMC[1]). The peak hatching period for pink shrimp occurs between late March and early April (Butler, 1964; Dahlstrom, 1970). Newly hatched larvae pass through a planktonic phase which lasts approximately 4 months from late winter to July, and the developing juvenile shrimp inhabit successively deeper waters as they grow. They usually turn up in commercial catches by late summer (Dahlstrom, 1970; Rothlisberg and Miller, 1983; PFMC[1]). Growth rates, typically highest during the spring and summer, vary by region, sex, age, and year class (Dahlstrom, 1970; Gotshall, 1972).

Pink shrimp undergo a diel migration pattern moving between a deeper, northward flowing undercurrent during

[2]MSC. 2007. The Oregon pink (ocean) shrimp trawl fishery. Mar. Stewardship Counc., London, U.K., Final Rep. Version 3, 137 p. (online at http://www.msc.org/assets/docs/Oregon_pink_shrimp/Final_Report_Oct_2007.pdf).

the day to a generally southward, surface moving current during the night (Pearcy, 1970; 1972). Some horizontal, onshore-offshore transport may occur within the confines of a single bed due to prevailing currents and feeding activity. Planktonic larvae may be carried long distances, but no convincing evidence suggests pink shrimp exhibit large coastwide migratory behavior (Dahlstrom, 1970; Pearcy, 1970; Rothlisberg and Miller, 1983).

Pink shrimp are an important component of the food web in the northeast Pacific Ocean (Field et al., 2006). They feed primarily at night, ascending in the water column to locate smaller planktonic crustaceans, such as euphasiids and copepods (Pearcy, 1970; Gotshall, 1972). The vertical migration of pink shrimp may also reduce their susceptibility to visual predators during the night (Pearcy, 1970). Pink shrimp are preyed upon by mostly groundfishes, such as Pacific hake, *Merluccius productus*; arrowtooth flounder, *Atheresthes stomias*; sablefish, *Anoplopoma fimbria*; petrale sole, *Eopsetta jordani*; spiny dogfish, *Squalus acanthias*; and several species of rockfishes, *Sebastes* sp., and skates, *Raja* sp. (Gotshall, 1969; Dahlstrom, 1970; Hannah, 1995). Natural mortality rates vary considerably from year to year and have been linked to the abundance of Pacific hake (Hannah, 1995).

In the last 3 years, the age composition of pink shrimp harvested off the Oregon coast has fluctuated greatly. The age-1 year class was strong in 2005, weak in 2006, and strong again in 2007, constituting 85%, 15%, and 83% respectively of the catch (ODFW[3]). Age-1 shrimp generally range from 13 to 17 mm, age-2 range from 18 to 25 mm, and age-3 from 25 to 29 mm (Fig. 3) (Dahlstrom, 1970).

Short-lived invertebrates, such as pandalid shrimp and market squid, *Loligo opalescens*, tend to exhibit large natural fluctuations in abundance, yet the fisheries targeting these invertebrates appear to be sustainably managed with relatively minimal regulatory actions (Field and Francis, 2006). However, changes in growth, age, and sex composition of the pink shrimp catch have been partly attributed to the trawl fishery. Hannah and Jones (1991) found that when the catch of age-3 pink shrimp decreased, the catch of age-1 shrimp increased, and the percentage of age-1 shrimp transitioning from males to females increased concurrently with a reduction in CPUE.

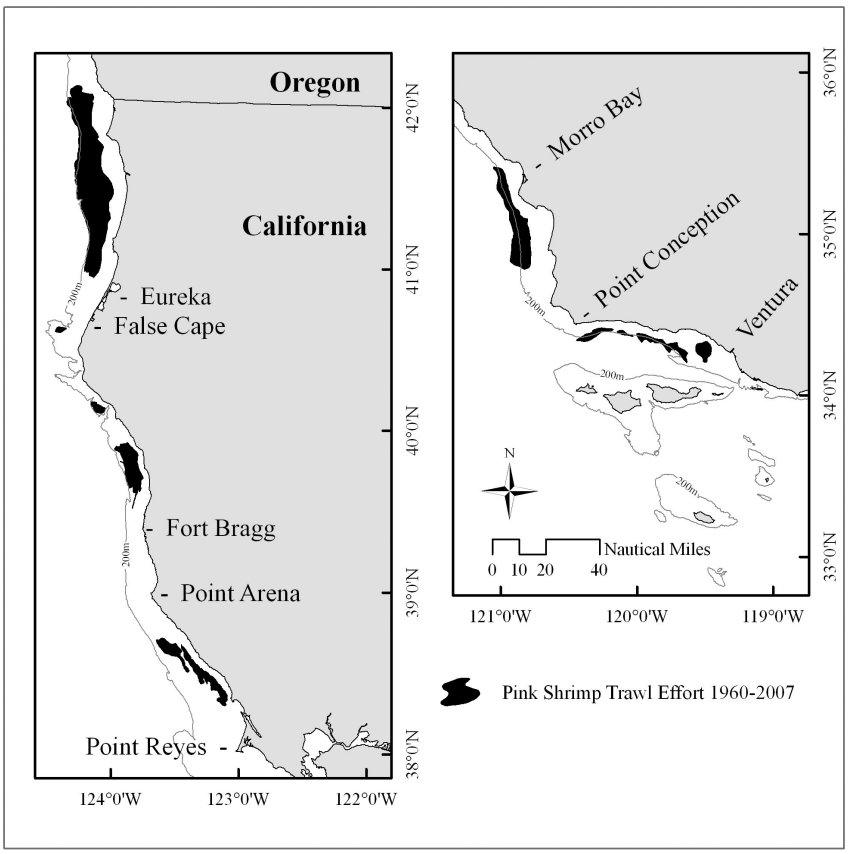

Figure 2.—Historical pink shrimp trawl effort from 1960 to 2007 showing the main pink shrimp beds off the coast of California. Source: CDFG historical Annual Ocean Shrimp Reports (i.e. Administrative Reports) and CDFG pink shrimp logbook data.

Despite the potential fishing effects on the population, pink shrimp are short-lived, may exhibit density-dependent growth patterns, and their abundance appears to be primarily influenced by environmental factors (Hannah and Jones, 1991; Hannah, 1993; 1999; Perry et al., 2000). Annual recruitment success has been linked to the strength and timing of the "spring transition," which is the most critical period for seasonal plankton production cycles and refers to the seasonal change in wind patterns that force a shift in coastal currents from a winter downwelling condition to a summer upwelling condition. An early, strong transition is necessary to produce a large year class (Hannah, 1993; 1999). This suggests fishing pressure may have relatively little effect on stock status, although overfishing may be possible if intensive fishing occurs on a failed year class.

History of the Fishery

The commercial trawl fishery for pink shrimp began in 1952 off Morro Bay, California, after commercial concentrations were found in 1950 and 1951 by CDFG research vessels (Dahlstrom, 1961). The pink shrimp fishery expanded in California off Bodega Bay, Fort Bragg, Eureka, and Crescent City, and northward to Oregon and Washington

[3]ODFW. 2008. 19th Annual pink shrimp review. Oreg. Dep. Fish Wildl., Mar. Resour. Program, Newport, Oreg., 8 p. (online at http://www.dfw.state.or.us/mrp/publications).

Figure 3.—Three size (age) classes of Pacific ocean shrimp, *Pandalus jordani*. Credit: Robert W. Hannah, ODFW.

in the mid to late 1950's (Dahlstrom, 1973). The CFGC designated three regulatory areas for the harvest of pink shrimp in 1952 (Areas A, B, and C), which encompassed both state and Federal waters adjacent to California.

The CFGC first established regulations for the fishery in 1952 including the use and submittal of logs to document catch and effort, gear restrictions, open and closed seasons, and annual catch quotas. Fishermen were limited to the use of beam trawls with a minimum net mesh size of 38 mm from 1952 to 1963, and trawling in state waters was prohibited in 1953. In 1963, fishermen were allowed to use otter trawl nets with the 38 mm net mesh size. After 1963, beam trawls were phased out and otter trawl gear became the primary gear used. All vessels in California pulled a single rig of one net and two doors prior to the 1974 season, when vessels towing a double rig (one net deployed on each side of the vessel) entered the fishery (Collier and Hannah, 2001).

Catch quotas governed landings in each regulatory area from 1952 to 1976. The quota system was abandoned in 1976, and the following regulations were enacted in an effort to protect the resource for long-term sustainability: 1) season closure from 1 Nov. through 14 Apr. to protect egg-bearing females, 2) minimum net mesh size of 35 mm to allow for escapement of small zero age shrimp, 3) maximum count-per-pound of 170 or less intended to protect 1-year-old shrimp, and 4) minimum catch rate of 350 pounds-per-hour to protect shrimp when the population was at a low level. Consistent coastwide management measures were established in 1981 based on an agreement with the Oregon Department of Fish and Wildlife (ODFW) and the Washington Department of Fish and Wildlife (WDFW). The resulting regulations, which remain in effect, include an open season from 1 Apr. through 31 Oct. and a maximum count-per-pound of 160. In California, there is an additional requirement of a minimum net mesh size of 35 mm.

Since 2000, three additional regulatory measures have been implemented in the California pink shrimp fishery. First, regulations mandating the use of Bycatch Reduction Devices (BRD's) in the U.S. west coast pink shrimp fishery were adopted in 2000 after the PFMC determined that canary rockfish, *Sebastes pinniger*, were overfished (PFMC[4]). In California, the requirement of a BRD on trawl nets used in the pink shrimp fishery was approved by the CFGC in 2001 and implemented in 2002. Three types of BRD's currently satisfy the requirement for this device in the California fishery: the Nordmøre grate (rigid-grate excluder) (Fig. 4), soft-panel excluder (Fig. 5), and fisheye excluder (Fig. 6) (California Code of Regulations, 2008a).

Second, the management of pink shrimp harvest in California was changed in 2001 from the three management regions (A, B, and C) used historically to two management regions (northern region and southern region). The northern region is a limited entry fishery extending from the California–Oregon border to Point Conception (California Code of Regulations, 2008a). The permit required for fishing in the northern region may be transferable or nontransferable. Permit transferability is limited to the transfer of a vessel permit to a replacement vessel that is no more than 5 feet longer than the original permitted vessel under the same ownership, or the transfer of a permit to an heir upon death of the permit holder. The southern region is an open access fishery extending from Point Conception to the California–Mexico border (California Code of Regulations, 2008a). Permits are required in the southern region, but there is no limit to the number that can be issued.

The third recent regulatory change in the California pink shrimp fishery occurred in 2004 when new and amended statutes granted the CFGC management authority over all state-managed bottom trawl fisheries not managed under a Federal or state fishery management plan, and prohibited pink shrimp bottom trawling in state waters after 1

[4]PFMC. 2000. Status of the Pacific Coast groundfish fishery through 2000 and recommended biological catches for 2001: stock assessment and fishery evaluation. Doc. prep. for the council and its advisory entities. Pac. Fish. Manage. Counc., Portland, Oreg.

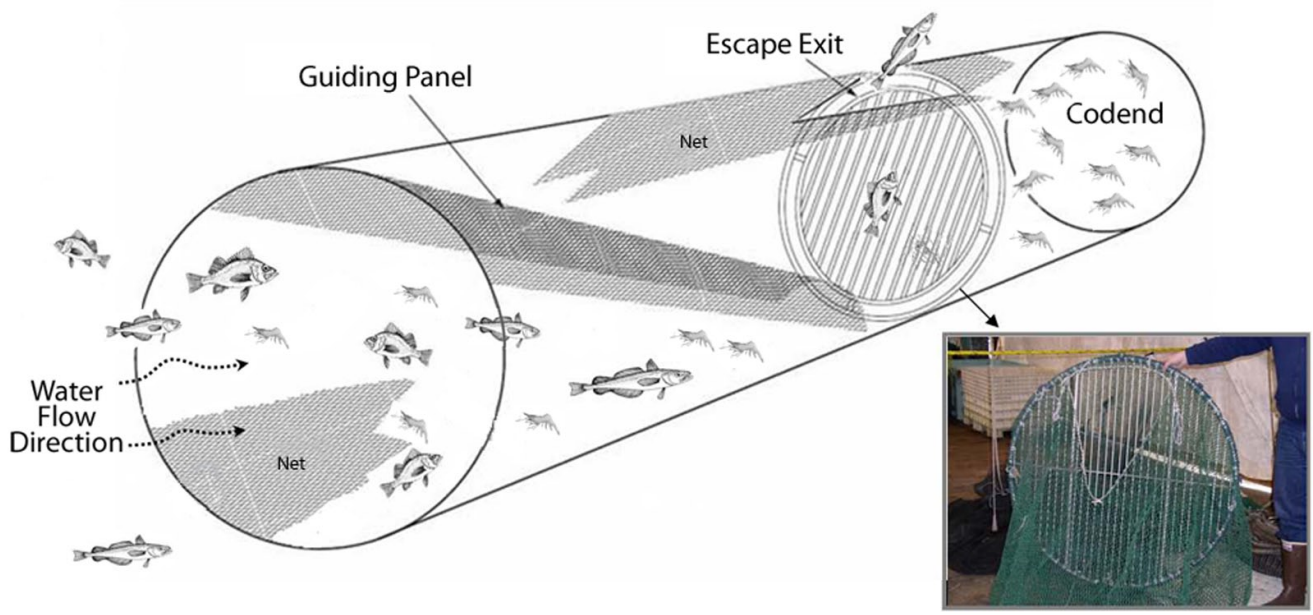

Figure 4.—Diagram of a typical rigid-grate excluder. The diagram shows shrimp traveling through the BRD, while larger fish species are deflected by the BRD and guided through the escape opening. The inset picture is a rigid-grate excluder with 32 mm bar spacing. Credit: Adam Frimodig, CDFG; diagram and inset picture modified from Robert W. Hannah, ODFW.

Jan. 2008 (California Fish and Game Code, 2008a). Prior to that date, bottom trawling for pink shrimp was authorized in state waters between 2 and 3 n.mi. (3.7 and 5.6 km) from the mainland on the north coast of California from Point Reyes to False Cape.

This portion of state waters, often referred to as the "pink shrimp trawl grounds," was the only area open to pink shrimp fishing in state waters. According to logbook data, an average of 21% of annual pink shrimp landings statewide were taken from within state waters from 2000 to 2007. The CFGC has the authority to open any state waters for bottom trawls if it determines that bottom trawling in those areas is sustainable, does not harm benthic habitat, and does not unreasonably conflict with other users (California Fish and Game Code, 2008b).

Bottom fishing gear types, such as trawling, have been considered one of the foremost global anthropogenic sources of disturbance to hard-bottom benthic communities (Auster and Langton, 1999; Turner et al., 1999; NRC, 2002). However, the effects of bottom trawling on soft-bottom habitats are

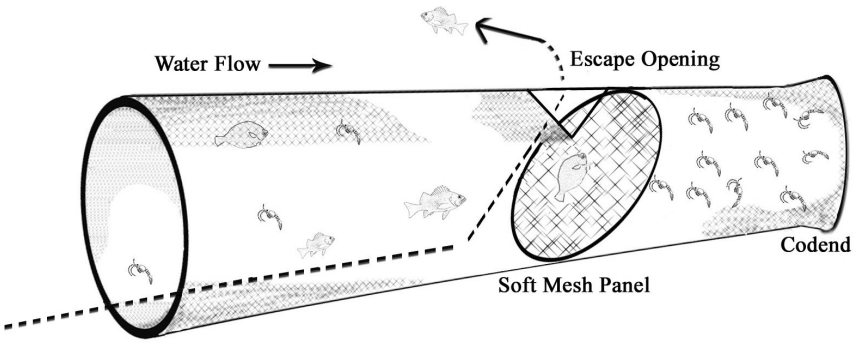

Figure 5.—Diagram of a typical soft-panel excluder. The soft-panel excluder works similarly to rigid-grate excluder, but the device is made of soft mesh rather than aluminum. Credit: Brian Owens, CDFG.

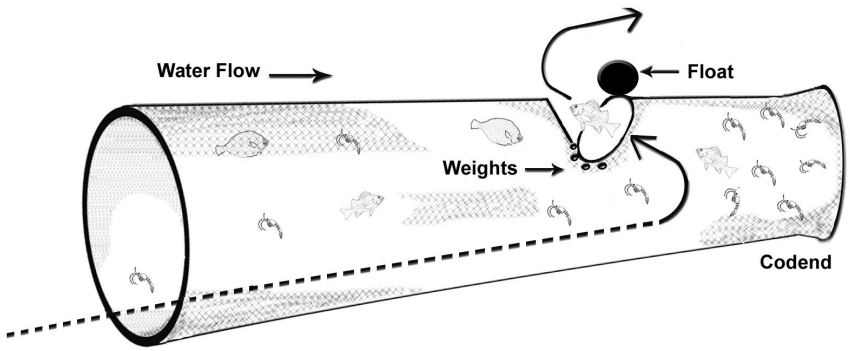

Figure 6.—Diagram of a typical fisheye excluder BRD. The diagram shows shrimp and fish moving to the codend of the net. Strong swimming fish can exit through the escape opening of the net which is held open by floats and weights, while shrimp passively enter the codend. Credit: Brian Owens, CDFG.

not as well known (Hilborn, 2007). In 2005, the National Marine Fisheries Service (NMFS) designated the soft-bottom areas where pink shrimp effort occurs to be within the lowest sensitivity classification for impacts to seafloor habitat by bottom trawling, and estimated the recovery rates from trawl gear in the pink shrimp fishing grounds to be less than one year (NMFS, 2005). The frequency of disturbance by bottom trawling for pink shrimp is limited by an 8-month open season and a general reduction in fleet size from the Federal fishing capacity reduction program, or vessel buyback program, implemented in the U.S. west coast groundfish fishery by NMFS in 2003. The voluntary vessel buyback program relinquished a total of 85 pink shrimp permits coastwide, 31 of which were California permits (Federal Register, 2003). The semi-pelagic trawl gear used in the pink shrimp fishery may also have less impact on benthic communities than other cold-water shrimp gear types (Roberts, 2005); however, this remains speculative as there are no known direct pink shrimp trawl gear impact studies.

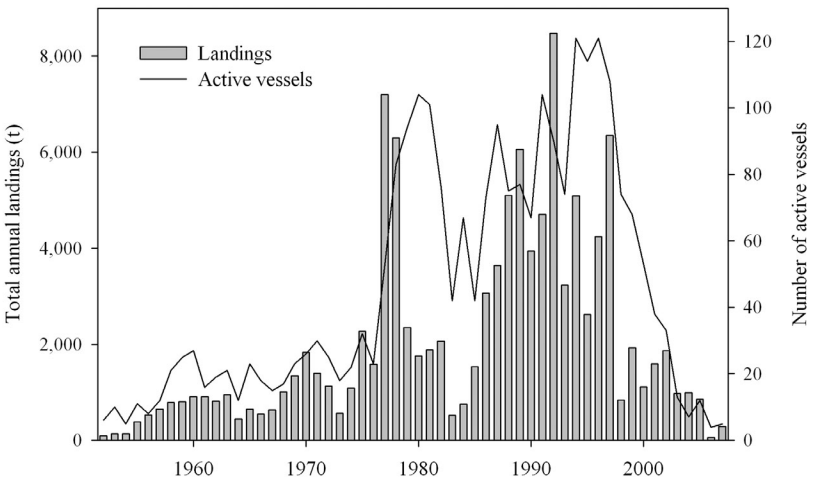

Figure 7.—Total annual commercial landings (t) and number of active vessels in the California pink shrimp fishery from 1952 to 2007. Source: Market receipt data from CFIS (2008).

Pink Shrimp Catch from 1992 to 2007

Commercial landing receipts (market receipts) are required for every commercial landing in California including pink shrimp. We used CDFG market receipt and vessel license data from 1992 to 2007 to analyze the total annual landings, average annual price-per-pound received by fishermen, total annual ex-vessel revenue, number of active vessels in the fishery by gear type (single rig or double rig), fishing periods, ports in which pink shrimp were landed, number of permits sold, and inactive permits in the California pink shrimp trawl fishery.

Total annual landings fluctuated greatly from 1992 to 2007, ranging from a historical high of 8,474 t in 1992 to a historical low of 63 t in 2006 (Table 1, Fig. 7). The fishery was consistently more productive from 1987 to 1997 compared to any other period in its 56-year history, and the number of active vessels reflected the trends in annual landings (Table 1, Fig. 7). In 1998, the landings decreased to 836 t, which was approximately an eight-fold reduction from 1997 and the lowest annual total since 1983. Although landings recovered somewhat in 1999, they have not exceeded 2,000 t since 1997, and have plummeted to record lows in the last 2 years (Table 1, Fig. 7). The dramatic decline in California's annual landings in recent years has resulted in a drop of its contribution to the total U.S. west coast pink shrimp catch. From 2000 to 2005, the California portion of the total U.S. pink shrimp catch was 8%, and only 1% and 3% in 2006 and 2007 respectively (Fig. 8) (PacFIN[5]).

The market value for pink shrimp landed in California also fluctuated dramatically from 1992 to 2007. The average annual ex-vessel price (price-per-pound) received by fishermen in the California pink shrimp fishery ranged from a high of $0.72/lb in 1995 to a low of $0.32/lb in 2003 (Table 1). The average annual price-per-pound rose considerably from 1993 to 1994 and stayed relatively high until 2001, when it fell to $0.34/lb and was less than $0.40/lb each

Table 1.—Characteristics of the California pink shrimp fishery from 1992 to 2007. Source: Market receipt data from CFIS (2008).

				Number of Vessels		
Year	Landings (t)	Ex-vessel revenue[1]	Price-per-pound	Active	Single-rig	Double-rig
1992	8,474	$16,880,933	$0.35	90	59	31
1993	3,233	$6,442,816	$0.36	74	50	24
1994	5,092	$10,152,951	$0.59	121	76	45
1995	2,624	$5,234,887	$0.72	114	72	42
1996	4,242	$8,466,195	$0.60	121	76	45
1997	6,351	$12,683,019	$0.41	108	60	48
1998	836	$1,670,492	$0.58	74	46	30
1999	1,924	$3,846,121	$0.53	68	34	34
2000	1,115	$2,230,852	$0.52	53	28	25
2001	1,592	$3,185,198	$0.34	38	15	23
2002	1,867	$3,737,900	$0.38	33	10	23
2003	974	$1,950,827	$0.32	13	1	12
2004	992	$1,988,454	$0.44	7	0	7
2005	859	$1,722,424	$0.48	12	1	11
2006	63	$127,297	$0.46	4	0	4
2007	289	$579,848	$0.47	5	2	3
Average	2,533	$5,056,263	$0.47	58	33	25

[1]Ex-vessel revenue from 1992 to 2007 was adjusted for inflation to year 2007 dollars.

[5]PacFIN. Pacific Coast Fisheries Information Network. Pac. States Mar. Fish. Commiss., Seattle, Wash. Retrieved 12 May 2008 (http://www.psmfc.org/pacfin/).

year through 2003. Since 2004, the average annual price-per-pound leveled out to an average of $0.46/lb from 2004 to 2007 (Table 1). The Oregon pink shrimp fleet experienced similar market value conditions this decade, although they received an average price-per-pound of $0.08/lb less than the California fleet from 2000 to 2006 (Table 1; ODFW[3]). Both fleets received an average price-per-pound of $0.47/lb in 2007. This price is significant for the Oregon fleet because it was $0.10/lb more compared to 2006, and the price is expected to continue increasing (ODFW[3]).

The Oregon pink shrimp fishery was recently certified in accordance with the Marine Stewardship Council's (MSC) Principles and Criteria for Sustainable Fishing, which is the world's first sustainable shrimp certification under this program (MSC[2]; Hannah[6]). However, the same increase in market value may not occur in California because the vessels that are permitted in California and land pink shrimp in California ports are not MSC certified.

The total annual ex-vessel revenue brought into California's economy from the pink shrimp fishery was computed by multiplying the total annual landings by the average annual price-per-pound. From 1992 to 1999, the total annual ex-vessel revenue averaged $8,172,000 (all revenue values have been adjusted for inflation to 2007 dollars). From 2000 to 2007, the total annual ex-vessel revenue averaged $1,940,000, which is a four-fold decrease compared to the 8-year period from 1992 to 1999 (Table 1).

The number of active vessels has generally reflected the trends in annual landings (Table 1, Fig. 7). The number of active vessels in the fishery has decreased steadily over the course of this decade. The use of double rig vessels in the entire U.S. west coast pink shrimp fishery has steadily increased since the 1970's because they are approximately 1.6 times more effective than single rig vessels (PFMC[1]). The percentage of double rig vessels in the California fleet

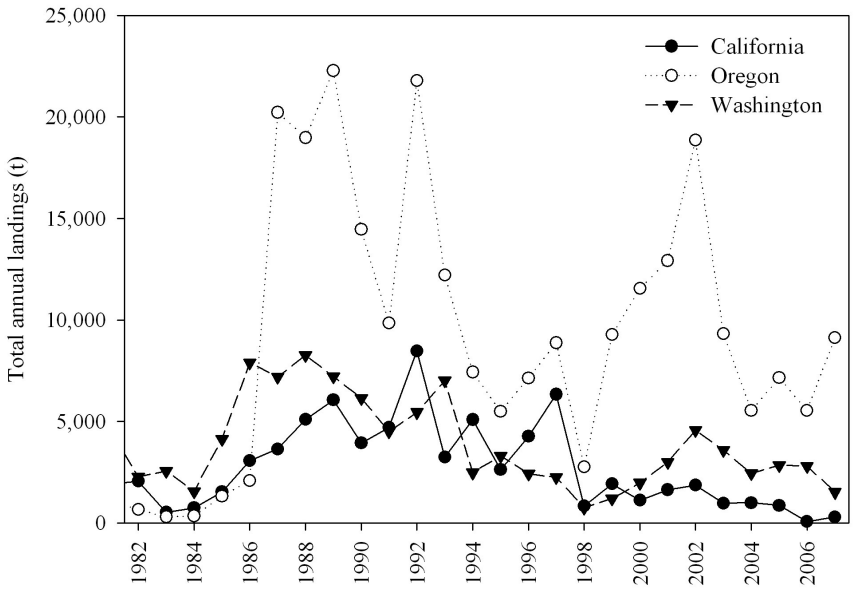

Figure 8.—Total annual commercial landings (t) of pink shrimp in California, Oregon, and Washington from 1982 to 2007. Source: CFIS (2008) and PacFIN(text footnote 5).

was 30% in the late 1970's (PFMC[1]), 38% and 39% during the 1980's and 1990's respectively, and 66% from 2000 to 2007 (Table 1). Although the entire California fleet consisted of double rig vessels in 2004 and 2006, there were two single rig vessels that participated in the fishery during the 2007 season (Table 1). Similarly, nearly all of the current pink shrimp vessels operating in Oregon and Washington are double rig (Hannah[6]; Wargo[7]).

Pink shrimp are landed in California primarily during the late spring and summer of each year in northern region ports (Point Conception to the Oregon border). From 1992 to 2007, nearly 83% of the total annual pink shrimp catch was landed in Eureka, followed by 12% in Morro Bay, 4% in Fort Bragg, and less than 1% in the combined port areas of Monterey, Bodega Bay, Santa Barbara, San Francisco, and Los Angeles (CFIS, 2008). In the most recent years of the fishery (2001–07), over 99% of the annual catch was landed in northern region ports, particularly the Eureka area, and no pink shrimp have been landed in ports south of Morro Bay since 2003 (Table 2).

There have been a significant number of inactive permits in the fleet in recent years for both management regions (Table 2). For example, in 2006, a record low of four of the 40 permitted vessels in the northern region actively participated in the fishery. Historically, both the number of permits sold and the percentage of active vessels are considerably less in the southern region compared to the northern region. This difference may be explained by the infrequent occurrence of pink shrimp in commercial quantities south of Point Conception.

A combination of factors may be attributed to the decrease in fishery production in terms of annual pink shrimp landings and active vessels in California in recent years (Tables 1 and 2). Two factors directly limited the size of the fleet, including the 2003 Federal vessel buyback program and the establishment of a limited entry fishery in the northern management region. The 2003 vessel buyback program reduced the fleet size in the California pink shrimp fishery. Of the 31 California pink shrimp permits relinquished from the buyback program

[6]Hannah, R. W., Oregon Department of Fish and Wildlife, Marine Resources Program, 2040 S.E. Marine Science Dr. Newport, OR 97365. Personal commun., Feb. 2008.

[7]Wargo, L. Washington Department of Fish and Wildlife, 1111 Washington St. SE, Olympia, WA 98501. Personal commun., Feb. 2008.

Table 2.—Number of permits sold, number of active vessels, and annual commercial landings (t) in the two management regions for the California pink shrimp fishery from 2001 to 2007. Source: CDFG License and Revenue Branch and market receipt data from CFIS (2008).

	Southern region[1]			Northern region[2]		
Year	Permits sold	Active permits	Landings (t)	Permits sold	Active permits	Landings (t)
2001	56	6	0.8	78	32	1,591
2002	57	7†	0.7	80	26†	1,866
2003	46	4	0.1	78	9	974
2004	38	0	0.0	47	7	992
2005	35	1†	0.0	43	12†	859
2006	21	1†	0.0	40	4†	63
2007	21	1	0.0	39	4	289
Average	39	3	0.2	58	13	948

[1] Refers to California waters south of Point Conception.
[2] Refers to California waters north of Point Conception.
† In 2002, 2005, and 2006, one vessel landed pink shrimp in both management regions.

Table 3.—The number of processing plants that bought pink shrimp in California from 1992 to 2007. Source: CFIS (2008).

Year	No.[1]	Year	No.[1]
1992	7	2000	7
1993	8	2001	4
1994	11	2002	2
1995	12	2003	3
1996	13	2004	2
1997	16	2005	2
1998	8	2006	2
1999	8	2007	1

[1] Number of processing plants that processed at least 1,000 lbs (0.45 t) of pink shrimp in California each year, according to CFIS (2008).

(Federal Register, 2003), 18 had landed at least 2 t of pink shrimp in California ports from 2000 to 2003. The northern management region was established as a limited-entry fishery in 2001, thereby creating a cap for the number of vessels allowed to participate (California Code of Regulations, 2008a). Moreover, the decrease in fishery production in recent years may also be attributed at least in part to environmental conditions that negatively affect recruitment (Frimodig et al., 2008; MSC[2]). As with other short-lived pandalid shrimp species, pink shrimp stocks are highly variable from year to year (Hannah, 1993; 1999; Perry et al., 2000; MSC[2]). Since the center of pink shrimp distribution occurs off the Oregon coast (Dahlstrom, 1970; PFMC[1]), the population may fluctuate more at the edges of their range such as California (Hannah[6]).

In addition to the fleet reduction from the 2003 vessel buyback program, only a fraction of the permitted fleet (<10%) in both the northern and southern regions have landed pink shrimp in California ports since 2004 (Table 2). The reduced fishery participation in California this decade may be largely price-driven. The average price-per-pound received by fishermen from 2000 to 2007 is $0.43 compared to $0.52 in the 1990's (Table 1), and may be the result of considerable changes that have occurred in the processing sector. From 1992 to 1997, there was an average of 11 processing plants in California that bought pink shrimp (Table 3). However, the number of processing plants has decreased nearly every year since 1997 reaching a low of only one in 2007 (Table 3). Fuel prices have also risen substantially in recent years. According to the U.S. Energy Information Administration[8], there was an 85% increase in diesel fuel sold in California from 2000 to 2007. The increased fuel prices have undoubtedly limited fishing participation as well as the trucking and distribution costs of the product. Additionally, many pink shrimp permit holders also hold Federal groundfish permits.

Fishermen may have targeted groundfish species such as Pacific hake over pink shrimp more in recent years because they fetched a higher price or were preferred by processors. Pacific hake is the most abundant groundfish off the U.S. west coast and supports a valuable domestic commercial fishery (Ressler et al., 2007). Lastly, market prices and demand for pink shrimp appear to be negatively affected through increased competition from other cold-water shrimp, especially the larger-sized northern shrimp, *Pandalus borealis,* harvested on the east coast of North America. The collapse of Atlantic cod, *Gadus morhua*, stocks in the North Atlantic Ocean during the late 1980's and 1990's led to a considerable surge in both biomass and fishing effort of northern shrimp (Lilly et al., 2000; Worm and Myers, 2003), and a subsequent increase in demand for northern shrimp in the U.S. and Canadian markets. The northern shrimp fishery is the most important cold-water shrimp fishery in the Northern Hemisphere in terms of commercial landings (Roberts, 2005; Lem, 2006), and the U.S. west coast pink shrimp fishery has a proportionally smaller impact on ex-vessel prices (Gallagher et al., 2004).

[8]U.S. Energy Information Administration. Retrieved 20 June 2008, from http://www.eia.doe.gov.

Catch per Unit of Effort

Pink shrimp CPUE was estimated for California permitted vessels fishing and catching pink shrimp in ocean waters adjacent to California by matching reported logbook effort and catch with market receipt data from 2000 to 2007 using a single-rig equivalency (SRE) conversion (PFMC[1]). This standardization accounts for the difference in effort between double-rig and single-rig vessels, so that direct comparisons can be made throughout the fleet. Logbook compliance in the California pink shrimp trawl fishery is expressed as the frequency of known fishing trips where the required logs are submitted to the CDFG (California Code of Regulations, 2008b). Compliance rates for the California pink shrimp trawl fishery ranged from 20% to 70% with an overall rate of 53% from 2000 to 2007 (Table 4). In contrast, the compliance rates for the limited-entry U.S. west coast groundfish trawl fishery operating in ocean waters adjacent to California averaged 87% from 2002 to 2007 (PacFIN[5]). Reported logbook effort (SRE hours) was adjusted using annual compliance rates to calculate the estimated total effort for each year from 2000 to 2007 (Table 4). However, CPUE was instead calculated from only those trips in which data for both logbook effort and official landings records were available.

Table 4.—CPUE, effort, compliance, and extrapolated effort in the California pink shrimp fishery from 2000 to 2007. Source: CDFG pink shrimp logbook data and market receipt data from CFIS (2008).

Year	CPUE (kg/SRE h)	Effort (SRE h)	Compliance percent	Est. effort (SRE h)
2000	315	1,823	53%	3,441
2001	436	1,449	55%	2,634
2002	372	2,667	52%	5,128
2003	291	1,303	34%	3,832
2004	340	2,094	67%	3,125
2005	289	1,383	53%	2,609
2006	239	43	20%	215
2007	478	179	70%	255
Average	345	1,368	53%	2,655

The statewide estimated trawl effort (SRE hours) for pink shrimp from 2000 to 2007 ranged from a high of 5,128 h in 2002 to a low of 215 h in 2006 (Table 4). Fishing effort in southern California occurred off the Santa Barbara coast and comprised less than 1% of the overall statewide effort over this period (Fig. 9a). Effort occurred primarily in northern California, including 39% in the Eureka area and 40% in the Crescent City area, while 19% occurred in the Morro Bay area, and less than 1% occurred in the Monterey area (Fig. 9a). Although seven landings of pink shrimp were made in the Bodega Bay and Fort Bragg areas, effort and CPUE were not estimated for these ports because only two of the seven trips were in the logbook database.

Annual pink shrimp CPUE (kg/SRE hour) from 2000 to 2007 ranged from a low of 239 kg/h in 2006 to a high of 478 kg/h in 2007 with an average CPUE of 345 kg/h (Table 4). Although logbook compliance was relatively high in 2007 at 70%, effort was low and the relatively high CPUE was influenced by one especially successful trip. There was a north to south gradient in CPUE, with the highest CPUE occurring in Crescent City (330 kg/h) and Eureka (386 kg/h), followed by the Morro Bay (302 kg/h) and Santa Barbara areas (28 kg/h) (Fig. 9a). The low CPUE for the Santa Barbara area may be due to unsuccessful exploratory trips during the 2000 and 2001 seasons, since only one trip landed more than 136 kg (0.14 t). The monthly average CPUE from 2000 to 2007 peaked in May (569 kg/h) and was lowest in September (199 kg/h), whereas monthly effort peaked in August (330 SRE h) (Fig. 9b).

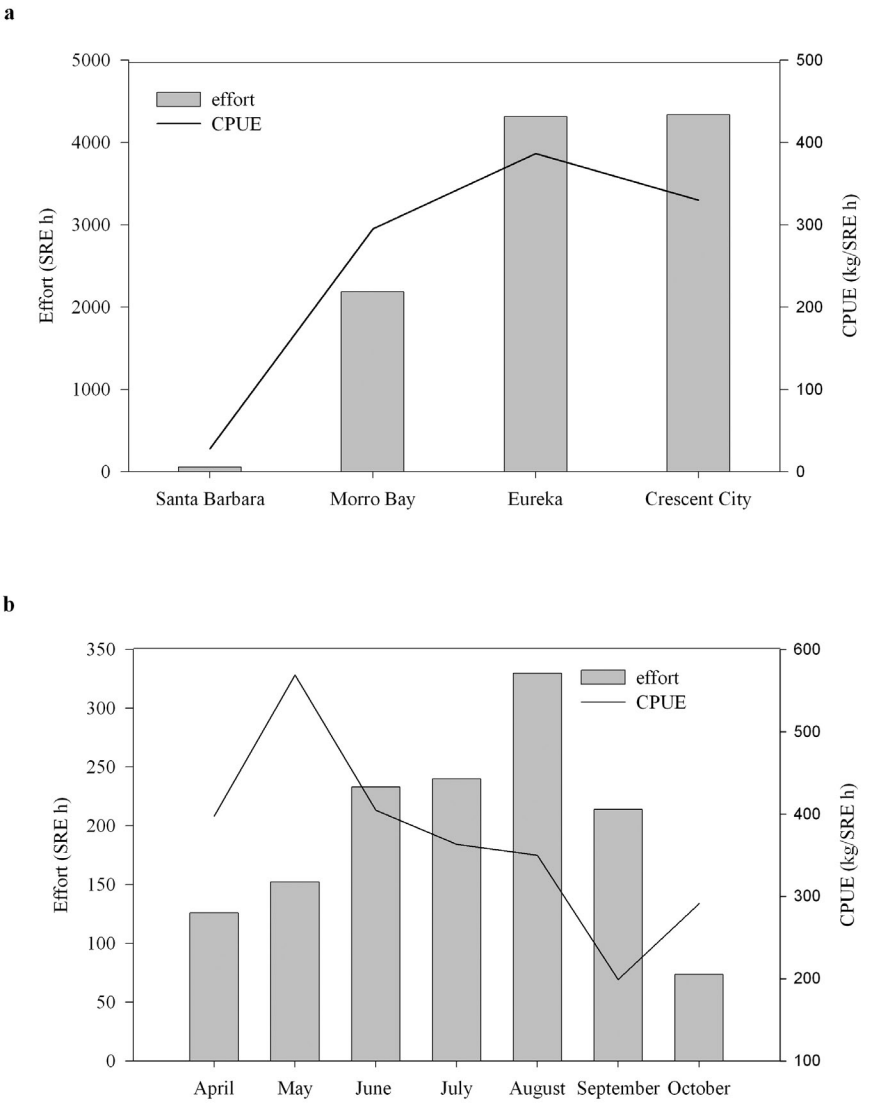

Figure 9.—Total trawl effort (SRE h) for pink shrimp and average CPUE (kg/SRE h) by geographic area from 2000 to 2007 (Fig. 9a). Average pink shrimp effort (SRE hours) and CPUE (kg/SRE hours) by month from 2000 to 2007 (Fig. 9b). Source: CDFG pink shrimp logbook data and market receipt data from CFIS (2008).

Overall, from a geographical context, fishing effort and CPUE were highest off northern California (Fig. 9a). Increased fishing effort on the north coast may be explained by the close proximity to processing plants and the most productive shrimp bed in the state. From 2001 to 2007, few pink shrimp processors occurred in the California marketplace (Table 3), and an average of 68% of the state's total pink shrimp landings was processed in Eureka (CFIS, 2008). The northern most and largest pink shrimp bed in California is the most productive bed historically. This bed extends from Eureka to approximately 10 km north of the California–Oregon border (Fig. 2), also making it the closest bed in California to the center of the species' range off the central Oregon coast (Dahlstrom, 1970; PFMC[1]).

Fishing effort and CPUE varied substantially on a monthly and yearly basis (Table 4, Fig. 9b). Overall fishing effort was mostly limited to summer months, and there was an overall trend of decreasing monthly CPUE from May to September. These trends are most likely explained by market conditions, the availability of the resource, or a combination of the two. The market for pink shrimp in California can be very restrictive in terms of when and where pink shrimp are purchased and processed. For example, in 2007, pink shrimp were landed exclusively in Eureka and processed, only from June to September, by a single buyer in Eureka (CFIS, 2008). The decreasing monthly CPUE trend is expected considering pandalid shrimp typically form dense seasonal aggregations that affect fishery catch rates (Balsiger, 1981). CPUE may also be related to pink shrimp availability which is dependent upon environmental conditions. For example, short-term CPUE for pink shrimp has been positively correlated with environmental factors, such as wind stress, water temperature, and salinity (Perry et al., 2000).

Bycatch

Trawl nets used in shrimp fisheries are typically built with mesh sizes smaller than those used to target benthic finfish species, and therefore can capture a wide size range of finfish as bycatch because some species commonly occur on shrimp fishing grounds. The amount and composition of bycatch in shrimp trawl fisheries around the world has been a concern for decades because approximately 85% of their total estimated bycatch is discarded (Alverson et al., 1994). Bycatch is either: 1) discarded because it is an unmarketable, prohibited, quota-managed, or regulatory discard species; or 2) retained and sold as marketable incidental catch. Shrimp and benthic finfish trawl fisheries account for over half of the total estimated discards in the world, and tropical shrimp trawl fisheries have the highest discard rates of any fishery in the world (Kelleher, 2005). Since the mandatory requirement of BRD's, discard rates in the U.S. west coast pink shrimp fishery are minimal compared to other worldwide shrimp fisheries (Table 5).

Managers involved in the U.S. west coast pink shrimp fishery, particularly those at the ODFW, have actively researched methods of reducing bycatch since the early 1990's. Although no data has been collected on BRD's directly from the California pink shrimp fishery, extensive research on the efficacy and differences among BRD types has been conducted by the ODFW (Hannah and Jones, 2007; Hannah et al.[9, 10]). The ODFW research results may apply to the California fishery since the vessels in the California fleet tend to use gear similar to that used by the Oregon fleet. The two most notable gear innovations resulting from the ODFW research include: 1) modifications to the traditional footrope, and 2) the use of BRD's in the pink shrimp fishery.

The Oregon pink shrimp fleet switched from the traditional "tickler chain" style of footrope to a roller/ladder style of footrope in the 1990's, which effectively reduced the bycatch of small rockfish and flatfish (Hannah and Jones, 2000). The footrope configurations are semi-pelagic, elevating the net approximately 30–90 cm above the seafloor, while the trawl doors and the center of the nets are in contact with the seafloor (Hannah[6]).

Since the early 1990's, a great deal of research has been focused on the development and experimentation of BRD's in shrimp and prawn trawl fisheries around the world (Kennelly, 2007). Pink shrimp fishermen and the ODFW began experimenting with BRD's in response to especially high abundances of Pacific hake during the 1990's on the shrimp grounds off California, Oregon, and Washington (Hannah et al.[9]).

A recent study by Hannah and Jones (2007) indicates the use of BRD's resulted in a 66–88% reduction in total fish bycatch. Bycatch percentages ranged from 32–61% prior to the use of BRD's, and decreased to an average of 8% when BRD's were used. The MSC certification recently applied to the Oregon pink shrimp fishery is attributed mostly to the use of BRD's. The pink shrimp trawl fishery off the U.S. west coast has recently been described as "one of the cleanest shrimp fisheries in the world" (MSC[2]). Additionally, the Monterey Bay Aquarium and Blue Ocean Institute have recently indicated that pink shrimp harvested off California, Oregon, and Washington is a good choice for environmentally conscious consumers (Roberts, 2005; Blue Ocean Institute[11]).

CDFG market receipt data from 1998 to 2006 indicate that the amount of marketable incidental groundfish landed with pink shrimp in California has declined from 11.5 t in 1998 to less than 0.3 t in 2002, and no marketable incidental groundfish was landed in subsequent years (Table 6). Significant reductions of marketable incidental groundfish were also demonstrated in Oregon and Washington (Table 6), thus removing the economic incentives to use less efficient BRD's (Hannah and Jones, 2007). Additionally, the use of BRD's in the U.S. west coast pink shrimp fishery

Table 5.—Top weight-based discard to landed target catch ratios by geographic region. Source: Alverson et al. (1994) and for Oregon coast only, Hannah and Jones (2007).

Shrimp trawl fishery	Pounds discarded per pounds of shrimp landed
Trinidad	32.4
Indonesia	26.5
Australia	24.5
Sri Lanka	24.3
U.S., Gulf of Mexico	22.7
Mexico	21.4
India, west coast	18.7
U.S., southeast coast	17.6
Persian Gulf	9.3
Brazil	9.0
India, east coast	8.4
Malaysia	6.6
Senegal	6.0
North Sea	3.2
Newfoundland	3.0
U.S., Oregon coast	0.1

[9]Hannah, R. W., S. A. Jones, and V. J. Hoover. 1996. Evaluation of fish excluder technology to reduce finfish bycatch in the ocean shrimp trawl fishery. Oreg. Dep. Fish Wildl., Mar. Resour. Program, Newport, Oreg., 46 p.

[10]Hannah, R. W., S. A. Jones, and K. M. Matteson. 2003. Observations of fish and shrimp behavior in ocean shrimp (*Pandalus jordani*) trawls. Oreg. Dep. Fish Wildl., Mar. Resour. Program, Newport, Oreg., 28 p.

[11]Blue Ocean Institute. 2005. Guide to ocean friendly seafood species score card: pink shrimp (retrieved 20 July 2007 from http://www.blueoceaninstitute.org/seafood/species/139.html).

has changed the bycatch species composition from commercially important large fish species to primarily smaller fish species with little or no commercial value (Hannah and Jones, 2007).

Rigid-grate excluders are widely considered to be the most effective of the three allowed BRD types in reducing groundfish bycatch (Hannah and Jones, 2007; Hannah et al.[9, 10]). Soft-panel excluders have been demonstrated to be effective in reducing groundfish bycatch, although excessive shrimp loss and other problems have also been associated with this design (Hannah et al.[9, 10]). Fisheye excluders were banned in Oregon and Washington in 2003 because they were found to be much less effective in excluding groundfish species when compared to rigid-grate and soft-panel excluders (Hannah and Jones, 2007; Hannah et al.[10]).

The current usage of BRD's in the California pink shrimp fleet was documented via a telephone survey we conducted in 2007 and 2008 with pink shrimp fishermen who participated (i.e. landed shrimp) in the fishery in at least one of the fishing seasons from 2005 to 2007. The 10 fishermen surveyed represented 58% of the active fleet in the 2005 season, 75% of the active fleet in the 2006 season, and the entire active fleet in the 2007 season. Results from the phone survey indicate that 90% of the current California fleet use rigid-grate excluders, and 10% use fisheye excluders (Table 7). In the current Oregon pink shrimp fleet, 93% use rigid-grate excluders, and 7% use soft-panel excluders (Table 7). BRD use appears to be similar in the Washington pink shrimp fleet, which typically consists of approximately 24 active vessels. WDFW contacted between 15 and 20 active fishermen during the spring and summer of the 2006 fishing season. All of the fishermen reported using rigid-grate excluders, except for one who reported using soft-panel excluders (Wargo[7]).

Bar spacing on rigid-grate excluders ranges from 29 to 51 mm in the current California pink shrimp fleet and 25 to 51 mm in the current Oregon pink shrimp fleet, with the average bar spacing being slightly larger in the California fleet (Table 7). The State of Washington is considering reducing the allowable bar spacing on rigid-grate BRD's from 51 to 37 mm, because the majority of the fishermen reported using bar spacing of 37 mm (Wargo[7]). Recent research suggests that decreasing the bar spacing to 19 mm or less on rigid-grate excluders may further reduce bycatch rates to well below 5% of the total catch by weight (Hannah and Jones, 2007).

None of the California fishermen contacted in the phone survey were active in the southern region. While there has essentially been no fishery in the southern region in recent years, it could become viable depending on the unit price-per-pound, market demand, and oceanic environmental conditions that affect availability of shrimp on the southern fishing grounds.

Additionally, the southern region pink shrimp fishery is designated by the state as an open access fishery with no cap on the number of potential permit holders. Pink shrimp fishermen in the southern region have historically used single rig vessels, and they have reported that soft-panel and fisheye excluders are preferred because rigid-grate excluders are crushed when the codend is wrapped on the net reel (McCorkle[12]). Hinged, or foldable, rigid-grate excluders have been designed to roll onto the stern reel of double- or single rig shrimp vessels (Fig. 10), and offer a possible alternative to soft-panel or fisheye excluder designs. Hinged rigid-grate excluders reduce the bending of the BRD when the net is reeled on top of it, and they can be constructed to fold either forward or backward (ODFW[13]). According to the 2007–08 CDFG phone survey, the majority of the California fishermen contacted reported using hinged rigid-grate excluders. Since 2003, both double- and single rig vessels in the Oregon pink shrimp fleet have successfully used hinged rigid-grate excluders (ODFW[13]).

Table 6.—Amount of marketable groundfish bycatch brought in for vessels in the Federal open access pink shrimp fishery for U.S. west coast states from 1998 to 2006. Source: Market receipt data from CFIS (2008) and PacFIN(text footnote 5).

State	Year	No. of vessels	Landings (t)
California	1998	21	11.5
	1999	19	13.4
	2000	13	3.1
	2001	8	0.7
	2002	2	0.3
	2003	0	0.0
	2004	0	0.0
	2005	0	0.0
	2006	0	0.0
Oregon	1998	53	130.0
	1999	51	187.1
	2000	42	120.0
	2001	33	77.3
	2002	28	31.1
	2003	3	1.2
	2004	3	1.9
	2005	2	0.1
	2006	0	0.0
Washington	1998	19	64.2
	1999	15	42.9
	2000	15	45.5
	2001	17	25.9
	2002	15	20.4
	2003	2	0.2
	2004	2	0.1
	2005	4	0.0
	2006	1	0.0

Table 7.—Summary of the results from the CDFG 2007/2008 telephone survey on BRD usage reported by active pink shrimp fishermen in the California fishery during the 2005 to 2007 fishing seasons compared with results reported by ODFW on active pink shrimp fishermen in the Oregon fishery during the 2007 fishing season ODFW (text footnote 3).

Item	California fleet	Oregon fleet
Percent using rigid-grate BRD's	90%	93%
Percent using fisheye excluders	10%	0%
Percent using soft-panel excluder	0%	7%
Average bar spacing (mm) on rigid-grate BRD's	37	32
Range of bar spacing (mm) on rigid-grate BRD's	29–51	25–51

Conclusions

To review the California pink shrimp trawl fishery from 1992 to 2007, we 1) analyzed fishery-dependent data, 2) evaluated gear developments and key management measures, and 3) interviewed fishermen who have actively participated in the California pink shrimp fishery in recent years. During the 16-year study period (1992–2007), the fishery has experienced multiple regulatory changes, several gear innovations, and a reduction in fishery production.

The contribution of California's landings to the total U.S. pink shrimp catch

[12]McCorkle, M. Southern California Trawlers Association, 6 harbor Way, Box 101, Santa Barbara, CA 9310. Personal commun., Jan. 2008.

[13]ODFW. 2004. 15th Annual pink shrimp review. Oreg. Dep. Fish Wildl., Mar. Resour. Program, Newport, Oreg., 8 p. (online at http://www.dfw.state.or.us/mrp/publications).

Figure 10.—Photograph of a hinged, or folded, rigid-grate BRD. Credit: Adam Frimodig, CDFG.

is currently negligible (PacFIN[5]). The current pink shrimp fishery is also minor compared to other fisheries within the state. In 2007, there were 21 California fisheries with greater landings than the pink shrimp fishery (CFIS, 2008). The reduction of fishery production, particularly in recent years, appears to be primarily driven by market conditions. However, the resource itself appears to be healthy, and the recruitment and abundance of pink shrimp appears to be mostly influenced by oceanic environmental conditions (Hannah and Jones, 1991; Hannah, 1993; 1999; Perry et al., 2000). Pink shrimp recruitment is predicted to be strong in the foreseeable future, particularly off southern Oregon and potentially northern California (ODFW[14]).

Fishermen participation in the California pink shrimp fishery has been low in recent years, although there is potential for growth if market conditions become more favorable. Although there is a cap on the number of vessels allowed in the limited entry northern region fishery (California Code of Regulations, 2008a), only a fraction of the fleet capacity has been active in recent years. Many pink shrimp permit holders also hold groundfish permits and switch their gear throughout the year depending on the more profitable or available target species. The demand for pink shrimp harvested off the U.S. west coast may increase based on the recent MSC certification of the Oregon pink shrimp fishery (MSC[2]) and the recent designation by the Monterey Bay Aquarium and Blue Ocean Institute of pink shrimp harvested off the U.S. west coast as a good choice for environmentally conscious consumers (Roberts, 2005; Blue Ocean Institute[11]). An increase in market demand could provide more incentive for California pink shrimp permitees to participate in the fishery.

The essential fishery data collected to monitor and accurately assess the California pink shrimp fishery has been reduced since the 1991 fishing season compared to historical data collection. CDFG commercial landing receipt data is a reliable record of catch, but trawl logbook records for the pink shrimp fishery are currently incomplete. Valid or complete logbook data are available prior to 1992 and from 2000 to 2007. Logbook data from 1992 to 1999 has gaps, due in part to low compliance by fishermen, that may affect the accuracy of spatial and temporal calculations of effort, location, intensity, and CPUE.

The pink shrimp logbook form for California is antiquated, and could be revised to reflect changes in the fishery. Logbook records could be improved by capturing information on BRD type and bar spacing on rigid-grate excluders as well as estimates of fish bycatch and shrimp discard. Adding these fields to the form would make the California and Oregon logbooks comparable (ODFW[3]; Hannah[6]). Moreover, instructions for recording fishing trip locations in the current logbook format are outdated. Fishery participants are instructed to record locations in Loran, despite the fact that most modern vessels utilize more accurate Global Position System based technology for navigation. This has resulted in inefficient and unnecessary reporting of trawl locations in Loran units, which is less accurate and more time consuming for CDFG staff to convert to latitude/longitude units.

The quality and accuracy of the logbook information provided by fishermen could also be improved through increased port-side communication, particularly in the two main ports that pink shrimp are landed (Eureka and Morro Bay). Increased port-side communication between biologists and fishermen would also help to clarify any confusing or missing logbook and market receipt data, provide an educational tool to keep fishermen better informed of current regulations and management issues, and increase fishermen compliance in submitting their logbooks. Port-side communication between biologists or samplers and fishermen in the Oregon pink shrimp fishery has proven to be very effective, which is evident by their

[14]ODFW. 2009. 20th Annual pink shrimp review. Oreg. Dep. Fish Wildl., Mar. Resour. Program, Newport, Oreg., 11 p. (online at http://www.dfw.state.or.us/mrp/publications).

excellent logbook compliance rates (Hannah[6]). Two recently implemented Federal management measures, mandatory observer coverage and the requirement of a vessel monitoring system aboard vessels fishing in Federal waters, will provide additional data on the pink shrimp fishery.

In addition to logbook deficiencies, the dockside biological market sampling program for pink shrimp in California ports ended in 1992. Reinstating the program would provide valuable fishery-dependent information on the health of pink shrimp stocks in California that is currently lacking, such as size, age composition, and sex ratio of the landed catch. The fishery is not currently operating at its full capacity, however if it were to operate near its full capacity, the sampling program is recommended. Fishery-independent investigations, such as determining the efficacy of BRD's used in the pink shrimp fishery, have already been done extensively by ODFW. Other research, such as documenting habitat impacts associated with bottom trawl gear, would also provide valuable fishery-independent information.

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