

**Informational Report:
Bycatch Reduction Devices Used in the Pink Shrimp Trawl Fishery**

**Report to the
California Fish and Game Commission**



Prepared by

**Adam J. Frimodig
California Department of Fish and Game
Marine Region
State Fisheries Evaluation Project**

(4/14/2008)

Executive Summary

The California Fish and Game Commission (Commission) has the authority to require one or any combination of Bycatch Reduction Device (BRD) types in the trawl fishery within California waters for Pacific ocean shrimp (*Pandalus jordani*), most commonly referred to as pink shrimp. The purpose of this report is to provide the Commission with the best available information about the BRDs used in the pink shrimp trawl fishery. The mandatory requirement for BRDs occurred in California in 2002, and in Oregon and Washington in 2003, resulting from an effort to minimize bycatch of overfished and quota managed groundfish species. Three types of BRDs currently satisfy the requirement for this device in the California fishery: 1) the Nordmøre grate (rigid-grate excluder); 2) soft-panel excluder; and 3) fisheye excluder; however, the design, specifications, and efficacy differ by BRD type. Although no data has been collected on BRDs directly from the California pink shrimp fishery, extensive research on the efficacy and differences among BRD types has been conducted by the Oregon Department of Fish and Wildlife (ODFW) since the mid-1990s.

Rigid-grate excluders are widely considered to be the most effective of the three BRD types at reducing groundfish bycatch. Over 90 percent of the Oregon pink shrimp fleet use rigid-grate excluders. The majority of the current California pink shrimp fleet also uses rigid-grate excluders, according to a telephone survey conducted by the California Department of Fish and Game (Department) in 2007-2008 of pink shrimp fishermen who have been active in the California fishery in recent years. Hinged rigid-grate excluders have been developed in recent years to reduce the bending of the BRD on vessels that employ net reels to stow and deploy their trawl nets, and they have been used successfully on both single- and double-rig vessels in Oregon. Soft-panel excluders have been demonstrated to be effective at reducing groundfish bycatch, although excessive shrimp loss and other problems have also been associated with this design. Fisheye excluders have been used in the California fishery in the past, but they were disapproved in Oregon and Washington in 2003 because they were found to be less effective at reducing groundfish bycatch than other designs. The reputation of the United States west coast pink shrimp fishery as one of the cleanest shrimp fisheries in the world is largely attributed to the effectiveness of BRDs at reducing groundfish bycatch. Nevertheless, BRD research and development is still a relatively new field and additional modifications and methods may further reduce bycatch rates in the pink shrimp fishery.

Introduction

In 2004, the Legislature approved Senate Bill 1459, adding Fish and Game Code (FGC) §8841 to statute, granting the Commission management authority over California's commercial bottom trawl fisheries and amending FGC §8842, which pertains specifically to management of the trawl fishery for Pacific ocean shrimp (*Pandalus jordani*), most commonly referred to as pink shrimp. At the Commission's November 2007 meeting, a member of the public raised a question regarding the regulations for BRDs in the California pink shrimp trawl fishery. The question posed was "why California regulations are not consistent with Oregon regulations, particularly because one type of BRD appears to be more effective than others." In the pink shrimp trawl fishery, BRDs are gear modifications that are designed to reduce the catch of non-target species, in particular, bottom dwelling fish (groundfish) that are found on the

same fishing grounds as the pink shrimp. At the Commission's February 2008 meeting, the Commissioners requested a brief report with background information about BRDs, including differences in design and efficacy among the various types used in the west coast pink shrimp trawl fishery. The Commission has the authority to require one or any combination of BRD types in the California pink shrimp trawl fishery (FGC §8841).

The purpose of this report is to provide the Commission with the best available information about the BRDs used in the pink shrimp trawl fishery. No data have been collected on BRDs directly from the California fishery. Information for this report is from BRD research conducted by ODFW, relevant scientific literature and informational documents published by academic, government agencies, and non-government organizations, as well as a telephone survey conducted by the Department in 2007-2008 of active pink shrimp fishermen in the California fishery in recent years.

Regulations and Descriptions of BRD Types

Regulations mandating the use of BRDs in the California pink shrimp fishery were adopted after the Pacific Fishery Management Council (PFMC) determined that canary rockfish (*Sebastes pinniger*) were overfished in 2000 (PFMC 2000). In California, the requirement of a BRD on trawl nets used in the pink shrimp fishery was approved in 2001 and permanently required in 2002 under Title 14 §120 of the California Code of Regulations (CCR). Three types of BRDs currently satisfy the requirement for this device in the California fishery: 1) the Nordmøre grate (rigid-grate excluder; 2) soft-panel excluder; and 3) fisheye excluder (CCR, Title 14 §120). The description and specifications for each are:

1) The rigid-grate excluder is generally a circular device constructed of aluminum with a series of vertical bars built into the frame which is positioned diagonally within the codend of the net at a 45° angle (Hannah et al. 1996, Hannah and Jones 2007). The vertical bars are spaced apart to allow shrimp to pass through the grate into the codend, whereas larger fish and other unwanted species are deflected by the grate and guided out of the trawl net through the escape opening (Figure 1). Most nets with a rigid-grate excluder also include a guiding panel constructed of mesh to funnel fish to the bottom of the net and forward of the BRD, thus minimizing the accumulation of shrimp in front of the BRD when fish are present (Isaksen et al. 1992, Hannah and Jones 2007) (Figure 1). In California, rigid-grate excluders must completely cover some portion of the net in diagonal cross-section, none of the openings between the bars of the grate (i.e., bar spacing) may exceed two inches, and the escape opening on the top of the net must be at least 100 square inches in surface area and positioned forward of the grate (CCR, Title 14 §120).

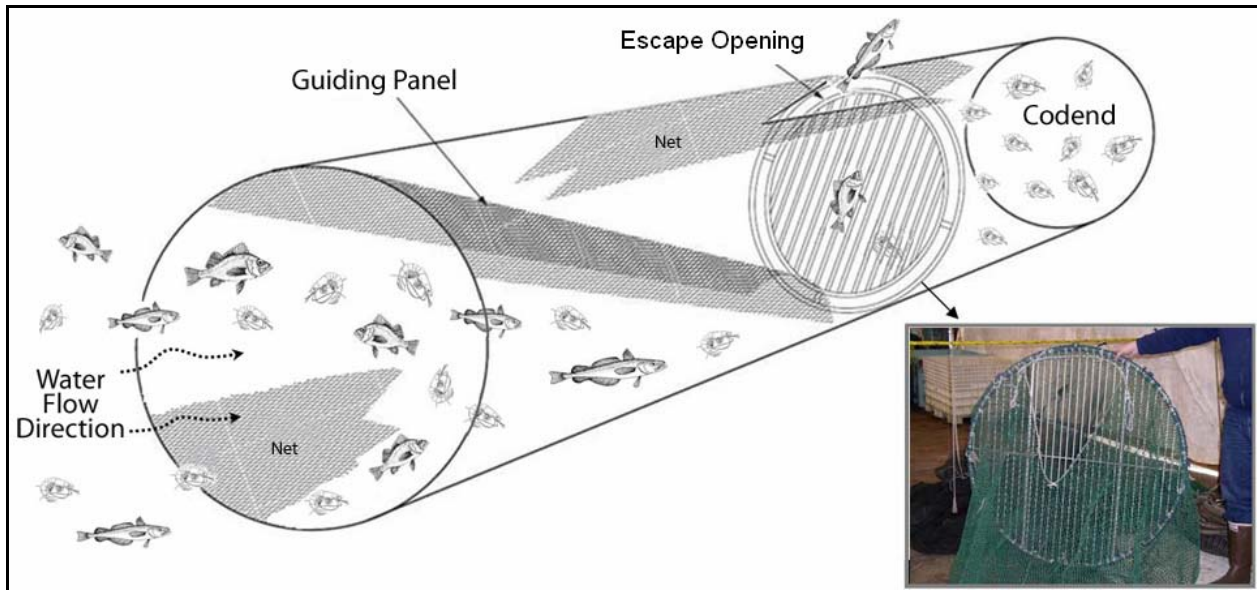


Figure 1. Diagram of a typical rigid-grate excluder. The diagram shows shrimp traveling through the BRD, while larger fish species are deflected by the BRD and guided through the escape opening. The inset picture is a rigid-grate excluder with one- and one-half inch bar spacing. Credit: Diagram and inset picture modified from Robert W. Hannah, ODFW.

2) The soft-panel excluder works in the same fashion as the rigid-grate excluder, and it is also built into the net at a 45° angle, but the device consists of a panel constructed of soft mesh rather than a hard grate (Figure 2) (Hannah et al. 1996, Hannah and Jones 2007). The gear specifications for soft-panel excluders in California are also similar to rigid-grate excluders. Soft-panel excluders must completely cover some portion of the net in diagonal cross-section, be constructed with mesh no larger than six inches, and the escape opening must be at least 100 square inches in surface area and positioned forward of the panel (CCR, Title 14 §120).

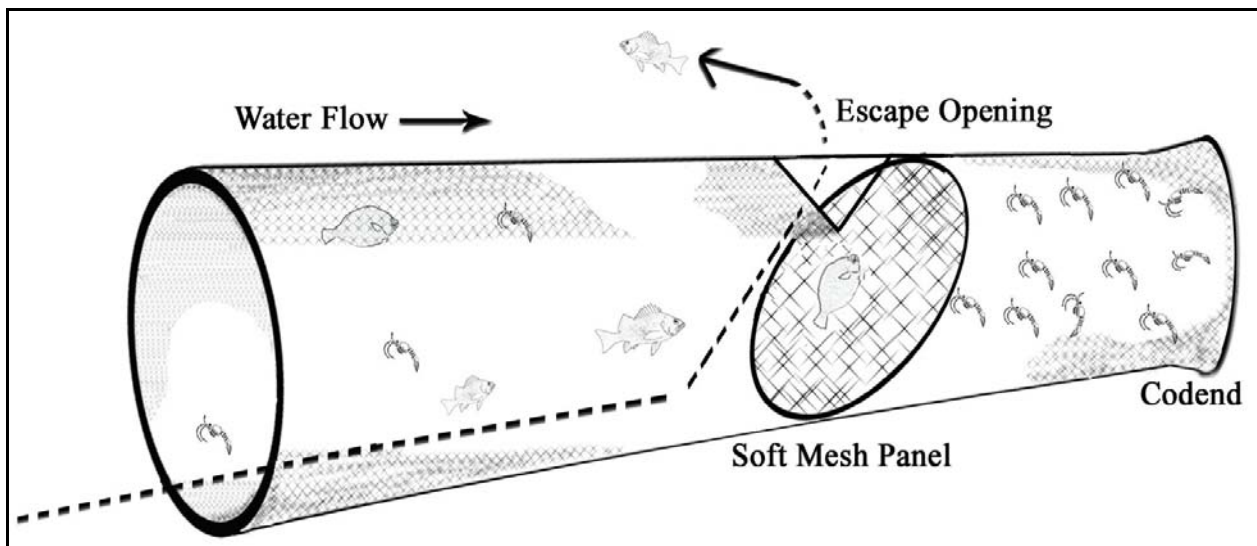


Figure 2. Diagram of a typical soft-panel excluder. The soft-panel excluder works similarly to rigid-grate excluder, but the device is made of soft mesh rather than aluminum. Credit: Brian Owens, CDFG.

3) The fisheye excluder generally consists of a steel or aluminum frame, or a combination of floats and weights secured to the top or side of the net creating an escape opening near the codend. A forward facing escape opening from the frame or float and weight configurations allow strong swimming fish to swim through the escape opening, while shrimp passively enter the codend (Figure 3) (Watson et al. 1999, Hannah et al. 2003, Eayrs 2007). This device differs from the other two approved BRD types because it does not have a soft-panel or rigid-grate inserted into the body of the net to guide fish away from the codend and out of the net. Instead, the device relies on fish to actively swim through the escape opening. In California, the fisheye excluder must be placed on top of the codend, and the escape opening must be forward facing and no less than six inches in height and no less than ten inches in width (CCR, Title 14 §120).

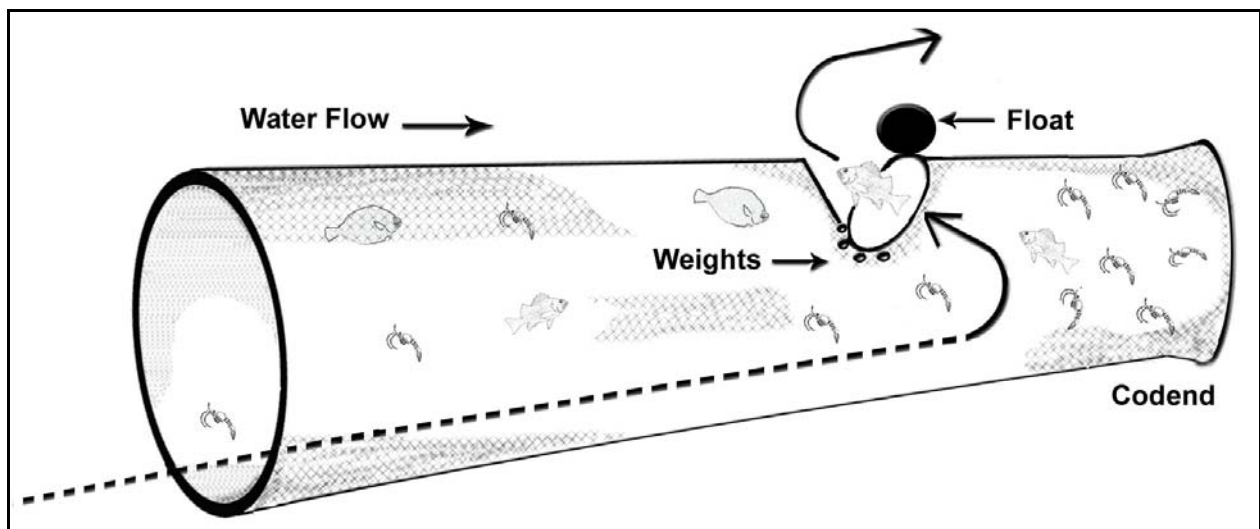


Figure 3. Diagram of a typical fisheye excluder BRD. The diagram shows shrimp and fish moving to the codend of the net. Strong swimming fish can exit through the escape opening of the net which is held open by floats and weights, while shrimp passively enter the codend. Credit: Brian Owens, CDFG.

All BRD regulations specified above for the California pink shrimp fishery apply to the northern (Point Conception to the Oregon border) and southern (Point Conception to the Mexico border) management regions (CCR, Title 14 §120).

Similar BRD specifications and regulations are in place for the pink shrimp trawl fisheries in Oregon (Oregon Administrative Rules [OAR] 635-005-0190) and Washington (Washington Administrative Code [WAC] 220-52-050). In both of these states, BRDs were required to minimize canary rockfish catches to meet allocation goals set by the PFMFC. In Oregon and Washington, BRDs were required inseason on August 1, 2001 and July 1, 2002, and then permanently required in 2003. Fisheye excluders were approved in Oregon and Washington in 2001 and 2002, but removed from the approved list 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 et al. 2003, Hannah and Jones 2007).

History of BRDs in the United States West Coast Pink Shrimp Fishery

Interest for BRDs in the United States west coast pink shrimp trawl fishery began in the 1960s when High et al. (1969) developed a method of separating fish bycatch from the shrimp catch with a modified otter trawl net. The design consisted of a large mesh cover that stretched across the entire opening (i.e., mouth) of the net, followed by several mesh panels that diverted fish and shrimp into separate codends. The codend that collected the fish was open at the terminal end, thus allowing fish to escape. However, this design was not very practical because it was difficult to construct and maintain, and too many shrimp escaped out of the opening in the fish codend (PFMC 1981). Over the next 20 years, other gear modifications and developments took precedence over BRDs, including changes to footrope and headrope configurations and a variety of on-deck sorting devices (PFMC 1981, Jones et al. 1996).

Since the early 1990s, a great deal of research has been focused on the development and experimentation of BRDs in worldwide shrimp and prawn trawl fisheries (Isaksen et al. 1992, Brewer et al. 1998, Watson et al. 1999, Broadhurst 2000, FAO 2005, Fonseca et al. 2005, Loaec et al. 2006, Eayrs 2007, ICES 2007, Suuronen and Sardà 2007, Watson 2007). During the early 1990s, ODFW researchers and the Oregon pink shrimp fleet began experimenting with BRDs again (particularly soft-panel excluders), in response to especially high abundances of Pacific hake (*Merluccius productus*) on the shrimp grounds off California, Oregon, and Washington (Hannah et al. 1996, Hannah and Jones 2000). Subsequent studies by ODFW built on earlier studies by further evaluating, testing, and developing more successful BRDs for pink shrimp trawls (Hannah et al. 2003, Hannah and Jones 2007).

Efficacy of Different BRD Types

Since the mandatory requirement of BRDs in the Oregon pink shrimp trawl fishery, discard rates have been nominal compared to other shrimp fisheries in the world (Table 1). Mandatory BRD use has also changed the species composition of the fish bycatch from commercially important large species to primarily smaller species with little or no commercial value (Hannah and Jones 2007). The pink shrimp fishery in Oregon was recently certified in accordance with the Marine Stewardship Council (MSC) Principles and Criteria for Sustainable Fishing, due in large part to the use of BRDs. This is the world's first sustainable shrimp fishery certification under the MSC certification program. The Monterey Bay Aquarium (Roberts 2005) and Blue Ocean Institute (Blue Ocean Institute 2005) have recently indicated that pink shrimp harvested off coastal waters of California, Oregon, and Washington is a good choice for environmentally conscious consumers.

The reputation of the pink shrimp fishery on the United States west coast as one of the "cleanest shrimp fisheries in the world" (MSC 2007) is due, in large part, to researchers at ODFW who have been investigating the efficacy and differences among various types of BRDs since the mid-1990s. Table 2 provides a summary of these studies. Hannah et al. (1996) evaluated the efficacy of three inch, five inch, and eight inch net meshes for soft-panel excluders and rigid-grate excluders with one inch bar spacing. They found that rigid-grate excluders with one inch bar spacing and three inch net mesh soft-panel excluders were the most effective in reducing groundfish bycatch. In a later study, Hannah et al. (2003) used underwater video observations to investigate

shrimp and fish interactions with several BRDs, including fisheye excluders, rigid-grate excluders with one inch bar spacing, and soft-panel excluders ranging from mesh sizes of three inches to eight inches. Rigid-grate excluders generally performed better than soft-panel and fisheye excluders. Fisheye excluders were somewhat effective, but effectiveness was highly variable depending on their placement on the net. A large number of problems and excessive shrimp loss were found to be associated with soft-panel excluders. Hannah and Jones (2007) evaluated the effectiveness of rigid-grate and soft-panel excluders, and various bar spacing intervals of rigid-grate excluders. They found that the use of BRDs since 2003 has resulted in a 66 to 88 percent reduction in total fish bycatch compared to pre-BRD levels, and rigid-grate excluders were more efficient than soft-panel excluders.

Table 1. Worldwide shrimp fisheries ranked by bycatch discard ratios. Data source: Alverson et al. (1994) and *Hannah and Jones (2007).

Shrimp trawl fishery	Pound discard per pound landed
Trinidad	32.4
Indonesia	26.5
Australia	24.5
Sri Lanka	24.3
U.S., Gulf of Mexico	22.7
Mexican	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

Table 2. Summary of ODFW studies on the efficacy of different BRD types.

Study	BRDs investigated	Conclusions
Hannah et al. (1996)	Rigid-grate (one inch bar spacing) and soft-panel (three inch, five inch, and eight inch mesh)	Rigid-grate, followed by three inch mesh soft-panel excluders were most effective. Rigid-grate excluders caused less shrimp loss than five inch and eight inch mesh soft-panel excluders.
Hannah et al. (2003)	Fisheye, rigid-grate (one inch bar spacing), and soft-panel (three- to eight inch mesh)	Rigid-grate excluders generally performed better than soft-panel and fisheye excluders. Fisheye excluders were somewhat effective but extremely sensitive to placement. Many problems and excessive shrimp loss were associated with soft-panel excluders.
Hannah and Jones (2007)	Rigid-grate (one- to one-half inch bar spacing) and soft-panel (four- to five- and one-half inch mesh)	The use of BRDs on trawl vessels since 2003 has reduced fish bycatch by between 66 and 88 percent. Rigid-grate excluders were more efficient than soft-panel excluders at removing fish bycatch with minimal shrimp loss. The most common bar spacing in rigid-grate excluders was one- and one-fourth inch, however three-fourths inch bar spacing or less may further reduce bycatch rates.

Rigid-grate excluders are widely considered to be the most effective of the three BRD types (Hannah et al. 2003, ODFW 2006, Hannah and Jones 2007). Over 90 percent of the Oregon fleet has used rigid-grate excluders since 2004 over the soft-panel excluders (ODFW 2008), which is the only other approved type of BRD in Oregon (OAR 635-005-0190) and Washington (WAC 220-52-050). ODFW recommends all Oregon shrimp vessels should use rigid-grate excluders because they are 'simply the most efficient BRD available' (ODFW 2008, Robert W. Hannah, ODFW, personal communication).

Usage of Different BRD Types

The Department conducted a telephone survey in 2007-2008 of the current California pink shrimp fleet. The fleet is considered current based on the fact that each of the fishermen contacted had participated (i.e., landed pink shrimp) in the fishery in any or all of the seasons from 2005-2007. The majority of the California fleet in each of the past three fishing seasons was contacted: 58 percent of the active fleet from the 2005 season, 75 percent of the active fleet from the 2006 season, and the entire active fleet from the 2007 season. Results from the phone survey indicated that 90 percent of the current California fleet use rigid-grate excluders, 10 percent use fisheye excluders, and no fishermen reported using the soft-panel excluder (Table 3). Similarly, 93 percent of the Oregon pink shrimp fleet used rigid-grate excluders during the 2007 season. Different from the California fleet, seven percent of the Oregon fleet used soft-panel excluders during the 2007 season (Table 3). Bar spacing on rigid-grate excluders in both the current California and Oregon pink shrimp fleets ranges from one to two inches, but the average bar spacing is smaller in the Oregon fleet (Table 3). Hannah and Jones (2007) suggested that three-fourth inch bar spacing may further reduce bycatch rates to well below five percent of the total catch by weight. It appears that

BRD use is similar in the Washington pink shrimp fleet. During the spring and summer of the 2006 fishing season, 15 to 20 active Washington fishermen were contacted by WDFW. The Washington fleet typically consists of approximately 24 active vessels at one time out of approximately 80 permits sold each year. Nearly all of the fishermen contacted reported using rigid-grate excluders, although one fisherman reported using a soft-panel excluder. The state of Washington is considering reducing the allowable bar spacing on rigid-grate BRDs from two inches to one and a half inches because the majority of the fishermen contacted reported using bar spacing of one and a half inches (Lorna Wargo, WDFW, personal communication).

Table 3. Summary of the results from the Department's 2007-2008 telephone survey on BRD usage reported by active pink shrimp fishermen in the California fishery during the 2005-2007 fishing seasons compared with results reported by ODFW (2008) on active pink shrimp fishermen in the Oregon fishery during the 2007 fishing season.

	California pink shrimp fleet (2005-2007 fishing seasons)	Oregon pink shrimp fleet (2007 fishing season)
Percent using rigid-grate excluders	90%	93%
Percent using fisheye excluders	10%	0%
Percent using soft-panel excluder	0%	7%
Average bar spacing on rigid-grate excluders (inches)	1.5	1.25
Range of bar spacing on rigid-grate excluders (inches)	1.1 - 2.0	1.0 - 2.0

The use of soft-panel excluders was not reported by any of the fishermen in the California fleet contacted in the Department's 2007-2008 phone survey (Table 3), although one fisherman preferred the soft-panel excluder but thought it was illegal in California. Another fisherman reported using the fisheye excluder despite experiencing poor performance. He indicated it was his only option, since rigid-grate excluders did not work with his single-rig vessel. None of the California fishermen contacted were active in the southern management region. Nevertheless, the phone survey results are likely to be representative of the entire, active California pink shrimp trawl fleet in recent years since over 99 percent of the annual landings from 2001 through 2007 occurred in ports located in the northern management region (CFIS 2008). The northern management region ranges geographically from Point Conception to the California-Oregon border. No landings have been recorded in ports south of Point Conception since 2003 (CDFG 2007, CFIS 2008).

Rigid-grate excluders are well suited for the northern California fleet because the double-rig vessels do not wrap their otter trawl nets on a reel but pile them on the deck after the load has been released. While there has essentially been no fishery in the southern region in recent years, it could become viable in the future depending on the unit price per pound, market demand, and oceanic environmental conditions. Pink shrimp fishermen in the southern region have historically used single-rig vessels, and have reported that soft-panel excluders are preferred because rigid-grate excluders can

get crushed when the codend is wrapped on the net reel. Fisheye excluders have also been used in the southern region in the past (Mike McCorkle, Southern California Trawlers Association, personal communication). Hinged, or foldable, rigid-grate excluders have been designed for the purpose of rolling onto the stern reel of double- or single-rig shrimp vessels (Figure 4), and this offers a possible alternative in situations where soft-panel or fisheye excluder designs were previously used. 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 2004). According to the Department's 2007-2008 phone survey, the majority of the California fishermen contacted reported using hinged rigid-grate excluders. Both double- and single-rig vessels in the Oregon pink shrimp fleet have successfully used hinged rigid-grate excluders since 2003 (ODFW 2004).



Figure 4. Photograph of a hinged, or folded, rigid-grate BRD. Photo credit: A. Frimodig, CDFG.

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