

LOAN COPY ONLY



*Reduction*  
**of SEABIRD**  
**ENTANGLEMENTS**

*in Salmon Drift*

*Gillnets*

*Through*

**GEAR**

*Modification*

*Edward F. Melvin  
in cooperation with  
The Puget Sound  
Gillnetters' Association*

**REDUCTION OF SEABIRD ENTANGLEMENTS  
IN SALMON DRIFT GILLNETS  
THROUGH GEAR MODIFICATION**

EDWARD F. MELVIN  
Marine Fisheries Specialist  
Washington Sea Grant Program  
Marine Advisory Services  
3716 Brooklyn Avenue NE  
Seattle, WA 98105

*In cooperation with*

THE PUGET SOUND  
GILLNETTERS' ASSOCIATION  
1402 West Marine View Drive, Suite C  
Everett, WA 98201

May 3, 1995

WSG AS 95-01

# INTRODUCTION

**S**eabirds and marine mammals are taken as bycatch in the commercial gillnet fisheries in Puget Sound and throughout the Pacific Northwest and Alaska. Of immediate concern is the incidental capture of marbled murrelets (*Brachyramphus marmoratus*). Marbled murrelets are listed as a threatened species in Washington state under the Endangered Species Act (ESA). There is concern that marbled murrelets are incidentally captured in both tribal and non-tribal gillnet fisheries targeting Fraser River sockeye and pink salmon from mid-July to early September, and Puget Sound pink, coho and chum salmon from early September to late November. Under the ESA an incidental take permit must be issued by the U.S. Fish and Wildlife Service before these commercial fisheries can proceed. Receiving such a permit is contingent upon the submission of a conservation plan to mitigate incidental take and the determination that the number of such takings is not sufficiently high to threaten the survival and recovery prospects of the species.

Other seabirds are protected under the Migratory Bird Treaty Act (MBTA), and some are inadvertently captured and killed by commercial net fisheries. Unlike the Marine Mammal Protection Act, the MBTA has no provision for the incidental capture of protected species—in this case seabirds—in net fisheries. Such takings are a misdemeanor offense and may result in seizure of the vessel. The U.S. Justice Department (U.S. Fish and Wildlife Service is the implementing agency) under MBTA requires the commercial net sector of the fishing industry to plan, develop and implement a conservation action plan to identify effects on migratory birds and to develop methods to reduce seabird takings. The action plan requires the industry: 1) to assess the status of seabird populations that may be experiencing conservation problems and the nature of their interaction with net fisheries; 2) to propose and implement modifications to net fishing gear intended to reduce encounters and/or allow seabirds to escape unharmed; and 3) to identify best fishing practices that reduce encounters with seabirds.

Puget Sound populations of wild coho and chinook salmon are in decline, and wild coho salmon are being considered for listing under the ESA. Biological concern for wild coho led to the closure of the coastal Washington commercial and recreational troll fisheries in 1994. The incidental capture of these species in Puget Sound gillnet fisheries targeting sockeye, pink and chum salmon has become a biological concern and a contentious topic between recreational and commercial in-

terests. Gillnet gear modifications that reduce the incidental capture of coho and chinook salmon, as well as seabirds, are highly desirable.

A pilot research program was carried out in the 1994 non-treaty Fraser River sockeye salmon drift gillnet fishery in areas 7 (San Juan Islands) and 7A (north of the San Juan Islands to the Canada border) of Puget Sound to initiate the development of gear modifications that might reduce or eliminate the incidental capture of seabirds in salmon drift gillnets. This study addressed items two and three (paragraph above) of the conservation action plan mandated by the U.S. Justice Department under the MBTA. The results of this research program are reported here. The original research proposal called for extending this work to the fall chum fishery in areas 10 (South Puget Sound) and 12 (Hood Canal); however, funds were not available to do so.

---

## **PUGET SOUND SALMON DRIFT GILLNETS**

Drift gillnets currently in use in Washington commercial salmon fisheries are made from single strand monofilament nylon (approximately 0.5 mm in diameter). Monofilament is effective for catching fish because light passes through the fibers making the net virtually invisible. The nets are 1,800 feet long, and the minimum mesh size and depth vary by fishery. Sockeye nets have a minimum mesh size of 5 inches and average about 200 meshes deep (approximately 60 feet). Skiff gillnetters tend to use shallower nets, 25 to 120 meshes deep. Chum nets have a minimum mesh size of 6.25 inches and average 180 meshes in depth (approximately 66 feet).

There are three basic components to a gillnet: netting, corkline and leadline. These components are sewn or "hung" using hanging twine, usually in three 600-foot sections, referred to as shackles. The shackles are sewn together into a complete net. The netting is machine made from monofilament strands of nylon into net units of a specified length and depth. The netting is suspended in the water column between the corkline and the leadline with 1,200 feet of netting hung to 600 feet of cork and leadline. Corks are the floats strung along the corkline, which are visible on the surface of the water. A typical Puget Sound gillnet has 600 corks per net (about one every 3 feet). They serve to float the net in the water column and to make the net visible to boaters. Different color floats delineate distance along the corkline (every 50 feet) by state law. The leadline is made of braided polypropylene with a Dacron cover over a flexible lead core.

## GOALS AND OBJECTIVES

**T**he goal of this pilot study was to begin to identify and develop methods to eliminate or reduce the incidental capture of seabirds in gillnet salmon fisheries without significantly reducing fishing efficiency. Nets with reduced fishing efficiency would have to be fished over greater periods of time to attain fish allocations for that fishery, possibly offsetting any reduction in seabird entanglement rates.

The objectives were:

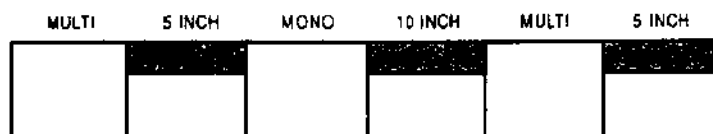
- To determine whether the incidental capture of seabirds in Puget Sound sockeye salmon and chum salmon drift gillnets might be eliminated or significantly reduced through gear modification and/or changes in fishery practices without significantly reducing the fishing efficiency of the nets.
- To determine whether these gear modifications and fishery practice changes also reduce the incidental capture of coho and chinook salmon and/or marine mammals.

## METHODS

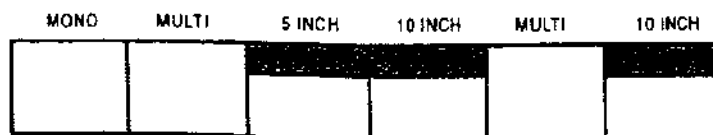
**S**cabird, marine mammal and fish entanglement rates were determined for three experimental gillnets fished in the 1994 Fraser River non-treaty sockeye salmon fishery in areas 7 and 7A of Puget Sound. The experimental nets consisted of two multi-paneled nets and a traditional monofilament net with red corks. All three nets were 1,800 feet in total length and 200 meshes deep (approximately 60 feet) and were constructed from new net material.

The multi-paneled nets were made up of six experimental net panels, each 300 feet long, and hung into a single net 1,800 feet in length (Figure 1). The multi-paneled nets incorporated four experimental net designs into a single net with two of the designs repeated in each net. Fishing multiple gear types in a single net was an innovation to test as many net modification ideas as possible with the funds available.

**F/V Nightstalker — Point Roberts**



**F/V Brendan D II — Salmon Banks**



**Figure 1. Configuration of multi-paneled nets.**

Following are the four gear modifications incorporated into the multi-paneled nets:

#### **Monofilament**

One panel in each net was made up of 5-inch-mesh monofilament netting, the traditional gear used in Puget Sound drift gillnet fisheries, to serve as a control.

#### **Multifilament**

Two panels in each net were made up of 5-inch-mesh three-strand multifilament netting (three strands of monofilament twisted together). Multifilament netting is more visible than monofilament in the water because the twisted fibers allow less light to pass through. Multifilament netting may reduce seabird and perhaps marine mammal entanglements because it is more visible.

#### **5- or 10-Inch-Mesh Poly**

Three panels in each multi-paneled net were made up of 5-inch-mesh monofilament netting with either 5-inch- or 10-inch-mesh opaque netting in the upper quarter of the net. The opaque netting used was No. 24 white polypropylene (poly). No. 24 poly twine (2 mm) is four times the diameter of monofilament nylon (0.48 mm). This heavy, opaque material in the upper 15 feet of the net is highly visible to birds, mammals and fish. Birds and mammals are likely to see this material readily and avoid the net; sockeye may dive and be captured in the nearly invisible monofilament below the heavy twine. This configuration may also reduce the incidental capture of coho salmon, which tend to occur higher in the water column than sockeye salmon and are more likely to swim laterally to avoid the net. The 10-inch-mesh poly netting may be sufficient to stimulate avoidance by birds, mammals and fish, and may be large enough to allow birds to pass through.

#### **Third experimental net**

The third experimental net was a 1,800-foot monofilament net with red corks instead of traditional white corks. Its purpose was to determine whether cork color was related to seabird entanglements. Some fishers have suggested that seabirds are attracted to white corks and that darker-colored corks might reduce seabird entanglements.

The nets were constructed and fished by volunteers from the Puget Sound Gillnetters' Association. The three experimental nets were fished in most sched-

uled openings for non-treaty gillnets in areas 7 and 7A. A multi-paneled net with two 5-inch poly panels and one 10-inch poly panel was fished by the *F/V Nightstalker* in Area 7A (Figure 1). The other multi-paneled net with two 10-inch poly panels and one 5-inch poly panel was fished by the *F/V Brendan D II* in Area 7. The monofilament net with red corks was fished by the *F/V Seeker* in Area 7.

Trained observers aboard each vessel recorded the following data for each set:

- Seabird and marine mammal numbers by species in an area 100 meters around the corkline as it was deployed and throughout each set (sightings).
- Seabird and marine mammal numbers by species in an area within 10 meters of the corkline throughout the set (encounters).
- Seabird and marine mammal entanglements and fish catch by species and location in the net.
- Several physical variables (time, weather, tide, depth, date, visibility, sea state, distance from shore, and location).

The purpose of this program was to identify gear modifications that are likely to reduce or eliminate the incidental capture of seabirds in drift gillnets for further study, and to eliminate gear alternatives with little merit. This study was not intended to be conclusive, but rather to be a pilot project for more in-depth research.

Given the limited scope of this research program, statistical analyses of the resulting data were inappropriate. The sampling program was limited by fiscal resources, the number of experimental nets available, bird and fish abundance, and the number of scheduled fishery openings.

# RESULTS AND DISCUSSION

## **EFFORT**

Three fishing vessels fished the three experimental nets a total of 16 fishing days completing a total of 62 full net or 357 panel sets (Table 1). (A panel set is defined as the deployment and retrieval of a 300-foot gear unit or panel within a full 1,800 foot gillnet). Fishing effort was less than expected due to generally poor fishing across the U.S. Puget Sound sockeye salmon fleet.

The *F/V Nightstalker* fished a multi-paneled net in the Birch Point-Whitehorn Point section of Area 7A, approximately 3 to 4 miles offshore. It fished a total of eight fishing days, completing 22 full net sets or 154 panel sets.

The *F/V Brendan D II* fished a multi-paneled net in the Salmon Banks area of Area 7, southwest of San Juan Island, over two miles from shore. After the closure of Area 7 to protect coho stocks in mid-August, it fished one opening in area 7A north of Sucia Island. It fished a total of five fishing days, completing 27 full net sets or 125 panel sets.

The *F/V Seeker* fished a monofilament net with red corks in the Strawberry Point area of Area 7, 0.25 to 2 miles off the west shore of Cypress Island. It fished three days, completing 13 full net sets or 78 panel sets.

## **SEABIRDS**

Seabird encounters (sighted within 10 meters of the corkline) occurred in 15 of 62 full net sets (24 percent) or 90 of 357 panel sets (25 percent; Table 1). (A seabird encounter along any part of the full net was considered an encounter for each panel in that net.) Encounters were primarily with common murre. Other net encounters were with either unidentified alcids or rhinoceros auklets. All seabird encounters occurred in the first two fishing days of the season, August 3-4 and August 10-11, with the exception of one encounter August 19. (A fishing day usually begins the evening of one day and ends early the next morning.)

A total of 11 seabirds were entangled in the three experimental gillnets (Table 1); all were common murre (Table 2). In the multi-paneled nets, three common murre were entangled in monofilament netting and two common murre were entangled in the multifilament netting for a total of 5 murre (Table 2). These entanglements occurred in three different full-net sets or four different panel sets. In one case two common murre were taken in a single monofilament panel. No sea-

Fishing Vessel	Nightstalker	Brendan D II	Seeker	Totals
Net type	multi panel	multi panel	mono/red corks	-
Area	7A	7	7	-
Location	Point Roberts	Salmon Banks	Strawberry Point	-
Days fished	8	5	3	16
Total number of full net sets	22	27	13	62
Total number of panel sets	125	154	78	357
Sets with bird interactions	5	6	4	15
Sets with bird entanglements	2	1	2	5
Total bird entanglements	4	1	6	11
Bird entanglements per set	0.18	0.04	0.46	0.18
Total sockeye	387	220	173	780
Upper 50 meshes (% of total)	57 (15%)	79 (36%)	133 (77%)	269
Lower 150 meshes (% of total)	330 (85%)	141 (64%)	40 (23%)	511
Sockeye per panel set	3.1	1.4	2.2	2.2
Total coho	0	2	0	2
Total chinook	3	9	2	14

**Table 1. Data summary table**

birds were entangled in any part of the panels with 10- or 5-inch opaque netting in the upper portion of the monofilament net.

Six common murres were entangled in the monofilament net with red corks, yielding an entanglement rate of 0.46 seabirds entangled per set. The entanglements occurred in two of the 13 full-net sets or five of the 78 panel sets: one murre in one full-net set and five in the other. There was no evidence to suggest that seabirds were avoiding red corks. The seabird entanglement rate study carried out by the Washington Department of Fish and Wildlife in the non-treaty drift gillnet fishery in Area 7 estimated the entanglement rate of traditional monofilament nets with white corks at 0.49 seabirds per full-net set (Erstad et al., 1994). Given the similarity of entanglement rates between monofilament nets with red and white corks and no apparent avoidance of red corks by seabirds, monofilament nets with red corks do not appear to be a suitable alternative to monofilament gillnets with white corks.

Analysis of entanglements by time of day and tidal state are limited by the few entanglements observed and the fact that most openings occurred from early to late evening until early the following morning. Entanglements occurred at all times of day (daytime, nighttime, and the morning and evening change of light) and at ebb and flood tides (Table 2). All but two birds were entangled on the first fishery opening, August 3-4.

Sets with entanglements were rare. Of the 357 panel sets made by all three experimental nets only nine (2.5%) of these sets entangled birds (Figure 2). Of the 90 sets with observed seabird encounters, eight of these (9%) entangled seabirds. In all but one set with entanglements, seabirds were sighted within 10 meters of the net.

---

## **MARINE MAMMALS**

One harbor seal was entangled in the multifilament panel of the multi-paneled net fished off Point Roberts. No other marine mammals were entangled.

---

## **SOCKEYE SALMON**

Fishing success across all gear types was relatively low in the 1994 Puget Sound sockeye fishery due to the sockeye ocean migration pattern. Eighty-five to 90 percent of Fraser River-bound sockeye migrated to their spawning grounds via Johnstone Straits (North Vancouver Island) leaving few fish available to the fish-

No. Murres	Panel Type	Area	Location	Date	Time of Day	Tide
1	multi	7	Salmon Banks	8/19/94	pm COL*	ebb
2	mono	7A	Point Roberts	8/4/94	am COL	ebb
1	multi	7A	Point Roberts	8/4/95	am COL	ebb
1	mono	7A	Point Roberts	8/10/94	nighttime	flood
1	mono/red corks	7	Strawberry Point	8/3/94	daytime	flood
1	mono/red corks	7	Strawberry Point	8/3/94	daytime	flood
1	mono/red corks	7	Strawberry Point	8/3/94	daytime	flood
1	mono/red corks	7	Strawberry Point	8/3/94	daytime	flood
2	mono/red corks	7	Strawberry Point	8/3/94	daytime	flood

\*COL indicates change of light in the morning (am) or the evening (pm).

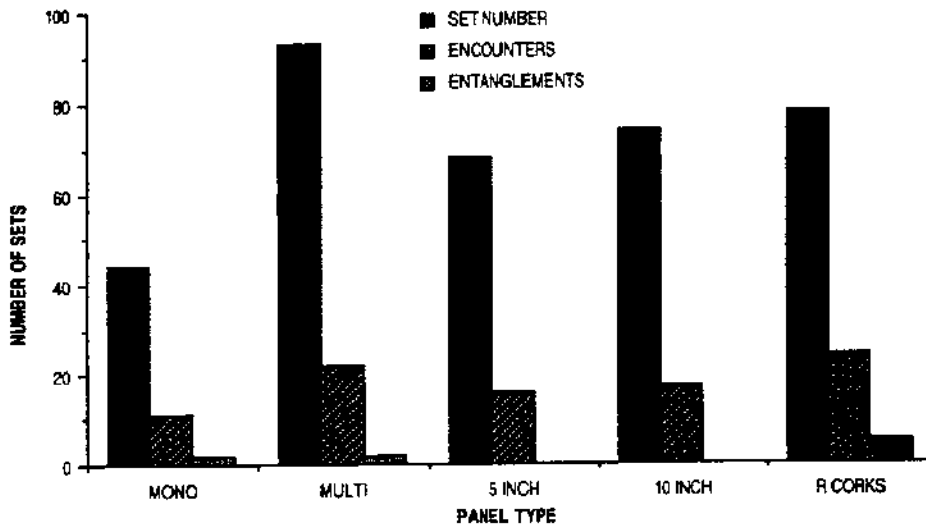
**Table 2.**  
Seabird entanglements per panel set by panel type, area, location, date, time of day and tidal state.

ery in Puget Sound. Fewer fish and allocation disputes with Canada led to more and longer fishery openings and poor catch rates. The vessel owners who volunteered their vessels for this study found it difficult to offset their costs under these conditions, yielding fewer fishing days than expected for the experimental gear program. Of 357 panel sets made by the three experimental nets, 155 panel sets (43 percent) did not catch fish.

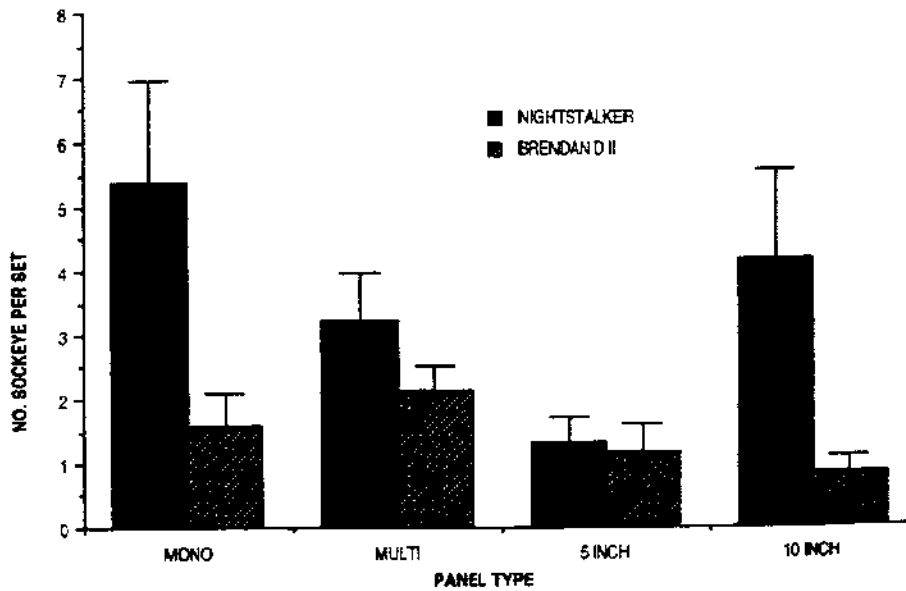
Catch rates varied by area, the highest occurring off Point Roberts (3.1 sockeye per panel set) and the lowest off the Salmon Banks (1.4 sockeye per panel set) with an average of 2.2 sockeye per panel set for all experimental nets (Table 1).

The monofilament net with red corks caught sockeye at a rate of 2.2 sockeye per panel set. The vessel operator fishing this net indicated that the red corks were difficult to see, especially at night, leading to difficulties in operating the gear. As noted earlier, the monofilament net with red corks caught seabirds at a rate similar to other monofilament nets operating in area 7 and does not appear to provide a suitable alternative to the monofilament nets with white corks traditionally used in this fishery.

The fishing efficiency of each of the four panel types varied between the two experimental multi-paneled nets (Figure 3). The monofilament and the 10-inch



**Figure 2. Total number of panel sets, total number of sets with seabird encounters, and total number of sets with seabird entanglements by experimental gear type.**



**Figure 3. Comparison of sockeye caught per set between the F/V Nightstalker (Area 7A) and the F/V Brendan D II (Area 7).**

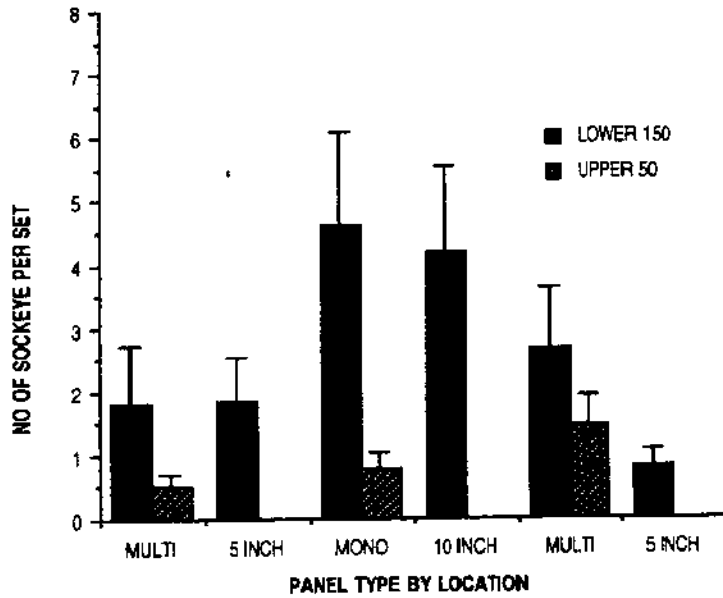
poly panels were most effective (5.4 and 4.2 sockeye per set, respectively) off Point Roberts with most of the fish (85 percent) caught in the lower 150 meshes of the panels (Table 1 and Figure 4). In contrast, the multifilament and the monofilament panels (2.1 and 1.6 sockeye per set, respectively) were most effective on the Salmon Banks (Figure 2) with a more even distribution in catch between the upper 50 meshes (36 percent) and lower 150 meshes (64 percent) of the net (Table 1 and Figure 5).

The opaque mesh itself did not catch fish except when in a single case a chinook salmon was caught in 5-inch poly mesh during a nighttime set (between midnight and 1:30 a.m.).

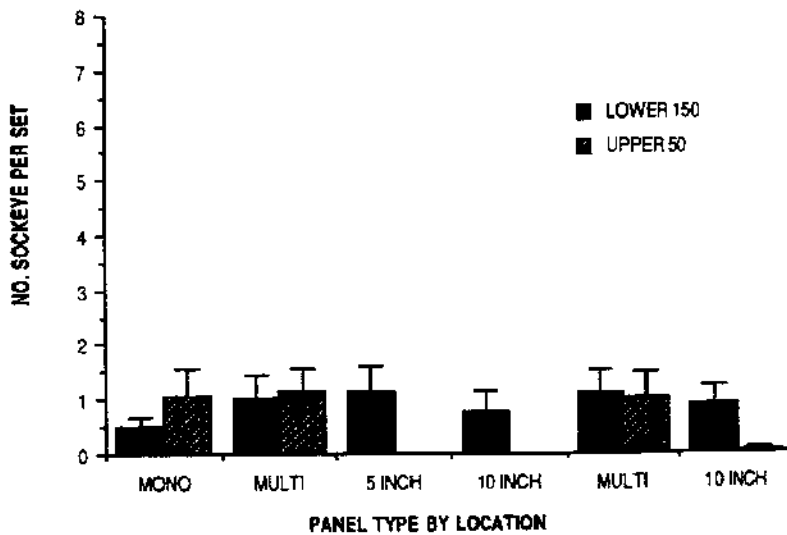
Relatively poor fishing conditions and greater wind exposure on the Salmon Banks, and the interaction among different gear panels based on their placement relative to each other are the most likely reasons for the difference in catch between the two multi-paneled nets. Catch rates on the Salmon Banks may have been sufficiently poor that too few fish interacted with the net to allow meaningful comparisons of sockeye catch rates between the panel types. Also, fishers report that in the rougher waters of the Salmon Banks fish tend to be higher in the water column. This observation is consistent with the relatively higher catch rates in the upper portion of the Salmon Banks net.

In order to avoid placement effects of the different panel types on the catch rate of adjoining panels, we planned to randomize the placement of panels in each net before each opening. Poor fishing conditions and extended openings provided no opportunity to continually change the position of net panels relative to each other. Evidence exists in the literature (Larkins, 1963) that salmon will lead or follow along more visible netting and be captured in adjoining netting that is less visible. On the Salmon Banks, where fish were higher in the water column, it is possible they were led into the monofilament and multifilament netting after encountering the more visible poly netting in adjoining panels, thus creating interaction among the panels based on their placement. This would have been less of a factor in the Point Roberts area, where fish were lower in the water column.

For these reasons it is assumed that the results from the Point Roberts net are most representative of the relative catch efficiency of the four experimental net panels. Panels with 5-inch poly in the upper net deployed poorly off the net reel and deployed slowly in the water column to a vertical fishing position. Furthermore, due to the amount of poly material in a 5-inch mesh configuration, their bulk is too great for a full 1,800-foot net to fit on a typical net reel used in the fishery.



**Figure 4. F/V Nightstalker sockeye catch per set in the upper 50 meshes and lower 150 meshes by panel type (monofilament, multistrand, 5- or 10-inch opaque netting in upper net) and panel location.**



**Figure 5. F/V Brendan D II sockeye catch per set in the upper 50 meshes and lower 150 meshes of the net by panel type (monofilament, multistrand, 5-inch or 10-inch opaque netting in the upper net) and panel location.**

These observations and the fact that 5-inch poly panels caught fish at consistently low rates in both nets strongly suggest that they are not a suitable alternative gear for this fishery.

Ten-inch poly panels, on the other hand, deployed smoothly off the net reel and in the water. Given that the 10-inch poly panels caught fish at rates very similar to monofilament in the Point Roberts net (4.2 and 5.4 sockeye per panel set, respectively) and did not entangle birds in both experimental multi-panel nets, 10-inch poly in the upper portion of the net may provide a suitable alternative gear to monofilament nets.

Because multifilament nets caught seabirds and a harbor seal, they do not appear to provide a suitable alternative to monofilament netting for this fishery. The potential use of 10-inch poly in the upper portion of a monofilament net as an alternative to monofilament netting in Puget Sound drift gillnet fisheries should be tested further using a robust sampling design in multiple Puget Sound salmon gillnet fisheries before new gear regulations are implemented.

---

### **COHO SALMON**

The sockeye fishery in Area 7 was closed mid-season due to concern over the incidental take of coho salmon, leaving little opportunity to test the relative capture rate of coho salmon among the different experimental gears. Only two coho salmon were caught by experimental nets.

---

### **CHINOOK SALMON**

A total of 14 chinook salmon were caught in the three experimental nets and were distributed among all gear types tested. No analysis of relative capture rates was possible due to the small sample size.

## CONCLUSIONS

**S**eabird entanglements were rare, occurring in 2.5 percent of the experimental panel sets. Conclusive studies of the effect of different gear types on seabird entanglement rates require large sample sizes and should be focused in areas where seabird densities are high to maximize net encounters.

Monofilament gillnets with large (10-inch), opaque mesh in the upper portion of the net demonstrated the greatest potential as an alternative gear to traditional monofilament gillnets because they did not entangle seabirds or marine mammals and caught sockeye at rates similar to monofilament.

Multifilament nets may not offer a viable alternative to traditional gillnets because they caught birds at similar rates to monofilament nets and entangled one harbor seal.

Monofilament nets with 5-inch opaque netting in the upper portion of the net do not appear to provide an acceptable alternative to traditional monofilament nets. Although they did not entangle seabirds or marine mammals, they consistently caught fewer fish than the other gear types, they deployed poorly and, because of their bulk, they will not fit on net reels typically used in this fishery.

Monofilament nets with red corks do not appear to offer an alternative to monofilament gillnets with white corks because they entangled birds at similar rates, the corkline was difficult to see during fishing operations, and there was no behavioral evidence to support the contention that seabirds avoid red corks.

No conclusions were possible regarding differences in seabird entanglement rates between daytime and nighttime fishing or between tidal states for the gear types tested.

Coho and chinook salmon were captured too infrequently to test their capture rates among the experimental gears tested.

## LITERATURE CITED

- Erstad, Pamela, S. J. Jeffries, and D. J. Pierce. 1994. 1994 preliminary report for areas 7 and 7A Puget Sound fishery observer program: non-treaty sockeye gillnet fishery. Washington Department of Fish and Wildlife, 600 Capitol Way N., Olympia, WA 98501-1091
- Larkins, Herbert A. 1963. Comparison of salmon catches in monofilament and multifilament gill nets. *Commercial Fisheries Review*, Vol. 25, No. 5, pp. 1-11.

## ACKNOWLEDGMENTS

**T**his work was funded in part by a grant from the Washington Sea Grant Program, University of Washington, pursuant to National Oceanic and Atmospheric Administration Award No. NA36RG0071, and in part by the net industry. LFS Marine Supply in Bellingham coordinated donations from LFS, Inc., Samson Rope Co., Redden Net Co., Momoi Net Co., and Bao Long Float Co.

Volunteers from the Puget Sound Gillnetters' Association built the experimental nets. Jim Piercey and Peter Walton, of the *F/V Nightstalker*, Chuck Mason of the *F/V Seeker*, and Jim Norris of the *F/V Brendan D II* fished the experimental nets. Bruce Marston, Mike Cotton, Ed Melvin, and David Drummond worked as observers.

Lanny Pillatos, Puget Sound Gillnetters' Association, Terry Crump and Stew Ellison, LFS Marine Supply, Mike Mustain, fishing gear consultant, Dr. Jim Norris and Dr. Steve Mathews, University of Washington School of Fisheries, Jeffrey June, Natural Resource Consultants, and Bruce Sanford, Washington Department of Fisheries and Wildlife, contributed to the design and implementation of this research program.