Development of New Salmon-Excluder Trawl Designs on Bering Sea Pollock Catcher-Processors

Final Report

Pollock Conservation Cooperative
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Introduction

During the mid-1990s, the North Pacific Fishery Management Council (NPFMC) developed salmon-savings-area management measures to control the bycatch of Chinook and chum salmon in the Bering Sea and Aleutian Islands (BSAI) pollock fishery. These regulations established "wide-area" fishing closures at times and places when salmon bycatch had been highest. Despite these efforts, salmon bycatch in the BSAI pollock fishery increased (Table 1). Most of this bycatch occurs in the eastern Bering Sea (EBS) outer-continental shelf (OCS) and is thought to originate from river systems in western Alaska (NPFMC 2008b).

The recent bycatch increases do not appear the result of more time spent fishing for pollock. Rather, it seems that salmon abundance over the southeastern EBS increased markedly, especially since 2003-2004 (e.g., see Haflinger et al. 2007, Figures 4-7). One plausible explanation for the increase in salmon abundance on the pollock fishing grounds is the recent very warm period (2000-2005) in the Bering Sea. When ocean temperatures over the Bering Sea shelf are high, development of the pelagic portion of the food web is favored. Such circumstances can provide favorable ocean feeding and survival for all species of Pacific salmon. Because salmon are upper tropic-level consumers, these effects may appear with a short time lag. During 2008, bycatches of both Chinook and chum salmon approached historically low levels.

Table 1. Salmon bycatch in the BSAI pollock fishery by season, 1998-2008.

	- - - - Chinook - - - -			- - - Other (Chum) - - -		
Year	Total	A	B	Total	A	B
	- - - - Numbers of Salmon - - - -					
1998	51,322	15,193	36,130	64,042	4,002	60,040
1999	11,978	6,352	5,627	45,172	362	44,810
2000	4,961	3,422	1,539	58,571	213	58,358
2001	33,444	18,484	14,961	57,007	2,386	54,621
2002	34,495	21,794	12,701	80,782	1,377	79,404
2003	45,794	32,609	13,185	189,184	3,834	185,350
2004	51,696	23,093	28,603	440,472	422	440,050
2005	67,396	27,379	40,017	704,590	595	703,995
2006	82,694	58,438	24,256	309,643	1,332	308,311
2007	121,638	69,408	52,230	93,660	8,523	85,137
2008	19,477	15,501	3,976	14,982	320	14,662

Source: NMFS Alaska Region catch statistics, December 18, 2008.

Over the past several years the NPFMC has employed alternative methods to minimize salmon bycatch in the EBS pollock fishery. These focused mainly on implementing a series of weekly, rolling salmon "hot-spot" closures determined and enforced by industry. However, in 2009 the NPFMC will consider new measures for Chinook salmon that include an annual bycatch cap of 47,591 fish. Another alternative allows for a higher cap of 68,392 fish combined with an incentive program to minimize bycatch under all future conditions of pollock and salmon abundance. Acceptable incentive measures include rewards for high salmon bycatch performance and-or penalties for low performance (NPFMC 2008a,b).

Pollock-industry efforts to minimize salmon bycatch began in 2001, motivated in large part by low returns to rivers in western Alaska during 1999-2001 (salmon "crisis" years). These efforts continue today, and include: 1) development of new mid-water trawl designs intended to exclude salmon from the catch; 2) design and refinement of a salmon "hot-spot" closure program; 3) funding for DNA-based methods to uncover the stream-of-origin of salmon bycatch; and 4) for basic research about whether changes in climate and ocean temperature may have altered salmon feeding migrations and so contributed to higher salmon bycatch. Given expected changes in bycatch management, a functional salmon-excluder trawl could reduce the future cost of salmon bycatch.

Salmon-Excluder Trawl Design Evolution

Vessels fishing for pollock deploy wide-opening trawl nets designed to catch pollock in mid-water. First-generation "tunnel" and "funnel" salmon-excluder designs incorporated a relatively short tunnel, and a highly tapered, cone-shaped net, each suspended inside the intermediate section of an otherwise standard mid-water trawl. Several diamond-shaped escape portals (holes) were cut just behind where these nets attached to the trawl (as many as two located in the top of the trawl and perhaps additional holes on the sides). The designs attempt to exploit a belief that salmon are stronger swimmers than pollock, and possess instinctive behaviors triggered by changes in currents sensed along the lateral line. Initially, the objective was to find a design that created a current-change just behind the inner net as a means to stimulate the captured salmon to swim forward (as in preparation for a jump). This was expected to take the salmon forward along the outside of the inner net and toward the escape portals (Anonymous 2004).

Reduced-scale tunnel and funnel designs were tested in a tow-tank, and then prototype nets were evaluated on the catcher vessels F/V Vesteraalen and F/V Auriga during the 2003 pollock B-season. The ability of the net to exclude salmon while retaining pollock was investigated by placing recapture bags over the escape portals, and initial trials indicated that salmon escapement was about 10-12 percent with pollock escapement at just 1-2 percent (Gauvin and Gruver 2008). However, testing also revealed that the designs increased the drag of the net, which reduced door spread and the size of the fishing circle. In addition, high catch rates often caused the shape of the net to become distorted due to an accumulation of pollock "pinned" along the leading edge of the inner net. During testing, these distortions (bulges) resulted in tears and fishing disruptions. During 2004 and 2005 significant redesign and testing effort was allocated to improving the designs with very little success. The design flaws threatened to block widespread adoption of these salmon-excluder trawls by pollock fishermen (Gauvin et al. 2003, 2004).

During 2006 further development produced a second-generation "flapper" design that employed a short, inverted, U-shaped section of diamond-mesh webbing to serve as a collapsible inner liner (Figure 1). The "flapper panel" functions somewhat like the one-way valve often found in the discharge line of a sump pump (anti-backfill or flapper valve). At speeds employed during fishing (about 4 knots), the panel is held close to the outer webbing and covers the escape portals (open position). The rear portion of the panel is weighted with lead line such that it will collapse (close) at slower speeds (about 1-1/2 knots). As envisioned, during fishing the vessel slows down periodically to close the flapper and provide salmon with an opportunity to escape. As the flapper panel collapses it creates a "false bottom" that blocks fish passage forward and so guides advancing salmon to the escape portals. Preliminary results from this second-generation design show escapement rates of up to 40 percent, and further testing to investigate factors suspected responsible for the high rates was conducted during the 2008 B-season (Gauvin and Gruver 2008, Figure 2).

Over the past four years development, testing, and refinement of the salmon-excluder designs occurred mainly aboard pollock catcher vessels. These vessels range from 30-60 meters in length and deliver pollock to processing plants on the Aleutian Islands. However, about half of the BSAI pollock catch is by larger vessels that catch and process pollock at sea. These vessels range from 80-120 meters in length, have more horsepower and use larger nets than catch-only vessels, and carry about one hundred workers to process the catch. Mainly due to the high cost of idling a processing plant while on the grounds, it was not practical to carry out design development on catcher-processor vessels.

But now a point has been reached in the development of the flapper design where testing can be carried out on a catcher-processor vessel with little chance of fishing being disrupted. That is to say, a point has been reached where further design refinement and adoption industry-wide would benefit from a scaling-up and transfer of flapper design testing to the catcher-processor vessels. To gain this benefit, the project described here was proposed and carried out. Project objectives include: (1) to evaluate the effects of the flapper panel on pollock fishing efficiency; and (2) to determine if it is possible to operate the flapper panel such that its position can be controlled by changing vessel speed and-or the depth of the net.

Materials and Methods

As noted above, preliminary results from prior testing of the flapper design showed some high salmon escapement rates, but also that achieving good performance consistently was not possible (Gauvin and Gruver 2008). Factors thought to influence escapement include: the proximity of the flapper panel and escape portals to the cod end; the shape and construction of the panel; the amount of weight placed on the panel; and the nature and timing of vessel changes in towing speed and direction. To investigate these factors, mid-water trawls from the F/Ts Arctic Fjord and Northern Jaeger were fitted with excluder net-sections made of 4-1/2 inch mesh, each 100 meshes long (Figure 1).

The particular design features of the flapper panel were determined by Swan Net USA based on findings accumulated over five years of trials. The excluder section was placed just in front of the cod-end. This location is as far back in the trawl as possible and places the salmon escape holes about 12 meters in front of the cod-end. This location was thought to provide the best opportunity for salmon escapement while also minimizing the possibility that the panel would affect the fishing efficiency of the trawl. However, there may be a trade-off in locating the excluder so close to the cod end, and that would be a greater chance of pollock escaping via the salmon escape holes.

Two tools were used to monitor the performance of the salmon-excluder trawl design. The first was a remote-recording imaging sonar supplied by Imagenex of Canada (Appendix 1). To provide power to and record data from the sonar, a micro computer and rechargeable battery pack were enclosed in a cylindrical, titanium pressure housing (12 by 60 centimeters) fabricated for this purpose. Mounting structures were fabricated such that the sonar could be attached to the underside of the top panel of the excluder section just before setting the trawl. In this position, the sonar "looks down" on the flapper panel, and examination (playback) of the sonar data reveals the nature and timing of panel movement. After the net is hauled on deck, the sonar and pressure housing were removed and the data brought to the vessel bridge for review and analysis. To facilitate analysis, time-stamped sonar images were compared to a log of vessel movements expected to open and close the flapper panel.

The other tool used to monitor flapper movement was a remote-recording video camera made by JT electric of the Faroe Islands (Appendix 2). This "trawl-cam" consists of a video recorder and rechargeable battery pack in an aluminum pressure housing connected to a waterproof camera and light. All of the components are contained within a stainless-steel frame (25 cm by 50 cm by 60 cm) that can be mounted inside the excluder section in strategic locations above, behind, and in front of the flapper panel. The trawl-cam functions much like the sonar; it is placed in the trawl prior to setting, and after haul-back the frame is removed and the recorder brought to the vessel bridge. As with the sonar, a time-stamp on the camera images allows for rapid analysis of the information.

The seasonal abundance of Chinook salmon on the pollock grounds changes due to variations in the timing of an annual feeding migration that typically brings two age-cohorts onto the EBS OCS in the fall (Figure 2). They remain on the grounds until late winter, although the times of their arrival and departure are difficult to predict. If they find the grounds early, then bycatch begins to increase just before the first of September. Because Chinook salmon are stronger swimmers than chum salmon, an attempt was made to conduct the excluder trials as late as possible in the B-season, so to increase the odds of observing Chinook inside the trawl. However, with an EBS pollock catch at only one million tons, both vessels were expected to finish by late August or early September. As a compromise, both trawl-net experts boarded on or about August first, and observed fishing for a total of five vessel-weeks.

While aboard the vessels the experts collected sonar and trawl-cam images during normal fishing operations. Between instrument deployments, the data was analyzed, mainly by: (1) examining the video images; (2) cataloging variations in pollock catch rates; and (3) tracking movements of the vessel and the flapper panel. Some observations on salmon swimming in the trawl were also made. Both the sonar and trawl-cams functioned as expected, and very little time was lost to equipment malfunction. A 20-minute compilation of selected video sequences was produced to illustrate and summarize the results, and this information was presented at two information-share meetings during November.

Results

Although the main project objectives were to evaluate the effects of the salmon-excluder on pollock fishing efficiency and determine whether it is possible to control the position of the flapper panel, achieving these objectives required efforts to develop tools with which to observe fish and trawl movement within the trawl during fishing operations. With regard to the remote-recording sonar, the unit was assembled in two months from parts sourced exclusively from North America. Its total cost was approximately $18,000, and it could be placed in the trawl in less than ten minutes. The sonar functioned as expected, and images from the device proved useful in determining the position of the flapper panel. However, because the device records data remotely, the position of the panel is determined only after the fact (i.e., not known in real time).

The cost of a trawl-cam was about $25,000. Prior to project implementation, there were doubts about the potential utility of camera images primarily due to concerns over the adequacy of the artificial-light. As it turned out, direct comparison of the sonar and camera technologies showed that while each is dependable, information from the camera is more useful. In particular, the field of view and lighting proved more than sufficient to allow the camera to record fish and flapper-panel movements within the trawl in close detail. And the camera also could be placed in and removed from the trawl in less than ten minutes. In the future, evaluation of flapper performance is expected to use mainly if not exclusively video camera images and artificial light. While some believe that artificial light may have a predictable effect on fish behavior, our experience leads us to believe that the light provided by the trawl-cam does not affect fish behavior to any significant degree.

The trawl-cam also provided an alternate means to evaluate the shape of the trawl net during fishing. In fact, through analysis of early camera images on the F/T Arctic Fjord it was observed that the cod-end was not maintained properly. In this case, repairing the cod-end considerably enhanced the performance of the flapper panel.

The "lagged" nature of the observations from the remote-recording devices motivated attempts at integrating technology to provide real-time monitoring of flapper-panel movement on the vessel bridge. Personnel from Harris Electric Company in Seattle, SIMRAD in Lynnwood, WA, and WESMAR in Woodinville, WA led these efforts. All the prototype systems were designed to bring data to the bridge in real time via the vessel net mensuration system. This measuring device uses a sonar mounted on the trawl head-rope (in a "suitcase") to monitor the forward portion of the trawl. The head-rope sonar is connected to a display on the bridge via an armored wire (third-wire) that is tended by an auto-winding winch located on the aft of the vessel. Additional sensors mounted farther back on the trawl can indicate roughly how much pollock is in the cod-end. After the net is hauled back, but before it is stored on the net reel, the suitcase is removed from the head-rope and stored.

A prototype installation by SIMRAD was designed to carry sonar data from a point just above the flapper panel to the suitcase via a run of two hundred meters of lightweight third-wire cable. The design of the cable run was adapted from that used to connect a set of catch indicators to the SIMRAD FH Trawl Eye, and was tested during pollock fishing on the F/T Northern Jaeger in July. During system testing cable breaks proved troublesome, and additional design work is now ongoing to solve the problem. SIMRAD also has under development a video camera that can transmit images over two hundred meters of cable if sufficient energy is provided to the unit. The development of a submersible, rechargeable battery pack is possible and could address this need (Hillers 2008).

A second device, called the Inner Net, or IN-Sounder, was developed by WESMAR. The unit contains a video sounder that sends data to the suitcase via an acoustic link, and then on to the bridge via the third wire. A functioning IN-Sounder was shown at Fish Expo in Seattle in November, and a complete, pressure-tested system that communicates with the head-rope sonar is expected to be available just after Christmas. System testing is planned aboard the F/V Pacific Prince during the 2009 pollock A-season. The company hopes to deliver a second IN-Sounder to the F/T Arctic Fjord, also for use during 2009. The IN-Sounder images are comparable to those made of the forward part of the net by the WESMAR TCS 780 head-rope sonar, and so an upgrade and option to compare the images is advertised for owners of the 780 sonar. A new off-the-shelf system that integrates acoustic communications with the In-Sounder and catch sensors and transmits the data to the bridge via the third-wire is expected to be available in 2009 (Soderberg 2008).

The net experts monitored the performance of the salmon-excluder trawls for five vessel-weeks during August 2008. At the time the vessels were fishing in the vicinity of 172-176°W longitude and 58-60°N latitude along the northwest portion of the EBS OCS (Ianelli et al. 2008, Figure 1.5). Their B-season pollock catches and salmon bycatches are shown in Table 2. During August the combined bycatch performance was 395 and 157 tons of pollock per Chinook and Other Salmon, respectively. These are high values, because for both Chinook and chum, the bycatch numbers are very low. For chum salmon, August is the month when abundance on the grounds is expected to be highest, and so it is likely that the low chum bycatches indicate low abundance on the grounds. For Chinook salmon, the bycatches indicate low abundance; however it could be that most of the salmon did not move onto the OCS until October. Whether the relevant factor is abundance or seasonal change may be best determined with reference to bycatch performance during the upcoming 2009 A-season.

A main project objective was to assess whether the flapper panels affected the fishing efficiency of the trawls. In this regard, it was the opinion of the skippers of both vessels that the excluder did not affect the fishing efficiency of the trawl very much if at all. These opinions were reinforced through analysis of the video images. For example, even when large amounts of weight were placed on the flapper panel, such that the panel remained near-closed at normal towing speeds, pollock catches still flowed back underneath the panel to the cod-end. And this was the case even though the F/T Arctic Fjord was using an 89 x 70 mid-water trawl supplied by Swan Net USA, and the F/T Northern Jaeger was fishing a 1600 mt mid-water net made by Egersund Trawl. These results are consistent with the idea that a modular, salmon-excluder net-section can be fitted to any trawl from any maker at the point where the cod-end connects to the intermediate section of the trawl with minimal effect on fishing efficiency.

Table 2. Pollock and salmon catches by month for the F/Ts Arctic Fjord and Northern Jaeger, B-season 2008.

Vessel	Month	Pollock (metric tons)	Chinook Salmon (number)	Other Salmon ^ (number)
Arctic Fjord				
	June	992	0	0
	July	6,648	6	16
	August	5,131	12	15
		12,771	18	31
Northern Jaeger				
	June	1,581	4	0
	July	8,654	0	12
	August	7,111	19	63
	September	5,701	30	84
		23,047	53	159

^ Other salmon bycatch in the pollock fishery is generally more than 95 percent chum salmon.

The other main project objective was to determine whether the movement of the flapper panel could be controlled. At the outset, it was thought that the volume of water flowing through the net would make control difficult to achieve. But it was found out that during normal towing conditions the excluder displayed great potential in the ability of the vessel to control the inclination and rate of descent of the flapper panel. This control could be achieved either through placing weight on the panel or changes in vessel speed. During the course of the trials, it was determined that it is not critical for the panel to cover completely the escape portals while fishing (open position). In fact, it is now thought that it may be possible to maintain the flapper panel in a near-closed position at normal towing speeds, and so perhaps provide salmon a more or less continuous opportunity to escape during fishing. This concept is of interest, and is planned for investigation in future trials.

As noted above, it is not yet known with confidence that placing the flapper panel close to the cod-end will not affect fishing efficiency. Preliminary observations indicate that placement of the flapper panel in relation to the cod-end full-bag mark will be important in favoring salmon escape while keeping the odds of pollock escape low.

Based on observations from this project, the flapper panel should be located between 12 and 18 meters from (forward of) the full-bag mark on the cod-end.

A somewhat unexpected result concerned observations where the side panels of the excluder section appeared slack, causing some "waving action" in the side panel, especially during the early part of the tow. A question arose: why does this occur? It is now thought that reducing the "hang rate" of the rib lines would minimize this movement. While this could be expected to tighten the side panels of the excluder section, such an adjustment may not improve salmon escapement. That is to say, it is conjectured that the "waving action" could entice salmon to move towards the escape portal. Further trials are needed to improve understanding of this.

Discussion

An information-share meeting for personnel from PCC member-companies was held on November 14th at the At-sea Processors Association, Fishermen's Terminal, Seattle. Perhaps 30 people attended the meeting, including about ten skippers. The agenda began with a presentation of project results by Seamus Melly and Chris Brewer, the net experts who coordinated the excluder trials on the F/Ts Northern Jaeger and Arctic Fjord, respectively. A presentation by personnel from Harris Electric and SIMRAD followed, and described efforts to create a "hard-wire" link between a sonar mounted near the flapper panel and the vessel bridge. Technologies that are just-now available to transmit camera images from the excluder to the head-rope sonar via a wire link were also discussed.

A second information-share meeting was held on November 20th at North Pacific Fishing Vessel Owners Association, Fishermen's Terminal, Seattle. This meeting was during "Fish Expo" week in Seattle and was advertised to the pollock industry. About 75 people attended, including many pollock catcher-vessel and catcher-processor skippers. Events included presentations by Seamus Melly and Chris Brewer of Swan Net USA on the trials results from this project, and by Dr. Craig Rose of the Alaska Fisheries Science Center and John Gauvin of Gauvin Associates on results from trials conducted on the F/V Pacific Prince during the 2008 pollock B-season. In addition, representatives from WESMAR and SIMRAD summarized on-going initiatives to develop new tools to assist with monitoring fish and net movements within the trawl in real time while fishing. Finally, John Gauvin and John Gruver of United Catcher Boats, the pollock inter-cooperative coordinator, discussed their plans for field-testing excluder-trawl designs during the 2009 pollock A-season under an experimental fishing permit from the National Marine Fisheries Service (NMFS).

The industry meeting ended after a wide-ranging discussion and appraisal of the prospects of the current flapper-panel design. During the discussion, camera images of salmon escaping the trawl were reviewed. A majority of skippers offered the opinion that it may be possible "to make the flapper panel work" such that some fraction of salmon bycatch, perhaps as large as twenty percent, would escape the net. Achieving this, however, was thought to require a substantial increase in the knowledge base concerning salmon behavior inside the trawl during fishing operations. Based on observations so far obtained, it is clear that salmon do find the escape portals, and when they do, they escape quickly and unharmed back into their natural environment with very little effort.

The location of the flapper panel in the trawl is a design issue that is thought to bear directly on the likelihood that salmon will find the escape portals. For the trials described here, the excluder section was located as far back in the trawl as possible. In contrast, trials on the F/V Pacific Prince were conducted with the flapper panel placed further ahead (forward) in the intermediate section of the trawl. Compared to the guidance developed during this project, which is to locate the flapper panel between 12 and 18 meters forward of the full-bag mark on the cod-end, the flapper panel on the F/V Pacific Prince was placed about 35 meters ahead of the cod-end.

Speaking relatively, water flow is thought to slow as the distance to the cod-end decreases. As such, salmon might find it easy to gather close to the cod end. If this were to be true, then dropping an "exit ramp" just forward of this location could promote escapement. But to really understand salmon behavior in the trawl, more observations of salmon swimming in the net are needed. As noted above, salmon bycatch rates during August were very low fishery-wide, and so only very limited observations on salmon behavior were made. One of these, a group of four chum salmon swimming in the vicinity of the flapper panel for 45 minutes (at the time no escape portals were cut), is shown on the results video.

Perhaps the greatest concern over placing the flapper panel so close to the cod-end is whether doing so increases the possibility of pollock escaping the net. In particular, at times when the forward portion of the net is being hauled aboard and the winches stop, there is a tendency for the pollock to exit the cod-end in a great surge that brings lots of fish towards the escape portal(s). Examples of this are included near the end of the results video. Learning whether pollock are likely to escape <u>during net haul-back</u> will require additional trials over one or two more seasons.

The other design issue that emerged is the desirability of "over-weighting" the flapper panel. The results video shows a panel fished by the F/T Northern Jaeger, described as over-weighted, and appearing in a near-closed position during fishing, that is making very good catches and where pollock "flow like water" underneath the panel and into the cod-end. It may be that forcing the flapper to maintain a near-closed position does not affect the catching efficiency of the trawl. Fishing with the flapper panel in a near-closed position would provide salmon a more or less continuous opportunity to escape the net. Learning if there truly may be advantages to fishing with a flapper panel always in the near-closed position is another near term objective.

The Pollock Conservation Cooperative is planning to coordinate additional salmon-excluder evaluations on the F/Ts Northern Glacier and Island Enterprise during the 2009 pollock A-season. In addition, the F/T Starbound was selected to conduct salmon-excluder trials under an experimental fishing permit from the NMFS, also during the A-season. In general, Chinook salmon abundance is higher during the A-season, and so chances are that a more observations on salmon swimming in the excluder section will be obtained. In this regard, the trawl-cam has proven to be a relatively simple, compact tool that allows observation of fish and trawl movements within the net in close detail. The trawl-cam is also easy to install and remove from the trawl (the results video shows installation and removal). In addition, the devices can also be used to trouble-shoot trawl fishing efficiency, and obtaining more hours of camera images of fish and excluder panel movements is also a near-term objective. Wider use of trawl-cams is expected to speed the pace of salmon-excluder innovation and testing, and increase the odds that a valuable salmon-excluder design will be found.

References

Anonymous. 2004. Salmon Excluder Shows Promise for Pollock. Alaska Fishermen's Journal, February 2004.

Gauvin, J. R., Paine, B. and J. Gruver. 2003. "An Exempted Fishing Permit Application to Test a Salmon Excluder Device for Pollock Trawls." NMFS Alaska Region Office, P.O. Box 21668, Juneau, Alaska.

Gauvin, J. R., Paine, B. and J. Gruver. 2004. "Draft Final Report to the NPFMC on EFP 03-01: Test of a Salmon Excluder Device for the Pollock Trawl Fishery January 2003 through March 2004." NMFS Alaska Region Office, P.O. Box 21668, Juneau, Alaska.

Gauvin, J.R. and J. Gruver. 2008. "Request for a new exempted fishing permit (EFP) to continue research on salmon bycatch reduction devices." NMFS Alaska Region Office, P.O. Box 21668, Juneau, Alaska.

Haflinger, K., Gruver, J. and D. Christensen. 2007. "Report to the North Pacific Fishery Management Council for the Bering Sea and Aleutian Islands Management Area (BSAI) Groundfish Fishery Exempted Fishing Permit #07-02." North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, Alaska.

Hillers, M.H. 2008. Personal communication. Mike Hillers, SIMRAD Fisheries, 19210 33rd Avenue West, Suite A, Lynnwood, WA 98036.

Ianelli, J.N., Barbeaux, S., Honkalehto, T., Kotwicki, S., Aydin, K. and N. Williamson. 2008. "1. Assessment of the Walleye Pollock Stock in the Eastern Bering Sea." Appendix A. Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Region. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, Alaska.

North Pacific Fishery Management Council (NPFMC). 2008a. "C-2 Bering Sea AFA pollock trawl fishery salmon bycatch." Motion, as approved June 6, 2008. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, Alaska.

North Pacific Fishery Management Council (NPFMC). 2008b. Bering Sea Chinook Salmon Bycatch Management. Draft Environmental Impact Statement/Regulatory Impact Review/Initial Regulatory Flexibility Analysis, December 2008. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, Alaska.

Soderburg, D. 2008. Personal communication. Dennis Soderburg, WESMAR (Western Marine Electronics), 14120 NE 200th Street, Woodinville, WA 98072.

Figure 1. Schematic drawing of flapper-panel trawl section.

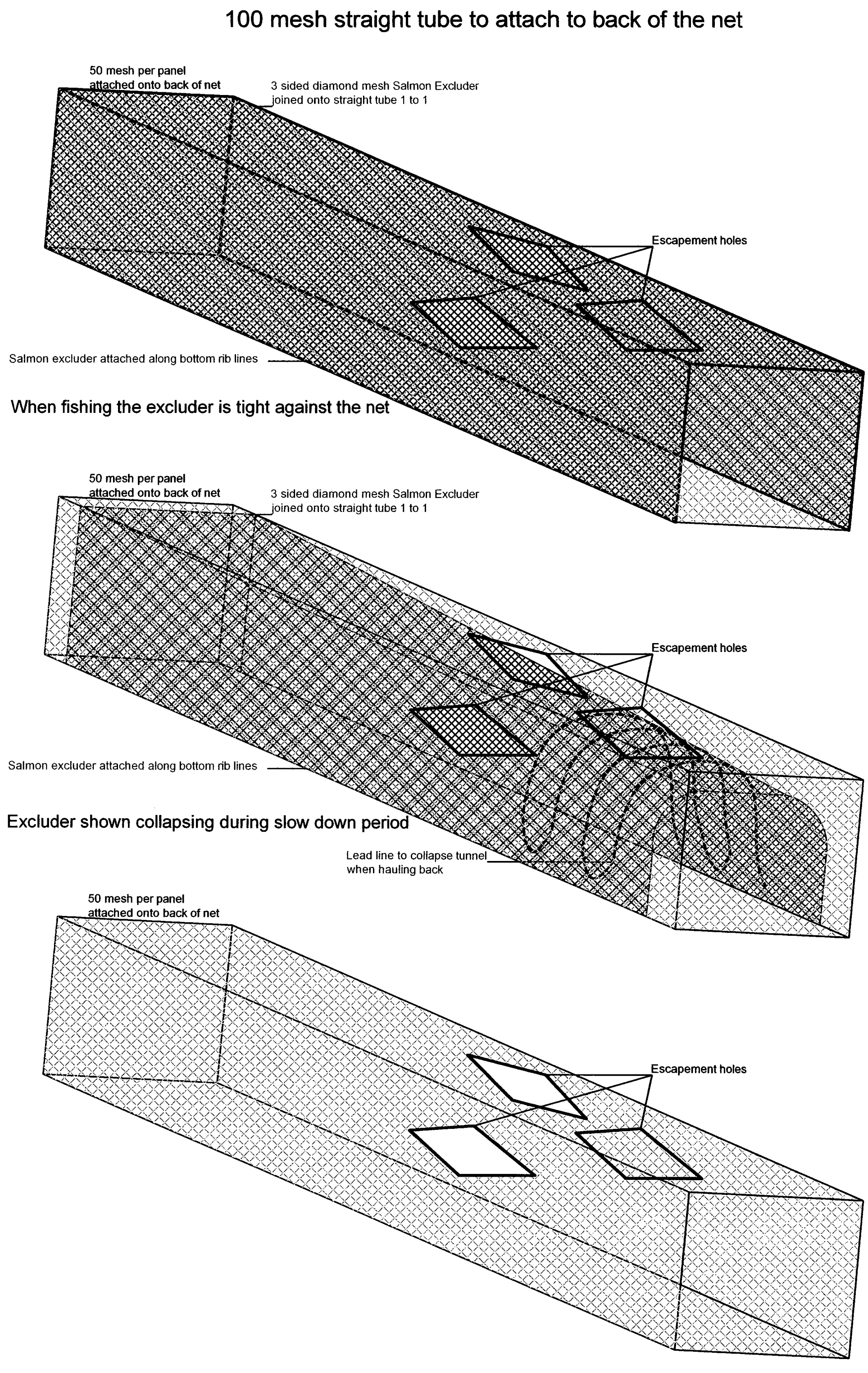
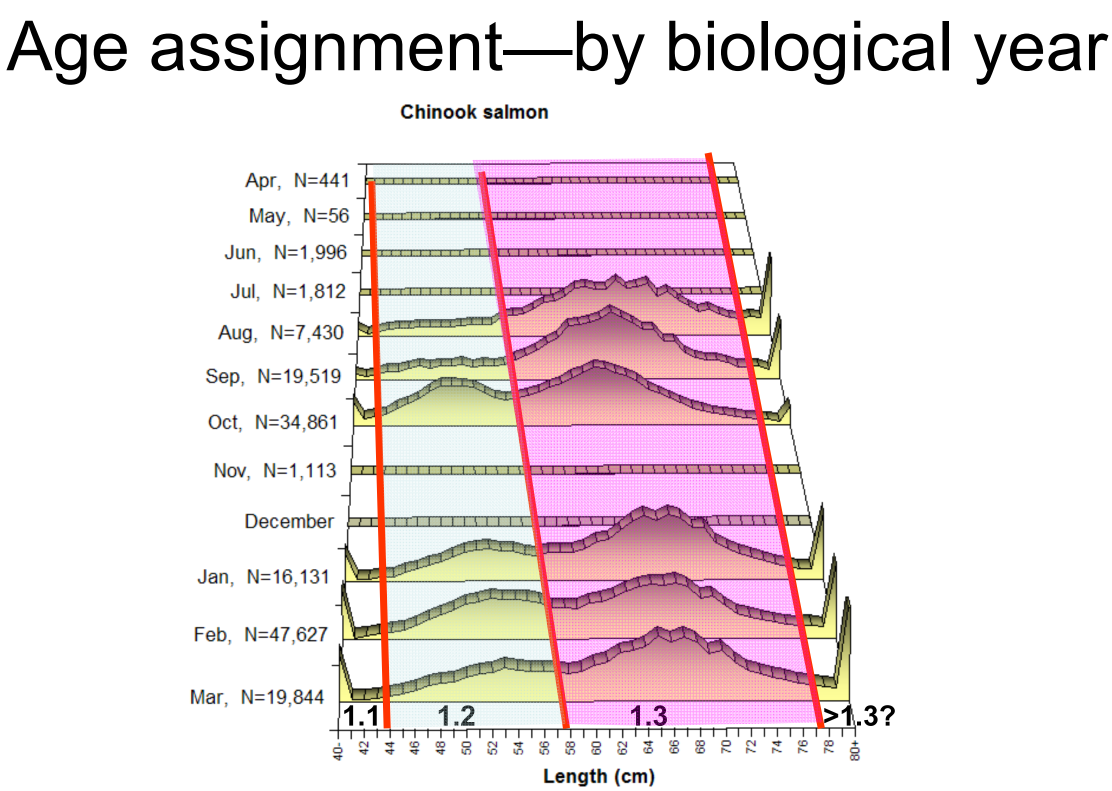


Figure 2. Length frequency and estimated ages of Chinook salmon bycatch in the eastern Bering Sea pollock fishery, 2000-2008.



Appendix 1.

Imagenex Model 881A
Digital Multi-Frequency Imaging Sonar

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IMAGENEX MODEL 881A
DIGITAL MULTI-FREQUENCY IMAGING SONAR

APPLICATIONS:

- ROV, AUV, & UUV
- Offshore Oil & Gas
- Sunken Timber Recovery
- Diving Support
- Surveying
- Search & Recovery
- Inspection
- Underwater Archaeology
- Scientific Research

FEATURES:

- Programmable
- Multi-frequency
- High performance
- Lower cost
- Low power
- Simple set-up and installation
- Digital telemetry
- Full scale range from 1 m to 200 m
- Compact size
- Communication format available to user

Now with Multi-frequency Sonar, operators can generate highly detailed full-scale images with just one unit. The 881A is a programmable multi-frequency digital imaging sonar that you can operate using default frequency settings or customize the configurations for your own situation. High performance, lower cost, low power and simple set-up and installation, make this sonar perfect for the largest ROV's to the smallest inspection ROV's, plus AUV or UUV applications.

Appendix 2.

JT electric TrawlCAM 2008-S1
Autonomous Deep-Water Video Recording System

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Seattle, WA 98199

Know more... fish more...

TrawlCAM 2008-S1

PRODUCT NEWS

New Trawl Camera

JT electric

Features

- **Sturdy shock resistant stainless steel frame**
- **Battery pack 18 hours duration**
- **JT Seaeye 2008 high resolution video camera**
- **JT Seabeam 2008 Ultra bright HID light**
- **MPEG4 video recorder - 40 hours recording (80 hours optional)**
- **40 Gb hard drive (80 Gb HD optional)**
- **Depth rating min. 1000 metres**
- **User friendly**
- **Flexible operation**

The new JT electric TRAWLCAM2008 is an autonomous deep water video recording system that has been specifically designed to provide a compact and robust unit for capturing underwater video data. The TrawlCam 2008 is design for and in conjunction with fishing trawler owners operating in the harsh environment in the North Atlantic Ocean near Faroe Islands and Iceland, and the Arctic Sea near Greenland.

A primary application of TRAWLCAM 2008 is pelagic and demersal trawler fishing. The unit can be applied to aquacultural fish farming, seabed inspection, oceanographic research for academic, military and commercial markets. Configured with an MPGP4 digital video recorder and 40 Gb hard drive, TRAWLCAM 2008-S1 provides up 40 hours storage of high quality video data.

Equipped with extra powerful re-chargable battery pack enables video recordings 18 hours. The TRAWLCAM2008 is provided til JT Seaeye 2008 high resolution camera and the powerful JT Seabeam 2008 HID underwater lamp, which gives an excellent illumination in the view area.

The unit features a unique flexibility of both vertical and horizontal adjustment of the lamp and camera to alter the recording position after the unit is fixed to the trawl net. The sturdy stainless steel frame is designed to protect the camera, lamp, battery and video recording unit when used in the harshest environments.

References:

Arctic Viking (FO)	: Shrimp Trawler
Fr.Mckee (IRE)	: Pelagic Trawler
Brendelen (IRE)	: Pelagic Trawler
Fagraberg (FO)	: Pelagic Trawler
Vónin Ltd. (FO)	: Trawlmaker
Egersund Trawl (NO)	: Trawlmaker
Am. Seafoods (USA)	: Trawlers
Remøy Havfiske (NO)	: Shrimp Trawler

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