

# **Qualitative Estimates of Current Gillnet Loss in the Puget Sound Commercial Salmon Fisheries through Semi-Structured Interviews**

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## **Introduction**

Since 2002 the Northwest Straits Marine Conservation Initiative (NWSI) has been conducting derelict fishing gear (DFG) surveys, research and removal in the Salish Sea waters of Washington State (Puget Sound, Straits of Juan de Fuca and Georgia Strait), referred to in this document as the Puget Sound. A variety of derelict gear types have been documented throughout Puget Sound including; crab traps, shrimp traps, seine nets, gillnets, trawl nets, aquaculture nets, and some others. In 2007, with contributions from state, federal and tribal agencies, non-profit groups, commercial fishers and industry experts, the NWSI completed the process of prioritizing gear types and locations for derelict gear removal operations. Fishing nets were identified as the main focus of derelict gear recovery based on the observed prevalence of them in highly productive marine habitat areas and their propensity to indiscriminately entangle and often kill various types of marine life (NWSF 2007). During this process, survey-estimated derelict gear densities yielded a projected 4,500 derelict nets in Puget Sound. While information about net loss from the gillnet fleet was solicited early in the stages of the DFG program with little response; information from various conversations with industry participants provided estimates that approximately 3 to 5% of non-treaty fishers lose at least a portion of a gillnet each season (Jeff June, personal communication 2011). This loss rate was also applied to the treaty fleet when estimating accumulated net loss. Prior to that, estimates of derelict net gear in Puget Sound were documented in a Seattle Times article in June 1990, when a Washington Department of Fish and Wildlife (WDFW) biologist was recorded using an estimate of 3,000 to 4,000 nets (Klahn 1990), similar to the numbers later reported by NWSI. While there has been documentation of derelict nets in Puget Sound Basin river systems, the research reported in this document refers only to the marine waters of the Puget Sound as defined by the outer boundaries of Puget Sound Salmon Management and Catch Reporting Areas (SMCRA) (WAC 220-22-030) (Figure 1).

The WA State DFG database was created in the mid-1990s after WDFW fisheries biologists began documenting gillnets, seine and trawl nets that they would encounter during their surveys. This database was managed by WDFW until 2002 when management was transferred to the NWSI. This database includes a reporting system, giving members of the public the opportunity to report any DFG they would see while boating, diving, beach-walking, fishing, etc. Commercial fishermen have been encouraged to report derelict gear that they themselves lose or witness being lost, through a “no fault” system. However, of the 57 known newly lost gillnets identified by the NWSI DFG program through reports or removal operations, only four have been reported by the fisher who lost the net. Since 2002, the NWSI has removed over 4,000 portions of nets in Puget Sound, of which gillnets represented 95% (Table 1) (Figure 1). The salmon gillnet fleet and associated effort has decreased significantly in recent decades; therefore, it has been assumed that the majority of derelict nets present (and removed) are those accumulated from the years of heavy fishing effort (1970s to early 1990s). The NWSI refers to derelict nets accumulated from that time period as “legacy nets.” After the majority of legacy nets are removed, habitat degradation and marine life mortality caused by derelict nets in the Puget Sound should diminish significantly; at which point removal efforts will move to “maintenance mode”.

Table 1. Derelict nets removed by type from WA Salish Sea marine waters from 2002 through 2011.  
Source: WA State Derelict Fishing Gear Database

Net Type	Number of Nets Removed	% of Total
Gillnet	3,881	95.2%
Purse Seine	136	3.3%
Aquaculture Net	49	1.2%
Trawl Net	8	0.2%
Grand Total	4,075	100%

In order to minimize or eliminate re-accumulation of derelict nets, it is important to understand the frequency at which nets are lost. Recent net loss reporting requirements have been placed on non-treaty fishers through WA Senate Bill 5661(enacted in June 2012) and the Biological Opinion (BiOp) accompanying the 4(d) evaluation of the Puget Sound Chinook Harvest Plan (2011). With this legislation in place, it is anticipated that thorough net loss reporting by gillnet fleets will occur, however, past experience with voluntary no-fault reporting is not encouraging.

### **Goals & Scope of Work**

The goal of this project is to better understand and quantify the current rates of gillnet gear loss in the Puget Sound commercial salmon fishery through semi-structured interviews with the members of the fleet, resource managers and other industry experts. Information gathered from this research will build towards refined estimates of the rate of derelict net re-accumulation in Puget Sound marine waters.

The scope of work for this project was to complete semi-structured interviews with at least six active fishers and resource managers in the Puget Sound commercial salmon gillnet fishery, analyze the information gathered, correlate that information with fleet statistics provided by WDFW and compare the results in a final report. The final report includes goals, methods, findings, discussion and a refined estimate of gillnet loss in Puget Sound.

Data and results of this project will be incorporated into the author's master's thesis at the University of Washington School of Marine and Environmental Affairs. The thesis will compare Salish Sea net fisheries between British Columbia and Washington and estimate the extent of derelict fishing nets in the inside waters of British Columbia.

### **Background**

The Puget Sound commercial salmon fishery utilizes purse seine nets, gillnets and reef nets for harvesting both wild and hatchery stocks of sockeye (*Oncorhynchus nerka*), chum (*Oncorhynchus keta*), Chinook (*Oncorhynchus tshawytscha*), coho (*Oncorhynchus kisutch*) and pink (*Oncorhynchus gorbuscha*) during their adult return to spawning grounds. Several management adjustments have taken place over the history of the fishery, but none as significant as those following the "Boldt Decision" of 1974 (US v.

Washington 1974) which mandated equitable harvest of the salmon resource between the state and the regional Indian tribes within their "Usual and Accustomed Areas" (U&A). As a result of the Boldt Decision, co-management of the salmon resource between WA State and Puget Sound Treaty Tribes was implemented. Since then, the commercial fleet has been defined by two separate sectors; treaty (aka: tribal or Indian) and non-treaty (aka: state or all-citizen). The non-treaty sector is managed by WDFW and treaty fisheries are managed by the separate tribes, with assistance from the Northwest Indian Fisheries Commission (NWIFC). Management of the fishery includes a variety of spatial, temporal and gear restrictions depending on the target species, location and other considerations such as habitat conservation and bycatch concerns. The commercial gillnet fleet and associated effort in the Puget Sound has decreased significantly since the 1970's (Figures 2, 3 and 4) as the result of a series of license limitations, buyback programs (NOAA 1999) and conservation measures related to reduced stock abundance, bycatch and endangered species act (ESA) concerns (NRC 1999). From 2001 to 2011, the number of active participants (those who have reported landings) in the gillnet fishery per year has ranged from 530 to 894, compared to over 3,000 active participants during the late 1970's.

A gillnet consists of three major components; corkline, mesh (webbing) and leadline. Corkline includes a strong, lightweight line with small hard-foam floats attached approximately every 10 feet. The mesh is the primary component of gillnets, comprised of varying mesh sizes depending on the target species. Gillnet mesh employed in the Puget Sound salmon fisheries are commonly made of monofilament as well as multi-filament line. During the 1950s, the production of gillnet mesh transitioned from linen to nylon and by the 1970s, all gillnet mesh utilized in the Puget Sound was nylon. Leadline is heavy line that is weighted by lead surrounded by a nylon jacket. The thickness and weight of leadline varies depending on fisher preference and other variables associated with the fishery. The corkline suspends the mesh along the top of the water column below which the mesh forms a wall along the length of the corkline. Mesh size and mesh count determine the depth of gillnets and the lower extent of the mesh is terminated where it is attached to the leadline. Gillnet mesh is diamond in shape and mesh size is measured by the distance between the top and bottom point of each mesh when vertically stretched tight. Mesh size regulations vary throughout the Puget Sound depending on target species and location. Minimum mesh sizes range from 4.5 inches (pink salmon in SMCRA 10) to 7 inches (Chinook salmon). While actively fishing, the mesh of a gillnet is open, slightly decreasing the depth of each mesh by a small percentage

There are three types of gillnets commonly fished in the Puget Sound commercial salmon fisheries. The drift gillnet fleet generally utilizes the full complement of allowable gear in accordance with WDFW regulation (WAC 220-47-302) not to exceed 1,800 feet (300 fathoms) in length. There are no depth restrictions on drift gillnet gear and while depths vary depending on user preference, it is common for drift gillnets in Puget Sound to reach 90 to 100 feet in depth. Drift gillnets are deployed and retrieved from vessels using power driven reels or "drums." At the terminal end the net is connected to a large float or buoy and a "jack-light" if used during night hours and the other end remains connected to the tending vessel. Set gillnets (set nets), which in the Puget Sound are used only in the treaty fisheries, are stationary with one end attached to the beach. The net extends out into the water perpendicular to the shore and the terminal end is anchored offshore and marked with a float. Set nets generally may reach 600 feet in length and typically reach 25 to 30 feet deep. The skiff gillnet fisheries, operating in a few specific locations; utilize their gear in a similar fashion as the drift gillnet fleet. However, they operate off of smaller vessels and deploy and retrieve gear by hand without the assistance of power driven reels.

Non-Treaty skiff gillnets are limited to 600 feet in length with mesh counts of 60 (Port Gamble only) to 90 meshes equating to approximately 25 to 45 feet in depth, depending on the target species. Treaty skiff gillnets vary in size and can reach 1,200 feet in length with depths similar to those in the non-treaty skiff fleet. The length and depth of gillnets utilized in Puget Sound salmon fisheries vary within the regulated size limits depending on user preference and the physical features (water depth, tidal flow, etc.) of the fishing grounds where effort takes place.

For the purposes of this document, the term “derelict gillnet” pertains to any portions or component of gillnet gear (webbing, leadline, corkline, or any combination thereof) that has been lost, discarded or abandoned and does not necessarily infer a full or complete lost net. Furthermore, nets or portions of nets that become snagged but are eventually recovered by the owner are not considered derelict or lost. An entire drift gillnet in the Puget Sound may total an area of 180,000 feet<sup>2</sup>, while the average estimated area of a removed gillnet piece during NWSI derelict gear removals is 6,056 feet<sup>2</sup> and the average length is 189 feet. Figures 5 and 6 show the size frequency of derelict gillnets removed during NWSI DFG operations.

## **Methodology**

### *Interviews*

Field work for the project consisted of 26 semi-structured interviews conducted to obtain local knowledge for a better understanding of gillnet gear loss in the Puget Sound from the perspective of those directly involved in the fishery. Because derelict fishing gear is a professionally sensitive subject among some fishers, the level of interview participation was anticipated to be relatively low. For this reason original interviews targeted potential participants who have either shown interest in the derelict fishing gear program by reporting observed derelict nets or by supplying information to improve effectiveness of the program. Additionally, resource managers provided names of fishers who they assumed would want to be involved in discussion of this topic. The list of potential interviewees grew with the number of completed interviews, as many of the interviewed fishers supplied contact information for their colleagues whom they assumed would be willing participants. Beyond members of the gillnet fleet, sources familiar with the industry such as net suppliers, fisheries enforcement officers, resource managers and scientists from agencies and tribes were contacted for various pieces of information related to the gillnet fishery and specifically, gillnet loss (Table 2). A separate NWSF research project designed to investigate best practices and possible gear modification for derelict net prevention was conducted during the same time period as this research. Because both of these projects included solicitation of information from the Puget Sound gillnet fleet and other industry professionals, coordination between project leads helped facilitate introductions to potential participants when appropriate.

Table 2. List of interviews conducted by type of interviewee and location of interview

Interviewee Type	Interview Location				Grand Total
	Marina	Home	Office	Telephone	
Fisher	4	1		5	10
Fishery Manager			4	4	8
Enforcement				5	5
Net Supplier			2	1	3
Grand Total	4	1	6	15	26

Methods for approaching interview subjects consisted of a telephone call, an email, or a combination of both, explaining the purpose of the project and a request to discuss the Puget Sound salmon fishery and derelict fishing gear. In addition to interviews scheduled by phone or email, several impromptu interviews were conducted at marinas hosting commercial fishing fleet members. All interviewees participated voluntarily and were informed that all comments and information provided would be anonymous. A semi-structured interview technique was used to elicit responses to a few specific questions through informal and (hopefully) candid conversations. Depending on the participant's desire to be heard, these conversations lasted between ten minutes and three hours. An important part of the interview process, particularly with fishers, was to give the participant the opportunity to not only discuss the set of questions guiding the conversation, but also to expand on those topics about which they were most passionate. This often lead to the collection of interesting and informative data related to the Puget Sound and Pacific salmon fisheries but beyond the scope of the current research and therefore, not reported in this document. Amongst the myriad of topics that the interviews touched, the one question that was asked of each participant was, "*Do you have an estimate of how many portions of gillnets are lost in the Puget Sound each year?*" or some iteration thereof. Additionally, fishers were asked if they had ever lost a net or a portion of a net in the Puget Sound gillnet fishery. When time was limited, these were the only questions asked of the interviewee. Interviews performed in person were recorded with a digital voice recorder upon agreement from the participant. Otherwise careful notes were taken using pen and notepad. All recorded interviews were transcribed then destroyed and all content that could identify the interviewee was made anonymous through coding. Responses were organized into nine separate categories for further analysis; *DFG Locations, DFG Loss Rates, DFG Reasons, Enforcement, Fishery Description, Gear Description, Main Points, Perception, Suggestions*. In some cases, nautical charts were provided for interviewees to mark locations of potential high net loss, particularly if any were identified outside NWSI derelict net removal areas.

Nine of the ten fishers interviewed were members of the non-treaty fleet and only one was a treaty fisher. Based on the difference in participation and activity between sectors, it is clear that personal accounts from members of the treaty fleet is underrepresented in the suite of local knowledge accessed during the interviews. Most gear loss information and estimates provided by interviewees were specific to one or a portion of one sector of the gillnet fleet (i.e., treaty, non-treaty, full time/part time, specific treaty tribe) and in some cases specific to geographic location (SMCRA) or target species (i.e., sockeye, chum). Two of the ten fishers interviewed provided estimates of Puget Sound gillnet loss rates and eight of the ten fishers provided information about the amount of net loss they have incurred over the course of their

Puget Sound fishing career. Additionally, three enforcement officers provided estimates of yearly net loss within their jurisdiction based on observations and reports.

All gillnet loss rate estimates provided by respondents were done so under the caveat that the information was anecdotal, speculative or a “best guess” and should not be considered empirical evidence. Nevertheless, documentation of their information and opinions not only assist in refining previous estimates, but also help identify ways to further refine these estimates in the future.

### *Quantifying Fishing Effort*

Fishing effort metrics such as days fished, pounds landed and active vessels assist in projecting estimates of derelict gear throughout a fishery over several years. A dataset of historical gillnet fishing effort in the Puget Sound was analyzed and used to apply gillnet loss rate estimates throughout the fleet over time. Washington State law requires commercial fishers to generate fish receiving tickets, or ‘fish tickets’, upon each delivery or sale of commercially caught salmon in Puget Sound waters (WDFW 2012). A variety of information is recorded on fish tickets which are sent to WDFW (non-treaty) and NWIFC (treaty) via mail, fax or email within six working days of the date of sale, eventually becoming cataloged into a database held by WDFW. While required information differs between treaty and non-treaty fish tickets (WAC 220-69), several entries are similar, and can be used to quantify fishing effort across both sectors. Because of discrepancies in the Fish Ticket Database between sectors, ‘Tribal ID’ was used in place of ‘Vessel ID’, all of which were anonymously coded and used to distinguish active participants in the fishery. For the purpose of this study, *active participant* or *fishery participant* refers to any vessel or tribal member generating at least one fish ticket during a given Puget Sound salmon fishing season.

Count of fish tickets was used as a proxy for days fished. Possible biases associated with this process are assumed to be consistent throughout the sampling period. Additionally, using ‘Tribal ID’ in place of ‘Vessel ID’ has the potential to overestimate the number of vessels within the treaty fleet, as in some cases multiple fishers may generate fish tickets from the same vessel, however, several inquiries into the ratio between fisher per vessel did not produce enough information to apply a correction factor. Conversely, using Vessel ID for the non-treaty fleet accurately depicts the number of vessels but lacks information on whether the operator was the owner or an alternate, therefore, potentially underestimating the number of individuals involved in operating vessels. Nevertheless, the conclusion was made based on the data available that these metrics would be the most useful for the purpose of quantifying fishing effort for both treaty and non-treaty sectors since the Boldt Decision was enacted.

### *Estimating Gillnet Loss*

Gillnet loss rate estimates provided by interviewees were applied to the fishing effort statistics from the WDFW fish ticket database in order to estimate the amount of gillnet portions lost or abandoned each year in the current Puget Sound commercial salmon gillnet fisheries. Due to the qualitative nature of the information collected by interviewees and the fact that the number of fishers interviewed only accounts for approximately 1% of the total currently active fleet (5% of non-treaty fleet and 0.1% of treaty fleet), no statistical analysis was performed on the data collected or estimates of net loss provided by analysis of the data. Also, most of these estimates were based on information provided by non-treaty fishers about

all, or portions of the non-treaty fleet, then assumed to be constant throughout and across sectors (treaty and non-treaty).

Estimate 1: The interviewer explained to interviewee (PSGN1) that the current estimate for gillnet loss rate is that 3 to 5% of active fishers lose some portion of their net each year. PSGN1 predicted that since the fleet and its effort has diminished greatly, that the current loss rate is less than that but historically when the fleet was large and very active, the loss rate was probably closer to 5 to 10%. Based on this response, 2 to 4% was applied to the gillnet fleet from 1995 to 2011, and 5 to 10% was applied to the fleet for the years 1968 to 1994.

*Current Loss (1995 - 2011):*

*(total # active participants per year) \* 0.02 = low # gillnet loss*

*(total # active participants per year) \* 0.04 = high # gillnet loss*

*Historic Loss (1968 - 1994):*

*(total # active participants per year) \* 0.05 = low # gillnet loss*

*(total # active participants per year) \* 0.10 = high # gillnet loss*

*Combined Loss (1968 - 2011):*

*Current Loss Low + Historic Loss Low = low cumulative # gillnet loss*

*Current Loss High + Historic Loss Low = high cumulative # gillnet loss*

The same fisher, PSGN1, estimated that one piece of gillnet, fleet-wide, is lost on every “competitive” day of fishing per season, particularly referring to sockeye openings. This statement consisted of several caveats that did not coincide with fish ticket or days fished database and therefore, a gillnet loss rate was not applied.

Estimate 2: The interviewee (PSGN8) estimated that out of approximately 60 non-treaty vessels that fish the maximum amount of days possible, about six to eight of them per year may lose a portion of their net during a season. Based on this response, the number of fish tickets generated per year for the (approximately) 60 most active vessels in the non-treaty fleet was summarized by year from 2001 to 2011. Assuming that these fishers lose six to eight gillnet portions per year, a low and high estimate of loss rate was determined by dividing six and eight, respectively, into the number of fish tickets produced by those most active non-treaty vessels for each year from 2001 through 2011, then the average yearly loss rate per fish ticket was determined and multiplied by the total number of fish tickets generated by both sectors of the gillnet fleet to result in the estimated number of gillnet portions lost per year.

- a. Average of (6 / (total # fish tickets per year from ~60 most active NT fishers)) = low loss rate*
- b. Average of (8 / (total # fish tickets per year from ~60 most active NT fishers)) = high loss rate*
- c. (low loss rate) \* (total # fish tickets generated per year) = low # gillnet loss/year*
- d. (high loss rate) \* (total # fish tickets generated per year) = high # gillnet loss/year*

While this fisher was clear that his estimate was specific to the approximately 60 most active non-treaty vessels, the projection was made throughout the remaining non-treaty fleet as well as the treaty fleet based on the assumption that gillnet loss is proportional to effort, in this case documented by fish tickets.

Estimate 3: In an interview with PSGN5, the following was said:

*“... in my acquaintance, and I know personally about half of the [non-treaty] gillnetters that fish, and there was two instances of net loss this year [2011], both by the same person.”*

Based on this statement, a net loss rate was estimated by simply dividing two by half of the active 2011 non-treaty fleet. This number was then assumed to be constant throughout the active 2011 non-treaty vessels and additionally projected into the active treaty fleet. This same rate was multiplied by the number of active participants for each year from 2001 to 2011 to estimate number of net loss for each of the years.

$$(2 / (0.5 * 2011 \text{ active non-treaty vessels})) * (\text{total \# active participants per year}) = \# \text{ gillnet loss/year}$$

Because this information was based on only one year of information it was not extrapolated into historical gillnet loss beyond 2001.

Estimate 4: Conversations with fishery enforcement officers from different regions in the Puget Sound provided the basis for this estimated number of gillnet portions lost per year. One officer (PSE1) speculates that approximately ten gillnet portions are lost yearly in Bellingham and Samish Bay (SMCRAs 7B and 7C); five to ten may be lost in the Salmon Bank/Iceberg Point/Eagle Point region of SMCRA 7; and ten to 20 may be lost on the fishing grounds at Point Roberts in SMCRA 7A during a robust Fraser River fishery, or five to ten during a slow season. Another officer (PSE2) reported that their team addresses approximately six derelict gillnets (including set nets) per year in Hood Canal. A third enforcement officer (PSE3) reported that he addresses two to three derelict gillnets per year from central Puget Sound to Point Roberts. From 2004 to 2011, between four and 12 (average: 7) newly lost derelict gillnets are reported to, identified and/or removed by the NWSI derelict gear removal program throughout the Puget Sound. At least half of the newly lost derelict net reports received by the NWSI were also reported to and possibly addressed by enforcement officers.

Based on this information, the range of total yearly gillnet loss in Puget Sound was estimated by adding all reports by enforcement officers and half of the newly lost nets documented by NWSI derelict gear removal team.

$$\begin{aligned} & (PSE1 \text{ low estimate total}) + (PSE2 \text{ low estimate}) + (PSE3 \text{ low estimate}) + ((0.5 * NWSI \text{ reports})) \\ & = \text{low \# gillnet loss/year} \\ & (PSE1 \text{ high estimate total}) + (PSE2 \text{ high estimate}) + (PSE3 \text{ high estimate}) + ((0.5 * NWSI \\ & \text{reports})) = \text{high \# gillnet loss/year} \end{aligned}$$

While this calculation estimates yearly gillnet loss in Puget Sound, it also shows that some of the nets that become derelict are addressed and often removed by WDFW and tribal enforcement officers and the NWSI derelict fishing gear removal program. This calculation does not estimate the number of nets that are lost, not reported and not found during field operations.

## **Results & Findings**

### *Interviews*

Of the ten fishers interviewed over the course of the project, nine (90%) were members of the non-treaty sector and one (10%) was a member of the treaty fleet. One (10%) of the non-treaty interviewees was retired from the Puget Sound fleet. Nine (90%) of the interviews were successful in eliciting interesting and informative insight into the Puget Sound gillnet fishery while also providing opinions and information regarding gillnet loss. One (10%) of the interviewed fishers briefly shared his opinion about the subject only; referring to derelict fishing gear information stating that, *“These are lies being made up by well organized gangs who are trying to ruin the commercial fishing industry.”* For all nine fishers who shared information, each had over 20 years and some over 40 years of active fishing in the Puget Sound. Many of these fishers participate in other fisheries in Alaska and Washington, and are involved in or retired from other endeavors both related and unrelated to the fishing industry. In years of experience per active fisher, this set of interviewees all fall within the upper 11% of the 2011 Puget Sound gillnet fleet (treaty and non-treaty), many of whom were fishing prior to 1977 (earliest year of effort data presented).

Of the five fishery enforcement officers interviewed, three (60%) are employed by separate tribes and two (40%) work for WDFW. Three (60%) provided estimates of the number of derelict nets that they address per year within their jurisdiction or detachment, while two (40%) explained that they did not have an estimate or that they have not encountered derelict nets in the last few years. Three (38%) of the eight fishery managers were from WDFW, two (25%) from NWIFC and three (38%) from separate tribes. The fishery managers all provided insightful information and sometimes data regarding their respective fleets, especially regarding activity and effort as it pertained to interpreting fish ticket data and interviewee responses. Managers additionally provided contact information for fishers, enforcement officers and other resource managers that would provide useful information.

Gillnet sales representatives from three of the commercial gear supply companies in the Puget Sound region were asked how many times within the middle of a Puget Sound salmon season does somebody request a replacement net. All three said that due to the lack of effort in the current fishery and the cost to replace a net, this rarely, if ever happens. One supplier in the Seattle area noted that at times fishers may call and ask for a price quote to replace a piece of gear that was struck by a freighter or barge in order to be compensated for their loss. However, the occurrence of this varied so greatly that he could not provide an estimate for how often it happens. The net suppliers interviewed also provided helpful information regarding the cost, size and material of gillnets in Puget Sound over the years.

All fishers interviewed stressed that entire (drift) gillnets do not get lost, rather if gear is lost it is in the form of pieces and portions of net gear. Additionally, most all fishers reiterated that skilled experienced fishers lose little to no gear. The most commonly described reasons for net portions to become derelict are generalized in the following list.

- Operator inexperience: ‘part-time’ fishers, alternate operators, first or second year fishers, recent transfers to location, lack of current, tide and geographical knowledge.

- “...probably 75% of all gear that is lost is lost by people within their first or second year of fishing.”
- “wrong place, wrong time”
- Equipment failure: engine quits, hydraulic malfunction – drift towards reef or beach and snag gear.
  - “...it’s all about the health of the fleet” (i.e., condition of vessels)
  - “undercapitalized vessels”
- Operator incompetence:
  - “... the same people over and over”
  - “unintelligent, bad decisions, wrong gear”
- Others reasons for net loss as described by interviewees:
  - size of nets (mismatch of net depth and water depth)
  - net too full of fish and sinks (target or non-target species)
  - vessel strikes net and cuts off a portion that becomes lost
  - crowding in particular locations (less common now)
  - short fishery openings causing rush to fish
  - uncharted snags: wood debris (dead heads)

When discussing locations and regions where gillnet loss is more likely to occur, most fishers who offered information listed areas where extensive derelict net removal operations have taken place such as Salmon Bank, Eagle Point, Hein Bank, Point Roberts, Jefferson Head and others. Additionally, a few locations such as portions of Bellingham Bay and Samish Bay were identified by fishers and enforcement officers as locations where net loss occurs that had not been a high priority in past derelict fishing gear surveys.

### *Quantifying Fishing Effort*

Figures 2, 3 and 4 give a view of the changes in fleet size, activity and effort since 1977. Since 2001, the number of active participants in the fishery and the number of fish tickets generated have fluctuated with a slightly increasing trend. Greater fluctuation in total yearly landings shows that catch per unit effort (CPUE) has varied more than effort alone. Between 2001 and 2011, the average number of active gillnet participants per year was 688 (531 treaty and 157 non-treaty) and the average number of fish tickets generated per year was 5,442 (3,756 treaty and 1686 non-treaty). During this same time period, the average number of pounds landed per year was 4.45 million (2.88 treaty and 1.57 non-treaty).

Analysis of fish ticket data shows that the distribution of experience (years fished) amongst active fishers in 2011 is not uniform, and varies between sectors. Of the 155 active non-treaty fishers, 51 (33%) had over 20 years of active fishing, 41 (27%) had fished for 11 to 20 years, 44 (28%) fished for three to ten years and 19 (12%) had only fished for one to two years. Of the 632 treaty fishers, 95 (15%) had been actively fishing for over 20 years, 156 (25%) had fished for 11 to 20 years, 254 (40%) fished for three to ten years and 127 (20%) had been actively fishing for one to two years. To illustrate the distribution of experience between active Puget Sound gillnet fishers, Figure 7 shows the number of active participants in 2011 per number of years active in the non-treaty and treaty gillnet fleets combined. This not only shows the experience distribution between active participants but the figure also shows that the dataset of

fisher interviewees is underrepresented by fishers with less than 20 years of actively fishing in the Puget Sound gillnet fleet. It is important to note that in the non-treaty fleet is depicted by vessel and not operator and there may not be a direct correlation to the level of experience between operator and vessel (i.e., new operator on old vessel).

In terms of fleet size and activity, many of the interviewees referred to *full time*, *serious* or *hardcore* fishers, meaning those fishing close to the maximum amount of openings available in the non-treaty sector and *part time* fishers who fish much less than the total allowable openings. It was also reported that some fishers keep active sales of just one fish ticket per year to prove commercial activity in order to maintain the reduced moorage available to commercial fishers at many marinas. Different interviewees referred to different numbers of *full time* fishers within the non-treaty fleet; one claimed that there are only 28 to 35, others described the *full time* non-treaty fleet as 60 fishers and others used the range of 80 to 90. The fish ticket database shows that in the 2011 non-treaty fleet, 32 (20%) fishers generated more than 20 fish tickets, 57 (37%) fishers produced 15 or more fish tickets and 86 (55%) generated more than ten tickets. Within the treaty fleet, 52 (8%) fishers generated more than 20 fish tickets, 109 (17%) produced 15 or more tickets and 150 (24%) fishers produced more than 10 fish tickets. To show the average distribution of effort across sectors over time, Figure 8 depicts the number of active participants by average number of fish tickets produced from 2001 through 2011 for non-treaty and treaty gillnet fleets combined. Of the 2,448 total active fishers, 57 (3%) generated more than 20 fish tickets per season, 269 (11%) produced an average from 11 and 20 fish tickets, 821 (34%) fishers averaged from four to ten tickets and 1,301 (53%) of the active fishers 2001 to 2011 averaged one to three fish tickets per season.

### *Estimating Current Gillnet Loss*

Based on fisher information obtained early in NWSI derelict gear program, an estimate that 3% to 5% of gillnet fishers lose a whole or part of a net during each active year of fishing that has yielded a range from 2001 to 2011 of 16 to 45 derelict gillnet portions lost per year. This same rate has been applied uniformly to all years dating back to 1968 to provide an estimate for historical accumulated gillnet loss in Puget Sound that on the upper estimate has correlated well with the findings from ten years of derelict gear surveys and recovery in the Puget Sound. The results provided below attempt to refine the previous estimates based on increased information gathered from industry professionals and 10 years of a derelict fishing gear removal program.

Estimate 1: Using the yearly loss rate based on speculation that 2% to 4% of active fishers lose a portion of gillnet gear per year, from 2001 to 2011 the estimated number of nets lost per year ranges from 11 to 36.

Estimate 2: The estimated average net loss rate per fish ticket produced from 2001 to 2011 ranges from 0.00524 to 0.00699 nets/ticket/year. When applied to the total yearly amount of fish tickets produced fleet-wide over the course of those years the estimated number of gillnet portions lost per year ranges from a low of 20 in 2001, to a high of 52 in 2010.

Estimate 3: Based on an estimate that two net portions are lost each year per half of the active fishing fleet, the gillnet portion loss rate is estimate 0.026 nets/fisher/year. When multiplied by the total number of active vessels for each year from 2001 to 2011, the estimated number of gillnet portions lost ranges from 14 to 23. Unlike the previous two estimates, this does not include low and high calculations, only a uniform multiplier.

Estimate 4: Based on newly lost net reports and encounters in the field, this calculation of yearly loss rate simply summarizes the combined estimates from four different sources across the Puget Sound. The estimated number of gillnet portions lost per year from 2004 to 2011 ranges from 30 to 55. It should be noted that some portion of these estimates are set nets and may not only be from the drift gillnet fleets.

Since all of these estimates are based on experience gathered by those involved in the fishing activity, including fishers, enforcement officers and manager and results of the DFG program, all are viable alternatives to estimate gillnet loss in the Puget Sound. Therefore, the final estimate includes the average of all low range estimates and the average of all high range estimates including the original estimate previously used by NWSI, that produces an overall estimate of 18 to 42 portions of gillnets lost annually in the Puget Sound.

## **Discussion & Conclusion**

Using qualitative information, the study estimates that 18 to 42 portions of gillnet become derelict in the Puget Sound each year. This estimate slightly refines the previous (original) estimate by decreasing the range by five (17%) nets. It also shows that multiple calculations were able to validate the estimates used previously by the NWSI derelict gear program.

Each fisher interviewed made it very clear that losing an entire drift gillnet never happens in today's fishery and when net gear is lost it is typically portions of web and/or leadline usually around 60 feet in length. Replacing a full drift gillnet costs anywhere from US\$7K to \$15K and would likely be enough of a financial hardship to discontinue that fisher's gillnet activity in the Puget Sound. They proposed that the majority of the derelict gear being recovered from the Puget Sound are from previous decades (70s and 80s) when the amount of activity was much higher and that very little gillnet loss occurs currently due to the small number of vessels on the water and the relatively few of days available to fish. In the past, crowding on the fishing grounds was a major cause for gear loss as competition for fishing areas drove some fishers to marginal areas where snags and heavy tidal activity increased the chances of gear being snagged and lost. Some of the interviewed fishers explained that crowding still occurs in certain areas (i.e., Hood Canal and Point Roberts), especially when allowable fishing days are few and the target species provides high ex-vessel value, however, compared to years past the diminished fleet size has reduced this problem.

Operator inexperience was identified as one of the most important underlying reasons for gillnet loss to occur in the Puget Sound salmon fisheries. One of the fishers responded to this by saying that probably 75% of the gear being lost within a given year is by first or second year fishers and several interviewees explained that losing gear will significantly increase fishers' chances of exiting the fleet due to the cost of gear replacement. This notion was explored by identifying the fishers in the WDFW fish ticket database

who (a) fished for their first or second year and (b) exited the fishery after only one or two years of participation (Table 3). Results from this query show that while fleet activity remains at a fraction of what it was decades ago, both sectors experience new participants that for whatever reason do not continue their participation in the gillnet fishery. There are surely many reasons for this, one of which could be the loss of investment in net gear. Related to this, some interviewees explained that the number of new participants or returning participants increase with the rise in ex-vessel value or a promising predicted forecast of certain target species (i.e., sockeye, Chinook, chum) that increases fishing activity on the fishing grounds. Another fisher explained that extra or alternate operators, as opposed to owner operators, can be inexperienced and have less invested in the gear utilized and may be more prone to taking risks on the fishing grounds that could lead to gear loss and less prone to taking the risks necessary for the retrieval of gear that is lost. While much of this is associated with new entries into the fleet, it was pointed out that there is a lot of area between Tacoma and Blaine with very particular tides and currents and that even fishers experienced in one or more location may not be experienced in others. Additionally, participants explained that gear loss is often caused by operator incompetence, regardless of experience, but that eventually the fleet is “self-correcting” and the fishers that continue to make mistakes and/or lose gear will eventually no longer participate.

Table 3. Number of first and second year participants and those exiting after first and second year of participation throughout Puget Sound salmon gillnet fishery (treaty and non-treaty combined). Source: WDFW fish ticket database.

Year	Total New Entries	Total 2nd Year Fishers	Total 1st & 2nd Year Fishers	Total Exiting after 1st Year	Total Fishers Exiting after 2nd Year	Total Fishers Exiting after 1 or 2 years
2001	56	37	93	27	3	30
2002	70	29	99	30	5	35
2003	37	40	77	21	7	28
2004	57	16	73	31	1	32
2005	55	26	81	26	5	31
2006	86	29	115	40	3	43
2007	100	46	146	47	6	53
2008	113	53	166	67	9	76
2009	77	46	123	39	10	49
2010	109	38	147	85	9	94
2011	93	24	117	NA	NA	NA
2001-2011 Total	853	384	1237	413	58	471
2001-2011 Low Range	37	16	73	21	1	28
2001-2011 Upper Range	113	53	166	85	10	94

‘Undercapitalized’ was a term used by one of the interviewees to describe vessels that have barely financially survived the reduction of fishing opportunities in the Puget Sound. The example given was that of a vessel that only fishes the fall chum season and is otherwise idle for the remainder of the year. When vessels sit for a long period of time and then are expected to perform on only a small number of days a year, the likelihood of engine, hydraulic or other mechanical malfunctions increase substantially. Additionally, some vessels may be in poor condition simply due to a lack of regular maintenance and safety checks. Equipment failure, while probably more common on undercapitalized vessels, can occur on any vessel and was described by interviewees as one of the two most common reasons for derelict gear loss. When nets are deployed and a vessel becomes immobilized by mechanical malfunction, vessel and

gear are often forced by the current and tides into shallow water or other compromising situations where gear becomes snagged and must be cut free in order to save the vessel and its personnel. Often when this happens, the fisher ties some type of marker buoy on the cut end of the discarded portion of net with plans to return later, however, this does not always occur. Increased technology on vessels (i.e., depth sounders, radar, GPS navigation, charting software, cellular phones, etc.) over the years has reduced mistakes that may lead to loss of net gear by giving the operator a better understanding of his/her situation such as proximity to reefs/snags, water depth, rate of drift, etc. However; not every vessel in the fleet is equipped with such equipment.

Some of the interviewed fishers, particularly those that target terminal fisheries with relatively shallow gear (60 mesh), proposed that net depth plays a large role in the loss of gillnets, referring to the fact that gillnet fisheries in Alaska and British Columbia have net depth restrictions (by mesh count) similar to those in the skiff gillnet fleet (60 to 90 meshes, depending on location). This argument is based on the simple concept that a shallow (i.e., 30 feet) net will not snag on a rock pinnacle or reef with a minimum depth of 60 feet as a deeper (i.e., 100 feet) net would. This argument correlates with other interviewee comments about the size of the gear used in Puget Sound that was summarized well by one fisher's statement: *"300 fathoms of these deep nets is about all anybody can handle...these deep nets basically fish you."* However, many shallow nets have been identified as derelict in the Puget Sound and some of the interviewees discussed their experience witnessing gillnet loss in other places, such as southeast Alaska, where depth restrictions are in place. These observations suggest that net depth is not the only cause of gillnets becoming derelict. Some interviewees also explained that using deep gillnets is a mandatory practice in certain target fisheries in order to maintain competition with the purse seine fleet. Gillnet loss was also correlated with gillnet length by one of the interviewed fishers, as he referred to a *"whiskey shackle"* as an extra portion of gear added to the maximum allowable 1,800 feet. This fisher reported that in the 1970s and 80s whiskey shackles were intentionally snagged on reefs by fishers in order to maintain their set without drifting away, then once the set was complete the excess net was discarded and left to become derelict. While none of the other interviewed fishers said that they had witnessed or heard of this behavior, many did claim that they have witnessed fishers using extra lengths of gear, sometimes as much as an extra 300 feet, and that the increase in length of gear would easily increase the chances of a portion of it becoming snagged and/or derelict.

When explaining the NWSI yearly gillnet loss estimates of 15 to 45 nets, most fishers had the opinion that it is less than that or that it seemed like an *"ambitious"* estimate. Nevertheless they understand that gear loss at some level does occur and that the appropriate action should be taken by the fisher who lost it. Many explained that fishers who snag their gear will work extremely hard to retrieve what they've lost, oftentimes calling a fellow fisher to assist in recovery of the gear. All agreed that it is the fishers' responsibility to properly report and assist in recovery of the nets in any way possible and that the facts of the net loss should be reported correctly. Some of the fishers expressed concern that how derelict fishing gear data is presented is not completely accurate. For example, most fishers interviewed said that the reported number of estimated accumulated derelict nets of approximately 4,500 is extremely inaccurate, since to them the term *"net"* refers to an entire 1,800 feet of web, leadline and corkline. Some also did not appreciate that the information is used by certain groups to promote regulations prohibiting the use of gillnets.

The qualitative nature of the gear loss estimates along with the small sample size and demographic uniformity of fishers that participated in the interview process did not allow for statistical analysis of the data. During one of the interviews, a fisher explained that he would like to see these estimates scientifically generated and the only way to do that would be to survey the entire fleet (or large majority), otherwise any estimate would be “*fictitious*.” He then continued to explain the difficulty in providing members of the fishing fleet with enough incentive to participate in such a survey. His concern was that if such an estimate eventually led to regulation or policy changes within the fishery, it would be unfounded and based on an “*educated guess*.”

It is clear by the information collected that gillnet loss is not directly correlated with long-term derelict gillnet re-accumulation. Some newly lost nets are recovered shortly after being lost or within the same season. All fishers interviewed believed that maximum effort is typically exerted by fishers to retrieve the lost portion of a net, sometimes returning to the site with assistance when conditions are more favorable for net recovery. It was also reported that members of the fleet will recover and salvage newly lost gear lost by other fishers if they encounter it on the fishing grounds. Additionally, fishery enforcement officers from WDFW and treaty tribes monitor fishing grounds during and after fishery openings and when a derelict net is encountered, it is usually recovered. The NWSI derelict fishing gear removal program has also encountered and removed newly lost gillnet portions during operations, and both NWSI and fisheries enforcement groups respond and many times remove newly lost nets reported by the public. However, an unreported gillnet portion that is snagged and lost at any depth beyond the maximum low water level is likely to remain there indefinitely until it is reported by a diver or fisher who encounter it or it is identified during a derelict gear survey targeting that location. Increased communications regarding derelict nets between WDFW enforcement, NWSI and treaty tribes along with the mandatory reporting required by WA SB 5661 and the Chinook salmon BiOp should prove to increase the potential for a full account of yearly gillnet (and other net) loss between both sectors in the coming seasons. Coordinated efforts with documentation of gear recovery will assist in determining what portions of those lost nets are re-accumulating.

The treaty set net fishery is quite extensive and only a small portion of the data provided for this research includes information regarding potential set net loss. Since 2000, the Puget Sound set net fleet has been comparable to the treaty drift gillnet fleet in both number of participants and fish tickets generated. Derelict set nets have been recovered by fisheries enforcement officers and NWSI derelict gear removal operations. Like other gillnet types, set nets are prone to vessel strikes and can become snagged in floating debris, drift away and/or sink. However, since they are utilized in relatively shallow water and are often accessible from land and/or small vessels, there is greater potential for them to be removed by enforcement teams, fishers, and others, possibly limiting their levels of accumulation. Whether set net or drift gillnet, considering the portion of the entire fleet comprised by the treaty sector, it is clear that treaty fishers are underrepresented in the pool of interviewees from this study. Further research into current gillnet activity and potential loss should include a greater number of representatives from both the drift gillnet and set net fleets of the treaty sector. This was reiterated by most all interviewees, as the difference in levels of activity and regulations regarding fishing locations between sectors have become enough for some to believe the two sectors are now incomparable.

Many of the interviewees recommended evaluation of effort and fishery activity by target species, allowable fishing days and operator type (i.e., owner, temporary). This was beyond the scope of this study. Further research would provide additional information regarding fleet statistics and net loss. It would also assist in ongoing related research using spatial analysis in ArcGIS to identify historical trends, activities and potential net loss within the Puget Sound on a regional scale by SMCRA.

In conclusion, while limitations of the study prevent statistical analysis of gillnet loss estimates in the Puget Sound, it refines and verifies previous gillnet loss estimates based on summaries of qualitative information from industry professionals and analysis of fleet activity. It also provides further insight on gillnet loss from those most involved in the fishery and recommends further research possibilities through inclusive surveys, spatial analysis and analysis of other datasets.

### **Acknowledgements**

This research is part of a master's thesis project at the University of Washington that requires that interviews be conducted in accordance with the exempt research requirements of the University of Washington Human Subjects Division and the Federal Policy for the Protection of Human Subjects (45 CFR 46), and therefore all interviewees will remain anonymous. I would like to thank the commercial fishers, enforcement officers, fishery managers and gillnet suppliers who took the time to discuss this topic and share their knowledge. Thanks to Joan Drinkwin at the Northwest Straits Foundation for securing the funds to support this project. Thanks to Jeff June at Natural Resources Consultants, Inc. for sharing his knowledge of Puget Sound derelict fishing gear. A special thanks to Carol Turcotte, Marjorie Morningstar and Pamela Singleton at WDFW for providing data from multiple requests.

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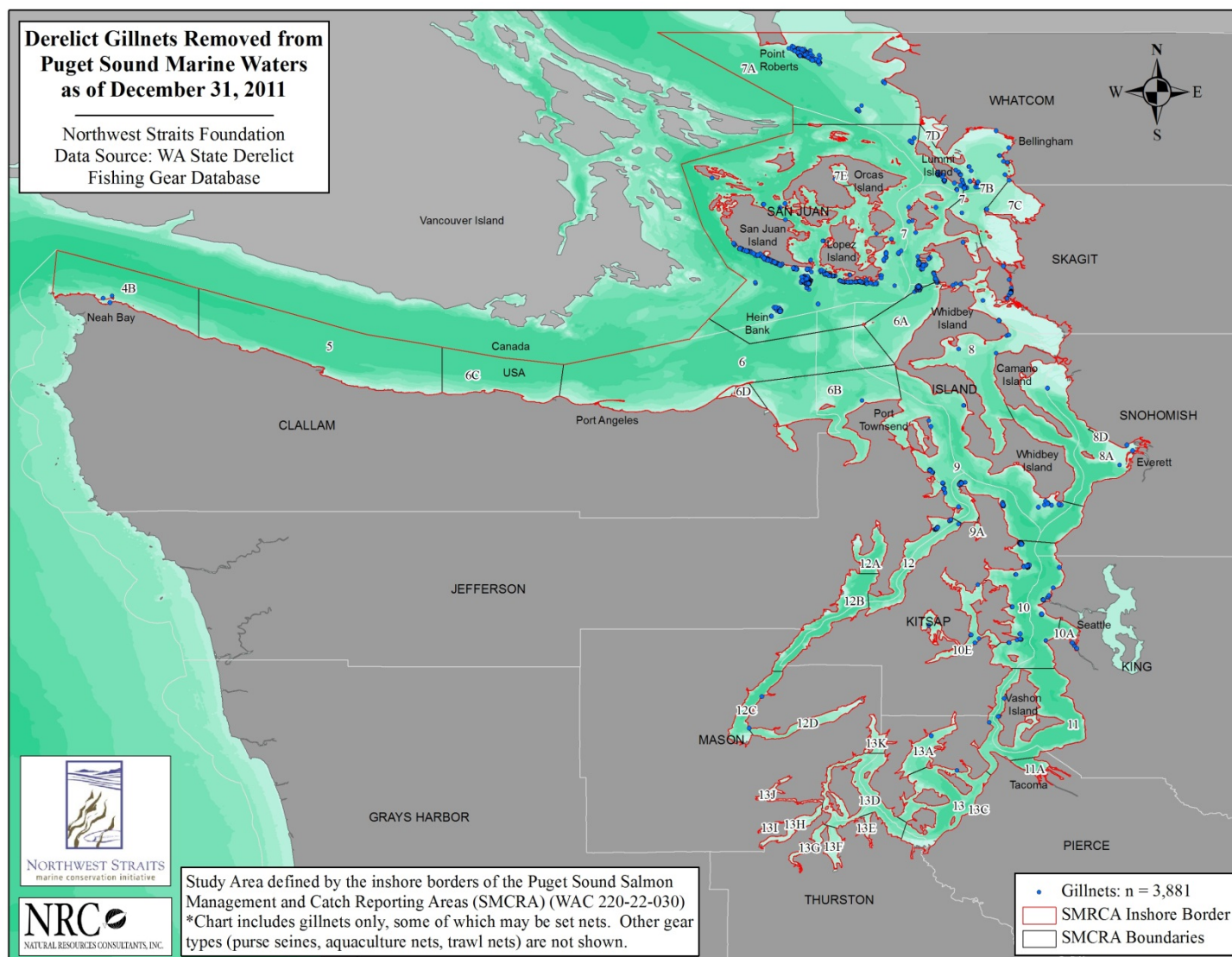


Figure 1. Derelict gillnets removed from Puget Sound marine waters by NWSI DFG program as of December 31, 2011. Source: WA State DFG Database, WDFW

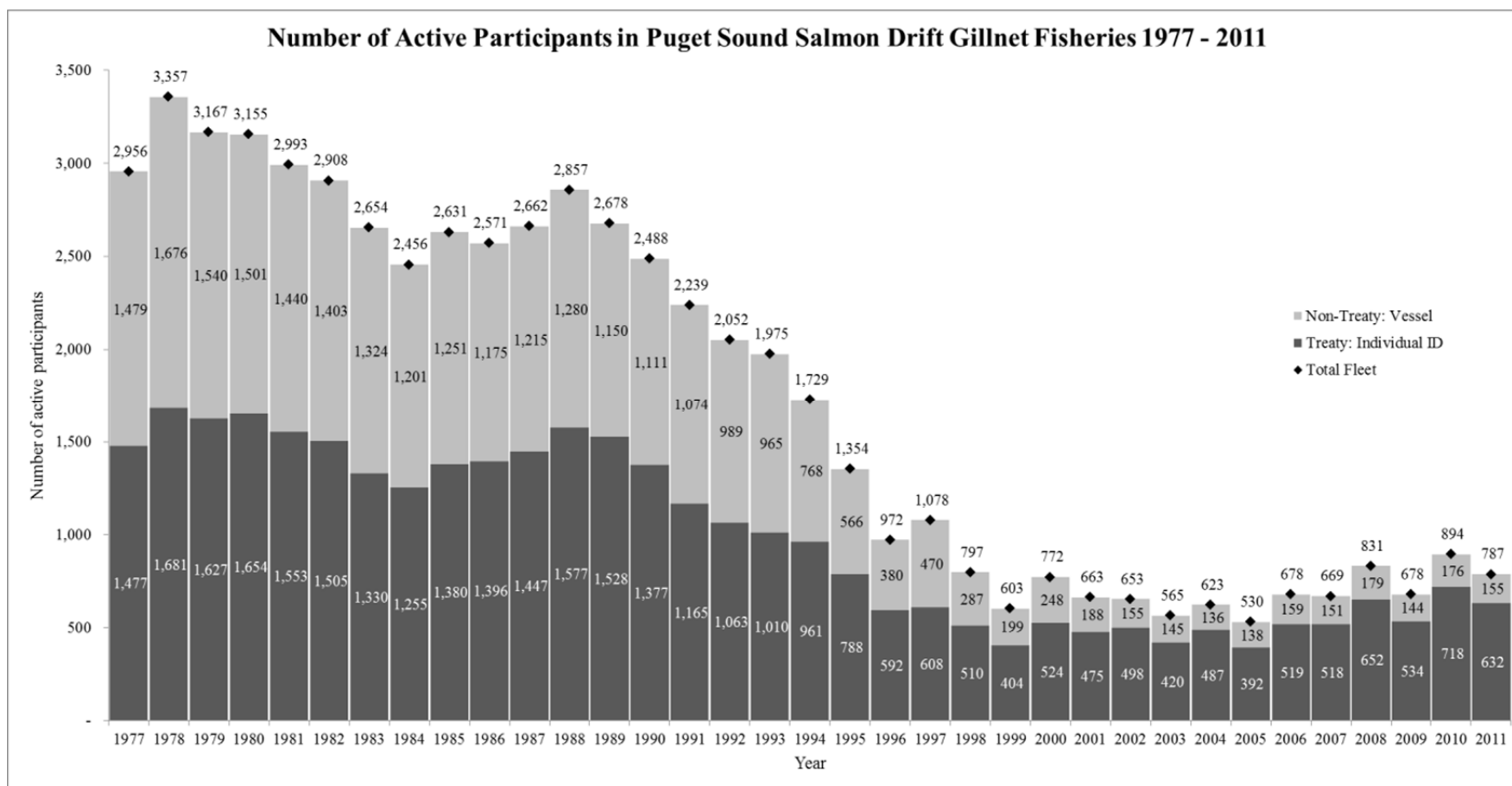


Figure 2. Number of active participants in Puget Sound salmon gillnet fishery by sector from 1977 to 2011. Source: WDFW Fish Ticket Database

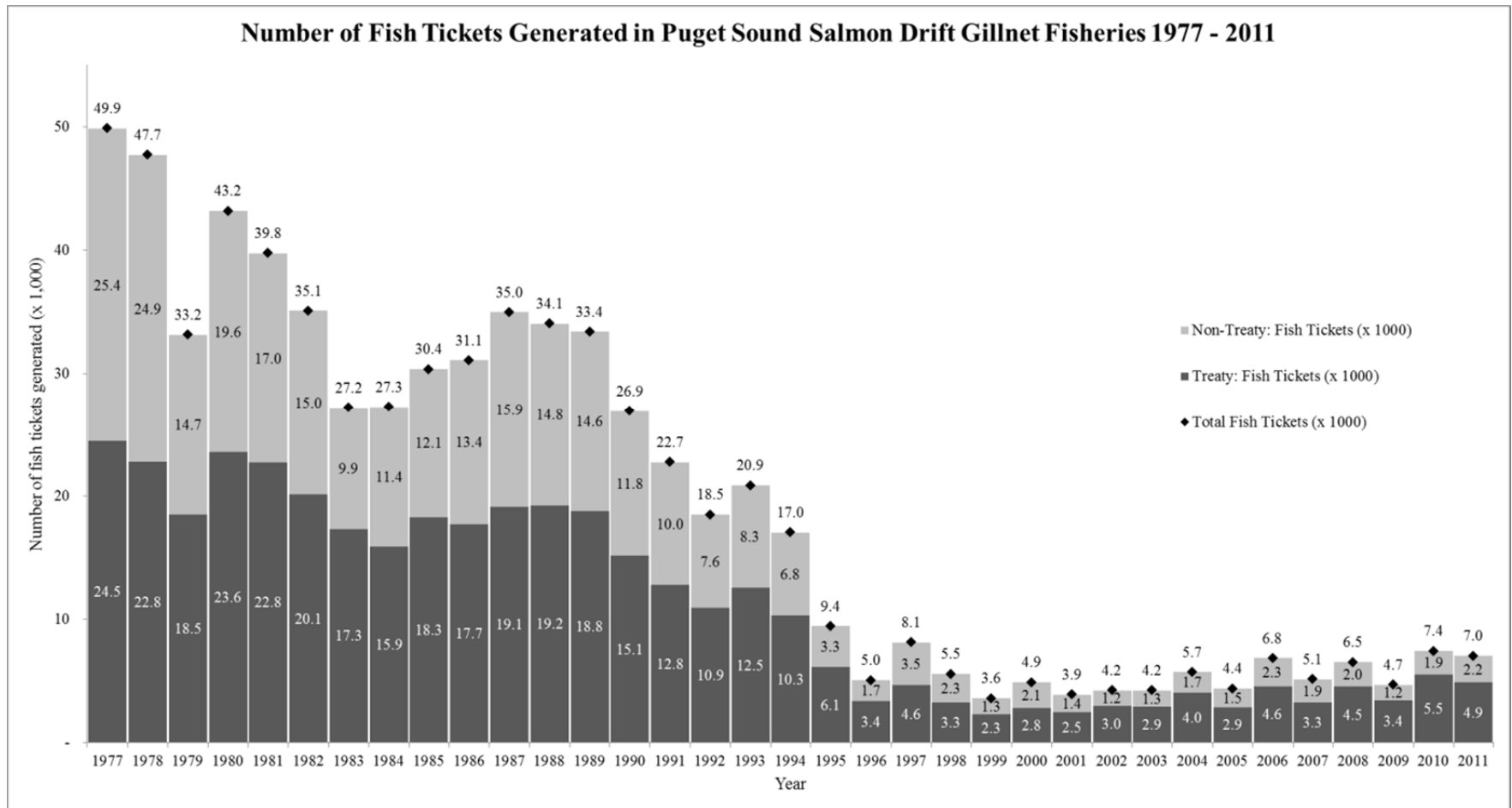


Figure 3. Number of fish tickets generated (x 1000) in Puget Sound salmon gillnet fishery by sector from 1977 to 2011. Source: WDFW Fish Ticket Database

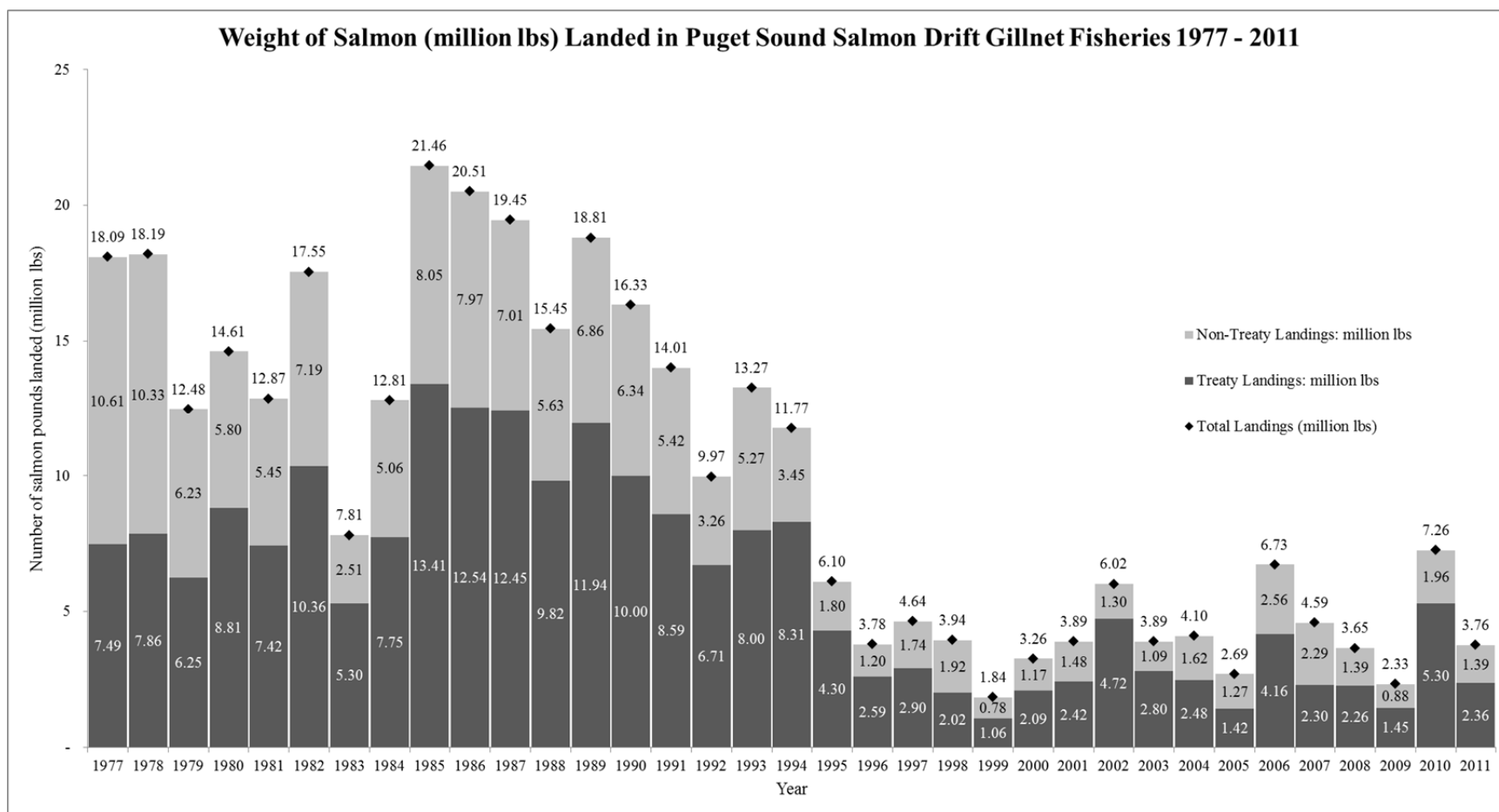


Figure 4. Number of salmon pounds landed (x 1000) in Puget Sound salmon gillnet fishery by sector from 1977 to 2011. Source: WDFW Fish Ticket Database

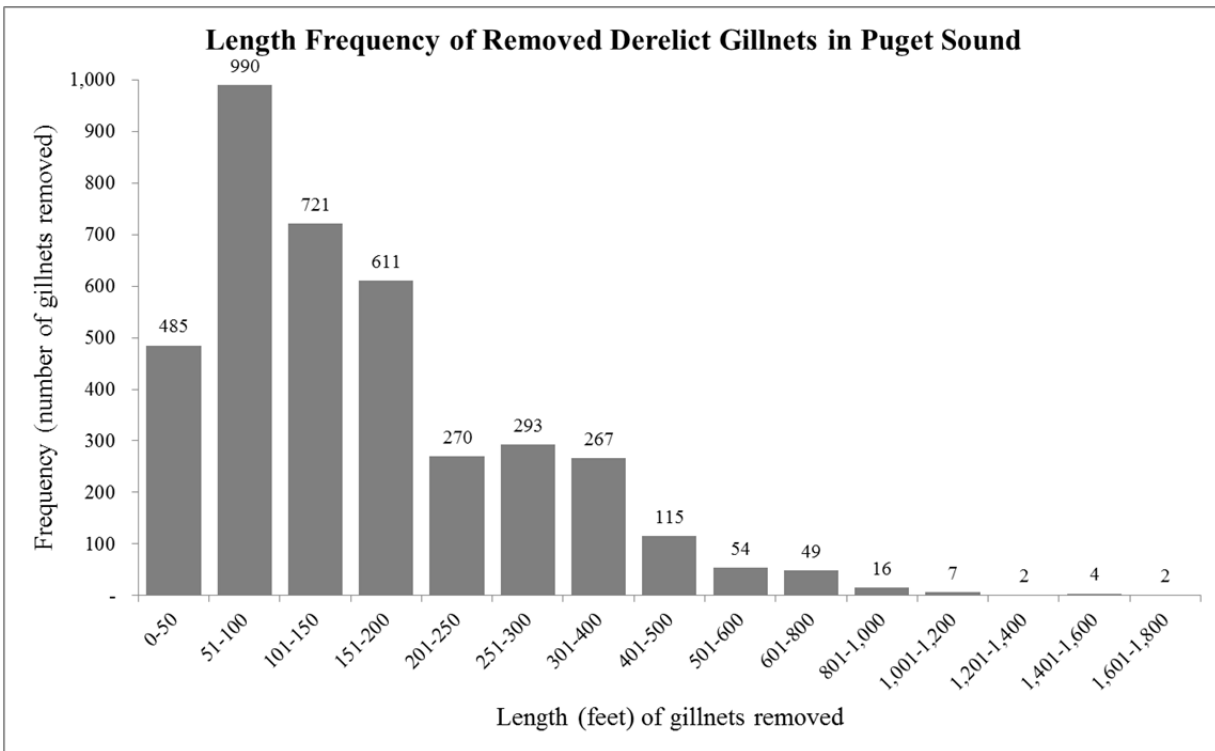


Figure 5. Length frequency of removed derelict gillnets from Puget Sound waters 2002 through 2011.  
Source: WA State Derelict Fishing Gear Database

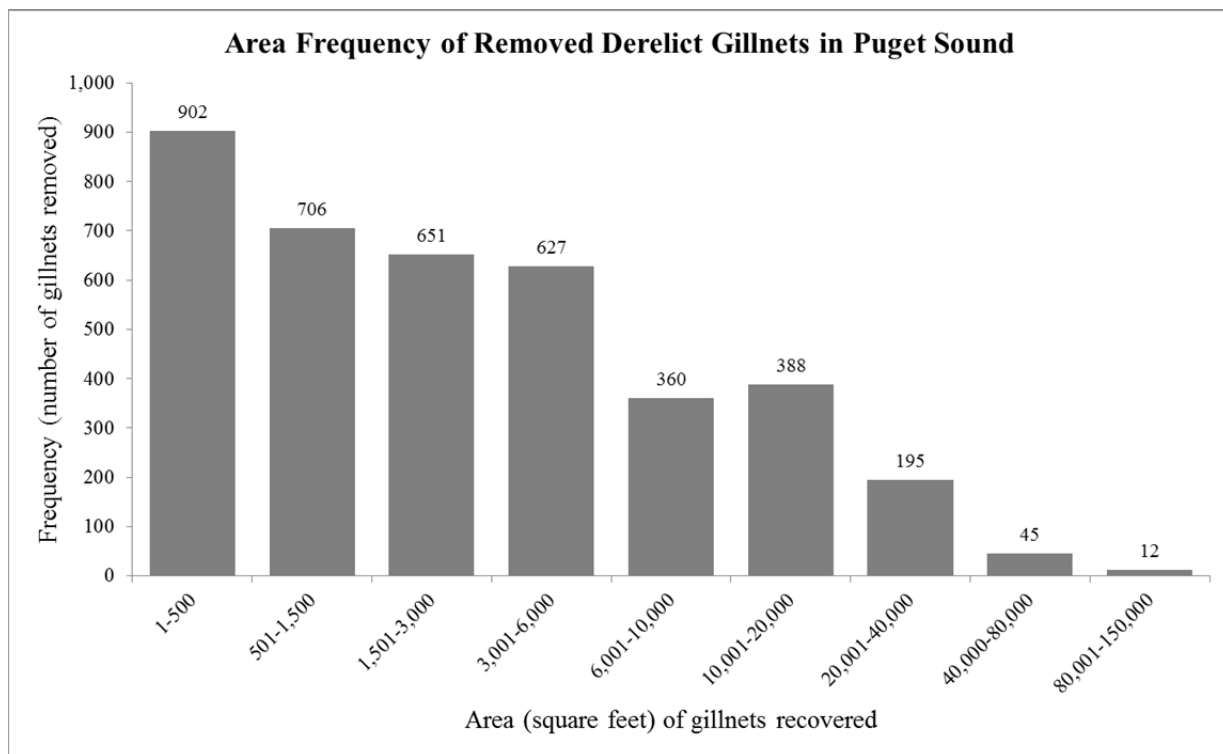


Figure 6. Area frequency of removed derelict gillnets from Puget Sound waters 2002 through 2011.  
Source: WA State Derelict Fishing Gear Database

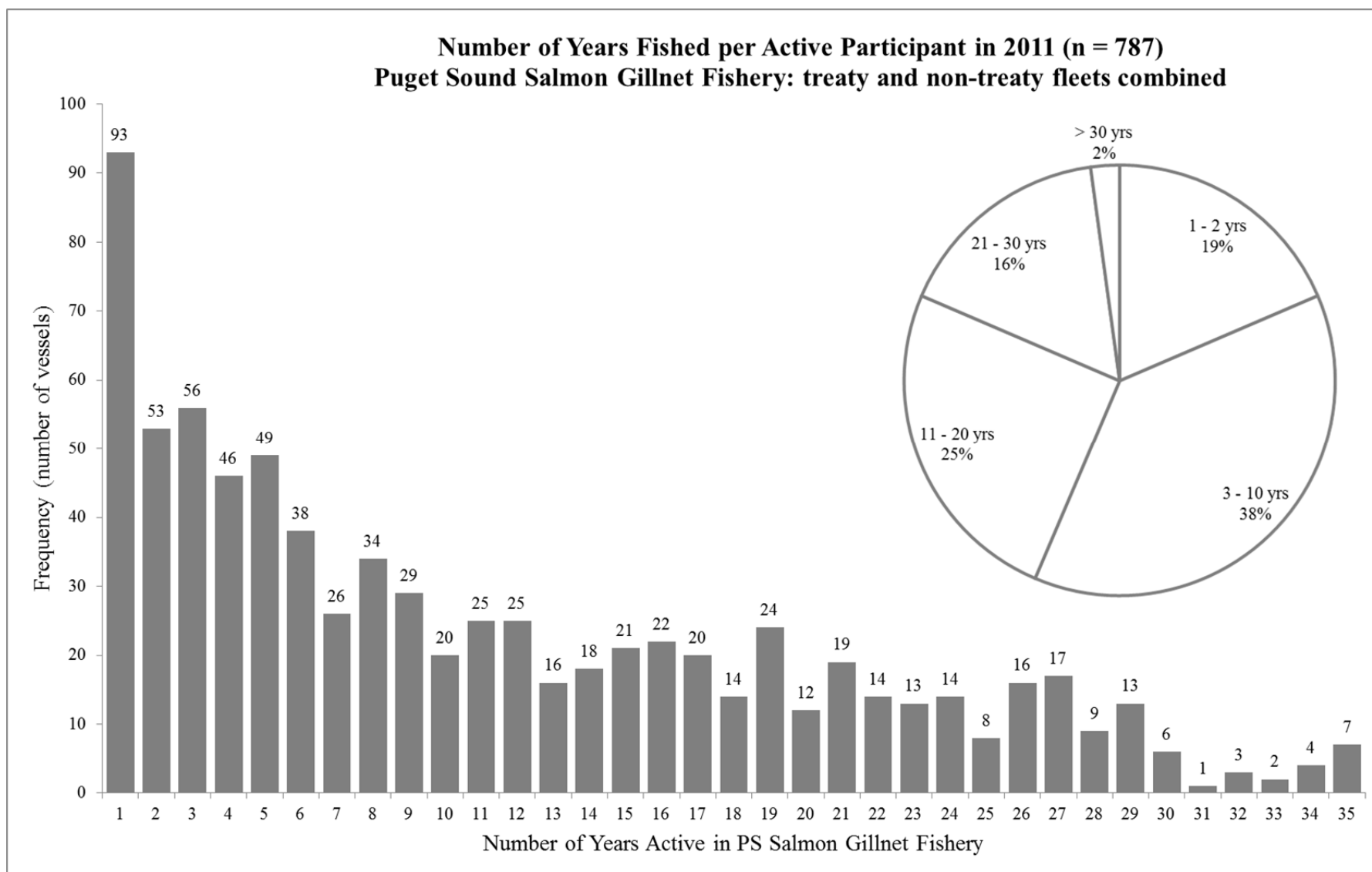


Figure 7. Number of active participants (treaty = tribal ID; non-treaty = vessel ID) in the 2011 Puget Sound salmon gillnet fishery by number of years active within the fishery. Source: WDFW Fish Ticket Database

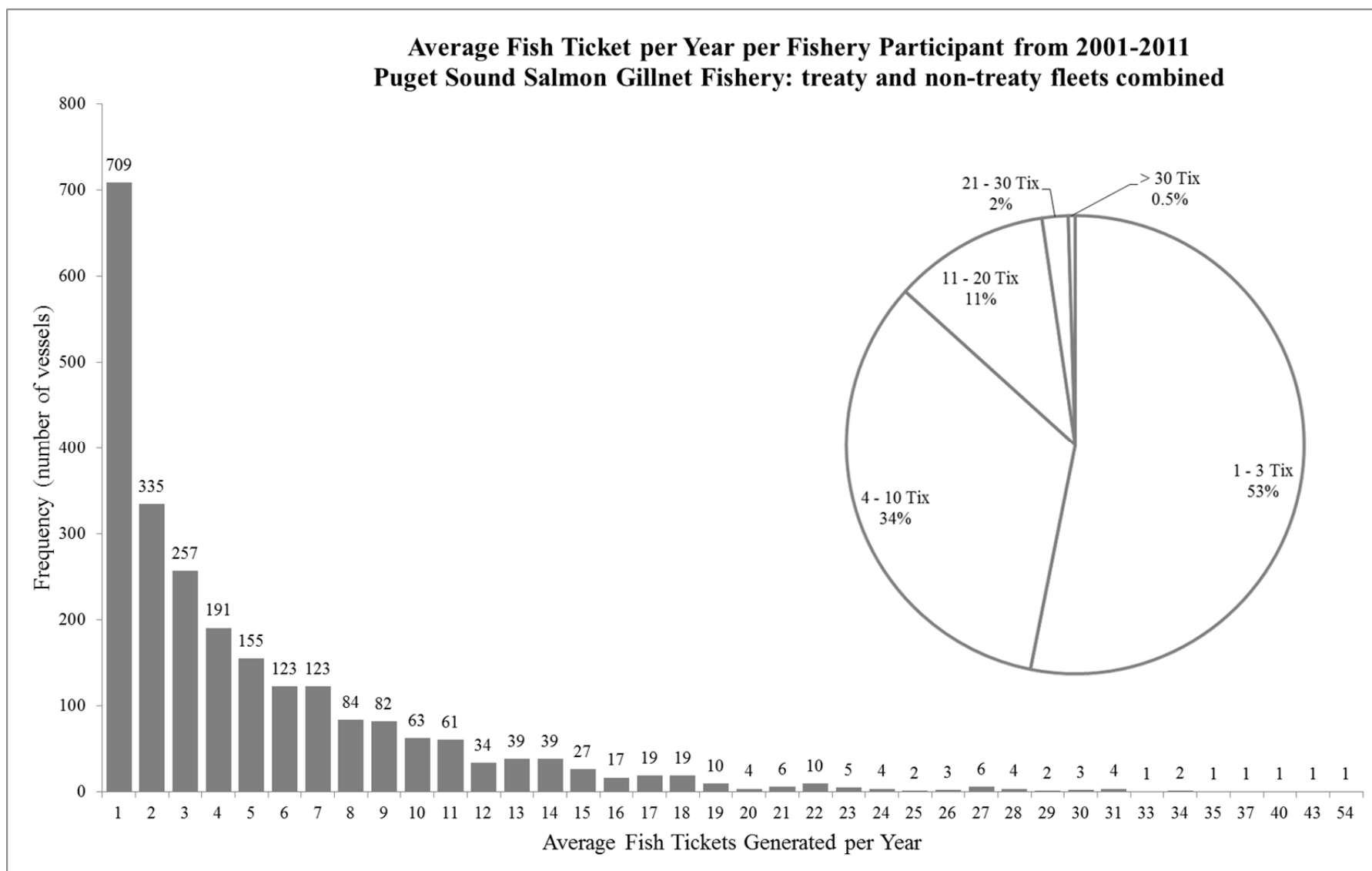


Figure 8. Average number of fish tickets per year per fishery participant from 2001 through 2011. Source: WDFW Fish Ticket Database