March 31, 2014

GRAYS HARBOR AND WILLAPA BAY COMMERICAL SALMON FISHERIES' MORTALITY RATES

INTRODUCTION

The Independent Fisheries Science Panel (IFSP) was tasked to provide recommendations on the release mortality rates to be used in the preseason planning of commercial salmon fisheries in Grays Harbor and Willapa Bay. From the IFSP's statement of work:

> "The IFSP final report will address the following questions and include rationale for each response:
>
> 1. What are the recommended mortality rates for Chinook and chum salmon released in the fisheries described in Table 1 and with fishers complying with the applicable rules and the practices described in the Fish Friendly workshops?

Table 1. Fishery Locations, Time Periods, Gear, and WACs for Consideration by the IFSP

Fishery Location	Time Period	Gear	Rules
Grays Harbor (areas 2A, 2b, 2C, 2D	Weeks 40-48	Gillnet, 6 ½" max. mesh	WAC 220-36-023
Grays Harbor (areas 2A, 2b, 2C, 2D)	Weeks 40-48	Tangle net, 4 ¼" max. mesh	WAC 220-36-023
Willapa Bay (areas 2M-2T)	Mid-August through	Gillnet, 9" max. mesh	WAC 220-40-021
	Mid-September		WAC-220—40-027
Willapa Bay (areas 2M-2T)	Mid-September through	Gillnet, 6 ½" max. mesh	WAC-220-40-021
	October 31		WAC-220-40-021

> 2. For these same fisheries, what are the recommended mortality rates for Chinook and chum salmon released taking into consideration actual practices in the fisheries?
>
> 3. If any mortality rates differed between your responses to questions 1 and 2, what were the major compliance issues that were the source of this difference?"

The statement of work further stated, "…the types of information that the IFSP shall rely upon shall include the following:

- Fishery rules codified in the Washington Administrative Code.
- Reports and publications on release mortality rates in Grays Harbor, Willapa Bay, and in other locations with similar fisheries.
- Fishery data including encounter rates, harvest rates, and the condition of Chinook salmon released.
- Environmental data including water temperature and salinity.
- Fisher behavior and compliance with rules."

This project was initiated on February 18, 2014.

The IFSP received information from the Department, the Twin Harbors Fish & Wildlife Advocacy (Advocacy) and from commercial fishers, including scientific literature, pertinent reports and analyses of the fisheries, previous reviews of mortality rates, environmental data, and testimonials (see Appendix 4).

The ISFP participated in a workshop on February 26, 2014 in Olympia Washington where they were provided presentations by the Department, the Advocacy and commercial fishers. Following the presentations, the attending public was provided time to provide additional testimony.

The ISFP consisted of Chair, Lars Mobrand, biometrician, Alex Wertheimer, fisheries consultant, and Stephen Smith, fisheries consultant. The ISFP was assisted by Jeannie Heltzel, biometrician.

A draft report was provided to the Department on March 11, 2014. The ISFP received comments on the draft report from the Advocacy on March 18th, the Department on March 19th and from a representative of the Willapa Bay and Grays Harbor Gillnetters Associations on March 19th. The ISFP considered these comments and comments from the Quinault Tribe forwarded by the Department in finalizing this report.

The Department's and Advocacy's comments requested the ISFP's thoughts on non-retention mortality for coho salmon. Unfortunately, the ISFP did not have the time and resources to presently conduct similar analyses for coho salmon.

SUMMARY OF SCIENTIFIC LITERATURE, DATA AND OTHER INFORMATION

The ISFP reviewed research results and recommendations from a number of scientific reports addressing release mortalities associated with commercial net fisheries, particularly the results of research on the Columbia River and Willapa Bay as reported by Ashbrook et al. (2004, 2007, 2009) and Vander Haegen et al. (2001, 2002, 2004). A summary of literature considered by the ISFP is provided in Appendix 1, wherein the ISFP has summarized the results of this research and the important biological, environmental and fishery variables associated with the studies that could be pertinent to the Willapa Bay and Grays Harbor fisheries.

The ISFP reviewed and applied other literature on the biology of Chinook and chum salmon, the potential effects of environmental factors on fish survival generally and specifically to potential stresses encountered in fisheries, and on the general effects of stress to fish health. The ISFP examined reports and analyses provided by the Department addressing environmental data (tides, temperature, and salinity) and aspects of the fisheries in Willapa Bay and Grays Harbor, including observer reports. Environmental data from the literature was also reviewed. Analyses of gillnet and tangle net mortalities by the Department and other fishery management entities were examined and considered. All of the information considered by the ISFP is documented in Appendix 4.

In preparing its report, the ISFP sought to apply the 'best available scientific information' in forming recommendations that would assist the Department in pre-season planning for fisheries in Willapa Bay and Grays Harbor. In developing its response to Question #1 above for Chinook, the ISFP relied on the quantitative information from studies of fisheries non-retention mortalities conducted in the Columbia River and Willapa Bay (see Appendix 3). In responding to Questions #2 and #3, and effects on chum the ISFP supplemented this quantitative information with qualitative information on many factors that may affect, or may be perceived to affect, fishery mortalities (Appendix 2).

The IFSP based its analysis and recommendations on the scientific literature pertaining to release mortalities from commercial fishery gears that was provided by the Department and could be gathered independently given the time and resources available. The ISFP also examined scientific literature addressing biological, environmental and fishery factors related to the fisheries and species of concern.

Concerning the task of recommending "…mortality rates for Chinook and chum salmon released in the fisheries…" the IFSP defined release mortalities as:

> Landed salmon that a) were intended for release and b) died before or subsequent to release as a result having been landed. Separate estimates were made for immediate and post-release mortality.

Drop-out mortality and any loss of reproductive success are also potential effects of capture and release of salmon, but the ISFP was instructed not to consider those effects in its recommendation of release mortality rates.

The ISFP notes that research on non-retention fish mortality has attempted to minimize mortality by reducing soak times and applying the best, Fish Friendly handling methods for captured fish rather than mimicking the WAC and actual fishery practices. As a result, research results provide a minimum estimation of non-retention mortality relative to the corresponding fisheries.

IFSP CONCLUSIONS

Table 1 provides the IFSP's conclusions regarding mortality rates for Chinook salmon released in the Grays Harbor and Willapa Bay with fishers fully complying with the applicable Washington Administrative Code (WAC) and the practices described in the Fish Friendly workshops as exemplified by the techniques used in the research studies (Question #1). These mortality figures are also the ISFP's best estimate for chum salmon. These would be minimum non-retention mortality rates.

Table 1. Chinook Salmon Release Mortality Rates for Gillnet and Tangle Net Fisheries Applying 'Fish Friendly' Techniques.

Location	Gear	Period (week)	Areas	Total Release Mortality
Grays Harbor	6.5" Gillnet	40-48	2A-2D	51%
Grays Harbor	4.25" Tangle	40-48	2A-2D	24%
Willapa Bay	9" Gillnet	33-38	2M-2T	58%
Willapa Bay	6.5" Gillnet	39-44	2M-2T	51%

Table 2 provides the IFSP's conclusion regarding mortality rates for Chinook salmon released in the Grays Harbor and Willapa Bay taking into consideration actual practices in the fisheries (Question #2). Again, these are also the ISFP's best estimate for chum salmon. In actual practice, the release mortalities would likely be greater than those estimated for the Fish Friendly scenario. The IFSP did not derive a quantitative recommendation for the survival adjustment to actual practice; however, the example in Table 2 illustrates a reasonable approximation.

The reader is referred to Appendix 3 for methods and calculations for the results shown in Tables 1 and 2. From the analyses in Appendix 3, the ISFP selected the research results from net mesh sizes less than six inches to represent the actual fisheries with 6.5 inch maximum mesh as the Department and fishers provided information that most fishers use nets with 5.25 – 5.75 inch mesh size in these fisheries (see Appendix 2, Net Gear).

Table 2. Chinook Salmon Release Mortality Rates for Gillnet and Tangle Net Fisheries Considering Actual Practices in the Fisheries.

Location	Gear	Period (week)	Areas	Total Release Mortality
Grays Harbor	6.5" Gillnet	40-48	2A-2D	56%
Grays Harbor	4.25" Tangle	40-48	2A-2D	31%
Willapa Bay	9" Gillnet	33-38	2M-2T	62%
Willapa Bay	6.5" Gillnet	39-44	2M-2T	56%

Per Question #3, the release mortality rates shown in Table 2 were attributed to:

1. Testimony and presentations from commercial fishermen asserting high compliance by a large majority of the fleet and an understanding of the necessity and value of compliance.

2. Observer data indicating that soak times are shorter than those that were used historically or required by regulation (45 minutes) and that mandated recovery tanks are utilized by the fleet, indicating that there is broad compliance with the regulations.

3. At high catch rates of target species, increased soak times due to the time it takes to work the net; as soak time increases, so does mortality (Buchanan et al. 2002). The ISFP also understands that soak times can increase when fishers need to remove grass from their nets.

4. The Washington Administrative Code provides for soak times up to 45 minutes, yet soak times within research studies that produced the mortality estimates were generally half that time.

5. Recovery tanks becoming over-crowded if encounter rates of non-targeted salmon, e.g. wild Chinook and chum salmon, are high.

6. Evidence presented to the ISFP that at least in some instances, fishery operations do not fully comply with the fish-friendly prescriptions for non-retention mortality. This evidence included submitted statements, and testimony at the workshop. Reported deviations from fish-friendly operations included longer soak times, rough handling and handling fish by gills, non-functioning recovery tanks, and underuse of recovery tanks.

7. Enforcement personnel issuance of citations for non-compliance.

The ISFP concluded that the research studies cited in Appendix 3 provided the best available estimates of non-retention mortality rates for all locations, time strata, and environmental conditions of each fishery within the bays.

Evidence presented to the ISFP indicates that Fish Friendly handling procedures may, or perhaps cannot, always be followed as implemented by research teams; consequently release mortalities in the fisheries will be higher in actual practice. The mortality rates from Table 2 above reflect a) evidence of deviations from techniques used in research studies, and b) qualitative information regarding the possible impacts of different environmental conditions in Willapa Bay and Grays Harbor relative to Columbia River conditions. The ISFP based its conclusions on the scientific literature and research conducted under specified, controlled conditions. The issue of compliance thus relates more to how closely the commercial fisheries adhere to the methods and techniques reported in that research, than on deviations of the commercial fisheries from implementing the Washington Administrative Code.

IFSP RECOMMENDATIONS

ADDITIONAL RESEARCH:

The ISFP recommends that the Department continue research studies in Willapa Bay to better estimate long-term catch and release mortalities associated with commercial fisheries. Future research should attempt to mirror the actual fishery and in mesh size, soak time and handling procedures, including use of recovery boxes. Prior to research, the parameters of a future fishery should be discussed with the commercial fishers to ensure the research closely approximates future fishery practices and conditions.

Research should quantify immediate mortality, and post-release mortality up to and including effects on reproductive success (to fed fry stage) of released female fish in a hatchery. The Department should consider using a passive trapping device to collect control fish in the lower bay, apply PIT tags, and deploy PIT tag detection arrays in rivers upstream of the fisheries and at appropriate hatcheries. PIT tagging of released fish should denote species, size, sex and release condition. Commercial and sport harvest should be monitored for PIT tag detection.

The survival effects of net encounters (drop-off mortality) and pinniped interactions pre- and post-capture should also be considered in a research design.

DROP-OFF MORTALITY:

The IFSP was instructed not to include drop-off mortality in its evaluation of release mortality, but a total accounting of the mortality associated with fishing should include drop-off mortality. It is included in other WDFW models, and should be included in the assessment of fishing mortality associated with the fisheries in Willapa Bay and Grays Harbor.

REDUCING STRESS IN FISHERIES:

From the ISFP's review of the literature, it is evident that non-retention commercial and sport fisheries conducted in warmer, estuarine waters should be regulated to minimize the period and extent of stress to fish during capture and release. For commercial fisheries, the time from fish encounter with a net to time of potential release could be reduced to limit stress and likely mortality. The Department and fishers may want to consider shorter WAC soak times and mesh sizes (tangle nets) that reduce handling time, including ease of fish removal from the net.

ACTUAL FISHERY PRACTICE RELATIVE TO FISH FRIENDLY RESEARCH:

When considering the fishery compliance as it relates to release mortalities, the ISFP understands that the Department may consider a compliance rate other than the example suggested in Table 2. To assist the Department, the ISFP believes the best available science supports gillnet and tangle net non-retention rates relative to the degree of compliance as indicated in Table 3 below.

Table 3. Relationship of Fishery Compliance (Actual Practice Rate) to Total Non-Retention Mortality Rate for Willapa Bay and Grays Harbor Commercial Fisheries.

Actual Practice Rate	Large Mesh Mortality Rate	Small Mesh Mortality Rate	Tangle Net Mortality Rate
100%	58%	51%	24%
90%	62%	56%	31%
80%	67%	61%	39%
70%	71%	66%	47%
60%	75%	70%	54%
50%	79%	75%	62%
40%	83%	80%	69%
30%	87%	85%	77%
20%	92%	90%	85%
10%	96%	95%	92%
0%	100%	100%	100%

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APPENDIX 1. Review of Release Mortality Literature

Table A1.1. Summary of gillnet and tangle net release mortality literature evaluated by the IFSP.

Study					Release Mortality				Biological Variables				Fishery Variables			Environmental Variables		Other Factors (see Notes if 'Yes')				
Method	Study	Location	Study Year	Study Month	Immediate Mortality Rate (%)	95% CI	Long-Term Mortality Rate (%)	95% CI	Species	Fish Size (cm)	Maturity State	Migration Duration (Days)	Gear	Mesh size (inches)	Soak Time (min)	Temp (°C)	Freshwater or Estuary	Dropoffs	Pinnipeds	Spawning success	Progeny survival	Notes
1	Ashbrook et al. 2004	Columbia River	2001	Spring	1.0	SE = 0.3	47.5	42.1 - 52.9	Sp. Chinook	NA	NA	180	Gillnet	8	24 - 65 ($\bar{x}$= 39)	4 - 11 ($\bar{x}$=8.9)	Freshwater	NA	NA	NA	NA	Long-term mortality assessed relative to control fish using tag recoveries (# fish reaching C.R. dams, hatcheries, sport fish recoveries, etc.). Also evaluated condition factor of captured fish. Fish in condition 1 were more likely to be recovered than fish in Conditions 2 and up.
2	Ashbrook et al. 2004	Columbia River	2002	Spring	0.9	SE = 0.2	42.7	35.5 - 49.9	Sp. Chinook	75.4	NA	180	Gillnet	5.5	24 - 65 ($\bar{x}$= 39)	4 - 11 ($\bar{x}$=8.9)	Freshwater	NA	NA	NA	NA	Long-term mortality assessed relative to control fish using tag recoveries (# fish reaching C.R. dams, hatcheries, sport fish recoveries, etc.). Also evaluated condition factor of captured fish. Fish in condition 1 were more likely to be recovered than fish in Conditions 2 and up.
3	Ashbrook et al. 2004	Columbia River	2001	Spring	3.2	SE = 0.8	8.8	0 - 53.0	Sp. Chinook	NA	NA	180	Tangle net	3.5 & 4.5	24 - 65 ($\bar{x}$= 39)	4 - 11 ($\bar{x}$=8.9)	Freshwater	NA	NA	NA	NA	Long-term mortality assessed relative to control fish using tag recoveries (# fish reaching C.R. dams, hatcheries, sport fish recoveries, etc.). Also evaluated condition factor of captured fish. Fish in condition 1 were more likely to be recovered than fish in Conditions 2 and up.
4	Ashbrook et al. 2004	Columbia River	2002	Spring	0.5	SE = 0.2	32.4	26.7 - 38.7	Sp. Chinook	76.3	NA	180	Tangle net	4.5	24 - 65 ($\bar{x}$= 39)	4 - 11 ($\bar{x}$=8.9)	Freshwater	NA	NA	NA	NA	Long-term mortality assessed relative to control fish using tag recoveries (# fish reaching C.R. dams, hatcheries, sport fish recoveries, etc.). Also evaluated condition factor of captured fish. Fish in condition 1 were more likely to be recovered than fish in Conditions 2 and up.
5	Ashbrook et al. 2009	Columbia River	2003	Spring	2.1	1.4 - 3.1	15.6	13.0 - 18.2	Sp. Chinook	NA	NA	180	Tangle net	4.25 & 4.5	23 - 63 ($\bar{x}$ =34)	7 - 12	Freshwater	NA	Yes	NA	NA	The long-term mortality rate shown (15.6%) includes pinniped predation. Long-term mortality was 12.8% (95% CI: 10.2-15.5%) when pinniped predation is excluded. Using PIT tags instead of jaw tags increased detection probability at dams and resulted in narrower CIs than 2001-2002 studies.
6	Ashbrook et al. 2007	Willapa Bay	2003	Sept/Oct	10.9	SE = 1.21	NA	NA	Coho	70	NA	30	Gillnet	5.75	0 - 38 ($\bar{x}$=13)	11 - 19 ($\bar{x}$=16)	Estuary	NA	NA	NA	Yes	Tangle net progeny had 5.5% higher eyed to fry survival than gillnet progeny.
7	Ashbrook et al. 2007	Willapa Bay	2003	Sept/Oct	11.3	SE = 1.41	NA	NA	Coho	68	NA	30	Tangle net	3.5	0 - 37 ($\bar{x}$=14)	11 - 19 ($\bar{x}$=16)	Estuary	NA	NA	NA	Yes	Tangle net progeny had 5.5% higher eyed to fry survival than gillnet progeny.
8	Ashbrook et al. 2007	Willapa Bay	2003	Sept/Oct	15.0	SE = 2.44	NA	NA	Chinook	83	NA	30	Gillnet	5.75	0 - 38 ($\bar{x}$=13)	11 - 19 ($\bar{x}$=16)	Estuary	NA	NA	NA	NA	Did not evaluate progeny survival in Chinook.
9	Ashbrook et al. 2007	Willapa Bay	2003	Sept/Oct	3.7	SE = 1.47	NA	NA	Chinook	85	NA	30	Tangle net	3.5	0 - 37 ($\bar{x}$=14)	11 - 19 ($\bar{x}$=16)	Estuary	NA	NA	NA	NA	Did not evaluate progeny survival in Chinook.
10	Vander Haegen et al. 2001	Budd Inlet	2000	NA	40.2	NA	NA	NA	Chinook	NA	NA	30	Gillnet	6.5	5 - 120	NA	Estuary	NA	NA	NA	NA	
11	Vander Haegen et al. 2001	Budd Inlet	2000	NA	24.3	NA	NA	NA	Chinook	NA	NA	30	Tangle net	3.5	5 - 120	NA	Estuary	NA	NA	NA	NA	
12	Vander Haegen et al. 2001	Willapa Bay	2000	Sept/Oct	20.5	NA	NA	NA	Chinook	NA	NA	30	Gillnet	7.25	8 - 60 ($\bar{x}$=30)	11 - 18 ($\bar{x}$=13.7)	Estuary	NA	NA	NA	NA	
13	Vander Haegen et al. 2001	Willapa Bay	2000	Sept/Oct	8.1	NA	NA	NA	Chinook	NA	NA	30	Tangle net	3.5	8 - 60 ($\bar{x}$=30)	11 - 18 ($\bar{x}$=13.7)	Estuary	NA	NA	NA	NA	
14	Vander Haegen et al. 2001	Willapa Bay	2000	Sept/Oct	24.5	NA	NA	NA	Coho	NA	NA	30	Gillnet	7.25	8 - 60 ($\bar{x}$=30)	11 - 18 ($\bar{x}$=13.7)	Estuary	NA	NA	NA	NA	
15	Vander Haegen et al. 2001	Willapa Bay	2000	Sept/Oct	19.9	NA	NA	NA	Coho	NA	NA	30	Tangle net	3.5	8 - 60 ($\bar{x}$=30)	11 - 18 ($\bar{x}$=13.7)	Estuary	NA	NA	NA	NA	
16	Vander Haegen et al. 2002	Willapa Bay	2001	Sept/Oct	12.8	7.6 - 20.6	NA	NA	Chinook	NA	NM	30	Gillnet	5.75	19 - 33 ($\bar{x}$=28)	12 - 19 ($\bar{x}$=13)	Estuary	NA	NA	NA	NA	See Table 10- no relationship between condition factor at release and percent recovered.
17	Vander Haegen et al. 2002	Willapa Bay	2001	Sept/Oct	3.7	1.4 - 9.1	NA	NA	Chinook	NA	NM	30	Tangle net	3.5	19 - 33 ($\bar{x}$=28)	12 - 19 ($\bar{x}$=13)	Estuary	NA	NA	NA	NA	See Table 10- no relationship between condition factor at release and percent recovered.
18	Vander Haegen et al. 2002	Willapa Bay	2001	Sept/Oct	9.2	6.7 - 12.5	NA	NA	Coho	68.7	NM	30	Gillnet	5.75	19 - 33 ($\bar{x}$=28)	12 - 19 ($\bar{x}$=13)	Estuary	NA	NA	NA	NA	
19	Vander Haegen et al. 2002	Willapa Bay	2001	Sept/Oct	13.0	10.0 - 16.7	NA	NA	Coho	64.4	NM	30	Tangle net	3.5	19 - 33 ($\bar{x}$=28)	12 - 19 ($\bar{x}$=13)	Estuary	NA	NA	NA	NA	
20	Baker and Schindler 2009	Bristol Bay	2005-2007	Jul/Aug	NA	NA	NA	NA	Sockeye	NA	NA	10-25 (in stream residence time)	Gillnet	NA	NA	NA	Estuary	NA	NA	Yes	NA	Many sockeye observed on spawning grounds had gillnet injuries (11-29%). More than half (51%) of injured fish that reached spawning grounds failed to spawn versus 6% of control fish. Injured fish had much higher incidence of fungal infections and much shorter residence time in spawning streams, suggesting spawning failure. Results suggest that escapement estimates are 5 to 15% too high if they do not account for gillnet drop-off mortalities. Study does not account for gillnet drop-offs that died before entering the spawning grounds.
21	Baranski et al. 1980	Lower Skagit River	1975	Jul	98.0	NA	NA	NA	Chinook	NA	NM	NA	Gillnet	8	NA	NA	Estuary	NA	NA	NA	NA	Chinook broodstock captured using set nets. Higher mortality rates for Chinook caught in lower Skagit River (98%) in July versus upper river (<5%) one month later. Concluded that in lower river, fish were not sufficiently adapted to FW enviroment to survive stress of capture.
22	Baranski et al. 1980	Upper Skagit River	1975	Aug	<5	NA	NA	NA	Chinook	NA	M	NA	Gillnet	8	NA	NA	Freshwater	NA	NA	NA	NA	Chinook broodstock captured using set nets. Higher mortality rates for Chinook caught in lower Skagit River (98%) in July versus upper river (<5%) one month later. Concluded that in lower river, fish were not sufficiently adapted to FW enviroment to survive stress of capture.
23	Buchanan et al. 2002	BC	2000	Jul-Sept	NA	NA	6.7	4.3-10.2	Coho	NA	2 sites-M; 1 site-NM	NA	Gillnet and Tangle net	4.25 & 4.5	40 & 140	NA	Estuary	NA	NA	NA	NA	Similar to methods in Farrell et al. 2001. Fish placed in recovery box for 2 hr then in net pens for 48 hours. No information on survival beyond 48 hours. Rates shown are for 40 min soak times. Mortality rates for 140 min soak much higher (60%).
24	DFO 1999	Alberni Inlet, BC	1998	Sept	46.5	NA	60.6	NA	Coho	NA	NA	NA	Gillnet	NA	30-60	NA	Estuary	NA	NA	NA	NA	Long-term mortality assessed after fish held in net pens for **xx hours** (not specified). Three different soak times used (30, 45, 60 min). Survival decreased with longer soak times. **No recovery boxes used?** See results on p. 11, 14, and 15. Mortality ~55% for 30 min soaks, increased to ~64% for 60 min soaks.
25	DFO 1999	Alberni Inlet, BC	1998	Sept	12.3	NA	NA	NA	Chum	NA	NA	NA	Gillnet	NA	30-60	NA	Estuary	NA	NA	NA	NA	See results on p. 11.
26	DFO 1999	Alberni Inlet, BC	1998	Sept	28.6	NA	NA	NA	Chinook	NA	NA	NA	Gillnet	NA	30-60	NA	Estuary	NA	NA	NA	NA	See results on p. 11.

Table A1.1. Summary of gillnet and tangle net release mortality literature evaluated by the IFSP.

Study					Release Mortality				Biological Variables				Fishery Variables			Environmental Variables		Other Factors (see Notes if 'Yes')				
Method	Study	Location	Study Year	Study Month	Immediate Mortality Rate (%)	95% CI	Long-Term Mortality Rate (%)	95% CI	Species	Fish Size (cm)	Maturity State	Migration Duration (Days)	Gear	Mesh size (inches)	Soak Time (min)	Temp (°C)	Freshwater or Estuary	Dropoffs	Pinnipeds	Spawning success	Progeny survival	Notes
27	DFO 1999	Alberni Inlet, BC	1998	Sept	10.6	NA	NA	NA	Sockeye	NA	NA	NA	Gillnet	NA	30-60	NA	Estuary	NA	NA	NA	NA	See results on p. 11.
28	Farrell et al. 2001	Alberni Inlet, BC	1999	Oct/Nov	NA	NA	2.3	NA	Coho	54-78	NA	NA	Gillnet	4.75	< 40	12-16	Estuary	NA	NA	NA	NA	No mortality observed after 2 hour recovery in Fraser box (n = 87). Only 2.3% mortality after 24 hours in net pens (following recovery in Fraser boxes). No information on survival beyond 24 hours.
29	Gallinat et al. 1997	Lake Superior	1992-1993	Various	NA	NA	Win 79%, Spr 69%, Sum 78%	76-82, 64-74, 73-82	Lake Trout	NA	NA	NA	Gillnet	4.25	1-5 nights	NA	Freshwater	NA	NA	NA	NA	Maximum soak time varied by season (1 night in summer, 3 nights spring, 5 nights winter). "'Released" fish were held at the hatchery for 48 hours- it's a bit confusing what this means, but it appears to be fish that were alive when they were landed. Survival assessed at end of 48 hr holding period. 'Released' fish had relatively high survival after 48 hours (70% or so). Mortality rates for the total number of fish captured in gill nets were much higher, but they used very long soak times.
30	Keefer et al. 2008	Upper Snake	2000	NA	NA	NA	NA	NA	Sockeye	52.5	M		Gillnet	NA	NA	>20 max	Freshwater	Yes	NA	NA	NA	Returning adult sockeye (n = 31) radio-tagged at Lower Granite Dam to assess drop-off mortality. Two fish had gillnet marks and did not survive to spawn. Overall, 41% of tagged fish (n = 12 of 29; 2 transmitters failed) reached spawning grounds (weirs at Sawtooth Hatchery or Redfish Lake creek).
31	Makinen et al. 2000	Finland	1990s	NA	NA	NA	NA	NA	Atlantic salmon	NA	NA	NA	Gillnet	NA	NA	NA	Freshwater	NA	NA	NA	NA	Radiotagged Atlantic salmon caught in gillnets exhibited signs of stress (running downstream after capture) and delayed upstream migration. We only have the abstract- it's not clear if fish were tagged before or after they were caught in gillnets, and whether stress is attributable to tagging as well as capture.
32	PSC Ad Hoc 1995	Quilcene Bay	1993	NA	26.0	NA	NA	NA	Chum	NA	NA	NA	Gillnet	NA	NA	NA	Estuary	NA	NA	NA	NA	
33	PSC Ad Hoc 1995	Quilcene Bay	1992	NA	10.0	NA	NA	NA	Chum	NA	NA	NA	Gillnet	NA	NA	NA	Estuary	NA	NA	NA	NA	
34	Thompson et al. 1969	Puget Sound	1968	Summer	69.5	NA	NA	NA	Sockeye	NA	NA	NA	Gillnet	5.25	12 hrs	NA	Estuary	Yes	NA	NA	NA	Two groups of sockeye held in a divided enclosure: one group exposed to gillnet for 12 hours, one control group. Nearly half of gillnet group escaped the net, but 80% of these fish died within 8 days (significantly lower survival than control fish). Of fish that were captured in the gillnet, immediate mortality was 70% (57 of 82 fish). But note that soak time was apparently 12 hours (Cook-Tabor Cove).
35	Thompson and Hunter 1972	Puget Sound	1968-1970	Summer	NA	NA	NA	NA	Sockeye	NA	NA	NA	Gillnet	5-5.25	12 hrs?	NA	Estuary	Yes	NA	NA	NA	Appears to use same methods as Thompson et al. 1969 with 12 hour soak time, but methods not described in the paper. Approximately 45% of sockeye that were initially enmeshed in gillnets became disentangled (estimate of drop-out rate). Compared survival rate of drop-outs to control fish; mortality was 4 times higher for drop-outs than for control fish.
36	USFWS 1955	Kodiak	1953	Jun-Aug	NA	NA	NA	NA	Sockeye	NA	NA		Gillnet	5.5	<15 min?	NA	Estuary	NA	NA	Yes	NA	Gillnet marked and control sockeye salmon were tagged. Survival to spawning grounds compared. Mortality of gillnet marked fish was 10-20% higher than control group. Most mortalities occurred soon after capture and marking. Of fish that made it to the spawning grounds, no difference in spawning success was observed between treatment/control groups. Note very short (<15 min) soak times.
Other gear types																						
37	Candy et al. 1996	Johnstone Strait, BC	1990-1992		NA	NA	23	13-38	Chinook	NA	NA		Purse seine	NA	22		Estuary	NA	NA	NA	NA	Estimated mortality of radio-tagged fish 24 hours after capture in purse seines; captured fish remained in shallow waters for next 24 hours, where they were more likely to be recaptured.

APPENDIX 2. Factors Considered in Addressing Fishery Mortality Rates

In addition to the quantitative results on non-retention mortality rates (Appendix 3), the ISFP considered biological, environmental and commercial fishery factors applicable, or perceived to be applicable, to non-retention mortalities in Willapa Bay and Grays Harbor. These factors were qualitatively considered by the ISFP when importing research results on Columbia River spring Chinook to Willapa Bay and Grays Harbor and in considering post release survival. Some factors were also considered by the ISFP as potentially affecting fish stress and survival, possibly when actual fishery practices were not aligned with Fish Friendly techniques.

BIOLOGICAL FACTORS

Several biological factors affecting, or perceived to affect, release mortalities were considered.

MATURATION CONDITION:

As Pacific salmon approach sexual maturity, they undergo major morphological and physiological changes. In the ocean environment, the fish are silvery with highly deciduous scales, and are fusiform shaped with minor or no external differences between males and females. As the fish mature, their scales become "set" in the scale pockets, the mucous layer on their skin thickens, gonads greatly increase in size, skin coloration changes ("watermarking", "blushing"), and males and females develop different morphological sexual characteristics. Pacific salmon that are close to maturity are resistant to stress, and exhibit lower mortality after being exposed to capture stress than fish caught and released in marine or estuarine environments (Raby et al. 2013; PSC 2004; Vincent-Lang et al. 1993).

Distance to spawning grounds is often associated with the maturation condition of Pacific salmon when they move from the ocean to their freshwater habitats, and the time they will be in freshwater prior to spawning. Fish with shorter migration distances in freshwater, such as Washington Coast fall-run Chinook and chum salmon, are more advanced in their maturation condition than fish with long freshwater migration distances, such as Columbia River spring-run Chinook salmon. Coastal fish can exhibit blushing or watermarking and obvious differences in morphology between sexes at freshwater entry, whereas Columbia River spring-run Chinook salmon are typically "ocean-bright" with deciduous scales. As such, the coastal fish may be more resistant to capture stress at first entry to freshwater, assuming they are captured in habitats that pose similar physiological challenges to the fish. Also, shorter time to spawning means that the fish most survive the stress of capture and release for a shorter duration until completing their maturation and reproducing.

The ISFP assumes that the fall running salmon in Willapa Bay and Grays Harbor are further mature than the spring Chinook studied in the Columbia River. This difference could make the fall salmon generally less vulnerable to the handling injuries.

ADAPTATION TO FRESHWATER:

Pacific salmon are well-known for their anadromous behavior, which requires them to be capable of living in both freshwater and marine habitats. These habitats require extremely different physiological responses (Clark and Hirano 1995). In marine habitats, salmon must retain water and excrete excess salts. They produce little urine, and actively excrete ions through specialized chloride cells in their gills. In freshwater, the kidneys produce copious amounts of urine, and ions for salts are actively taken up from the surrounding water by the chloride cells. These processes are hormonally mediated. As maturing salmon enter estuarine waters, they transition from one physiological state to the other. There is evidence that during this estuarine residency and physiological transition, salmon are more susceptible to stress, including capture stress. For example, mortality following catch-and-release on recreational fishing gear was much higher for coho salmon captured in an estuary than those captured in freshwater (Vincent-Lang et al. 1993), and Baranski (1980) observed much higher mortality for Chinook salmon captured by netting in the Skagit River estuary than in freshwater. The differences observed are probably an interaction of maturation condition and physiological stress during transition. However, the substantially higher immediate mortality reported by Ashbrook et al. (2007) for fall Chinook in the Willapa Bay estuary captured by gillnet or tangle net relative to spring Chinook captured in freshwater in the Columbia River (Figure A3-1) indicated that the fall-run fish were much more sensitive in the estuarine environment regardless of more advanced maturation condition associated with shorter freshwater migration distances.

The ISFP assumes that salmon in all fishing areas within Willapa Bay and Grays Harbor can be more vulnerable to injury and stress from fishing activities compared to results from spring Chinook in the Columbia River. This vulnerability is expressed in the immediate mortality rates. The ISFP assumes such increased vulnerability carries through into long-term mortality.

ABUNDANCE AND MARK RATE:

Abundance of target fish, such as marked hatchery Chinook salmon, and of non-retained fish such as unmarked wild Chinook salmon, can affect the soak time and handling of fish captured in gillnets or tangle nets. At high abundance, soak times can tend to increase because of the time required to remove fish for either harvest or release; as soak time increases, so does mortality associated with capture and release from the nets (Buchanan et al. 2002). At lower mark rates, the probability of over-loading recovery boxes increases, which affects the capability of the fishers to hold fish for sufficient time for revival to better condition at release.

The ISFP assumes that mortality rates can be expected to increase with greater abundance and encounters of both targeted and non-targeted fish. Similarly, lower mark rates of Chinook combined with higher abundance of fish can lead to less than optimal use of recovery boxes.

MULTIPLE RECAPTURES:

Multiple recaptures occur when fish that are captured and released in a selective fishery are subsequently captured again in the same or sequential fisheries. In considering mortality impacts in selective fisheries, when mortality is estimated by inferring the exploitation rate of the

released component from the exploitation rate of the harvested component, release mortality rates must be adjusted for multiple recaptures or release mortality will be underestimated (PSC 1995). In the case of the Grays Harbor and Willapa Bay net fisheries, total encounters of non-retained fish are estimated from observer (and log book) data. Recaptured fish are included as an encounter, and thus taken into account in terms of assessing non-retention mortality. There may be a bias to applying a "first-encounter" mortality rate to a fish that is recaptured. The stress of the first capture may make the fish more sensitive to the second stress, and thus cause higher mortality. We have no information to assess the frequency of multiple recaptures or the increase to the mortality rate upon recapture. However, we note that with gillnets the survival rate of a fish that is recaptured rapidly approaches zero. If we assume 50% survival for the first and subsequent recaptures, the probability of a fish surviving multiple recaptures is minimally 25% for one recapture, and minimally12.5% for three recaptures. Thus the overall effect of any additional mortality associated with recapture is likely small due to the compounding effect of the assumed single-event mortality.

Estimation of mortality from estimates of total encounters insures that recaptured fish are included in the overall estimate of dead fish associated with non-retention in the selective fishery. However, the total encounters will be an over-estimate of captured fish *surviving* the fishery, as some (unknown) number of recaptured fish have been counted more than once.

The ISFP assumes recapturing of released fish is adequately considered in the estimation of fishery impacts.

SPECIES:

Part of the original charge to the IFSP was to recommend release mortality rates for chum salmon as well as for Chinook salmon. Data on release mortality of chum salmon are sparse. We found no data estimating delayed mortality of chum salmon following release from gillnets or tangle nets. DFO (1999) reported immediate mortality rates of 12.3% for chum salmon caught in gill nets in Alberni Inlet, versus 28.6% for Chinook salmon; no information was provided on mesh size. Sample size was small (73 chum salmon, 133 Chinook salmon), but the results could be indicative of lower sensitivity to gillnet capture for chum salmon. However, this study, which was focused on coho salmon, had variable soak times, and no information was provided on the soak times for captures of chum or Chinook salmon. At the IFSP workshop on February 26, 2014, WDFW presented data that chum salmon captured in gillnets in 1992 and 1993 in Quilcene Bay had immediate mortality rates of 10% and 26% respectively. This range of immediate mortality is similar to the 12.8%-20.5% range observed for Chinook salmon captured in gillnets in 2000, 2001, and 2003 in Willapa Bay (Vander Haegen et al. 2001, 2002; Ashbrook et al. 2007). Based on these very limited data, we concluded that the same mortality rates applied to Chinook salmon should be used for estimating non-retention mortality of chum salmon.

In their March 18, 2014, response to the review of the preliminary IFSP draft report, WDFW requested that the IFSP provide guidance regarding the applicability of the proposed release mortality rates to coho salmon. Because of the scope of the IFSP assignment and the limited time to finalize this report, the IFSP does not have a recommendation for setting a release mortality

rate for coho salmon. We note that in the studies in Willapa Bay in 2000, 2001, and 2003 (Vander Haegen et al. 2001, 2002; Ashbrook et al. 2007), immediate mortality rates for coho salmon captured in gillnets ranged from 9.2-24.5%, very similar to the 12.8%-20.5% range observed for Chinook salmon. In contrast, immediate mortality of coho salmon caught in tangle nets in these studies ranged from 11.3% - 19.9%, substantially higher than the 3.7% - 8.1% range of immediate mortality observed for Chinook salmon caught in tangle nets. These data suggest that tangle nets may not be as effective in reducing release mortality relative to gill nets for coho salmon as they are for Chinook salmon.

The ISFP's conclusion was to apply the same release mortality to chum salmon as to Chinook salmon.

PINNIPED PREDATION:

The harvest of salmon with sport and commercial gears makes the fish vulnerable to pinniped predation. Seals and sea lions can remove salmon from net or sport gear, or capture the fish when released in a somewhat exhausted state. The exhaustion and stress of coho salmon following capture with gill nets is so severe that the metabolic status of the muscle is such that further muscular contractions would be severely limited. It is unlikely that these fish could avoid predators if released immediately following capture (Gallaugher and Farrell 1999).

Pinniped predation must be considered with evaluating non-retention mortality in commercial fisheries when these predators are present. Pinniped predation mortality on non-retained, netted salmon has been reported at about 2.8% in a Columbia River spring Chinook fishery (Ashbrook et al. 2009); 2.77% for spring Chinook released from tangle nets in Columbia River (Ashbrook et al. 2007); about 9% for Columbia River spring Chinook (Ashbrook 2008); 11.84% for spring Chinook (Ashbrook 2008); and 5.4% (tangle) and 8.8% (gill net) on Chinook in Budd Inlet (Vander Haegen et al. 2001). Both Vander Haegen et al. (2001) and Ashbrook (2008) reported the likelihood of additional and unaccounted for pinniped mortality when they pull entangled fish from the nets prior to capture.

The Columbia River Technical Advisory Committee's assessment of tangle net mortality on spring Chinook included a 1.9% mortality from immediate pinniped predation over a river distance of 7-20 miles.

The ISFP assumes that pinniped predation prior to bringing entangled fish to the boat likely increases salmon mortality associated with fisheries. Pinniped predation on released salmon also increases mortality, but is accounted for in estimates on long term, post-release mortality.

REPRODUCTIVE SUCCESS:

The ISFP heard concerns that reproductive success of released fish was compromised and reduced from the stress of capture. Baker and Schindler (2009) found that for sockeye salmon that had reached the spawning grounds for in Bristol Bay, fish with net marks (indicating they had dropped out of gillnets) had lower spawning success than control fish without net marks. The ISFP noted that data from Ashbrook (2008) indicate that at least some of the salmon released

from gill nets and tangle nets in Willapa Bay survive to reproductive maturity. Coho salmon released from gillnets and tangle nets were recaptured at an area hatchery and produced viable offspring (Ashbrook 2008). Because the immediate mortality rates observed for coho salmon in Willapa Bay are similar to those of Chinook salmon for gill nets, and substantially higher for tangle nets (Figure 1), there is no indication that Chinook salmon are more susceptible than coho salmon to the stress and trauma of capture, and that some also likely survive to spawn.

Ashbrook (2008) also reported that for coho salmon captured in Willapa Bay, eyed-egg to fry survival was significantly lower for embryos from females that had been released from gillnets than from control females, while eyed-egg to fry survival was not significantly different for embryos from females that had been released from tangle nets compared to embryos from control females. However, there was no significant difference in embryo survival from green egg to eyed egg among control, gillnet and tangle net females, and average survival from green egg to fry was actually substantially higher for embryos from gillnet and tangle net females than control females (see table adapted from Ashbrook 2008, Table 3-7). This suggests that there was no reduction in reproductive viability for females that had been released from the nets, and that the lower eyed-fry survival was an artifact of the timing of the embryo mortality.

Table A2-1. Table of egg-fry survival, adapted from Ashbrook (2008), Table 3-7.

Group	Average green-eyed egg survival	Average eyed egg-fry survival	Average green egg- fry survival
Control female x Control male	53.6%	97.5%	52.3%
Control female x Gillnet male	33.3%	92.4%	30.8%
Control female x Tangle net male	63.3%	98.0%	62.0%
Gillnet female x Control male	80.8%	90.3%	73.0%
Gillnet female x Tangle net male	79.5%	90.6%	72.0%
Tangle net female x Control male	66.5%	96.1%	63.9%
Tangle net female x Gillnet male	74.6%	95.9%	71.5%

The ISFP concludes that there are not sufficient data to indicate a reduction in reproductive potential of salmon released from gillnets and tangle nets in Willapa Bay and Grays Harbor and surviving to spawning. Further research is needed on this topic, including studies directed at Chinook and chum salmon.

ENVIRONMENTAL FACTORS

Several environmental factors affecting, or perceived to affect, release mortalities were considered.

WATER AND AIR TEMPERATURE:

Water temperature is a known factor affecting the condition of salmon captured in river and estuarine waters. Other than the presence of clean water itself, temperature is perhaps the most

influential environmental factor on salmon health and viability. The effect of a given temperature on a salmon is also dependent on the temperature to which the fish is acclimated. Key aspects of salmon physiology, performance, stress and mortality are directly affected by temperature and rapid changes in temperature. Salmon stress and mortality can be expected to increase at higher temperatures when faced with capture by sport and commercial fishing gears that exhaust or injure the fish.

Short term deviations from a given temperature in teleost fishes (including salmon) alter respiratory requirements, produce acid-base imbalance and cause disturbances in fluid-electrolyte regulation (Crawshaw 1977). These are symptoms of increased stress that can be expected to affect fish survival. Acclimation to a given temperature can counteract these disturbances.

Compounding the effects of temperature is that warmer waters and more saline waters hold less dissolved oxygen which contributes to the stress of salmon in the process of capture and release. High water temperature and lower dissolved oxygen are important factors in mortality caused by the hooking and handling of a variety of fish species (Muoneke and Childress 1994; Murphy et al. 1995). Environmental factors and biological factors interact with capture stressors to increase stress and mortality of by-catch (Davis 2002). Measures of fish stress have been related to subsequent fish mortality in fisheries (Davis 2010). Rapid shifts to new environmental conditions or to extremes in environmental conditions can lead to a stress response (Schreck 2000). Repeated exposure to stressors can shift the performance capacities of fish. Metabolic disturbances caused by short duration stress can continue for relatively long duration (Mazeaud et al. 1977).

An extensive review of the literature found that catch and release mortality increases as temperature increases both within and above species-specific thermal preferences (Gale et al. 2011). This relationship applies to commercial as well as sport fisheries where there is likely a positive relationship between hooking mortality and temperature (Mongillo 1984).

Hirose (2001) noted that all coho salmon captured in the lower Columbia River with tangle nets were lethargic in September compared to most fish in good condition in October when waters were cooler. Similarly, Ashbrook (2008) noted that Columbia River spring Chinook captured in tangle nets were more vigorous at capture than coho and fall Chinook in Willapa Bay which may be due to water temperature.

Research on commercial fishing in Willapa Bay found that Chinook salmon were captured at surface water temperatures between 15 and 19° C. The effect of water temperature was found to be not significant on immediate survival of captured fish, but that temperature did influence post-release survival, with Chinook captured at lower temperatures in the tangle net more likely to be recovered post-release (Ashbrook 2008). Ashbrook (2008) also noted that differences were observed for fall Chinook salmon, with fish captured by tangle net at lower temperatures more likely to be recovered post-release.

Another concern with higher water temperatures is that Ashbrook (2008) found that the recovery box was not as helpful in improving fish condition as expected, likely because of the warm water

temperature. Many fish were lethargic at capture, and could not always be revived to excellent condition before their release.

The netting of fish in Grays Harbor and Willapa Bay can be expected to rapidly bring fish from waters of one temperature into different air temperatures, imparting stress. The subsequent release of by-catch back to waters of various temperatures may continue this rapid temperature stress to which fish are not acclimated. Increased handling time, air exposure and water temperatures were identified as factors that affected released Atlantic salmon negatively (Thorstad et al. 2002).

The capture and release of salmon in Willapa Bay and Grays Harbor is occurring as the fish are acclimating to new temperature regimes. Ocean surface temperatures off the SW Washington coast are normally about 14-15°C in August, declining to 11-12°C in November (Hickey 2003). Water temperatures in Grays Harbor and Willapa are about 17-20°C in August and decline to about 7-9°C in November. For Grays Harbor and Willapa Bay, average daily high air temperatures are generally 19-20°C in August and September while average daily low temperatures are about 12°C. In October, the average daily high air temperature declines to about 15°C while the daily low temperature has declined to about 7°C. It appears that in the early months of the fisheries, non-retention salmon may be rapidly exposed to gradients in temperature from the natural to the capture environments, and then back. For salmon, these exposures to different water and air temperatures would be expected to elevate stress and may increase mortality as documented for other species such as sablefish (Olla et al. 1998).

Again, Ashbrook (2008) noted that if one type of fishing gear is more stressful than another, an additional stress such as warm water temperature may result in higher mortality for the more stressful gear, particularly as the salmon are going through physiologic transformation of estuarine waters.

The ISFP assumes that the higher water temperatures in early fall fisheries likely contribute to the higher immediate mortality rates measured in Willapa Bay compared to mortality rates measured in the cooler spring waters of the Columbia River. This effect of higher water temperatures could contribute to higher post-release mortality in Willapa Bay and Grays Harbor relative to that measured in the Columbia River studies.

SALINITY:

Surface ocean water salinity off the SW Washington coast is normally about 32 ppm in the summer and fall months when salmon are entering coastal bays (Hickey 2003). Ocean salinities can be affected lower by the Columbia River plume, but in the summer and fall the plume is generally moving southward or westward at this time (Fiedler 1990). Once in the bays, salmon are exposed to salinities from about 30 ppm to nearly freshwater depending on tides and depths.

All areas of the Grays Harbor and Willapa Bay gillnet fisheries are conducted in estuarine waters as Chinook and chum salmon are adapting to the change from saltwater to freshwater. Fish undergoing the physiologic change from saltwater to freshwater may make them more vulnerable

and susceptible to additional stressors as experienced in a non-retention gillnet fishery (Ashbrook et al. 2009; Vander Haegen et al. 2001).

In some parts of the bays, when salmon are netted they could be quickly exposed to a gradient of salinity as they are pulled from deeper (likely more saline) waters to surface waters (often less saline), potentially held in a recovery box supplied by surface waters and then when released, can settle back into the deeper more saline waters. These changes in salinity could contribute to stress and therefore long-term mortality associated with non-retention.

Related to these potential effects of changes in salinity on fish stress, is that at about 15°C, sea water has about 20% less dissolved oxygen than freshwater. These environmental effects are likely additive in some manner to the overall stress of the fish being captured and released.

The ISFP assumes that salinity, changes in salinity, and salmon's adapting to salinity changes can contribute to higher mortalities when fish are stressed in the estuarine environment. This complex environment likely results in the higher immediate mortality observed in Willapa Bay relative to the Columbia River studies.

TIDE:

Tides per se, were not evaluated by the ISFP in the time available, other than to understand and consider that tides affect salinity, temperature and water depth. The key scientific literature related to applicable release mortalities did not address tides and tidal effects on results.

FISHERY FACTORS

Several fishery factors affecting, or perceived to affect, release mortalities were considered.

NET GEAR:

The type of net gear deployed in a commercial fishery is a key element in estimating non-retention mortality. Previous reviews of non-retention mortalities of salmon released from gillnets and tangle nets were conducted by the Technical Advisory Committee (TAC) in the Columbia River and the Chinook Technical Committee (CTC) of the Pacific Salmon Commission.

In 2003, the TAC adopted a total mortality rate of 25% for non-retention mortality of Chinook captured in tangle nets when used in conjunction with short soak times and recovery boxes (PSC 2004). A non-retention mortality of 50% was applied to traditional gillnets when used with short soak times and recovery boxes. Subsequently, with more research information, the TAC (2008) reduced its estimate of non-retention mortality rate to 14.7% for proper use of tangle nets when used in selective spring Chinook fisheries on the Columbia River.

Initially, the PSC (1997) applied a 90% mortality rate for salmon (in their final year of life and close to maturity) when released from traditional gillnets. In a more recent review, the PSC

(2004) indicated that tangle nets used with short soak times, gentle handling and recovery boxes should allow the release of salmon with a total mortality of 25% and that traditional gillnets used with short soak times and recovery boxes would have a non-retention mortality of around 50%. The ISFP notes that these prior reviews and mortality estimates for management purposes were based on the studies of freshwater fisheries for Columbia River spring Chinook.

The ISFP reviewed a substantial amount of literature pertaining to non-retention mortality of salmon from traditional gillnets and tangle nets and has summarized the measured mortality rates and key biological, fishery and environmental variables associated with those studies (Appendix 1). From these data and consideration of other important factors relevant and specific to the Grays Harbor and Willapa Bay commercial fisheries, the ISFP developed its recommendations for non-retention mortality of Chinook and chum salmon as requested by the Department.

The scientific literature on net effects and related mortalities most applicable to the Grays Harbor and Willapa Bay fisheries is that conducted by Vander Haegen and Ashbrook, and the ISFP gave their results and observations considerable weight (Appendix 3). As stated by Ashbrook (2008), the survival values she presented are likely conservative and the highest that can be attained for these gears and salmonids under the reported conditions for these locations.

In considering the effects of gillnet and tangle net gears as indicated in Appendices 1 and 3, other aspects of net gear were noted relative to their potential effects on Chinook and chum salmon, including:

- The use of tangle nets in a Fraser River fishery caught 3-4 times more male chum than female chum salmon (Petrunia 1999). Male Chinook are more prone to capture in tangle nets 3:1 to females (Vander Haegen et al. 2001). These data may be important to the Department when modeling the effects of non-retention fishing mortality on escapement objectives and population productivity.

- A key advantage in using tangle nets rather than traditional gillnets is that it is easier to remove salmon from tangle nets than traditional gillnets (Vander Haegen et al. 2001). This is a consideration in applying Columbia River data to fisheries in Grays Harbor and Willapa Bay where summer and early fall water and air temperatures are higher and fish are being captured in estuarine waters. Shorter and gentler handling will reduce fish stress and long term, non-retention mortality.

- Another advantage of tangle nets over gillnets is that the fish are generally in better condition upon capture with lower initial mortality, leading to reduced total fishing mortality (Vander Haegen et al. 2001). Again, this can be important given the more vulnerable biological condition of salmon entering estuarine waters and the higher temperatures associated with the Grays Harbor and Willapa Bay fisheries.

- More Chinook captured by the tangle net were in excellent condition (status 1) and more fish caught in the gillnet were in lethargic and poor condition (status 3 and 5) than expected. Chinook salmon captured in the tangle net were more likely to be captured in

vigorous condition and by tangling while those captured in the gillnet were more likely to be captured in lethargic or poor condition and by gilling (Ashbrook 2008).

Observations reported by Ashbrook et al. (2007) were noted in the ISFP's consideration of the data and in the ISFP's subsequent recommendations, including:

- All chum captured by tangle net and gill net gears were captured and released in excellent condition and survived their immediate capture (Ashbrook et al. 2007).

- For every 1000 Chinook captured in tangle nets, 960 fish will survive, while for every 1000 Chinook captured in gillnets only 850 fish will survive immediate capture. This difference gives reasonable evidence for using a tangle net if managers desire to conserve (wild) Chinook populations that are captured as by-catch in a fishery (Ashbrook et al. 2007).

- Chinook captured in tangle nets will usually be captured around the jaw and face and suffer less body trauma than fish captured in gillnets. Chinook captured by tangle nets will also be in better condition at both capture and release. Ashbrook et al. 2007)

- The wild fall Chinook which must be released will have a higher immediate survival when captured in tangle nets, and because Chinook are in better condition upon capture in tangle nets, it can be expected that they will also have higher post-release survival (Ashbrook et al. 2007).

The ISFP also noted that it may be important to consider the actual gear used in the commercial fisheries and not that specified in regulations when developing non-retention fish mortalities. From information provided through the Department, the actual net sizes used in the Grays Harbor during week 40-48 fisheries are believed to be in the range of 5.5" to 5.75" mesh compared to the regulations' maximum mesh restriction of 6.5". For Willapa Bay fisheries, the actual mesh sizes used in the week 33-38 fisheries are 5.5" to 8" compared to the regulation restriction of 9" maximum. In the week 39-44 fisheries, the actual mesh used is believed to be 5.25" to 5.75" compared to the regulations' maximum limitation of 6.5". Use of smaller mesh should reduce gilling and injury of non-targeted Chinook.

This information on actual mesh sizes used by the fleets as compared to the regulations' maximum mesh requirement was important to the ISFP in assigning the mortalities associated with gear in the Willapa and Columbia River research studies to the questions at hand (the ISFP's estimated mortality for small mesh, <6", was assigned to fisheries with maximum mesh requirement of 6.5").

The ISFP's recommendation to the Department for reducing stress on non-retention stress was also based in part on the above observations of researchers.

RECOVERY BOXES:

Proper use of recovery boxes in gillnet fisheries can significantly reduce catch & release mortality. For example, use of a recovery box for 1-2 hours allowed significant metabolic recovery of both lethargic and vigorous coho salmon with greater than 90% revival of coho salmon that appeared dead (Farrell et al. 2001). Use of recovery boxes with tangle-type nets, short soak times and careful handling reduced short term mortality to as little as 6% whereas traditional gillnets caused 35-70% mortality (Buchanan et al. 2002). In Columbia River, Willapa Bay and other studies, the proper use of recovery boxes in most circumstances has repeatedly been shown to significantly improve the condition of captured fish prior to release. Improving the condition and reducing fish stress prior to release improves long term survival. The utility of the recovery boxes was also noted by commercial fishermen (Andy Mitby, pers. comm. 2014).

The proper handling and use of recovery boxes on research vessels is important to interpreting and applying the subsequent measurements of long-term mortality in management of actual fisheries. Prompt removal of less-than-vigorous salmon from the nets (a benefit of tangle nets over regular gillnets) and into a full-flow and operating recovery box is generally important to achieving reduced immediate and long-term mortality rates.

Use of recovery boxes by a fishing fleet can, however, not be as effective if the catch of non-retention salmon overwhelms the capacity of the boxes or causes recovering fish to be released prior to their fully attaining a vigorous or excellent condition (Ashbrook et al. 2007). Also, when surface waters are warm, Ashbrook (2008) found in Willapa Bay that use of the recovery box on lethargic fish did not work as well. To avoid higher immediate mortality rates, fish were promptly returned to the bay in their still lethargic condition (this may reduce immediate mortality, but not necessarily long-term mortality). In considering the benefit of recovery boxes, the ISFP also noted that in some cases researchers would supplement the regular recovery box operations by placing a tube with flowing water in the mouths of lethargic fish to further enhance the benefits of a recovery box (Ashbrook et al. 2007).

The ISFP notes that the Department's observer reports of Grays Harbor from 2006-2012 indicate that captures of Chinook salmon did not appear to occur in sufficient numbers to overwhelm the capacity of required recovery boxes. Most entries indicated 0 Chinook captured per set; a few entries of 1 Chinook and only an infrequent entry of 2 Chinook captured per set.
However, observer information from Willapa Bay in 2013 shows that the rate of encounters on non-targeted Chinook are highest in weeks 33-35 (late August) which could create potential for taxing the capacity and proper use of the recovery boxes.

It appears to the ISFP that proper use of recovery boxes in most circumstances is important in reducing long-term non-retention mortality. Therefore, factors or circumstances that do not result in full use of the boxes can be expected to reduce survival of non-targeted fish (i.e. high fish abundance or inadequate compliance with Fish Friendly techniques).

SOAK TIME:

Soak time is defined as the time elapsed from when the first of the gill net web is deployed into the water until the webbing is fully retrieved from the water.

Soak time of gillnets in a fishery is a critical element of non-retention fishing mortality. The longer a fish is struggling in the net or unable to attain sufficient oxygen, the greater its exhaustion and physiological stress. Consequently, gillnet soak times of 30 minutes compared to 60 minutes were found to be less stressful on coho salmon (Gallaugher and Farrell 1999). Similarly, Buchanan et al. (2002) estimated that short- term mortality in a coho salmon fishery increased from 10% with a 40 minute soak time to 60% with a 140 minute soak time. Chum salmon mortalities in 7" mesh nets increased with longer soak times (Petrunia 1999).

Short soak times and careful fish handling techniques are integral to utility of the tangle net and achieving its lower mortality rates compared to regular gillnets (Ashbrook et al. 2004). When conducting research on non-retention mortality in Willapa Bay, soak periods were shortened from the planned 20 to 25 minutes to as few as 10 minutes (average of 19 minutes) to ensure that fish were captured in good condition and survived their immediate capture at high rates (Ashbrook 2008). In conducting research on gillnet fishing in Willapa Bay, Ashbrook and Vander Haegen documented soak times of generally 0-60 minutes with average soak times of 30 minutes or less. The ISFP noted that the measurement of soak time was variable as at least in some research (Ashbrook et al. 2007) soak times were recorded as the time from first deployment of a net until initiation of its retrieval, not full retrieval.

The length of soak time can also affect subsequent proper handling and treatment of fish as noted by Vander Haegen et al. (2001) when in September so many fish were netted in Willapa Bay that they could not keep pace with reviving fish.

For the Grays Harbor and Willapa Bay fisheries, soak time is limited by regulation to 45 minutes maximum. Actual soak time can be shorter or in some cases longer to, for example, remove grasses from the mesh.

The ISFP's recommendation to the Department for reducing stress and mortality includes consideration of a shorter, regulated soak time.

HANDLING:

The Fish Friendly Workshop information stresses the importance of proper handling of captured fish to avoid bleeding, protecting scales and slime, and avoiding damage to gills, vertebrae and internal organs. Ashbrook (2008) noted the potential for Willapa fish to be more sensitive to handling effects and recommended annual training in proper fish handling techniques as a conservative and beneficial approach to improving fish survival. The CTC noted that "gentle" handling was an element of tangle net usage and effect.

The ISFP's recommendation to the Department for reducing stress and mortality includes consideration of reduced handling time such as typical of a tangle net compared to a gillnet.

REGULATIONS:

The 2013 commercial fishing regulations and the history of regulations for the Grays Harbor and Willapa Bay fisheries were reviewed by the ISFP. Regulations have been focused in recent years to reduce non-retention mortalities. Regulations require shorter soak times, use of a recovery box for bleeding and/or lethargic fish, Fish Friendly handling techniques, and net mesh sizes more conducive to better fish condition and better fish handling.

Regulations require that the boat operator attend a WDFW Fish Friendly class to increase conformance of the commercial fishery with the Fish Friendly techniques necessary to reduce non-retention fish mortality. However, the ISFP understands that the effectiveness of these classes may be less than desired if all fishermen on a given boat that may be handling fish are not required to take the class. Proper fish handling is critical to reducing non-retention mortality when using nets in warmer, estuarine waters.

2013 Grays Harbor regulations provide for commercial netting during 12-hour periods of daytime hours or 24-hour periods, but not 12-hour periods during nighttime hours. In Willapa Bay, 2013 regulations are similar, except in late August and early September when openings are for 12-hour periods during the nighttime. This timing of fisheries may affect non-retention mortality as daytime fishing would coincide with maximum air and possibly higher surface water temperatures when fish would be most stressed. High surface water temperatures can reduce the efficacy of the recovery boxes. Daytime fishing hours may also increase pinniped predation on netted and released fish.

The ISFP suggests that the Department and fishers discuss the utility of more nighttime fishing as a possible means to reduce stress and mortality to non-target fish. Regulations that more closely mirror the actions taken during research activities might also better align mortalities associated with the actual fisheries with those from research.

LOCATION:

The location of sport and commercial fisheries affects the stress and survival of non-retention salmon. As indicated elsewhere in this report, the Grays Harbor and Willapa Bay fisheries are located in waters where salmon are acclimating to significant and important changes in temperature and salinity requiring critical physiological changes while they are also undergoing morphological changes as they ripen for spawning. During this adaptation from saltwater to freshwater, salmon are more vulnerable to additional stressors (Ashbrook et al. 2007). Estuarine waters affect the physiology and thus the stress on salmon following capture in a selective fishery. These factors likely assist in making them more susceptible to capture mortality. (Vander Haegen et al. 2002; Ashbrook 2008). Capture of Chinook broodstock with nets in estuarine waters was also found to be problematic. Fish appeared to be vulnerable at this time, particularly females (D. Hamilton statement 2014)

The literature and observations of many indicate that estuarine waters are problematic for conducting non-retention fisheries. That said, the ISFP found insufficient scientific reports and environmental information to discern any important differences between the fishing site

delineations of the various Grays Harbor and Willapa Bay fisheries that would warrant applying differing non-retention mortality rates.

DATE:

Non-retention fish mortality could potentially be higher in August fisheries due to higher water and air temperatures and lower in November with lower air and water temperatures. Similarly, the variance in temperatures which effects stress and mortality declines from August to November.

Observer information from Willapa Bay in 2013 shows that the rate of encounters on non-targeted Chinook salmon is highest in weeks 33-35 (late August), when temperatures are warmest, which could create potential for taxing the capacity and proper use of the recovery boxes.

Observers started collecting more detailed information on condition of released fish in 2013 which could be useful in assessing if condition changes with date. The 2013 data did not indicate any change in average condition of released fish in Willapa Bay from weeks 33-35 to weeks 36-38. The numbers of observed releases were too small to evaluate changes in average condition for subsequent weeks in Willapa Bay or Grays Harbor.

The ISFP had insufficient scientific information to recommend differing non-retention mortality rates based on the week of various fisheries as requested by the Department. The ISFP believes the data are better applied in the form of a single season mortality rate.

ENFORCEMENT:

A written statement provided to the ISFP by the Department on enforcement efforts was supplemented by an oral statement from Officer Dan Chadwick at the February workshop. Officer Chadwick indicated that patrols of the Grays Harbor and Willapa Bay gillnet fisheries were not a high priority, with greater emphasis placed on the Columbia River commercial fishery due to the presence of ESA-listed species in those fisheries. Officer Chadwick indicated that there is more enforcement of the Grays Harbor fishery compared to the Willapa Bay fishery due in part to the ease of observation from the bank. Patrolling of these two fisheries is limited by the few numbers of officers, the substantial geography for which they are responsible, and the numerous fishing and hunting activities occurring in the late summer and fall.

Since 2010, WDFW has issued 29 total citations for the two commercial fisheries of which 15 were for illegal possession of wild Chinook or coho salmon and four citations for failing to use a recovery box while picking the net. Officer Chadwick mentioned that they see more illegal possessions of wild fish in the Grays Harbor and Willapa Bay fisheries compared to the Columbia River likely due to the presence of ESA penalties in that river.

A written statement from attorney Joshua Sneva on behalf of the Advocacy asserted that several important aspects of the commercial fishery regulations and Fish Friendly protocols would be "…nearly impossible to enforce".

From the information at hand, the ISFP assumes that past enforcement of fishing regulations, as they exist, and Fish Friendly practices does not appear to be a major factor that would contribute to limiting or reducing non-retention mortalities reported in the scientific literature. Proper application of the Fish Friendly techniques likely relies more on volunteer efforts of the fishers and their concern for fish conservation.

COMPLIANCE:

Compliance by commercial fishers with the intent of Fish Friendly techniques promoted by the Department is essential to achieving non-retention mortalities that are similar to those measured by local researchers and reported more broadly in the scientific literature. The fisheries in Grays Harbor and Willapa Bay are occurring in estuarine locations and during an important and sensitive physiological period for the salmon. Non-compliance with the best fish handling practices could have a substantially negative effect on the long-term survival of the released salmon.

Managing incidental harvest can be labor intensive. Practices directed at reducing mortality curtail the amount of time productively spent capturing fish of value to the fisher (Vander Haegen et al. 2001). Alternatively, in certain circumstances, following the Fish Friendly procedures can delay retrieval of the net and subject captured fish to longer periods of entanglement and struggle, or exposure to air. Much discretion is left to the commercial fisher to best implement fish-saving techniques.

Obviously, when fishermen have observers on board, compliance should not be an issue. As reported by Ashbrook (2008) for contracted fishermen who had completed the Fish Friendly workshop and handled the fish as prescribed by the workshop, " … no difference was found between post-release detections by fisherman; fisherman behavior does not appear to influence post-release survival when observed by WDFW personnel. These results were also found during the two previous years of test fisheries in the Columbia River (Vander Haegen et al., 2004; Ashbrook et al., 2004)."

But, in the actual fishery, full compliance is unlikely. The Department's enforcement report provided to the ISFP indicates that recovery boxes are not always operated and available for fish recovery.

The ISFP viewed the potential effects of noncompliance on fish mortality rates more at is relates to compliance with the techniques employed by the researchers that generated the estimates of morality rates than with compliance with the actual WAC. The effects of compliance or noncompliance are also important qualitatively relative to the environmental and biological factors noted above.

OBSERVER PRESENCE:

Observer presence in the fisheries is essential to validate and estimate encounter rates of non-target species. The use of Department observers to record information and encourage compliance with Fish Friendly techniques is variable, but sparse. In the Willapa Bay fisheries of 2011 and 2010, the Department recorded a total of 1,793 boat days across all fishing zones and an observer rate of 0.71% on these boats. For the Grays Harbor fisheries from 2006 through 2012 across all zones, a total of 918 boat days were recorded with an average observer rate of 13.5% (annual range of 2.7% - 47.7%).

To the ISFP, observer presence as implemented in past years is likely not sufficient to affect compliance rate for Fish Friendly techniques by the fishing fleet.

APPENDIX 3. Estimation of Recommended Release Mortality Rates

The IFSP identified those studies in the region that were specifically designed to estimate release mortalities for Chinook salmon in gillnet or tangle net fisheries (Table A3-1).

Table A3-1. Release mortality studies for Chinook used in IFSP analysis.

Location	Study Year	Gear	Mesh size (inches)	Immediate Mortality Rate (%)	Post release Mortality Rate (%) [1]	Report
Columbia River	2001	Gillnet	8	1.0	47.5	Ashbrook et al. 2004
Columbia River	2002	Gillnet	5.5	0.9	42.7	Ashbrook et al. 2004
Columbia River	2001	Tangle net	3.5 & 4.5	3.2	8.8	Ashbrook et al. 2004
Columbia River	2002	Tangle net	4.5	0.5	32.4	Ashbrook et al. 2004
Columbia River	2003	Tangle net	4.25 & 4.5	2.1	15.6	Ashbrook et al. 2009
Willapa Bay	2003	Gillnet	5.75	15.0	NA	Ashbrook et al. 2007
Willapa Bay	2003	Tangle net	3.5	3.7	NA	Ashbrook et al. 2007
Willapa Bay	2000	Gillnet	7.25	20.5	NA	Vander Haegen et al. 2001
Willapa Bay	2000	Tangle net	3.5	8.1	NA	Vander Haegen et al. 2001
Willapa Bay	2001	Gillnet	5.75	12.8	NA	Vander Haegen et al. 2002
Willapa Bay	2001	Tangle net	3.5	3.7	NA	Vander Haegen et al. 2002

[1] Termed “Relative long –term survival in Ashbrook et al. 2004—see e.g. Appendix A.

Where more than one study was applicable, data were combined to derive estimates of release mortality weighted by (the inverse of) standard errors (Tables A3-2, 3, and 4). Results are summarized in Table A3-5. Immediate mortality rates from Columbia River and Willapa Bay studies are depicted in Figure A3-1.

Table A3-2. Weighted estimates of immediate and long-term mortality for tangle nets from Columbia River studies.

		Immediate Mortality		Post release Mortality	
	Mesh Size	Reported	weighted average	Reported	weighted average
Ashbrook et al. 2004	3.5 & 4.5	3.2%	**1.3%**	8.8%	**19.9%**
Ashbrook et al. 2004	4.5	0.5%		32.4%	
Ashbrook et al. 2009	4.25 & 4.5	2.1%		15.6%	

Table A3-3. Weighted estimates of immediate release mortality for tangle nets from Willapa Bay studies.

		Immediate Mortality	
	Mesh Size	Reported	weighted average
Ashbrook et al. 2007	3.5	3.7%	**3.7%**
Vander Haegen et al. 2001	3.5	3.7%	

Table A3-4. Weighted estimates of immediate release mortality for small mesh gillnets from Willapa Bay studies.

		Immediate Mortality	
	Mesh Size	Reported	weighted average
Ashbrook et al. 2007	5.75	15.0%	**14.1%**
Vander Haegen et al. 2002	5.75	12.8%	

Table A3-5. Summary of study results.

Columbia River Release Mortality Estimates for Chinook

Tangle Net		Gillnet Small Mesh		Gillnet Large Mesh	
3.5" and 4.5" Mesh		5.5" Mesh		8" Mesh	
Immediate	Post-release	Immediate	Post-release	Immediate	Post-release
1.3%	**19.9%**	**0.9%**	**42.7%**	**1%**	**47.5%**

Willapa Bay Release Mortality Estimates for Chinook

Tangle Net		Gillnet Small Mesh		Gillnet Large Mesh	
3.5" Mesh		5.75" Mesh		7.25" Mesh	
Immediate	Post-release	Immediate	Post-release	Immediate	Post-release
4.6%	**NS**	**14.1%**	**NS**	**20.5%**	**NS**

NS= No Studies available

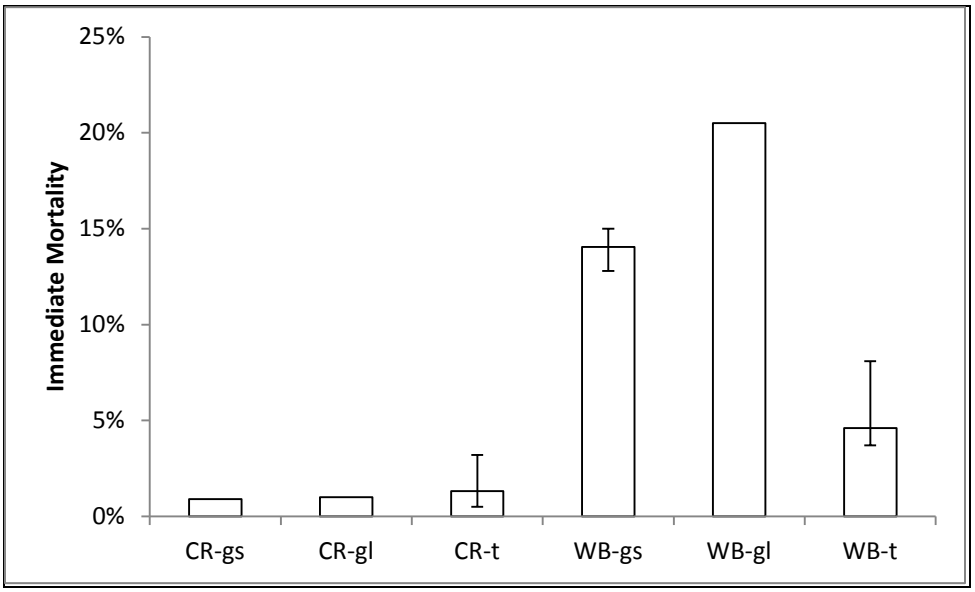

Figure A3-1. Immediate mortality rates observed for Chinook salmon captured in the Columbia River (CR) and Willapa Bay (WB) in small-mesh gillnets (gs; < 6 in), large-mesh gillnets (gl; >7 in), and tangle nets. Rates are from Vander Haegen et al. (2001, 2002) and Ashbrook et al. (2004, 2007, 2009). For strata with more than one estimation of mortality rate, bars are weighted averages and lines are the range of observed rates.

Mortality rates were then converted to survival rates to estimate total release mortality from the Columbia River studies (Table A3-6).

Table A3-6. Columbia River cumulative release mortality estimates.

	TANGLE NET	GILLNET small mesh	GILLNET large mesh
Mesh Size	**3.5” -4.5”**	**5.5”**	**8”**
Immediate survival	98.7%	99.1%	99.0%
Post-release survival [1]	80.1%	57.3%	52.5%
Total Survival	79.1%	56.8%	52.0%
Total release mortality	**20.9%**	**43.2%**	**48.0%**

[1] Termed “Relative long –term survival in Ashbrook et al. 2004—see e.g. Appendix A.

No long-term, post release estimates of release mortality were available for Willapa Bay or Grays Harbor. The IFSP concluded that the estimates for post-release survival from the Columbia River studies were the best available for Willapa Bay and Grays Harbor fisheries (Table A3-7).

Table A3-7. Willapa Bay long-term release mortality estimates.

	TANGLE NET	GILLNET small mesh	GILLNET large mesh
Mesh Size	3.5" - 4.5"	**5.5"**	**7.25" & 8"**
Immediate survival	95.4%	85.9%	79.5%
Post release survival [1]	80.1%	57.3%	52.5%
Total survival	76.4%	49.2%	41.7%
Total mortality	**24%**	**51%**	**58%**

[1] from Columbia River studies

Critical to the ISFP’s task was the application of research results from Columbia River spring Chinook fisheries to Grays Harbor and Willapa Bay fall fisheries. This task was complicated by the fact that long-term mortality rates from net captures reported by Ashbrook et al. (2004) and Vander Haegen et al. (2004) for Columbia River spring Chinook included effects on salmon lasting up to 180 days after release, after potentially migrating many river miles, and with potential passage over several dams. These conditions affecting post-release survival are not experienced by salmon released in Grays Harbor and Willapa Bay (closer to 30 days migration and maturation post release). However, it is also important to realize that the mortality attributed to capture and release from gillnets and tangle nets in the Columbia River are calculated relative to control groups that are also exposed to the same conditions as the treatment groups. The effect of migration timing on delayed mortality depends on the shape of the mortality curve with time following capture and release. If delayed mortality due to the stress of capture occurs relatively soon after capture and release, then additional mortality due to longer migration would be small.

Conversely, if the mortality due to the stress of capture occurs more uniformly through time until spawning, applying the results from studies on fish with longer migration and maturation timing post-capture would result in an over-estimate of mortality of delayed mortality of fish with shorter migration and maturation timing post-capture.

The ISFP considered information from the literature and data from the Columbia River studies to evaluate whether migration timing affects the applicability of the Columbia River data to Willapa Bay and Grays Harbor. Results from hooking mortality studies for both recreational and commercial gear indicate that most mortality observed occurs within the first 1-2 d from capture (e.g., CTC 1997, Figure 1; Wertheimer et al. 1989, Table 4), suggesting that stress-related capture mortality is asymptotic with time. The ISFP also examined the Columbia River data through an intermediate site (McNary Dam) more similar to post-release migration timing of fish in the coastal bays, and found no indication that mortality in the treatment groups relative to the controls continued to increase past this point. The ISFP concluded that the information available did not support reducing the long-term, post-release moralities from the Columbia River studies before applying them (Appendix 3) to the Grays Harbor and Willapa Bay fisheries.

In order to account for differences between study conditions and the scenarios of interest, i.e. the IFSP introduced a "survival adjustment factor" (Table A3-8).

Table A3-8. Estimates of release mortality for Fish Friendly scenario for Willapa Bay and Grays Harbor.

	TANGLE NET	**GILLNET small mesh**	**GILLNET large mesh**
Mesh Size	3.5 - 4.5	**< 6"**	**> 7"**
Immediate survival	95.4%	85.9%	79.5%
Survival adjustment	100.0%	100.0%	100.0%
Post release survival	80.1%	57.3%	52.5%
Total survival	76.4%	49.2%	41.7%
Total mortality	**24%**	**51%**	**58%**

The IFSP concluded that the best estimate for the survival adjustment under the Fish Friendly scenario in all locations and time periods is 100%.

Summary of assumptions and conclusions:

1. Weighted averages for immediate and long-term survival rates were calculated using 1/SE as the weighting factor (1/SE) for each estimate.

2. Best estimates for post release mortalities in the Willapa Bay/Grays Harbor fisheries are those estimated in the Columbia River studies.

3. Estimates in Table 1 are likely to be minimum estimates of release mortality rates in the actual fisheries. They are based on mortality rates associated with research using short soak times, optimal handling and use of recovery boxes; thus they were in full compliance with "fish-friendly" techniques.

4. The estimates do not include all factors that have been shown to contribute to fishery induced mortality. For example, drop out mortality and reduced reproductive success are not included in the estimates.

5. Estimates are for Chinook salmon, but are still the best available for chum as well.

The IFSP identified and reviewed the literature regarding their effects on release mortality (Appendix 2) and concluded that under actual practice, the release mortalities would likely be larger than those estimated for the Fish Friendly scenario. The IFSP did not derive a quantitative recommendation for the survival adjustment to actual practice; however the example in Table A3-9 illustrates a reasonable approximation.

Table A3-9. Estimates of release mortality for Actual Practice example for Willapa Bay and Grays Harbor.

	TANGLE NET	**GILLNET small mesh**	**GILLNET large mesh**
Mesh Size	**3.5 - 4.5**	**< 6"**	**> 7"**
Immediate survival	95.4%	85.9%	79.5%
Survival adjustment	90.0%	90.0%	90.0%
Post release survival	80.1%	57.3%	52.5%
Long-term survival	68.8%	44.3%	37.6%
Long-term mortality	**31%**	**56%**	**62%**

APPENDIX 4. Bibliography of All Literature and Data Sources Reviewed by the IFSP

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