Comments on FY 2003 Mainstem/Systemwide Province Proposal #200100700 Submitted to the Independent Science Review Panel of the Northwest Power Planning Council

Prepared by Nick Gayeski
On behalf of
Washington Trout, Oregon Trout, and Native Fish Society
August 23, 2002

The following comments are offered for the consideration of the ISRP in regards to Project # 20010700, "Evaluate live capture selective harvest methods for commercial fisheries on the Columbia River 2001-007-00".

We strongly concur with the several concerns and reservations stated by the ISRP regarding this proposal. Having reviewed not only the proposal at issue, but data from the 2002 demonstration commercial tangle net fishery in the lower Columbia and the results of the 2001 Evaluation funded by the Council under the Innovative Projects (Project ID: 23036 -- Evaluate Live Capture Selective Harvest Methods -- Contract # 200100700) that provided data on the basis of which the decision to conduct the 2002 demonstration fishery was made, we believe that the ISRP's concerns are, if anything, understated.

Most importantly, we find that the proposal provides no scientifically adequate justification for Objective 2, which would principally secure funding for ODFW and WDFW to conduct monitoring for a full fleet commercial net fishery in the lower Columbia River mainstem. While a scientifically legitimate case may be made for funding aspects pertaining to Objective 1, funding of a full fleet commercial fishery in whole or in part by the Council's Fish and Wildlife Program does not appear to be at all justifiable.

The ISRP accurately notes inadequate and confusing summarization of results from studies conducted in 2001 and 2002, the absence of any detailed analyses of past data directly relevant to the current proposal, and the absence of any presentation of a credible experimental design. We would further note that many of the detailed results from the 2001 Evaluation and from the 2002 demonstration fishery not presented or discussed in the proposal tell strongly against funding any "study" approaching the order of magnitude of a full fleet commercial net fishery in the lower Columbia River mainstem (Objective 2). These are discussed in the attached Issues paper which was submitted to Representatives of the Compact Managers on July 25, 2002 and in the attached Summary thereof.

The proposal is ostensibly motivated by allegedly unresolved uncertainties and concerns regarding the selectivity of various "tangle net" sizes, configurations, and manners of fishing (drift time, hang ratios, etc.). Such issues can be addressed with adequately replicated small-scale controlled studies -- along the lines of some of the elements of the

2001 evaluations (Project 23036). No case is made in the proposal to suggest that this is not the case.

Sample sizes and level(s) of replication necessary for deriving statistically robust results should be clearly addressed in proposals for such (small-scale) studies. The results of such studies should then be employed in a formal statistical risk assessment of the range of impacts to non-target taxa and stocks likely to arise in a full fleet commercial net fishery. Only after this has occurred and the risk assessment determines that there are configurations of such a commercial fishery that would have an acceptably low probability of inflicting adverse impacts on non-target stocks should provision of any funding under the Fish and Wildlife Program for the management of a test full fleet commercial fishery be considered. Anything less would appear to be a subversion of the purposes of the Fish and Wildlife Program and of the peer review process that is associated with the approval of projects that are intended to implement the Program.

Two general issues regarding the 2001 tests are relevant in the present context. First, the principal focus for the evaluation of immediate mortality (fish that could not be revived onboard a fishing boat to a condition in which they could actively swim away) and long-term mortality (survival to an upstream encounter destination in the form of a fishery, hatchery rack, or spawning site) of spring chinook was a comparison of 3.5-inch and 4.5-inch multi-strand tangle nets, and conventional 8-inch mesh monofilament gill nets. Second, neither 5- to 5.5-inch mesh monofilament gill nets nor multi-strand tangle nets of the same size were rigorously evaluated.

Clear differences between the 3.5- and 4.5-inch mesh tangle nets and the 8-inch gill net regarding both immediate and long-term mortality appear to have been shown. Tangle nets of the sizes tested clearly had lower long-term mortality rates.(See Issues-paper Summary and Final Report of February 2002 by Vander Haegen et al., both attached.) In addition, evidence was obtained that indicated that fish that could be released immediately without requiring recovery in onboard recovery boxes survived to upstream recovery destinations at a significantly higher rate than released fish that required some time in the recovery boxes; and fish caught in the small-mesh tangle nets had a considerably higher probability of being captured in such a manner as to not require onboard recovery prior to release than fish caught in the 8-inch gill net.

Some data was, however, also obtained during the 2001 Evaluation regarding both the immediate mortality rate of 5- to 5.5-inch monofilament gill nets and the manner and condition-at-capture of fish caught using these nets. While immediate mortality with the 8-inch mesh gill nets was 1% and with the small-mesh tangle nets averaged 3%, immediate mortality for 5-inch gill nets ranged from 8% to 10.3%.

These are among the "promising results for the use of live capture fishing gear and methods (Proposal, page 3)" that were considered when the full fleet demonstration fishery was planned with the "restriction" that nets could not exceed 5.5-inches in size , and which resulted in a fishery that employed conventional 5 to 5.5-inch mesh monofilament gill nets being described as a "tangle net fishery."

The ISRP review notes as another significant issue (b) the use of data from the 2002 commercial fishery "in establishing the 2003 regulations but in the absence of any results from the 2003 (sic!) research." It appears that this should read "…in the absence of any results from the 2002 research." Based upon the data reported for the 2001 Evaluation and the questionable use that was made of that data in reaching the decision to conduct a full fleet demonstration fishery that allowed 5.5-inch mesh gill nets in 2002, there appears to be reason for concern regarding the ability or willingness of project proponents/Compact fishery managers to employ the results of previous research in a critical, risk-averse manner, particularly in the context of prosecuting a full fleet commercial fishery.

In addition, the data reported for the 2002 commercial fishery are themselves incompletely and misleadingly described/summarized in the proposal itself (page 13). For example, the demonstration fishery itself is described as having used "live capture fishing gears (5 1/2 inch maximum mesh size)…" and it is asserted that one can conclude from this fishery that "[s]mall mesh tangle nets were effective at capturing spring chinook." The fishery almost exclusively used traditional 5 to 5.5-inch monofilament gill nets! By virtue of the standards evaluated during the 2001 tests, the 5 to 5.5-inch mesh nets were neither "tangle" nets, nor were they "small mesh". There was simply nothing innovative about the design of the nets employed in the 2002 fishery.

In this same context the proposal claims that "[u]nmarked spring chinook condition at release was good" and that "compliance rates were good." No substantive presentation or even summary of the data is provided. However, the data regarding observed immediate mortality rates for spring chinook and steelhead that has been reported for the demonstration fishery (spring chinook 0.7%; steelhead 2%) is considerably at odds with the data obtained and reported during the 2001 tests (spring chinook only: immediate mortality with true small-mesh tangle nets, 3%; immediate mortality with 5 to 5.5-inch gill nets 8 to 10.3%). The 2001 data resulted from 100% observation of test catches by 2 onboard observers, one of whom reportedly handled all fish brought aboard. The 2002 data resulted from summarized reports of incomplete observations by single observers dropped randomly aboard fishing vessels for no longer than 2 hours (1 to 2 hauls). At best, the low immediate mortality rates reported, given the use of 5.5-inch gill nets, are anomalous. No acknowledgment of this is contained in the proposal. There are, in addition, several discrepancies between the data reported in the observer summaries and the details of the actual observer log books containing the raw data from which the observer summaries are derived -- including numerous descriptions of unmarked chinook and steelhead being dropped or otherwise observed flopping on vessel decks, suggesting that the officially-reported immediate mortality rates in fact seriously under-estimate the actual rates.

Moreover, no estimation of long-term mortality on spring chinook and steelhead is made, yet the 2001 studies provide a basis for estimating a range of long-term mortalities based up immediate mortality rates, type of gear (mesh-size and construction), and manner of capture by the net (gilled, wedged, mouth-clamped, tooth-tangled). This latter kind of data -- manner of capture -- was shown in the 2001 studies to be relevant to both short and long-term mortality (including the probability that a captured non-retainable fish would require time in the recovery box) but was not required to be collected by observers (i.e., was not part of the monitoring effort).

All of these details cast serious doubt on any claims that the demonstration commercial fishery had low impacts on non-target spring chinook, much less steelhead. They also cast doubt on the ability of project proponents/Compact fishery managers to fully utilize relevant data collected and analyzed under the project.

Simply put, no case, whatsoever, has been made for including a full fleet commercial fishery as a component of the evaluation of potential selective net fishery methods (Objective 2). In particular, no case has been made (nor has the issue even been addressed) that the limits of small-scale directed studies evaluating various critical elements of net design and fishing methods and their impacts on non-target taxa caught and released from test nets have been fully reached and that there are substantive questions remaining that can only be adequately addressed by conducting a full fleet competitive commercial fishery!

We believe that the results of the 2001 Evaluation studies in fact provided enough data to support, at best, a need for one or two more years of small-scale, directed studies with regard to a goal of investigating whether or not a commercial, gill-net-type fishery in the lower Columbia mainstem could be changed so as to be sufficiently selective with regard to minimizing total (immediate and long-term) mortality rates to listed salmonid stocks. We recommend that the ISRP/ISAB review the attached Final Report on the 2001 Evaluations (Vander Haegen et al. 2002) and review the results of the 2002 studies that should be forthcoming in the next several months, prior to making any decision regarding continued support of even these small-scale studies (Object 1).

As the ISRP noted in its initial review of proposals for the 2001 evaluations (Project #23036) and elsewhere, there is a legitimate need for the evaluation of genuine selective capture methods that provide an alternative to current fishery methods. The proposal at issue is not directed at evaluating such methods, which the ISRP also notes in its current review. While there is also a need to evaluate whether current fishing methods can be modified in such a way as to make them sufficiently selective as to not risk unacceptable impacts on listed salmonid stocks, the current proposal lacks the minimum of scientific rigor to assure the public that the money invested will return the needed results.

The bulk of the budget for Objective 2, in fact, is devoted to the monitoring of a full fleet commercial fishery ($261,187 of a total of $293,695 (89%) proposed for 2003 alone, and an estimated $1,182,033 of the total estimated cost of $1,329,152 proposed for 2004 - 2007). Such funds should simply not come out of the Council's Fish and Wildlife Program budget, and are more appropriately and better spent funding other proposals that more legitimately intend to further the implementation of the Program.

W A S H I N G T O N

T R O U T

Issues Concerning the 2002 Lower Columbia River Chinook Salmon Tangle Net Demonstration Fishery

Draft Comments Presented by
Washington Trout, National Audubon Society, Native Fish Society, and Oregon Trout
To
Columbia River Compact Fisheries Managers at a Public Meeting at the WDFW Region 5 Headquarters in Vancouver, Washington
July 25, 2002

Prepared by
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Introduction

On April 30, 2002 Washington Trout, National Audubon Society, the Native Fish Society, and Oregon Trout sent a letter to the Columbia River Compact fisheries managers expressing our concerns regarding the impacts on non-target salmon and steelhead of the recently completed tangle-net demonstration fishery. The letter included a list of specific questions regarding issues and specific details of the results of the demonstration fishery that were not or were incompletely addressed in Compact Winter Fact Sheets and other public communications concerning the fishery.

On May 14, we received a reply to this letter on behalf of the Compact fisheries managers by Cindy LaFleur or WDFW. The reply consisted of 14 documents pertaining to the tangle net fishery, accompanied by a cover letter stating in part that the "documents contains (sic) the answers to many of your questions." While one of our expressed concerns was a lack of transparency in data regarding the demonstration fishery that had been made available to the public, among the 14 documents provided were the very same Fact Sheets and related Data Summaries that were explicitly stated to be wanting in the letter of April 30.

We have reviewed these 14 documents together with others that are directly relevant to the fishery at issue. Overall the documents fail to address the substantive issues and concerns expressed in our letter of April 30. If anything, several of the documents reinforce the concerns that have been expressed regarding the impacts of the fishery on non-target ESA-listed chinook and steelhead, and strengthen our concerns that Compact Managers have taken an insufficiently risk-averse approach to the management and the results of the fishery.

Based on our review of documents regarding to the 2002 demonstration fishery, and the related evaluation fisheries conducted in 2001, we have drafted the following comments. We present this draft directly to the Compact Managers for their consideration in evaluating and forming their recommendations for upcoming decisions regarding the 2003 fishing season. Our intention is to revise or add to these comments, if necessary, based on information presented by managers at this July 25, 2002 public meeting, and resubmit the final draft to the Compact Managers, as well as other relevant state and federal managers, regulators, and policy makers. We believe we have identified several issues that will require careful review before any decision to continue the tangle-net fishery can be justified.

Information Derived from the 2001 Evaluation project

Key Documents

The 2002 demonstration fishery at issue was approved largely on the basis of the preliminary results of a commercial live capture study conducted by ODFW and WDFW in April and May 2001 and funded by BPA under the Northwest Power Planning Council's "High Priority Proposals" program ("Evaluate live capture selective harvesting methods for commercial fisheries on the Columbia River," project number 23036). Preliminary results and conclusions from this study were reported in a Summary Fact Sheet from ODFW/WDFW dated October 29, 2001. Both the project proposal and the summary fact sheet were included among the 14 documents sent to Washington Trout. Curiously, the Final Report for this project ("Evaluate Live Capture Selective Harvest Methods," Vander Haegen, G.E., K.W. Yi, C.E. Ashbrook, E.W. White and L.L. Leclair) submitted to BPA and dated February 2002 was not included among the documents provided in response to the letter of April 30. However, the Final Report is a publicly available document, and we obtained it for review and comparison with the relevant documents provided by the Compact Managers.

Research Objectives

The Evaluation Project contained three Research Objectives of relevance to the determination and estimation of impacts of a Tangle-Net fishery on non-target salmon and steelhead in the lower Columbia.

Objective-1 attempted to compare the impacts of both capture and release from a conventional gill net and from a tooth net on long-term survival of adult spring chinook. This involved tagging spring chinook caught in test fisheries using 3.5- and 4.5-inch multifilament tangle nets and using an 8-inch mesh conventional monofilament gill net, and tagging spring chinook that presumably had not encountered fishing gear from the bypass trap in the north shore fish ladder at Bonneville Dam (these latter to serve as controls). Upstream recoveries of numbered color-coded tags from fish caught in fisheries, returning to hatchery racks, or counted on the spawning grounds would provide a basis for estimating the long-term post-release survival of tangle-net-caught and gill net-caught fish.

Objective-2 attempted to estimate the effect of soak time on catch rate and "short-term" survival of adult spring chinook captured and released from the two types and sizes of gear. Short-term survival was defined as survival to 72 hours post-release and was to be evaluated by transporting net-caught fish to nearshore floating net pens for holding. Survivals were to be reported by gear-type, soak time, and condition at capture (one of five categories of vigor and presence/absence of bleeding).

Among other reasons, the evaluation of short-term mortality was an important element to have been included in the proposal because it provided a feasible and measurable check on the usefulness of the five-category condition classification. Among the several issues concerning the usefulness of this classification in the conduct of a selective live-release commercial fishery is the reliability of Category-1 (vigorous, no bleeding) to indicate fish that were unlikely to suffer immediate and/or short-term mortality from their encounter with the net.

Objective-3 was to compare the catch efficiency and the condition-at-capture of spring chinook caught in different mesh-size tangle nets (3.5- and 4.5-inches) and to evaluate by-catch for each mesh size. Soak times were not to exceed 20 minutes. As reported in the October 29 Summary Fact Sheet, actual drift length (times) ranged from 10 to 30 minutes.

Objectives-1 and -2 were carried out by contracting two fishers (boats) to fish the different gears. One or two observers were aboard each boat each fishing day. The Final Report (p. 10) states that for Objective-1 two observers were on board each boat at all times one of whom handled and tagged all fish. Objective-3 involved 20 fishers (boats) fishing a total of "up to 10 days" each. According to the October 29 Summary, "[o]bservers were on board all boats participating in [the] fishery."

Importantly, among the data collected by observers during the long-term mortality study (Objective-1) was the manner in which each fish landed was captured by the net. For each net type and each mesh size, each landed fish was assigned to one of five categories: gilled, mouth clamped, tangled (by teeth or mouth), rolled in the net, and wedged (in front of the dorsal fin) (Final Report, page 10 and Table 3, page 13). In addition, for all Objectives each fish was classified into one of five condition-categories at both capture and release after time in the recovery box : 1 - lively, not bleeding, 2 - lively, bleeding, 3 - lethargic, not bleeding, 4 - lethargic, bleeding, 5 - no visible movement or ventilation.

An additional element was added during the course of the study due to the delayed arrival of the 3.5- and 4.5-inch mesh tangle nets. During four days in the latter half of April 2001 a 5-inch mesh gill net was fished in conjunction with the 8-inch monofilament net. This was reported on as Part 2 of the Final Report (pp. 27 ff.).

Reported Results from the 2001 Studies

Results from the several components of the study were reported in the October 29 Summary Fact Sheet and in the Final Report of February 2002.

Immediate Survival and Condition (Objective 1)

A total of 1372 adult chinook (including 20 recaptures) were captured in the test fisheries employing the two sizes of tangle nets and the 8-inch gill net (Final Report, p. 12). A total of 25 (1.8%) were immediate mortalities, fish that could not be revived. Of these, 19 were caught in condition-5 (no movement) and six in condition-3 (lethargic, not bleeding). Of the six caught in condition-3, three were caught in a 3.5-inch tangle net (out of nine total caught in this condition), two were caught in a 4.5-inch tangle net (out of a total of 30), and one was caught in an 8-inch mesh gill net (out of a total of 31 caught in this condition).

Of a total of eight fish caught in 3.5-inch nets that died immediately (were unreviveable), two were mouth clamped, and six were tangled (tooth-caught). Of nine caught in the 4.5-inch nets that were unreviveable, eight were mouth clamped, and one was tangled. Of the eight unreviveable gill-net-caught fish three were gilled, and five were wedged.

Of the 1372 adult spring chinook captured during the 2001 test fishery pursuant to Objective-1, 188 were captured by the 3.5-inch mesh tangle nets. 177 of these were captured by tangling, and the remaining eleven by gilling (three) or by mouth clamping (eight). A total of 348 were captured with the 4.5-inch mesh tangle net. 291 of these were tangled, 52 mouth clamped, one gilled, and four were wedged. A total of 836 were caught using the 8-inch gill net. 737 of these were wedged, 76 gilled, and 23 tangled. (Final Report, Table 3. Page 13).

This data yields the following simple point-estimates and 95% confidence intervals (as reported in Table 1 of the Final Report, p. 12) for immediate mortality for each of the three gear types/mesh sizes: 3.5-inch mesh tangle net, 8/188 = 4.3% (2.2% - 8.2%); 4.5-inch mesh tangle net, 9/348 = 2.6% (1.4% - 4.8%); 8-inch mesh gill net, 8/830 = 1% (0.5% - 1.9%).

The results of the use of the 5-inch mesh gill net fished in tandem with the 8-inch mesh net were as follows: 8-inch net, 58 total caught, zero immediate mortalities; 5-inch net, 39 caught, 10.3% immediate mortality (Final Report, Table 8, page 27).

Short-term (72 hours post-capture) Survival (Objective 2)

Neither the October 29 Summary Fact Sheet nor the Final Report of February 2002 provide detailed breakdowns for numbers caught by gear type, condition-at-capture and at-release, manner of net capture (tangled, gilled, etc.), or mortalities. Only summary data are provided. According to the Summary Fact Sheet, "[t]otal mortality rates were 19% for conventional gill nets (13% immediate and 7% short-term) and 10% for small [i.e., 3.5 inch] mesh tangle nets (7% immediate and 3% short-term)" (Summary, page 2; Final Report, page 25). These resulted from drifts no longer than 30 minutes.[1]

This study component appears to have provided some data with which to temper the estimates of the success of the on-board Fraser-type recovery boxes, and the reliability of using recovery-to-and release-in-condition-1 to assess the immediate and/or short-term mortality impacts of encounters with the different gears. While fewer fish were encountered in this test fishery and hence, sample size was considerably smaller than in the long-term mortality study (Objective-1) (73 -- 32 conventional gill net, 41 3.5-inch tangle net -- vs. 1372), this information is not to be dismissed.

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[1] Curiously, the Final Report treats the short-term mortality study results as a separate study, reporting the results as a personal communication from P. Frazier, ODFW. Yet in the October Summary Fact Sheet it is reported as one component of the 2001 study, of which it was clearly a component in the original proposal funded by BPA and in which Patrick Frazier of ODFW is clearly listed as one of two Principal Investigators.

The actual data for the tangle net-caught fish are likely as follows: 41 total caught, three immediate mortality; 38 transferred to net pens, one short-term mortality. If the true short-term mortality rate for fish released in condition-1 either immediately upon capture or after capture and onboard recovery were only 1% instead of 3%, 1 of every 100 fish released in condition 1 during the fishery would have to be accounted dead within 72 hours of release. This would, therefore, appear to be important data for the conservative estimate of mortality impacts from any permitted fishery employing this or a similar kind of gear.

Long-Term Survival (Objective 1)

The long-term survival study was to have had 2 components: a comparison of post-release survival to the Dalles and John Day dams of tangle-net-caught, gill net-caught and control fish, and survival to capture/spawning upriver in fisheries, at hatchery racks, and on spawning grounds. Tag color was to identify whether a fish passing the counting windows at the Dalles and John Day was a control, tangle net caught, or gill net caught test fish (white = gill net, yellow = tangle net); tag number would enable identification of date caught and mesh size of the net the fish was caught in. As it turned out, observers at the two dams were unable to distinguish the white and yellow tags, rendering it impossible to compare survival by gear-type to the dams. Illegibility of many tag numbers recovered at upstream capture/recovery sites meant that the only comparative survival estimates that were possible were between tangle net-caught and gill net-caught fish relative to controls.

According to the Final Report (pp. 15-18) upstream recoveries of tagged fish permitted estimations of the survival rates of tangle net-caught (3.5-inch + 4.5-inch) and (8-inch) gill net-caught fish relative to the tagged controls from the Bonneville ladder by-pass trap. Relative to the control group "92.0 % of the fish released from the tangle net survived to be recovered, while 49.7% of those released from the gill net survived" (p. 16). The Final Report summarizes these results, with an important qualifying comment, as follows:

> Using our calculated estimates of survival to demonstrate the effects of this difference, we expect that for every 1000 spring chinook salmon caught in the 8" gill net that must be released, 10 would die immediately (1%), and another 498 (50.3%) would die after release, for a total kill of 508 fish. However, using the tangle nets, for 1000 spring chinook captured that must be released, we would expect 32 (3.2%combined for both tangle net types) to die immediately, and another 78 (8.0%) to die after release, for a total kill of 110 fish. Therefore, about 6.5 times as many spring chinook salmon could be handled and released from the tangle nets for the same mortality caused by the gill net. *These rates would only be expected with the combination of the gears and the careful handling techniques we used* (page 17, emphasis added).

In addition to the relative survival rates for the different test gears, upstream tag recoveries also indicated that fish captured initially in condition-1 survived better than fish captured in one of the other conditions and recovered to condition-1 before release. "At capture, 86.2% of the fish were in condition-1, while 91.4% of the recovered tags were from fish that had initially been captured in condition-1" (Final Report, page 18). This is concordant with the results of the short-term mortality study.

A further important feature of the upstream tag recoveries noted in the Final Report was the under-representation among tag recoveries of fish initially captured by wedging (54% of tags released, 41% of tags recovered (p. 18). The majority of fish captured in the 8-inch mesh gill net (88.2%) were wedged (Table 9, p. 28).

Results From The 5-inch Mesh Gill Net

The use of the 5-inch gill net during four days of test fishing in April 2001 provides further information of significant relevance to the 2002 demonstration fishery. 39 spring chinook adults were caught by this type of net during this time. Of these, 5% were gilled and 5% were wedged. 43.6% were mouth clamped, compared to 4.3% of the 188 fish caught with the 3.5-inch mesh tangle net and 14.9% of 348 fish caught with the 4.5-inch mesh tangle nets. Only 42.6% were tangled compared to 87.8% of fish caught with the 3.5-inch mesh tangle nets and 81% with the 4.5-inch mesh nets (Table 9). The high percentage of mouth clamping with the 5-inch mesh gill net is significant. The Final Report notes that "[m]outh clamping proved detrimental to the immediate survival of the spring chinook salmon -- of the 29 adults killed during the test fishery, 13 (45%) had been captured by mouth clamping" (page 28). The Final Report also comments that the "web of our 5" gill net stretched to 5.25" (it is typical for gill net web to stretch, particularly when wet), and we suspect that this may be crossing the threshold between the nets that truly function as tangle nets and nets that function as gill nets (*hence the low rate of tangling in the 5" gill net*)" (ibid., emphasis added).

Catch Efficiency and Condition at Capture During a Limited (20 fisherman) Permitted Test Fishery (Objective 3)

The results of the fishery conducted pursuant to Objective-3 are not reported in the Final Report of February 2002. Part 2 of the Final Report reports only on the temporary employment of a 5-inch gillnet by two contract fishermen during the early weeks of test fishing pursuant to Objective-1 and discussed in the preceding section above.

The Summary Fact Sheet of October 29, 2001, however, contains a summary of the 20-boat permit fishery that "occurred during the four-week period of late April through late May in the Columbia River below Bonneville Dam" (p. 3). This is a summary of the Mesh Size Portion of the study. The stated objective of this study according to the Fact Sheet is to "[c]ompare effect of mesh size (3 1/2" and 4 1/2") on catch efficiency, condition at capture, and immediate mortality rates (p. 3)."

In addition to the 3.5-and 4.5-inch mesh tangle nets, "nets with 5" - 6" mesh sizes were fished during the last two weeks of the study. Restrictions regarding hang ratios, stringers or slackers were not in place for these nets (ibid.)." Drift lengths were "not to exceed 30 minutes", and "[o]bservers were on board all boats participating in the fishery (ibid.)." It does not appear that 8-inch gill nets were employed in this fishery.

It is unclear that the 5- to 6-inch mesh nets were standard gill nets or were of multifilament design. The Fact Sheet refers to them as "small mesh (3 ½" - 6") tangle nets (p.3)." The implication of this statement that 5- to 6-inch mesh nets are "small mesh" in the present context is contradicted by the remark on page 28 of the Final Report quoted above that reported on the low percentage of tangling when using 5 inch mesh nets during the early stage of Objective-1, stating that the 5-inch mesh size "may be crossing the threshold between nets that truly function as tangle nets and nets that function as gill nets."

Relevant in this case and in the case of the 2002 demonstration fishery at issue is the study by Farrell et al. 2001, which is cited several times in the Final Report of February, 2002. This study ("Successful recovery of the physiological status of coho salmon on board a commercial gillnet vessel by means of a newly designed revival box", Canadian Journal of Fisheries and Aquatic Sciences, v.58, pp. 1932 - 1946) reported on the use of the Fraser box on board gillnet vessels to revive gillnet-caught coho salmon. Mesh sizes used were 4- and 4 ¾-inch. The size of coho caught during the tests using these mesh sizes ranged from 54- to 78-cm. fork length.

The mean fork lengths of chinook captured in the test fishery pursuant to Objective-1 were 75.7-cm. for the 8-inch mesh gill net and 74.9-cm. for the 3.5- and 4.5-inch mesh tangle nets combined. Clearly, a 5" - 6" mesh net can be expected to function as a gill net when encountering salmonid up to 78-cm. (31 inches) fork length.

The Fact Sheet states that "[I]mmediate mortality rates were low for all mesh sizes (ibid.)," an assertion at odds with the results from the more controlled test conditions reported under Objectives-1 and -2, and at odds with the only data provided pertaining to the 20-boat fishery provided on page-4 of the Fact sheet, in the Table "Summary of Permit Fishery Results." This table reports on "Spring Chinook per Hour", "Spring Chinook Mark Rate", "Immediate Spr. Chin. Mortalities", and "Steelhead per Hour".

For the 3.5-inch and 4.5-inch mesh tangle nets, data is reported separately for hang ratios of 2:1 and 3:1. Steelhead were encountered at rates between 0.32 and 0.48 per hour among the three mesh sizes and hang ratios, with the highest encounters for the 3:1 hang ratios. For the 2:1 hang ratios steelhead encounters were 0.34 and 0.33 for the 3.5- and 4.5-inch tangle nets, respectively, which is nearly identical to the 0.32 encounter rate given for the 5" - 6" net.

During the four week fishery the 3.5- and 4.5-inch tangle nets combined landed and kept 846 spring chinook (including 223 jacks) and released 618 (106 jacks) from 454 drifts. The 5" - 6" mesh "tangle nets" landed and kept 532 (148 jacks) and released 308 (71 jacks) from 210 drifts (Summary Fact Sheet, p. 4). Immediate chinook mortalities were as follows:

3.5 inch tangle net, 3:1 hang ratio -- 1.6%
3.5 inch tangle net, 2:1 hang ratio -- 0.0%
4.5 inch tangle net, 3:1 hang ratio -- 8.3%
4.5 inch tangle net, 2:1 hang ratio -- 1.1 %
5 - 6 inch nets -------------------------- 8.0%

Other Results and Issues concerning the 2001 Studies

During the test fishery conducted under Objective 1, two observers were on board each vessel in addition to the contracted commercial fishers. One of the observers handled all the fish.

The Final Report notes that "nearly every adult chinook captured in the [8-inch mesh] gill net had net marks around the body in front of the dorsal fin or around the gills and virtually every adult captured in the tangle net had net marks around the snout. Net marks on the body tended to be severe -- scales were dislodged and missing, and the underlying skin was often abraded and red. While not visible, a loss of the protective slime layer would be associated with this injury… The slime layer on some of these [tangle net-caught] fish may have been disturbed if they rubbed against the net, or if the fish rolled itself into the net (page 14).” Fish caught by wedging regardless of net type would appear to have a significant probability of suffering damage to the protective slime layer, which has clear deleterious implications for long-term survival and reproductive success.

Fish caught in condition-1 or -2 were tagged and released “with minimal holding. We attempted to recover fish in conditions 3, 4, or 5 to condition 1 or 2 for release. Holding times in the recovery box ranged from 2 to 81 minutes…(Final Report, p. 14).” No statistics are reported for holding time in recovery boxes other than this. Summary data for time-in-the-recovery-box-to-recover-to-condition-1 by gear type, manner of capture, and/or condition-at-capture is important to obtain. This is especially relevant to the requirements for the adequate monitoring of a real fishery such as the 2002 demonstration fishery at issue.

By-catch of non-salmonids was extremely high for the tangle nets compared to the 8-inch gill net during the test fishing under Objective-1. Both shad (7022) and sturgeon (1608) were caught among a total of 9430 . 463 non-salmonids were caught by the 8-inch gill net, of which 441 were sturgeon. Quite apart from issues of impacts to by-caught taxa, the high by-catch alone for the tangle nets likely has important consequences for handling time and for the time a salmon or steelhead would otherwise have spent in the net prior to release or placement in a recovery box.

Summary of Results from the 2001 Studies

Several results from the 2001 tangle net evaluation are relevant to this year’s demonstration tangle net fishery and an assessment of its likely impacts on non-target salmonids.

- Each of the gear type evaluated results in some amount of immediate mortality, ranging from 3% for 3.5 inch and 4.5 inch tangle nets combined to 8% for 5 - 6 inch mesh nets.
- A significant proportion of fish released in condition-1 can be expected to experience delayed, long-term mortality, ranging from as low as 8% to as high as 50%.
- Fish caught in condition-1 and immediately released survive at higher rates than fish caught in other conditions and recovered to condition-1 on board in Fraser boxes. Even so, these fish will experience non-negligible long-term mortality.
- The manner in which fish are caught in the net affects both immediate and delayed mortality levels resulting from encounters with the gear. Gilling, wedging, and mouth-clamping all result in greater mortalities than tangling.
- Nets in the range of 5- to 6-inch mesh appear to have a probability greater than 0.5 of catching chinook and other salmonids 60 to 80 cm. fork length by gilling, wedging, or mouth clamping.
- It is important in monitoring any such fishery to obtain and report data on the manner in which each fish is caught by the net, as well as to obtain and report data on condition-at-capture, condition-at-release, and time required to recover each fish to condition-1.
- Time spent in the recovery box in order to attain condition-1 status can be significant (up to 81 minutes under test conditions in 2001), placing a clear limitation on the number of fish that can be revived following the retrieval of each set.

The 2002 Demonstration Fishery

Relevant documents provided to Washington Trout by the compact managers in response to our inquiry of April 30 included: the Spring 2002 Tangle Net demonstration Fishery Monitoring Plan (Monitoring Plan), the Joint Staff Report Season Summary Fact Sheet (Joint Staff Report) dated April 23, 2002, the summary document (Exhibit H) prepared for the April 12, 2002 Oregon Fish and Wildlife Commission meeting to review the 2002 tangle net demonstration fishery (Commission Document), and an Excel file containing the cumulative Tooth Net Observation Summary (Observation Summary) dated 5/8/02, which is identical in summary data to the April 3, 2002 summary file included as Attachment 6 of the summary document (Exhibit H) prepared for the April 12 Oregon Fish and Wildlife Commission meeting.

The maximum mesh size permitted in the demonstration fishery was 5 ½ inches (notwithstanding the warning from the Evaluation-Fishery final report that 5”-6” mesh “may be crossing the threshold between nets that truly function as tangle nets and nets that function as gill nets.”). None of the documents clearly describes the restrictions on the construction of the nets needed to qualify as a tangle net. This is in contrast to the rather clear description of the 3.5- and 4.5-inch mesh multifilament nets employed in the majority of the tests in 2001 the results from which were used to justify the demonstration fishery. Nowhere have we been able to find a clear statement that the allowable nets had to be anything other than a conventional 5 ½-inch gill net.

The Joint Staff Report states that 14,797 chinook were retained in the demonstration fishery and 14,975 unmarked chinook were released. In addition 21,600 steelhead were encountered and released, of which 12,960 (60%) were unmarked. The Commission Document states that the numbers of fishers that participated in the fishery “is unknown at this time” and that “[a]bout 200 were certified to participate .” (From Exhibit H, Attachment 1.)

These figures for the numbers of chinook and steelhead encountered, retained, and/or released are based upon the results of the onboard monitoring of the fishery by ODFW and WDFW staff. It is therefore important to evaluate the adequacy of the monitoring effort and the assumptions and exercises employed in extrapolating from the observer data to an estimate of the overall impacts of the fishery on unmarked steelhead and chinook.

Adequacy of the Monitoring Plan and Effort

According to the Monitoring Plan the fishery was to be monitored by 12 observers who were transported by four agency boats during all fishing periods. Single observers were deployed onboard randomly chosen fishing vessels to observe “one or more drifts” before being “shuttled to another fishing vessel by the transport boat.” This continued each day of fishing over the course of each 14-hour daily fishing periods. Assuming “3 hours daily for fueling, travel, and launching,” the plan estimated nine hours of daily onboard monitoring by each observer and a maximum of “2 hours of monitoring per boat/observer/day.” These assumptions yield a maximum total daily sampling time of 108 hours and an estimated daily sampling rate of 54 boats, which would result in a 36% observation rate of a 150-boat fishery or 27% of a 200-boat fishery.

If these assumptions held in actuality over the course of the fishery and if the number of fishing-boat-days for the fishery were known, an estimate could then be made of the total fishery impact on unmarked salmon and steelhead based upon the data obtained from the observed catch regarding the number and kinds of salmon/steelhead encountered. However, it is important to know what other assumptions are made, and what exercises are employed, regarding the relationships between the observer data and the unobserved fishery in order for such an observer-based estimation of total fishery impacts to be credible.

It is not clear that these types of credible assumptions or exercises were employed in the actual extrapolation from the observer data to the total fishery impact estimates contained in the Summary Fact Sheet. In no case would one expect that a simple projection of the observed mean (point estimate) encounter, condition-at-release, and immediate-mortality rates onto the point estimate of total fishing time would suffice to estimate the total fishery impact on non-retainable salmon/steelhead. A range of values for these impacts is the minimum that can be expected from such a sample. No such range or other acknowledgement of uncertainty is provided. Moreover, given the inconsistency between the immediate-mortality values for 5-inch mesh nets recorded in the 2001 evaluation fisheries (from 8%-10.3%), and the point estimates offered for the 2002 demonstration fishery (.7% for spring chinook; 2% for steelhead), these inadequacies in the 2002 monitoring-data analysis become more troubling, and the results even less credible

The raw observer data
Based upon the fishing calendar included on page-2 of the Joint Staff Report, there were 307 total hours of fishing time. If an average of 150 vessels fished the total time, there was 46, 050 (150 x 307) vessel hours fished during the season. Employing the assumptions of the monitoring plan that observers are actively observing nine of every 12 hours of daily fishing time, observers were able to make observations during 230 (307 x 0.75) of the 307 total hours of the season. Twelve observers would, therefore, tally a total of 2,760 onboard observer hours of the total of 46,050 hours fished, or 6% of the total fishing time.

The Observation Summary reports 206 “observers” under the effort summary, which is less than the maximum estimate above of 230 for a 150 -vessel average over the course of the entire season. This yields an estimated 1854 (206 x 9) hours of total observation time. The Joint Staff Report estimates that 21,600 steelhead “were handled for the season.” This appears to be a result of extrapolating directly from the total number of handled steelhead observed based upon the proportion of total observer time to the total fishing time available during the season. The Observation Summary lists 933 total steelhead observed caught. This yields an expansion factor from the observations of 21,600/933 = 23.15. (In other words, the total observer hours of 1854 represent 4.3% (1/23.15) of total vessel-hours fished or estimated to have been fished during the season.) Multiplying 1854 by 23.15 yields 42,922 total vessel hours fished for the season, which is reasonably close to the rough estimate in the previous paragraph. Accordingly, the total observer hours for the season appear to represent a little more than 4% of the total vessel hours fished during the entire season.

The Observation Summary contains both a “catch summary” of chinook and steelhead observed caught during observation periods and a “condition summary” for fish observed caught. According to the catch summary, 991 adult spring chinook were observed caught, of which 497 were marked and 494 were unmarked; and 933 adult steelhead were observed caught, of which 310 were marked, 472 were unmarked, and 151 were classified as "unknown".

The condition summary lists "number at capture", "number at release", and "release %" for each of the five conditions, separately for both chinook and steelhead. The totals for numbers captured are inconsistent with the numbers in the catch summary. Whereas the catch summary lists 494 unmarked adult chinook observed caught, the condition summary only lists 466 chinook captured and only 404 chinook released. Whereas the catch summary lists 933 steelhead caught, the condition summary lists only 883 captured, of which only 792 are listed as released. None of the documents examined acknowledges or explains these discrepancies.

The figures in the condition summary for "released %" are based exclusively on the figures for "number at release". The relevant data from the condition summary are provided below.

	Chinook			Steelhead		
	# at Capture	# at Release	Release %	# at Capture	# at Release	Release %
Condition 1	262	358	88.6	363	651	82.2
Condition 2	3	3	0.7	67	31	3.9
Condition 3	178	37	9.2	334	82	10.4
Condition 4	11	3	0.7	98	12	1.5
Condition 5	12	3	0.7	21	16	2
Totals	466	404	100	883	792	100

	Chinook	Steelhead
% Captured, not Released	**13.30%**	**10.31%**
Released in 1, not captured in 1	96	288
	27%	44%

Leaving aside the 28 chinook and 50 steelhead that somehow disappeared between the catch- and the condition-summaries, there are 62 chinook (466 - 404) and 91 steelhead (883-792) unaccounted for in the condition summary itself, representing 13% and 10%, respectively, of the numbers-at-capture. One might reasonably assume that fish reported under the condition summary only include fish that must be released, not both retainable and non-retainable fish. In other words, one would assume that no retainable fish would be included in such a summary. This is certainly reasonable in light of the 2001 Evaluations, where it was shown that among all fish released in condition-1, condition-at-capture was a significant factor in long-term survival (fish captured in condition 1 surviving at a higher rate than fish captured in other conditions and recovered to conditon1 prior to release).

If the unaccounted 62 chinook and 91 steelhead are indeed non-retainable, and they were not ultimately released, one might conclude that the immediate mortality rate is 14% ((62+3)/466) and 12% ((91+16)/883), respectively, not 0.7% and 2% as listed in the "release %" column and stated in the Joint Staff Summary and elsewhere. Whatever these apparent discrepancies do actually mean, they should be rectified and clearly explained to all interested parties.

Relevance of the Data and Concerns Regarding Conclusions Drawn from the Data
These discrepancies aside, it is clear that more observed non-retainable chinook and steelhead were released in condition-1 than were caught in condition-1. 96 chinook were released in condition-1 that were not caught in conditions 1 (27% of chinook released in condition-1), and 288 steelhead were released in condition-1 that were not caught in condition-1 (44% of steelhead released in condition-1). The data from the 2001 long-term survival study summarized previously clearly indicated that such fish were more likely to not survive to return to upstream fishing and spawning sites than fish caught in condition-1 and these figures clearly indicate that the percentage of chinook and steelhead released in condition-1 but not caught in condition-1 was considerable.

Moreover, the long-term survival study was based on comparisons between true small-meshed tangle nets and the 8-inch monofilament gill net. The 3.5- and 4.5-inch mesh tangle nets caught a much higher percentage of fish encountered by tangling and a significantly lower percentage by wedging or mouth clamping than the 5" – 6" nets evaluated. Total estimated immediate-plus-long-term mortality for small mesh tangle nets was 11% (3% immediate and 8% long-term). The 8-inch gill net which mouth-clamped a much smaller percentage of fish than the 5" –6" mesh nets had a total estimated mortality of 50+% (1% immediate and 50.3% long-term). Immediate mortality was greatest for the 5" – 6" mesh nets (8%)!

In light of these results from the 2001 evaluations, the employment of 5-inch mesh nets during the demonstration fishery in conjunction with the high numbers and percentages of fish that were observed to have been released in condition-1 but not caught in condition-1 suggest that estimated mortalities should be much higher than the immediate mortalities reported (0.7% for chinook and 2% for steelhead).

In fact, no long-term mortality estimates are provided in any of the Fact Sheets or season summaries we have examined. Furthermore, no estimates appear to figure into impact estimates that must be made in order to adjust allocations for upriver fisheries in light of likely unintended and/or unexpected impacts on listed upstream stocks from the demonstration fishery, in order for both the demonstration fishery and subsequent upstream fisheries to comply with the current biological opinion governing Columbia River fisheries

Additionally, among the relevant kinds of data monitored in the 2001 studies that were not reported (or collected?) by observers during the demonstration fishery are the manner in which encountered fish were caught by the net (tangling, mouth clamping, gilling, wedging), the numbers of fish placed in the onboard recovery boxes, and the duration that each fish was in the recovery box before being adjudged to have attained condition-1. This data is relevant to the estimation of long-term mortality impacts from the fishery.

In fact, no data is provided by observers as to the size and kind of net observed. One can only assume that no net with a mesh larger than 5 ½ inches was employed. Yet both mesh size and net construction (monofilament or multistrand) are relevant to impacts of the fishery on non-target salmon and steelhead, and should be reported.

Of particular importance in light of the large and unexpected number of steelhead encounters during the demonstration fishery is the incidence of wedging, gilling, and mouth-clamping of steelhead by the 5- or 5 ½-inch mesh nets allowed by the fishery. Several steelhead hatcheries, including the Kalama Hatchery, report unusually high numbers of steelhead (both marked and unmarked) showing up in lower Columbia River tributaries with clear evidence of gill net encounters that abraded the skin and removed the protective slime layer. Many of these fish have already been observed to have fungal lesions on their body and have been estimated to have a low probability of reproducing.

The time spent in the recovery box is relevant for another reason. Requirements for participating in the demonstration fishery included possession of operable Fraser-type recovery boxes onboard with capacity for two fish. The 2001 tests showed recovery times as high as 81 minutes. Clearly, it is possible for fish in need of long recovery times to occupy the two available spots in the recovery box while other in need of recovery are retrieved from the net. No guidelines appear to have been in place for prioritizing which fish (chinook or steelhead) goes into the recovery box if there are more non-retainable fish judged in need of recovery than there is space available. No data is reported for this among the observer report summaries.

Given that encounters with non-retainable fish outnumbered encounters with retainable fish by nearly three to one, and that according to the observed data well over half the encountered non-retainable fish required some amount of time in the recovery boxes (724 out of 1349 at capture for chinook and steelhead combined), it is likely this circumstance occurred during the fishery, at best creating confusion that could result in fish not being properly recovered or being released directly from nets in conditions weaker than condition-1, or at worst creating an impediment to full compliance by non-observed fishers with the protocols of the fishery. This does not appear to have been considered in the projection of immediate mortality or condition-at-release estimates from the observer data to the total-fishery impacts.

Over and above the short-comings of the monitoring data reported in the Observer Summary, the estimate of impacts on non-retainable salmon and steelhead resulting from the demonstration fishery appear to be based entirely upon simple extrapolation from the point estimates of encounter and immediate-mortality rates from the observer data. No confidence intervals are provided for these point estimates, though they are clearly the result of a sampling effort. At a minimum, there is likely to be some distribution to the extent of compliance with the regulations both by fishers whose boats were observed (after observers left) and by fishers who were never observed. After all, nearly 96% of total vessel hours were not observed. And even if compliance by all fishers were perfect, there would be an expected distribution of observed values arising from any finite sample of observations, even if the sample population is perfectly homogeneous with the total population and sampling is perfectly random.

In the present case, however, any associated confidence intervals can be expected to be relatively wide, in part because the portion of the population actually sampled (i.e., monitored) is not perfectly homogeneous with the total population -- any more than the sampled population of convenience stores observed by uniformed police officers when the officers are present in the store is homogenous with the entire population of convenience stores with regard to likelihood of being robbed. Estimates of the mean number of attempted robberies per day in unmonitored stores is not likely to be accurately estimated by the number of attempted robberies observed by uniformed officers during the time that the officers occupy (i.e., observe) the stores.

Even if the point estimates from the observer data are taken as representative of the relative frequencies of marked to unmarked chinook and steelhead caught and of the relative frequencies of fish captured in each of the five conditions and released in each of the five conditions, and even if the wide inconsistency between these estimates and the values recorded in the more controlled test fisheries could be reconciled, the estimation of total impacts to non-target stocks resulting from the fishery should still be accounted greater than the immediate-mortality rate observed. Long-term mortality is still to be accounted and the evidence from the 2001 tests, in conjunction with the use of 5- to 5 ½-inch mesh nets in the demonstration fishery strongly indicates that long-term mortality will be greater than that estimated for the 3.5- and 4.5-inch mesh tangle nets combined. This is likely to be greater than 10%.

For all of these reasons, the present assertion that the total estimable fishery impacts are 0.7% for chinook and 2% for steelhead are lacking in credibility and insufficiently risk-averse concerning listed, non-target chinook and steelhead stocks that were likely affected by the fishery.

Adequacy of Response to the Questions Raised in the Letter of April 30, 2002.

As noted in the Introduction, the documents reviewed and commented on above were sent to Washington Trout by the Compact Managers in response to specific questions regarding the 2002 demonstration fishery and the analysis of its monitoring data, attached to a letter sent to the Compact Managers by Washington Trout, the National Audubon Society, the Native Fish Society, and Oregon Trout on April 30, 2002. Unfortunately, after reviewing all 14 documents we must complain that they do not adequately address all of the questions in our inquiry. In brief, the documents at best provide a few answers to the questions asked in connection with "Fishing Methodology," but even so none of these answers was transparent

None of the questions that were asked regarding the use of point estimates and the accounting for uncertainties were answered, except in the negative. No uncertainties were acknowledged, much less considered in any statistically appropriate manner. No methodology for extrapolating from the point estimates based upon observer data to overall fishery impacts is provided. No data from the 2001 evaluations that was funded by BPA and the Power Council in order to provide data relevant to the justification of a demonstration tangle net fishery was incorporated in estimating the likely impacts on non-target salmonids resulting from that fishery.

No estimates for drop out mortality were made. Incomplete and contradictory data on the condition-at-capture and condition-at-release are contained in the Observer Summary Sheet.

The April 30 inquiry asked if Compact managers had any "working estimate or data on short-term or long-term mortality rates for chinook or steelhead (page 3)." Such data for chinook was clearly on hand from the 2001 evaluations, yet none finds its way into any of the estimates of impacts from the demonstration fishery.

None of the information provided and reviewed substantively addresses the final set of questions in the April 30 inquiry regarding the estimation of impacts to non-target chinook and steelhead stocks likely encountered by the fishery and the apportioning of those impacts across the various ESUs and management units, particularly the remaining upriver and tributary fisheries.

In fact, our review orf the documents provided raises further questions and concerns along the same lines as those raised in the April 30 inquiry, and reinforces the impression expressed in the letter that Compact Managers have seriously discounted and endeavored to under-estimate the likely impacts of the 2002 demonstration fishery to non-target, listed chinook and steelhead. Given the information provided in response to our inquiry, it appears that the observer data is being misused and is not being properly qualified in the way that data resulting from any legitimate sampling scheme should be.

Relevant data resulting from the 2001 evaluations is simply not being incorporated into the interpretation of the observer data or the estimation of potential mortality impacts. The noticeably higher immediate mortality of 5" – 6" nets in comparison to both the 8-inch gill net and the smaller mesh tangle nets in the 2001 test is ignored. The significantly different pattern by which fish are caught in the 5" – 6" net relative to the smaller mesh tangle nets and the evidence that higher long-term mortality rates result from these differences is ignored. The significant yet comparatively small immediate and long-term mortality rates for smaller mesh tangle nets compared to the 8-inch gill net coupled with the immediate mortality data for the 5" – 6" nets in the 2001 evaluations alone suggests that long-term mortality from the 5- to 5 ½-inch mesh nets employed in the demonstration fishery may be considerable. This possibility is ignored.

The eagerness of Compact Managers to take the observer point-estimates of immediate-mortality rates and extrapolate them *tout court* to the entire demonstration fishery and consider that the sum and substance of estimable fishery impacts, particularly in the face of contradictory data from their own previous evaluations of this methodology, is both disturbing and unjustifiable.

Until the inconsistencies and inadequacies in the data collection and analysis for the 2002 demonstration fishery can be rectified or reconciled, no estimate of its relative impacts on listed non-target chinook and steelhead can be considered credible enough to consider this fishery a successful application of a non-lethal selective-fishery technique adequate to ensure the conservation and recovery ESA-listed Columbia River salmon and steelhead populations, or to comply with the goals of the current Biological Opinion governing lower Columbia River salmon and steelhead fisheries.

July 2002
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W A S H I N G T O N

T R O U T

Issues Concerning the 2002 Lower Columbia River Chinook Salmon Tangle Net Demonstration Fishery

(Summary)

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July 2002

(Full draft submitted to: Columbia River Compact Fisheries Managers, July 25, 2002;
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Introduction

On April 30, 2002 Washington Trout, National Audubon Society, the Native Fish Society, and Oregon Trout sent a letter to the Columbia River Compact fisheries managers expressing our concerns regarding the impacts on non-target salmon and steelhead of the 2002 tangle-net demonstration fishery. On May 14, we received a reply from Compact managers, consisting of 14 documents pertaining to the tangle-net fishery.

Overall, the 14 documents failed to address the substantive issues and concerns expressed in our letter of April 30. Several of the documents reinforced concerns that Compact Managers have taken an insufficiently risk-averse approach to the fishery. Based on our review of the documents, we drafted comments summarized below, and submitted those comments to Compact Managers for their consideration at a July 25, 2002 public meeting. We believe we have identified several issues that will require careful review before any decision to continue the tangle-net fishery can be justified.

2001 Evaluation.

The 2001 evaluation proposed to compare 3.5- and 4.5-inch mesh multistrand tangle nets to conventional 8-inch mesh monofilament gill nets. Separate components of the study were to evaluate **long-term mortality** of fish caught in one of five conditions (1 - lively, not bleeding, 2 - lively, bleeding, 3 - lethargic, not bleeding, 4 - lethargic, bleeding, 5 - no visible movement or ventilation), and released in condition-1 or -2 (either released directly in condition-1 if caught in condition-1, or recovered in onboard recovery boxes to condition-1 or -2 prior to being released), **short-term mortality** (survival for 72 hours after being caught), and **immediate mortality** (fish in condition-5 -- no visible movement or ventilation -- that could not be revived in recovery boxes).

The evaluation examined 5- to 6-inch mesh gill nets only to a limited extent. First, during four days in April 2001 "[w]hile waiting for tangle nets to arrive from the manufacturer…"(Final Report of Feb. 2002, Part II, page 27). Sample size in this case was small but not negligible (39 adult chinook and four jacks). And, second, during the last two weeks of a 20-boat permit fishery. Sample size here was significant: 384 adult chinook and 148 jacks kept and 237 adult chinook and 71 jacks released. No fish caught in 5- to 6-inch mesh gill nets were tagged and used in the long-term mortality study. However, the immediate mortality was variously reported between 8% and 10.3%, significantly higher than for 8-inch mesh gill nets, 3.5-inch mesh tangle nets, and 4.5-inch mesh tangle nets hung with stringers and slackers at a 2:1 ratio.

The long-term mortality study involved tagging of test-caught fish below Bonneville and of control fish taken at the Bonneville north-shore ladder trap and analyzing the recovery of tags upriver in fisheries, at hatchery racks, and on the spawning grounds. Due to some problems with the tags the only long-term mortality comparisons that could be made were for tangle-net caught (3.5- and 4.5-inch mesh nets combined) relative to control fish and 8-inch gill net caught fish relative to control fish. The reported results are straightforward: immediate mortality with the 8-inch mesh gill net was 1%, but long-term mortality was 50%; immediate mortality for the 3.5- and 4.5-inch tangle nets was 3% and long-term mortality was 8%.

In conjunction with the immediate mortality data for 5- to 6-inch mesh gill nets (8% to 10.3%), data from the 2001 Evaluation concerning the manner in which each net captures individual fish indicate that long-term mortality from 5- to 5.5-inch mesh gill nets is likely to be considerably higher than for smaller mesh tangle nets. During the long-term mortality study the manner in which each fish was captured by the net was noted. Four main kinds of captures were identified: gilling, wedging (in front of the dorsal), mouth clamping, and tangling (tooth-caught). The majority of fish caught using the true tangle nets were caught by tangling (3.5-inch mesh: 177 out of a total of 188, of which six died immediately; 4.5-inch mesh: 290 out of a total of 348 caught of which one died immediately). Among these tangle net-caught fish, mouth-clamped fish had a higher immediate mortality rate (3.5-inch mesh: two immediate mortalities out of a total of six; 4.5-inch mesh: eight out of a total of 44).

The highest proportion of mouth-clamped fish among total fish caught by each gear-type/mesh size occurred with the 5-inch mesh nets: 44%. Only 46% were tangled, compared to 94% with the 3.5-inch mesh and 84% with the 4.5-inch mesh. In addition to 44% mouth clamped, 5% of fish caught with the 5-inch mesh net were gilled and 5% were wedged. Wedging appears to be responsible for significant de-scaling and other net-injuries that likely contribute to reduced probability of long-term survival. The Final Report of February 2002 notes that 54% of fish tagged in the long-term mortality study were wedged (almost entirely those caught by 8-inch gill nets) but only 41% of tag recoveries were from fish caught by wedging.

Combined with the relatively high (8% to 10.3%) immediate mortality rates, the results from the 2001 Evaluation suggests that long-term mortality from the use of 5- to 5.5-inch mesh nets is likely to be greater than 10%, which suggests that total (combined immediate and long-term) mortality is likely in the neighborhood of 20% or greater.

Results from the use of onboard recovery boxes are also of relevance to the long-term mortality that might result from 5-inch mesh nets. The 2001 tests were conducted with two observers/researchers on board in addition to the contracted fishers. One of these observers handled all fish. Of the total number of fish captured by 3.5- and 4.5-inch mesh tangle nets and 8-inch mesh gill nets during the long-term mortality study (1372), 86.2% (1183) were reported to have been caught in condition-1 (Final Report, Table 2, page 13).

The remaining 13+% were candidates for the onboard recovery boxes. Time spent in recovery boxes ranged from two to 81 minutes. "78% of adult spring chinook captured in conditions-3, -4, or -5 were "successfully recovered and released." (ibid.) Despite this optimistic-sounding data, fish caught in condition-1 -- i.e., those released without requiring any time in the recovery box -- had significantly higher long-term survival than fish recovered to condition-1 prior to release. "At capture, 86.2% of the fish were in condition-1, while 91.4% of the recovered tags were from fish that had initially been captured in condition-1." (Final Report, page 18).

Given that there is evidence that mouth-clamped, gilled, and wedged fish are more likely to require recovery than tangled fish (i.e., are less likely to be captured in condition-1), the 2001 data for 5-inch-mesh nets clearly indicates that fish caught by these nets have a higher probability of being in conditions -2 through -5 than fish caught in true, smaller mesh, tangle nets, and therefore will be more likely to suffer diminished long-term survival relative to tangle-net caught fish. Data from the 2002 demonstration fishery support this. According to the Tooth Net Observation Summary (data unchanged since April 3, 2002), of 466 chinook observed caught, 204 (44%) were not captured in condition-1 and, hence, were candidates for the recovery boxes; of 883 steelhead observed caught, 520 (59%) were not captured in condition-1.

2002 Demonstration Fishery

Not only were none of our substantive questions concerning the data reported for the demonstration fishery answered, it is clear that data shown by the 2001 evaluation to be relevant to an analysis of the performance and the assessment of impacts from a gill net/tangle net type of fishery were not collected, nor was the collection of such data part of the monitoring plan.

No true tangle nets were required for the demonstration fishery. The only requirement regarding net type was that mesh size not exceed 5.5 inches. Most nets fished were 5- or 5.5-inch monofilament gill nets. As noted above, this lead to a much higher proportion of fish captured other than in condition-1 and thus in need of the recovery box.

In our letter of April 30, we asked if there was a clear protocol for prioritizing which fish were put into recovery boxes when there were more fish in need of recovery than the two spaces required onboard. No such protocol existed.

Despite the clear evidence of the importance of the manner by which fish were captured by the nets (gilling, wedging, tangling, mouth-clamping) to both immediate and long-term survival of released fish, no such data was required or obtained by observers during the demonstration fishery.

There are also unresolved discrepancies between the numbers of chinook and steelhead reported observed caught and those reported as released. The "catch summary" of chinook and steelhead observed caught records 991 adult spring chinook caught (497 marked; 494 unmarked), and 933 adult steelhead caught. These numbers are inconsistent with numbers recorded in the "condition summary." Whereas the catch summary lists 494 unmarked adult chinook caught, the condition summary only lists 466 chinook captured and only 404 chinook released. Whereas the catch summary lists 933 steelhead caught, the condition summary lists only 883 captured, and only 792 released. None of the documents examined acknowledges or explains these discrepancies. These "missing" salmon and steelhead could suggest immediate mortality rates as high as 14% and 12% respectively, significantly higher than the estimates reported by compact managers (.7% and 2%), from the same data!

On balance, there is clear evidence that 5- to 5.5-inch mesh gill nets will have a greater probability of capturing fish in ways that will result in higher immediate and long-term mortality rates than 3.5- and

4.5-inch mesh true tangle nets. In addition, it is reasonably clear that "recovering" fish to condition-1 in onboard recovery boxes has a low probability of reducing long-term mortalities of fish captured relative to fish captured in condition-1 and not requiring recovery. Moreover, as noted in the 2001 Evaluation Final Report (page 25) the time required to recover fish to an extent sufficient to significantly increase its prospect for long-term post-release survival is impractical under the typical conditions of a competitive commercial fishery, particularly under the conditions experienced in this fishery, where encounters with non-retainable fish outnumbered encounters with retainable fish by nearly three to one, and well over half the encountered non-retainable fish required some amount of time in the recovery boxes. This does not appear to have been considered in the projection of immediate mortality or condition-at-release estimates from the observer data to the total-fishery impacts.

The immediate mortality figures reported for spring chinook and steelhead in the Observation Summary (0.7% and 2.0%, respectively) are considerably lower and thus at odds with those reported under the much more rigorously monitored and controlled conditions of the 2001 tests, and are considerably lower than what would be expected on the basis of the 2001 data. Leaving aside this inconsistency, and the un-reconciled discrepancies in data-reporting regarding numbers of fish captured and released, almost no aspect of the compact managers' 2002 monitoring effort, or analysis of the resulting data, suggests that their immediate-mortality estimates are credible.

Approximately 4.5% of total fishing boat hours during the entire demonstration fishery were observed. Estimates of total fishery impacts to non-target chinook and steelhead are based entirely on extrapolating the observer-reported point estimates of immediate mortalities, chinook 0.7% and steelhead 2.0%, to the total fishing effort. Even were these reported point-estimates credible, there is some sampling variance to be expected that should yield a range of estimated immediate mortalities. The failure of the Compact Managers to provide such estimates alone strongly suggests that impacts are under-estimated.

Even this, however, would fall far short of a credible risk-assessment of the impacts of the demonstration fishery. This is directly relevant to the final question that was asked of Compact Managers in the letter of April 30 concerning the manner by which the impacts of the fishery to listed upriver spring chinook and steelhead stocks would be apportioned and upriver fisheries adjusted accordingly. This issue has simply not been addressed at all to date. The immediate mortality estimates appear to have been used to "determine" that no allocations have been exceeded, and hence that no in-season adjustments need be made. It is, of course, likely that a risk-averse estimate of long-term mortality impacts would indicate that such adjustments are required. **Accordingly, we believe that it is likely that Compact Managers are in violation of ESA take restrictions as a result of impacts on listed stocks by the demonstration fishery and failure to adjust upstream fishery allocations.**

The eagerness of Compact Managers to take the observer point-estimates of immediate-mortality rates and extrapolate them *tout court* to the entire demonstration fishery, particularly in the face of contradictory data from previous evaluations, is both disturbing and unjustifiable. Until the inconsistencies and inadequacies in the data collection and analysis for the 2002 demonstration fishery can be rectified or reconciled, no estimate of its relative impacts on listed non-target chinook and steelhead can be considered credible enough to consider this fishery a successful application of a non-lethal selective-fishery technique.

EVALUATE LIVE CAPTURE SELECTIVE HARVEST METHODS

Final Report for BPA Contract 2001-007-00

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ABSTRACT

Selective fishing is the ability of a fishing operation to avoid non-target species or stocks, or when encountered, to capture and release them in a manner that minimizes mortality. Two gears, the tangle net and a floating trap net were tested on the lower Columbia River to selectively harvest adult spring chinook salmon (*Oncorhynchus tschawytscha*) and coho salmon (O. *kisutch*). Experienced gill netters simultaneously fished tangle nets (3.5" and 4.5" mesh size) and conventional gill nets (8" mesh size) on the Columbia River to evaluate their effectiveness for live release of non-target stocks of spring chinook salmon. Live fish were tagged and released for recovery in sport fisheries, commercial fisheries, at hatchery racks and traps, and during spawning ground surveys. Control fish that had not been captured in the test gears were tagged and released from an adult trap in Bonneville Dam, just upstream of the fishing area. The 4.5" tangle net was as effective for capturing spring chinook salmon as the conventional gill net, but the 3.5" net caught significantly fewer spring chinook salmon than the 8" gill net. Fish were generally captured in good condition. The immediate survival (from capture to release from the boat) of adult spring chinook salmon captured in the 8" gill net was 99%, compared to 96% from the 3.5" tangle net, and 97% from the 4.5" tangle net. However, spring chinook salmon released from the tangle nets were recovered at about 91% of the rate of controls, while spring chinook salmon released from the conventional gill net were recovered at about 50% of the rate of the controls. These tests showed that using conventional gear with short soaks and careful fish handling is not enough to ensure the survival of released spring chinook salmon. However, switching to the 4.5" or 3.5" tangle net, coupled with short soaks and appropriate fish handling is a viable selective harvest gear for the commercial gill net fleet fishing for spring chinook salmon on the Lower Columbia River because the post-release mortality on non-target stocks can be greatly reduced compared to a conventional gill net, without sacrificing catch efficiency.

We fished a 5" gill net in tandem with the 8" gill net on four occasions on the lower Columbia River near Camas, Washington to evaluate its potential for selective harvest of spring chinook salmon. During this short test, the immediate mortality of adult spring chinook salmon rose to 10%, compared to 0% in the 8" gill net during the same period. This increased mortality was likely caused by an increase in capture by mouth clamping in the 5" gill net rather than by tangling or by the body as in the 8" gill net.

In fall, 2001, we evaluated the feasibility of using the tangle net to capture marked coho salmon while releasing unmarked coho salmon near the mouth of the Columbia River. A variety of tangle net configurations were used and showed that this fishing method warrants further consideration if the mark rate is high. Immediate mortality of unmarked coho salmon was 17% but because 84% of the coho salmon were marked, relatively few unmarked coho salmon were killed.

In spring and fall, 2001, we tested the feasibility of using a floating trap net near the mouth of the Columbia River to capture marked salmon live and allow the release of non-target species and stocks. The trap net was ineffective at capturing fish.

INTRODUCTION

The Columbia River is one of the largest chinook salmon (*Oncorhynchus tschawytscha*) producing rivers in the world, and has supported fisheries since long before Europeans came to the area. However, like many other rivers in the Pacific Northwest, it has not been spared from declines in salmon populations; several stocks of spring, summer and fall chinook salmon are listed as threatened or endangered under the federal Endangered Species Act. The remaining non-treaty commercial salmon harvest on the Columbia River is done by gill net fleets that are managed using time, area, and gear restrictions to minimize catch of listed fish because there is little opportunity to release fish live and unharmed using conventional gears and fishing practices. Although there have been no non-treaty commercial fisheries for spring chinook since 1977 because of the small runs, the flesh quality and high fat content make it the most prized of all the Columbia River salmon. The process of reopening these fisheries began in spring 2001 with the largest recorded return of spring chinook salmon to the Columbia River.

Selective harvest technologies and practices allow a continued harvest, while protecting weak stocks. "Selective fishing", more accurately described as "live capture, selective harvest", is the ability of a fishing operation to avoid non-target species or stocks, or when encountered, to capture and release those animals in a manner that results in minimal mortality. Successful selective fishing requires that two objectives be met. First, a conservation goal must be achieved for the species or stock of concern, and second, a harvest goal must be met to make the fishery economically viable. Weak stocks of spring chinook salmon return to the Columbia River intermingled with healthy stocks returning to hatcheries and lower river spawning sites. Harvesting salmon with gill nets in these mixed stock fisheries is a problem because fishers inadvertently catch weaker species and stocks while targeting salmon from stronger runs. Because successful live release of salmon from a gill net is difficult, the only practical way these traditional gears can be more selective for the target species is by time and area closures. While these restrictions can be very efficient at reducing by-catch and meeting the conservation goal for the fishery, they necessarily reduce fishing opportunity for the target species and do not meet the harvest goals.

In 2001, protecting weak salmon stocks required significant restrictions in commercial harvest even though fish from the healthy stocks were numerous. We therefore began working with the commercial fishing industry to develop acceptable live capture gears that will provide more fishing opportunity while continuing to protect weak stocks. Simultaneous with the development of selective fishing methods, large portions of the hatchery production of spring chinook salmon are being identified by the excision of the adipose fin before release as juveniles. When these fish return as adults, fishers can distinguish them from naturally produced fish that do not have the adipose fin excised.

The tangle net is a possible substitute for gill nets that may meet the criteria for selective fishing. Tangle nets look similar to a gill net with a small mesh size (3.5"-4.5" compared to 8" in a conventional spring chinook salmon net). Tangle nets are made from multifilament web while gill nets are typically made from monofilament web. Both gears are fished in the same method and locations, but the similarities stop there. Unlike a gill net, which captures an adult salmon around the gills or body, the mesh size of the tangle net prevents adult fish from entering the net that far. Instead, the fish is caught by the maxillary or teeth, which allows it to continue respiring in the net so it can be released live. External and associated internal injuries are also reduced using this capture method. Modifications in fishing practices, including the use of fish revival boxes, short soak times, and careful fish handling, are as important as the gear in ensuring that fish are released live and unharmed.

The untested premise of live capture, selective harvest is that the released fish survive to contribute to rebuilding their stock. It is assumed that fish released in good condition will survive, but there have been no published studies looking at the long-term survival of fish that have been captured and released from commercial gill nets. Studies evaluating the survival of fish captured in sport fisheries indicate that mortality of released fish is variable and likely depends on the species captured, the skill of the fisher in releasing the fish, the water temperature, and the fishing method. Survival of lake trout captured in gill nets in Lake Superior and held in tanks for 48 hours varied seasonally from 68% to 77% (Gallinat et al. 1997) and studies evaluating coho salmon released from commercial fishing gears in British Columbia have shown that mortality of fish held in net pens for 24 hours was less than 3% (Farrell et al. 2001). However, evaluations of post-release survival of salmonids held in net pens are unlikely to reflect the post-release survival of free-swimming fish, because the fish in net pens are not subject to predation, currents, or encounters with obstacles to migration (e.g. dams, shallow parts of rivers, etc.) which a severely stressed fish, such as those captured in gears (Farrell et al. 2000) must contend with. Many tagging studies evaluating migration and population sizes suggest that fish can be captured and released with some success, but these types of studies were not specifically directed at looking at the effects of the capture gears on survival.

The main goal of this study was to test the fundamental assumption of selective fishing – that the released fish we are trying to protect really do survive at acceptable levels to contribute to rebuilding the weak stocks they are part of – by estimating the post-release mortality of spring chinook salmon released from tangle nets and conventional gill nets on the Columbia River. We also estimated and compared the immediate mortality and catch efficiency of the two gears and evaluated characteristics of fish caught in each gear. Gear changes may result in encounters with different non-target species (by-catch), and this is expected with the tangle net as many small fish species that dwell in the Columbia River can pass through the large mesh gill nets without incident, but would be captured in the smaller-meshed tangle net. Because it is undesirable to shift the impacts from one species to another, we also compared the capture of species other than spring chinook salmon in each gear. In fall 2001 we evaluated the tangle net for capturing marked coho salmon but requiring release of unmarked coho salmon. Our second objective was to examine the feasibility of using a floating trap net to capture spring chinook salmon and coho salmon in the lower Columbia River.

PART 1 SURVIVAL OF SPRING CHINOOK SALMON CAPTURED AND RELEASED FROM TANGLE NETS AND CONVENTIONAL GILL NETS

METHODS

The Columbia River is the second largest river in the United States, draining an area of 258,000 square miles. From its source in British Columbia to its mouth at the Pacific Ocean, the Columbia River flows 1,270 miles. Spring chinook salmon returning to the Columbia River encounter Bonneville Dam, the first mainstem hydroelectric dam, at river mile (RM) 146, and fish going further upstream will encounter nine more mainstem hydroelectric dams before they reach the impassable Grande Coulee Dam at RM 597. Fish venturing up the Snake River, the largest tributary to the Columbia River, encounter seven more dams. Spawning grounds for spring chinook salmon are dispersed throughout the Columbia River basin, as are a number of hatcheries that produce spring chinook salmon for supplementation and harvest. Consequently, spring chinook salmon returning to the Columbia River belong to a number of stocks that also disperse as they move upstream.

We fished for returning adult spring chinook salmon at the following locations downstream of Bonneville Dam: between Ainsworth and Benson State Park (RM 139); near Sheperds Dell State Park, above Bridal Veil (RM 134); across from Rooster Rock State Park (RM 130); near Crown Point State Park (RM 127); and near Cottonwood Point, on the western end of Reed Island (RM 126).

We contracted four local fishers to fish nets that were 75 fathoms of tangle net (1.5 mm x 4 strands, 3.5" or 4.5" mesh size hung at a ratio of 3:1 and 2:1, respectively) shackled to 75 fathoms of conventional gill net commonly used in their areas for the target species (monofilament, 8" mesh size, hung at a ratio of 2:1). The hang ratio describes the number of fathoms of mesh per fathom of cork line. Both gear types were hung to the same depth, and the depth of the nets was suitable to each area being fished. The net colors were based on availability from the manufacturer - most were a shade of light green and one panel of 4.5” tangle net was pink. Because we fished mainly at night to avoid conflicts with anglers, the color of the net did not affect catch efficiency. A diver net, which sinks and follows the bottom contours, as opposed to the other floating nets that remain at the surface, was used on two vessels. Each vessel was equipped with a hydraulic reel mounted in the bow that was used to deploy and retrieve the nets. Fishers contracted for this project had many years of experience gillnetting for salmon in the study area and were asked to mimic the fishery pertaining to the location and as to how nets were laid out.

When possible we alternated the end of the net that was closest to shore on subsequent sets so that the fishing effort of each net type was as similar as possible for each area fished. The nets were set by reeling them across the river (typically in a curved pattern) and allowing both ends to drift freely. Observers selected the appropriate set time for each set. The set time was defined as the time from when the first cork went into the water until the last cork was removed from the water.

All vessels were equipped with a recovery box made from ¾" plywood painted black. The recovery boxes were built with two compartments for holding fish. Each compartment was about 42" long, 16" high and 7.5" wide. The compartments of the recovery box were wide enough to allow a salmon to fit with its head facing the fresh water flow but narrow enough to prevent the fish from turning around. A 12 V, 3800 gallon/h submersible bilge pump was connected to a 1.5" discharge hose which supplied fresh water through pipes located at the bottom of the box. Overflow outlets were located at the opposite end of the recovery box.

Two observers were on board each vessel. One observer primarily recorded data, while the other observer handled fish. For each set observers recorded the time when the first part of the net was placed in the water, the time the first part of the net was removed from the water, the time the shackle between the two nets was removed from the water, the time the end of the net was brought on board, the longitude and the latitude for the set (using a Magellan handheld GPS unit), which net type was put in the water first and which net type was removed from the water first. Observers also recorded the date, skipper's name, boat name, observer names, set number, weather conditions, water and surface temperatures, presence of seals and any other observations pertaining to each particular set.

Observers informed fishers when to start picking up nets. Fishers were instructed on proper fish handling as they removed fish from the net, particularly to avoid touching the gill area or holding fish by its caudal peduncle. As possible, fishers also looked over the bow as the net was pulled up so they could lift fish over the roller. Fish were placed immediately into a tank of freshwater located near the bow. Any unusual observations about fish handling from net to tank were recorded.

For each spring chinook salmon caught, the observer noted the net type where it was captured (tangle or gill), the type of capture, whether the adipose fin was missing, the condition of fish at capture, and the sex. The observer then measured the fork length and tagged the fish with a numbered jaw tag covered with a plastic sheath and printed with a number. The plastic sheaths were colored to correspond to the net type where the fish was captured. We characterized the type of capture as tangled by teeth or mouth, rolled in net, gilled (net around the gills), wedged (web around body further than gills) or mouth clamped (net wrapped around mouth, clamping it closed). A fish was initially ranked as condition 1 if it was lively and not bleeding, condition 2 if it was lively but bleeding, condition 3 if it was lethargic but not bleeding, condition 4 if it was lethargic and bleeding, and condition 5 if it showed no visible movement or ventilation. Fish ranked condition 1 or 2 were tagged and released overboard immediately. Fish in conditions 3 to 5 were held in the recovery boxes until they either recovered to condition 1 or 2, and could be released, or they died. The time was recorded when fish were placed into the recovery box and at release or when resuscitation failed and fish was determined to be dead. Loss of scales, damaged fins and other visible injuries were recorded. Non-target species encountered were counted according to the net type where captured.

A control group of spring chinook salmon was collected and tagged with a colored jaw tag at the adult fish trap located in the fish ladder at Bonneville Dam on the Washington shore of the Columbia River. These fish had passed through all the same predatory pressures as the fish caught in the gears as well as similar fishing pressures, but had not been captured in our test gears. Because the fish had also passed through one additional popular sport fishing area and had successfully located the fish ladder, they may have an advantage compared to the spring chinook salmon released from the test gear that would be reflected as a higher post-release survival rate. In the trap, fish pass through a series of diverters and chutes and into a holding tank. Clove oil was added to the holding tank to temporarily anesthetize the fish. Each spring chinook salmon in the control group was then measured (fork length) and tagged, and the sampler noted whether it was missing its adipose fin and had other visible injuries. Fish were then transferred to fresh water until they revived back into lively condition and were released into a chute and diverted back to the fish ladder to continue their migration. Trapping occurred throughout the test fishery to ensure the same populations of migrating fish were tagged in each group.

To evaluate the survival of released fish, we monitored the number of tagged spring chinook salmon passing up fish ladders of three dams, contacted hatcheries and spawning ground surveyors for jaw tag recovery and informed the fishing public about where to return jaw tags. Bonneville, John Day and The Dalles dams are each equipped with two viewing windows located at the fish ladders. Technicians stationed at the viewing windows reported a daily total of the different colored jaw tagged fish as they passed through the ladders. Posters were produced requesting the following information: date of harvest, location of harvest, tag color and tag number. They were posted at various locations to target both treaty and non-treaty anglers. Hatchery crews and stream surveyors returned the same information.

For each day we were able to fish both nets equally, we compared the catch per hour of adult spring chinook salmon in the 3.5" and 4.5" tangle nets to the 8" gill net. While jack spring chinook salmon are captured in the tangle nets, they are not as important either for marketing or for stock management and were omitted from this analysis. The fishing time included only the time the nets were actually fishing and not time spent preparing for the next set. Because we recorded only the time the first cork went in the water, and not when the shackle went in, we designated the time to set the first net as 3 minutes in every case. The total fishing time for each net was then calculated as the time from when the first cork of that net was placed in the water to the time when the last cork of that same net type was removed from the water.

The frequency distributions of spring chinook salmon by condition at capture were compared using a chi-square analysis (P=0.05). Set times, total soak times, fish lengths, and the numbers of non-salmonids in sets with and without dead fish were compared using t-tests (P=0.05). We chose a conservative approach for comparing the post-release survival of spring chinook salmon released from each net and used the Z-statistic as described in Zar (1984) for comparing two proportions. To eliminate bias in how catch efficiency may be related to fish abundance, the catch efficiencies of each net type were compared using a sign test. Where appropriate, we combined the results for both tangle net types (3.5" and 4.5" mesh sizes) for comparison to the 8" gill net, and data were pooled among skippers and across fishing days to represent a more balanced picture of a fishing season.

RESULTS

IMMEDIATE SURVIVAL AND CONDITION

Test fishing with the tangle nets and conventional gill nets began on April 4, 2001 and we fished 61 boat days between that day and May 24, 2001. We captured 1,372 adult (including 20 recaptures) and 182 jack spring chinook salmon (including 1 recapture; here defined as fish that are 60 cm fork length or less) in the 3.5”, 4.5” and 8” nets. Of those, 25 adults (1.8%) and 13 jacks (7.2%) could not be revived after capture for release (Table 1). All live adults and 18 jacks were tagged before release, so that 814 chinook salmon captured in the 8” gill net were tagged and released, and 528 chinook salmon captured in the 3.5” and 4.5” tangle nets were tagged and released (**Figure 1**). Most jacks were released untagged because their jaw was too small for correct application of the tag. We tagged 1,206 spring chinook salmon in the control group at Bonneville Dam throughout the test fishing period. None died during handling.

Table 1. Immediate survival (%) of adult and jack spring chinook captured during test fishing in each net type on the Columbia River. N is the number of spring chinook encountered.

Mesh Size	Adults			Jacks		
	% Survival	N	95% Confidence Interval	% Survival	N	95% Confidence Interval
3.5”	95.7	188	91.8-97.8	95.1	41	83.9-98.7
4.5”	97.4	348	95.2-98.6	91.8	134	85.9-95.4
8.0”	99.0	836	98.1-99.5	100.0	7	64.6-100

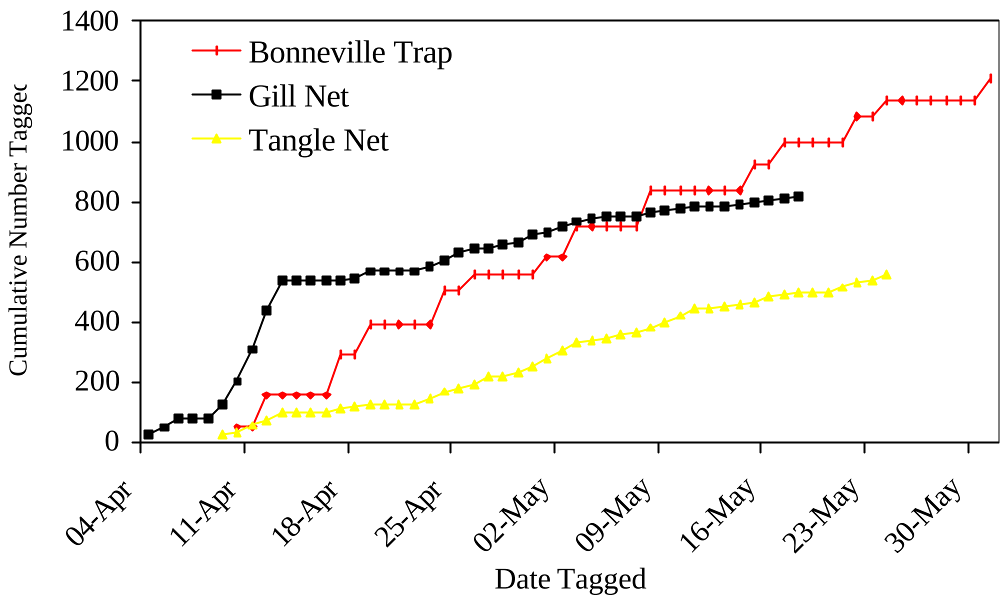

Figure 1. Cumulative number of spring chinook salmon tagged and released during test fishing below Bonneville Dam using the 8” gill net and the 3.5” and 4.5” tangle nets, and at the adult trapping facility in Bonneville Dam.

Twenty-one spring chinook salmon that we tagged and released were recaptured during the test fishery, with 14 being recaptured in the 8” gill net. The time between the initial and the second capture ranged from 50 minutes (a subsequent set on the same day) to 433.3 hours (about 18 days). All fish survived the second capture and were released in good condition. This low frequency of recaptures (1.5% of adults encountered) suggests that the potentially cumulative effects of multiple recaptures on survival may be minimal. However, if many boats are fishing close to one another, the rate could increase so care should be taken to release fish away from other fishers.

The initial condition of each fish was scored as the fish was brought on board. The distribution of adult spring chinook salmon in each category was significantly different between the tangle nets (3.5" and 4.5" combined) and the gill nets (chi-square = 59.5, df=4, $P<0.0001$), with the tangle nets having larger proportions of fish captured in conditions 3 and 5 than the gill net, and the gill net having a larger proportion of fish captured in condition 2 than the tangle net.

Table 2. Adult spring chinook salmon (including recaptured fish) scored in each condition at capture category that were released (Rel'd) or died for the tangle nets (3.5" and 4.5" combined) and the 8" gill net.

Mesh Size	Condition At Capture									
	1 Lively		2 Lively, bleeding		3 Lethargic		4 Lethargic, bleeding		5 No visible movement or ventilation	
	Rel'd	Died	Rel'd	Died	Rel'd	Died	Rel'd	Died	Rel'd	Died
3.5"	166	0	3	0	6	3	2	0	3	5
4.5"	293	0	5	0	28	2	0	0	13	7
8"	724	0	68	0	30	1	6	0	0	7
Total	1183	0	76	0	64	6	8	0	16	19

Fish captured in conditions 3 and 5 in the tangle net were typically captured by tangling or mouth clamping, methods that rarely occur when using the 8" gill net (Table 3). Capturing fish around the gills frequently caused bleeding, and the fish were then classified as condition 2 at capture. This capture type is common with conventional gill nets, but rare with the tangle net. Capture around the gills occurred in the tangle net when meshes were torn, such that the effective mesh size was larger than the original constructed mesh size, or when small fish were encountered.

Table 3. Capture types of adult spring chinook salmon (includes recaptures) that were released (Rel'd) or died.

Capture Type	Mesh Size					
	3.5"		4.5"		8.0"	
	Rel'd	Died	Rel'd	Died	Rel'd	Died
Gilled	3	0	1	0	73	3
Mouth Clamped	6	2	44	8	0	0
Tangled	171	6	290	1	23	0
Wedged	0	0	4	0	732	5
Total	180	8	339	9	828	8

Virtually every adult chinook salmon captured in the gill net had net marks around the body in front of the dorsal fin or around the gills, and virtually every adult captured in the tangle net had net marks around the snout. Net marks on the body tended to be severe – scales were dislodged and missing, and the underlying skin was often abraded and red. While not visible, a loss of the protective slime layer would be associated with this injury. Net marks from the tangle net tended to be less severe as the snout does not have easily dislodged scales. The marks tended to be dark lines where the net pressed on the skin, and tended to be on the lower snout and jaw. The slime layer on some of these fish may have been disturbed if they rubbed against the net, or if the fish rolled itself into the net. Other injuries included damaged fins, hook wounds and seal wounds. We noted seal wounds on 15% of the fish captured, and these ranged from scars to open wounds with substantial tissue trauma. While seals occurred in the areas we fished, they were infrequent visitors to the nets, so most recent wounds likely occurred during the upriver migration. Seals and sea lions are common near the mouth of the Columbia River.

Fish in conditions 1 or 2 were tagged and released overboard with minimal holding. We attempted to recover fish in conditions 3, 4 or 5 to condition 1or 2 for release. Holding times in the recovery box ranged from 2 to 81 minutes, with most fish showing a quick improvement in condition. We successfully recovered and released 78% of adult spring chinook captured in conditions 3, 4 or 5. No fish captured in condition 5 in the gill net could be recovered, while 57% of those captured in condition 5 in the tangle nets were revived.

During the test fishery, 25 adults died before they could be released overboard. The mean fork length of dead adults (76.1 cm, N=24) was not significantly different from the mean fork length of live adults (75.4 cm, N=1,285; t=1.71, df=23, P=0.34). These fish were captured in sets that were significantly longer than average (t=1.73, df=19, P=0.002). The total set time, the time from when the first cork goes in the water until the last cork comes out, for sets with dead fish varied from 38 minutes to 135 minutes, with an average set time of 68.5 minutes (N=19 sets). The total set time for all sets varied from 20 minutes to 135 minutes with an average of 50.1 minutes (N=241 sets). The average soak time (the time from when the first cork is put into the water until the first cork is pulled back out) for all sets was 20.2 minutes (N=24 sets), significantly shorter than the average soak time for sets with dead adults (22.3 minutes, N=19 sets, t=1.65, df= 258, P=0.03). The occurrence of dead fish was related to the total number of non-salmonids captured in a set, which itself affects the total set time, as more non-salmonids will take longer to remove from the net. Sets with dead adult spring chinook had significantly more non-salmonids (72.2 per set, N=19 sets) than all sets (38.9 per set, N=224 sets; t=1.70, df=31, P=0.047).

The relationship between the increased number of non-salmonids and increased immediate mortality may be an important factor in a tangle net fishery. The tangle net captured many more non-target species than the gill net (Table 4). The actual numbers of non-salmonids are likely underreported because this was not the primary goal for the observers. Sturgeon were generally released in good condition, while the condition of the other species was variable. Twenty-two steelhead salmon were encountered during test fishing, and all were released in excellent condition.

Table 4. Catch of non-target species in the tangle nets (3.5" and 4.5" combined) and the 8" gill net during test fishing on the Columbia River. "Other" includes walleye, flounder, carp, bass, etc. for which 10 or fewer animals were encountered.

Species	Tangle Nets	Gill Net
Shad	7022	10
Northern Pike Minnow	311	2
Steelhead	20	2
Sturgeon	1608	441
Suckers	438	1
Other	51	9
Total	9450	465

Surface temperatures during fishing ranged from 8°C in early April to 15°C in mid-May. The mean surface temperature of the 19 sets with dead fish was 11.6°C, not significantly higher than the mean surface temperature for all sets (11.0°C, N=241, t=1.17, df=258, P=0.12). Therefore, within the ranges we observed, temperature did not affect immediate survival.

Among all adults captured, 42.6% were unmarked, but among the dead fish, 56% were unmarked. Unmarked fish represent a mix of hatchery and wild origin fish. Scales were collected from the dead fish, and of those that could be assigned to either hatchery or wild, 10 were wild and 1 was hatchery. This suggests that there may be some differential mortality associated with capture for wild and hatchery fish, but it is difficult to explain why there would be such a difference, and it may simply be a result of the small sample size.

Post-release survival

We tagged and released 814 spring chinook salmon from the 8" gill net (including 2 jacks) and 528 from the 3.5" and 4.5" tangle nets (including 16 jacks). Tags were recovered throughout the Columbia River in sport fisheries, commercial fisheries, at hatcheries and on spawning grounds (Figure 2). The first tag was recovered on 12 Apr 2001 and the last was recovered on 11 Sep 2001. Not all of the tag colors were reported, and some of the tag numbers were illegible, such that some tags could not be assigned to the original net they were captured in, or to other subcategories identified at the time of capture (capture type, jack or adult, condition at capture, etc.).

Most recovered fish were reported in good condition. Recoveries were clumped in areas with popular sport fisheries and at hatcheries. These are the areas with the most intensive sampling, but do not indicate that tagged fish didn't return to other areas. We assumed that fish tagged in each net type were from the same populations, and therefore their tags were equally likely to be recovered, so that observed differences in tag recovery rates were due to survival differences. Figure 2 shows that tagged fish from each group were represented in each of the recovery areas, and that our assumption is therefore valid.

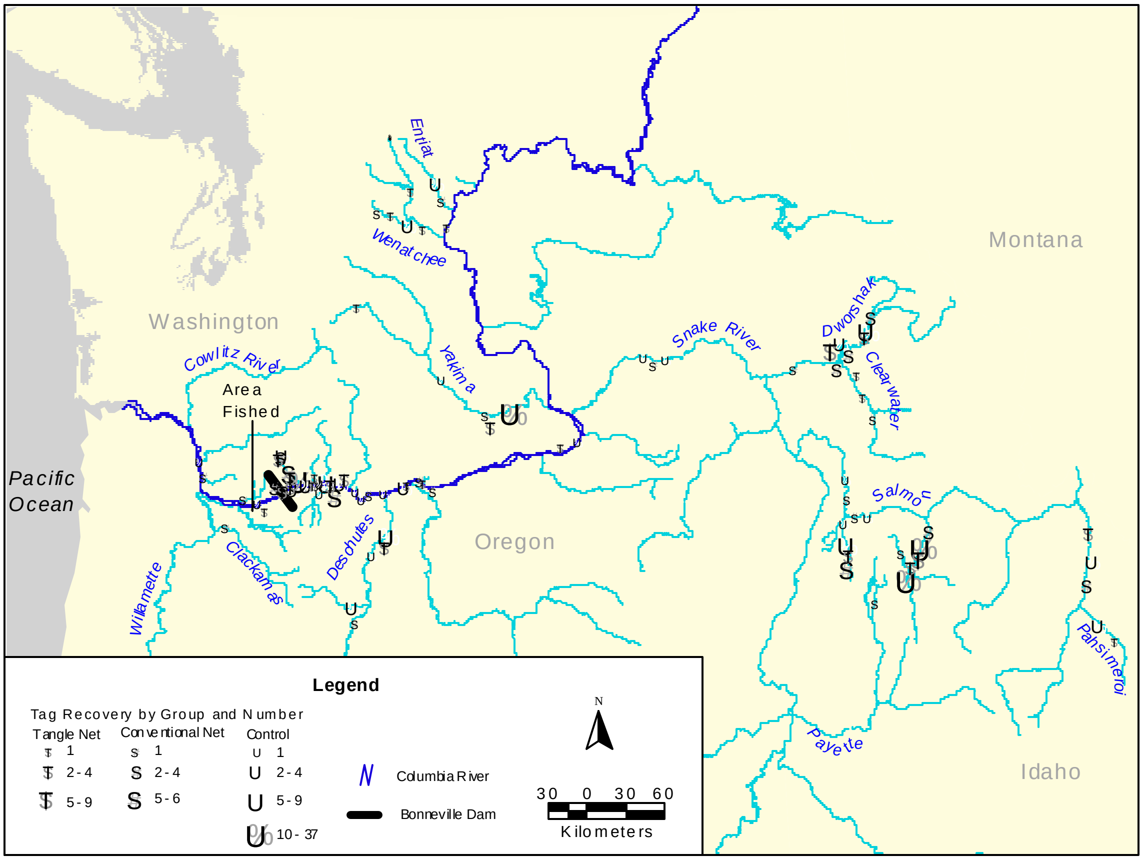

Figure 2. Recovery locations of spring chinook salmon captured and released from 3.5" and 4.5" tangle nets, 8" conventional gill nets and from the adult trapping facility at Bonneville Dam (controls). The "area fished" denotes the location where the test nets were fished and tagged fish were released.

Significantly more spring chinook salmon that were captured and released from the tangle nets were recovered than those captured and released from the gill nets (Table 5; $Z=3.77$, $P<0.001$). The control group of fish was assumed to be subject to all the same natural mortality as the test groups, except to the effects of capture in the nets. Therefore, relative to the survival of the control group, we estimated that 92.0% of the fish released from the tangle net survived to be recovered, while 49.7% of those released from the gill net survived. Spring chinook released from the 3.5" and 4.5" tangle nets were all tagged with yellow tags. Because the numbers printed on the tags were not always readable or reported when recovered, the survival from each net cannot be correctly assigned, and can only be underestimated. With this in mind, using only tags that could be assigned definitively to one net or the other, we calculated that about 80.9% and 88.4% of the spring chinook salmon released from the 3.5" and 4.5" tangle nets survived to be recovered, respectively.

Table 5. Recovery of tags from hatcheries, fisheries and spawning grounds.				
Group	Number Tagged	Number Recovered	Percent Recovered	95% Confidence Interval
Bonneville Controls	1,206	149	12.4%	10.7%-14.7%
Gill Net	814	50	6.1%	4.6% - 8.0%
Tangle Nets	528	60	11.4%	8.9%-14.2%
Total	2,548	259	10.2%	

Using our calculated estimates of survival to demonstrate the effects of this difference, we expect that for every 1000 spring chinook salmon caught in the 8" gill net that must be released, 10 would die immediately (1%), and another 498 (50.3%) would die after release, for a total kill of 508 fish. However, using the tangle nets, for 1000 spring chinook salmon captured that must be released, we would expect 32 (3.2% combined for both tangle net types) to die immediately, and another 78 (8.0%) to die after release, for a total kill of 110 fish. Therefore, about 6.5 times as many spring chinook salmon could be handled and released from the tangle nets for the same mortality caused by the gill net. These rates would only be expected with the combination of the gears and the careful handling techniques we used.

Fish tagged in each of the three main test fishing areas were subsequently recovered somewhere in the Columbia River Basin, with the recovery rate improving for fish captured nearer Bonneville Dam compared to those captured further downstream (Figure 3). Fish released closer to Bonneville Dam may have been more likely to pass over the dam and be recaptured in our focused search areas. The tag recovery rate varied among skippers and among areas they fished.

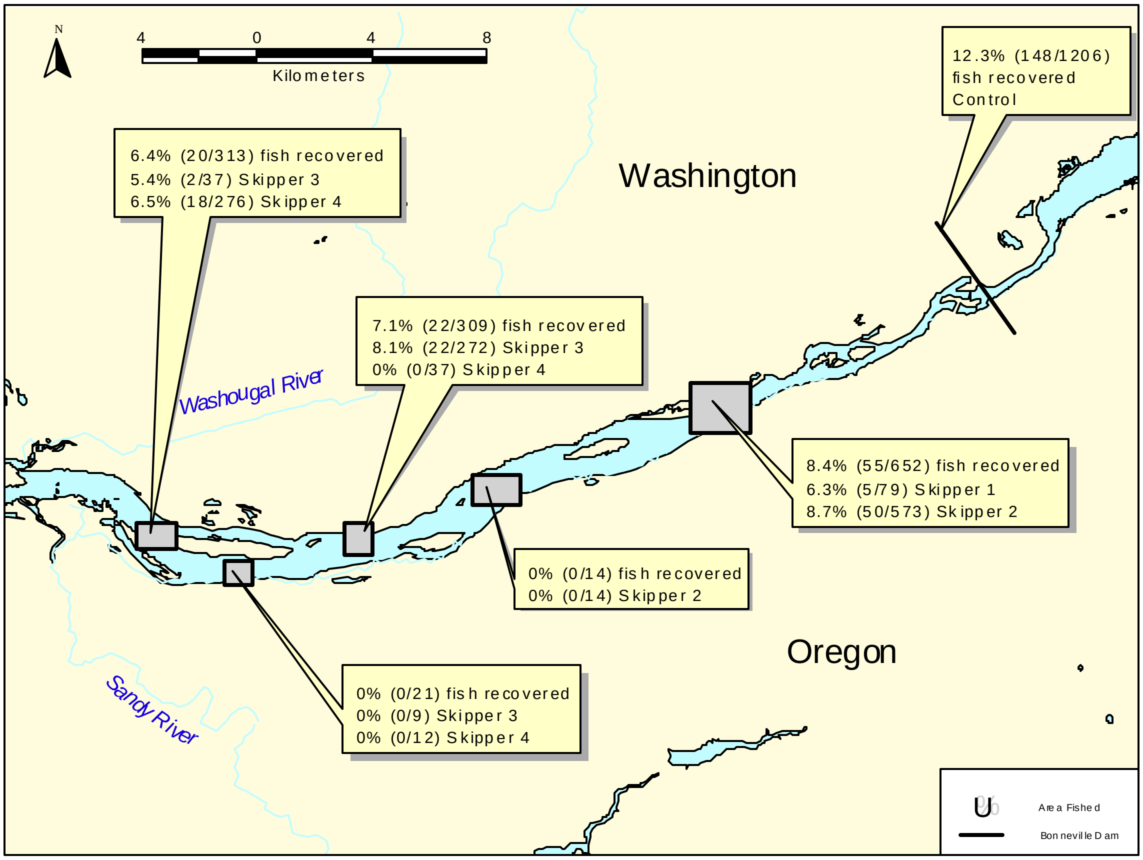

Figure 3. Percentages of tagged fish from each fishing area that were subsequently recovered, by skipper.

We recovered tags from spring chinook salmon captured in each condition category, but those captured in condition 1 were disproportionately represented in the recovered tags. At capture, 86.2% of the fish were in condition 1, while 91.4% of the recovered tags were from fish that had initially been captured in condition 1. This suggests that although fish captured in other conditions can recover to a state where they appear to be in condition 1 at release, physiologically, they have not fully recovered. Longer holding in the recovery box before release could improve survival.

Fish initially captured by wedging were underrepresented in the recovered tags (54% of tags released, 41% of tags recovered). All other capture methods were represented in higher proportions the recovered than the released tags, with fish caught by tangling showing the highest increase (35.8% at release, 43.8% at recovery). Capture methods are confounded with mesh size. There was no significant difference between the mean fork length of fish that were recovered (75.08 cm, N=102) and fish that were not recovered (75.05 cm, N=1,208).

CATCH EFFICIENCY

Each time we had paired sets with the 3.5" tangle net and the 8" gill net, the 8" gill net caught more fish than the 3.5" tangle net (Figure 4) and overall was significantly more effective than the 3.5" tangle net (Wilcoxon signed rank test; T=0, t=0, P<0.05). However, there was no significant difference between the number of fish caught in the 4.5" tangle net and the 8" gill net (Wilcoxon sign test, T=10, t=5, P>0.05).

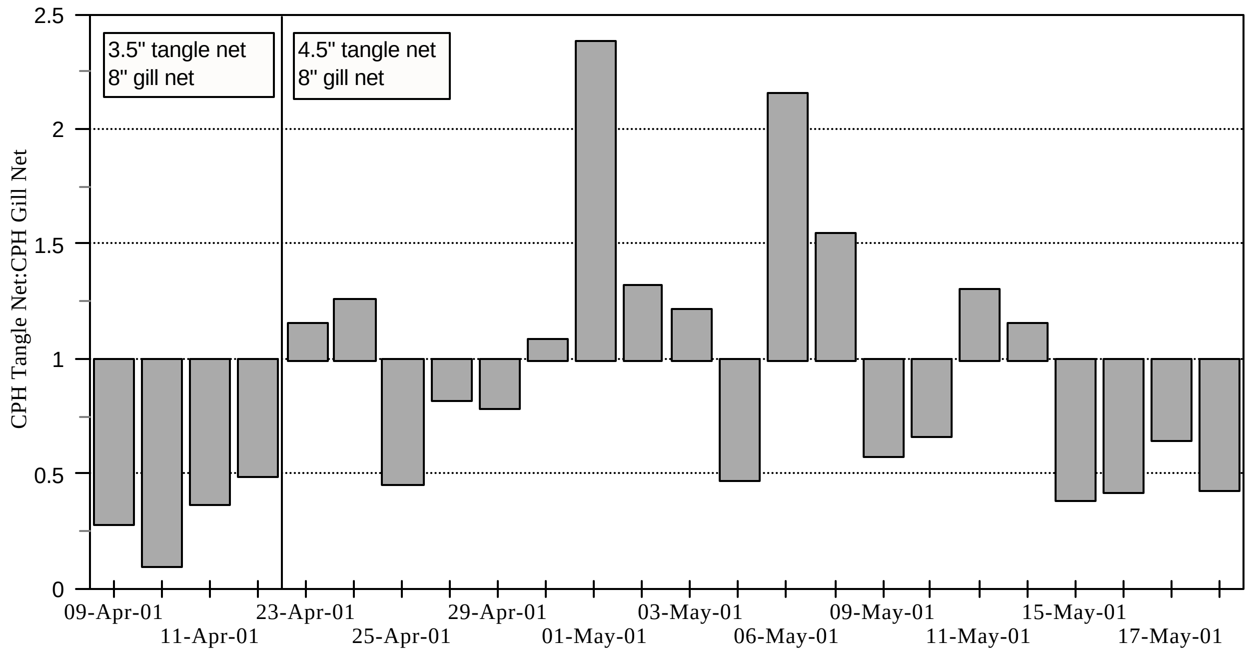

Figure 4. Relative catch of adult spring chinook salmon per hour (CPH) for the 3.5" net compared to the 8" gill net (bars to the left of the vertical line) and for the 4.5" tangle net compared to the 8" gill net (bars to the right of the vertical line). Values at 1 indicate equal catch efficiency, while those below 1 indicate the 8" gill net was more effective than the tangle net, and those above 1 indicate the tangle net was more effective than the 8" gill net. Paired sets were pooled by day across skippers.

The catch per hour was highest during the early part of the test fishery and dropped off in mid-April (Table 6). The highest numbers of spring chinook passed over Bonneville Dam during the weeks of April 8 and April 15, 2001 (Figure 5). Allowing for a few days of travel time, the highest densities of fish were likely available to us between April 6 and April 12. During this time, only the 3.5" net was available from the manufacturer, so we were unable to evaluate the catch efficiency of the 4.5" tangle net compared to the 8" gill net during the highest density of fish. However, based on the numbers of fish passing Bonneville Dam during the weeks of April 22 and 29, 2001, good numbers of fish were present when we did have the 4.5" tangle net available, so the catch efficiency of the 4.5" tangle net relative to the 8" gill net likely represents what would be expected if fish densities were higher. In contrast, the 3.5" net was deployed when the highest densities of fish were available, but not when densities declined.

Table 6. Capture of adult spring chinook salmon per hour (CPH) during comparable sets for each net type.			
Mesh Size	Min CPH	Max CPH	Average CPH
Period 1 (Early to mid-April)			
3.5”	2.1	5.6	3.7
8.0”	8.0	20.5	13.5
Period 2 (Mid-April to mid-May)			
4.5”	0.95	5.9	3.0
8.0”	0.96	8.5	3.4

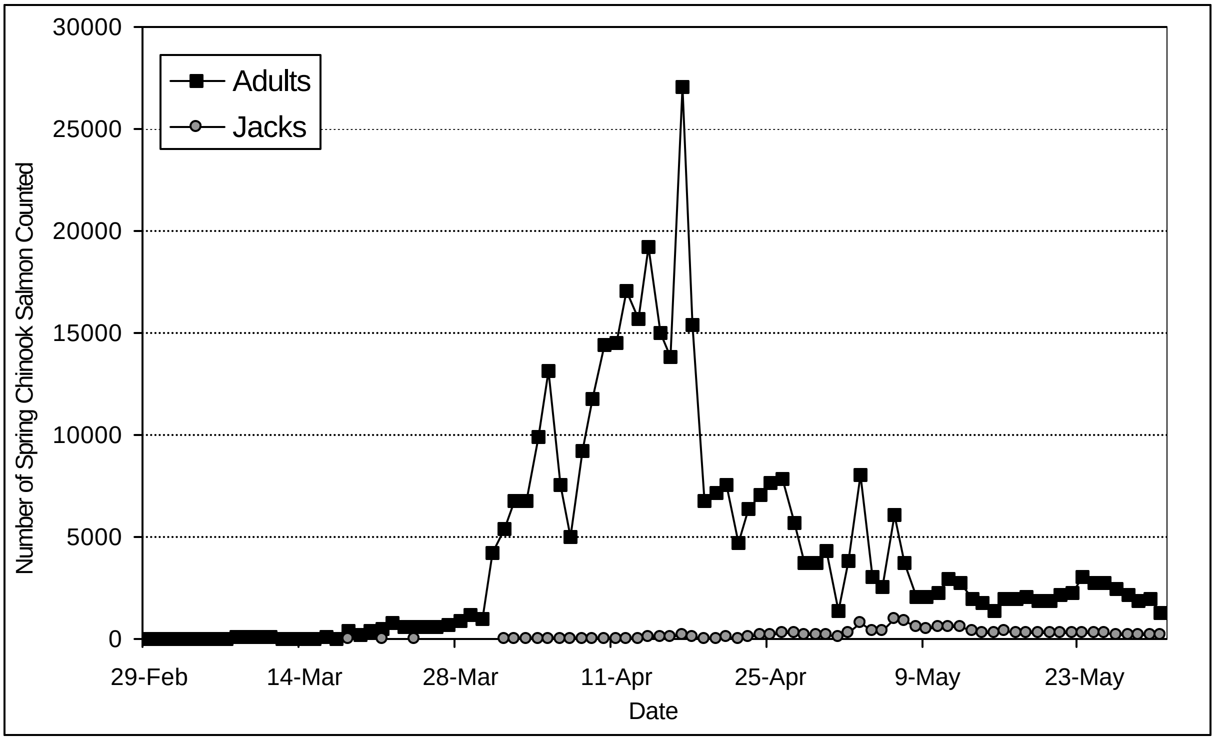

Figure 5. Number of adult and jack spring chinook salmon counted at the counting windows in Bonneville Dam, 2001. Data source is the US Army Corps of Engineers.

Size of Adults Captured

We found no significant difference between the fork lengths of adult spring chinook salmon captured in the 4.5” and 3.5” tangle nets (74.9 and 74.9 cm, respectively, t=1.96, df=531, P=0.84), so these data were pooled for comparison with the 8” gill net. A small, but statistically significant difference existed between the average fork lengths of adult spring chinook salmon captured in the tangle nets (74.9 cm, N=533) and those captured in the gill net (75.7 cm, N=776, t=1.96, df=531, P=0.002).

Jack Spring Chinook Salmon

We captured 182 jacks (here defined as small or immature chinook salmon 60 cm fork length or less) during the test fishery. Of those, 22.5% were captured in the 3.5" tangle net, 73.6% were captured in the 4.5" tangle net, and 3.9% were captured in the 8" gill net. Immediate survival was 92.5%. Jacks captured in the 3.5" net (N=41) were mainly captured by wedging (56.1%) or gilling (34.4%). Jacks captured in the 4.5" tangle net (N=134) were mainly captured by gilling or wedging (33.6% each) in the net. The increased number of jacks captured in the 4.5" tangle net compared to the 3.5" tangle net is likely due to the increasing numbers of jacks present during the time we fished the 4.5" tangle net, as well as the fact that we fished the 4.5" tangle net for many more days. Only seven jacks were captured in the 8" gill net as most are small enough to pass through. Compared to adults, a relatively low 71.4% of the jacks were brought on board in condition 1, with the rest mostly in conditions 3 and 5. However, we were able to revive all of the jacks captured in conditions 2 through 4 to condition 1, but only 38% (N=8) of those captured in condition 5. Many jacks were severely descaled as a result of capture.

Passage over Bonneville, The Dalles and John Day dams

The first tags were observed passing Bonneville Dam during the week of April 8, 2001, and were counted daily until July 31 at Bonneville, The Dalles and John Day dams (Figure 6, Figure 7, and Figure 8). It was clear that the technicians counting the fish were unable to distinguish yellow tags from white tags at The Dalles and John Day dams (they counted only white tags), but that at least some technicians were able to distinguish the tag colors at Bonneville Dam. However, because of the identification errors at The Dalles and John Day dams, we assumed that there was also some unknown identification error at Bonneville Dam, and therefore were forced to combine the counts of yellow and white tags (for tangle and gill nets). Future studies that evaluate passage through the dams must use more contrasting tag colors.

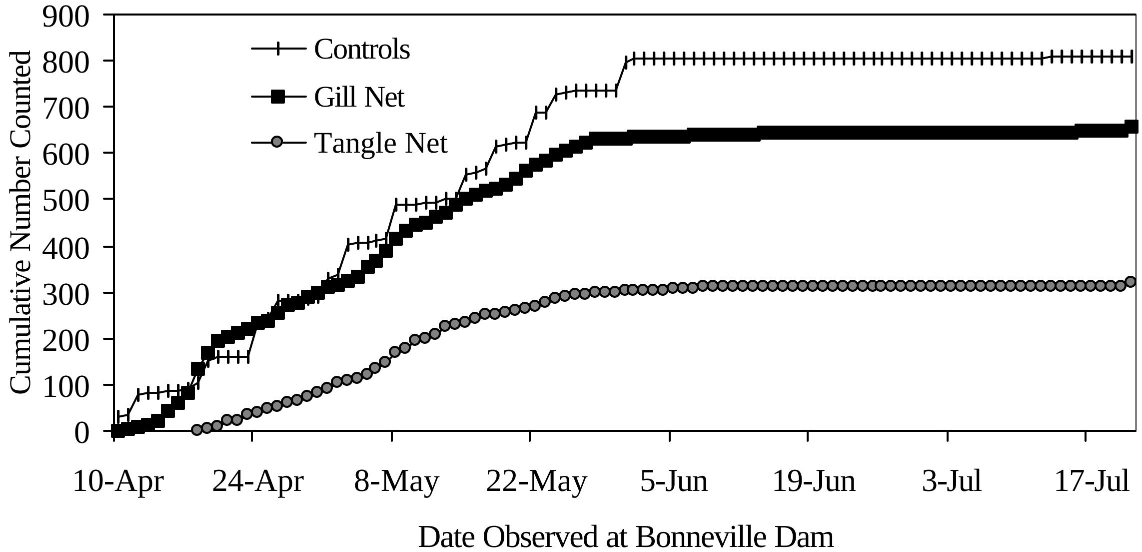

Figure 6. Cumulative number of jaw tagged spring chinook salmon observed passing the counting windows at Bonneville Dam in 2001. While the technicians were able to distinguish some yellow (tangle net) and white (gill net) tags, the identification error is unknown, and the two groups are not discreet.

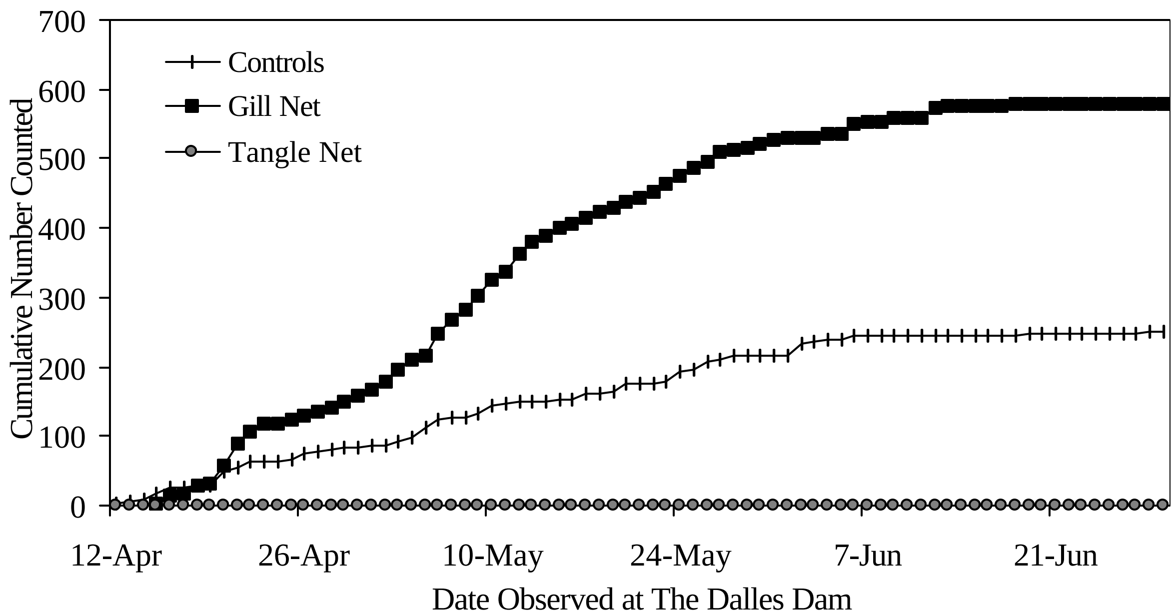

Figure 7. Cumulative number of jaw tagged spring chinook salmon observed passing the counting windows at The Dalles Dam in 2001. Because no yellow tags (tangle net) were counted, the technicians were clearly unable to distinguish yellow and white tags (gill net), thus the gill net counts represent combined tangle net and gill net tags.

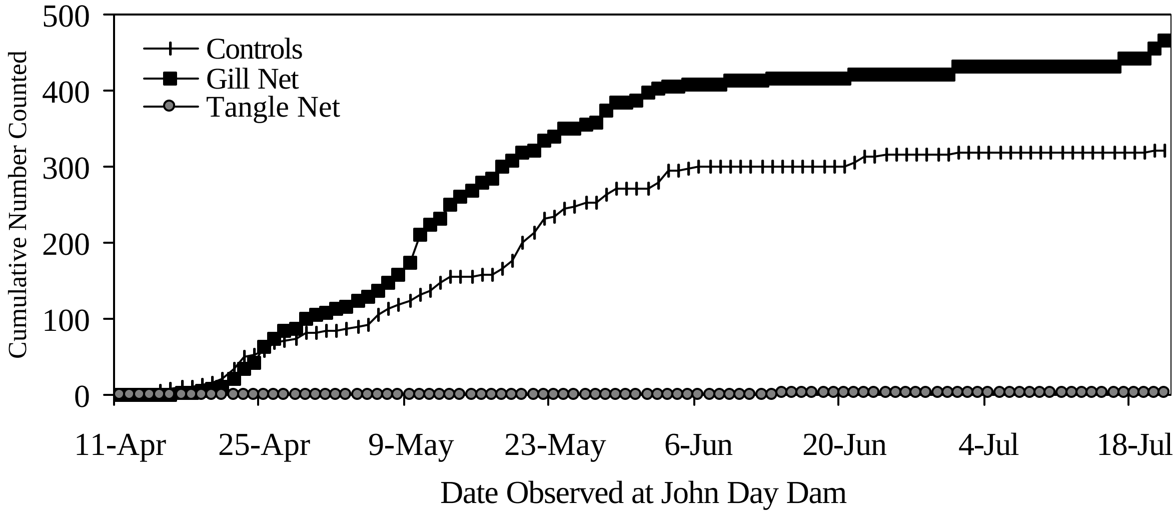

Figure 8. Cumulative number of jaw tagged spring chinook salmon observed passing the counting windows at John Day Dam in 2001. Because no yellow tags (tangle net) were counted, the technicians were clearly unable to distinguish yellow and white tags (gill net), thus the gill net counts represent combined tangle net and gill net tags.

Because we had to combine the tags from the gill net and the tangle net, the meaning of the passage results is unclear. We observed better passage over all three dams for fish captured and released from our gears than for the controls (Table 7) even though the controls were returned to the ladder just downstream of the counting window at Bonneville Dam. This estimated passage from the adult trap in Bonneville Dam is lower than observed for radio-tagged fish. Another anomaly in the data was the lower percentage of tags from the control fish observed at the Dalles Dam compared to John Day Dam, even though the fish must pass the window at the Dalles Dam before they reach John Day Dam. These observations indicate that the red tags used for the control fish were also difficult for the technicians to detect. While the numbers of tags counted over each dam cannot be interpreted, the temporal distribution of the counts supports our assumption that the fish tagged in the control group represented the same population as the fish in the two treatment groups.

Table 7. Total counts of tags released and counted at the upstream dams for the spring chinook salmon tagged in the trap at Bonneville Dam and captured in tangle nets and gill nets downstream of the dam.

	Controls		Gill Net/Tangle Net	
	Num Counted	% of Tagged	Num Counted	% of Tagged
WDFW Tagged and Released	1,206		1,371	
Counted at Bonneville Dam	811	67.3%	978	71.3%
Counted at The Dalles Dam	251	20.8%	580	42.3%
Counted at John Day Dam	321	26.6%	468	34.1%

DISCUSSION

Our results indicate that tangle nets could be used for selectively harvesting marked spring chinook salmon in a commercial fishery on the Columbia River. Tangle nets are as efficient at capturing adult spring chinook salmon as the conventional gill net, it has an acceptably low immediate mortality for fish brought on board, and we were able to show that the post-release mortality of spring chinook salmon released from the tangle net is about 1/6 that of fish released from the gill net. In addition, because they don't have net marks on their bodies (or the associated internal injuries), spring chinook salmon captured in a tangle net may realize higher market prices than fish captured in the gill net.

We see two possible reasons why the fish released from the tangle net survived better than the fish released from the gill net, given that the method of capture was the only difference between the two groups. First, unlike those caught in the tangle net, fish captured in the gill net sustain considerable external injury in the way of scale loss, skin abrasion and loss of the protective slime layer when they are captured in the body. We suspect that some of these injuries impair the fishes' ability to fight off disease, particularly the ubiquitous *Saphrolegnia* spp. fungus (spring chinook salmon migrating to the Columbia River generally enter the river about 4-5 months before spawning), osmoregulate, and successfully navigate the river.

Second, while removing chinook salmon from the nets, we observed that fish released from the gill net tended to be lively, difficult to hold, and generally fighting to get out of the holding tanks. Spring chinook salmon released from the tangle net were noticeably calmer, and seemed even to be in a slight stupor. We hypothesize that this behavior carries over from when they were in the net - spring chinook salmon captured around the body fight the net the entire time they are captured, and that those captured around the face tend to remain calm while in the net. If this is true, then spring chinook salmon coming on board from the gill net would be nearing physiological exhaustion even though they appear lively and able to swim at release. Farrell et al. (2001) showed that coho salmon captured in commercial gill nets were physiologically exhausted and stressed as a result of capture. In contrast, spring chinook salmon coming on board from the tangle net would be in much better physiological condition at release, and better able to avoid predators, navigate barriers, and adapt to changing currents than tired fish. This hypothesis could be tested by using underwater cameras to observe the behavior of the fish captured in the nets, and by analysis of stress hormones and lactic acid in blood samples from spring chinook salmon brought on board from each gear.

While we showed that tangle nets reduce post-release mortality of spring chinook salmon, it is still important to understand how the stress related to this capture method may affect reproduction and gamete quality. The stress response can be maladaptive to reproductive fitness (Shreck 2000), so while spring chinook salmon survived capture and release, their ability to reproduce may have been impaired, countering the potential conservation benefits of increased survival. However, spring chinook salmon spawn about 4 months after the fishery occurs, which could give them time to recover and resume the reproductive process. We recommend experiments examining the physiological responses of spring chinook salmon to capture and the resulting effects on reproduction.

Several studies have found minimal mortality after a short holding period in net pens. Farrell et al. (2001a) found that 2.3% of coho salmon captured in gill nets and held for 24 hours died. Farrell et al (2001b) found no post-capture delayed mortality after 24 hours of holding coho salmon captured by troll fishing in net pens. Gallinat et al. (1997) found mortality of lake trout captured and released from gill nets varied seasonally between 23% and 32% after 48 hours of holding. Holding spring chinook salmon in net pens on the Columbia River for 72 h after captured in gill nets showed 7% mortality while 3% of those captured in tangle nets died (P. Frazier, Oregon Department of Fish and Wildlife, personal communication 2001). These short-term observations of mortality are often used to represent the post-release mortality of free-swimming fish, because it was thought that most fish die within a short time of capture. There is a clear discrepancy with our estimates of post-release mortality. Either the assumption that holding fish in net pens is indicative of their free-swimming mortality during the observation period is invalid, or the assumption that most of the post-release mortality occurs within a few days of capture is invalid. Certainly, our results suggest that the holding mortality should not be used to estimate post-release mortality.

We expect the post-release mortality to vary between species, and with changing environmental conditions. Different species are known to have different responses to the same stressors (Schreck et al. 2001), and so may not respond to the nets in the same ways. A given species may also display a different response in a more stressful environment than a less stressful environment. In our study, the environment was likely favorable to capture and release because the water was relatively clear and cool during the spring chinook salmon migration. Fishing in poorer conditions (e.g. higher, warmer, or more turbid water, more predators present) would most likely increase mortality, although we don't know the magnitude of the difference.

The two-chambered recovery boxes used for lethargic fish were effective for recovering spring chinook salmon. Farrell et al. (2001a) found these types of recovery boxes effective for recovering coho salmon, although we were unable to achieve the 93.5% recovery of fish captured in gill nets in condition 5 (no visible movement or ventilation) that they observed. The reason for this difference is unclear, but may be a species difference, or because of the capture method. We also found that although a fish was observed to recover to a lively condition in the box, this did not necessarily mean the fish would survive after release, likely because a true physiological recovery requires much longer than the time for which we held fish, and much longer than would be practical in a competitive fishery. Post-release survival could probably be improved by holding fish for as long as possible, especially if the fish was brought on board in very poor condition, or by holding the fish in a cage alongside the vessel to promote active swimming during recovery (Farrell et al. 2001b).

The tangle net has shortcomings. As expected, it captured many more non-target species than the conventional gill net. As with any selective fishing operation, fishers using the tangle net must learn and use careful handling techniques to maximize survival of released fish. These include significant changes to fishing practices, and successful implementation requires concurrent redesign of the fishery by managers to encourage a high-priced market for a steady, but lower volume, supply of fish. Enforcing these types of behavioral changes is at best difficult, and a large investment in fishery observers will likely be necessary. Finally, there is a capital investment that is required by each fisher to purchase new nets, recovery boxes and other related equipment, as well as additional time needed to develop markets.

This experiment represents the first study we know of that evaluated the post-release survival of free-swimming fish released from commercial fishing nets and showed that the method of capture is critical to their survival. We observed more than a 6-fold decrease in post-release mortality of spring chinook released from the tangle nets compared to the 8” gill net. The tangle net therefore warrants consideration for selectively harvesting spring chinook salmon on the Columbia River while still protecting wild stocks. Achieving this potential requires that we continue solving the problems with the tangle net and refine handling techniques to maximize post-release survival.

PART 2 - A SHORT TEST OF 5" GILL NET FOR LIVE CAPTURE OF SPRING CHINOOK SALMON

METHODS

While waiting for tangle nets to arrive from the manufacturer, we fished a 5" gill net (3-strand) in place of the tangle net on April 18, 19, 24 and 25, 2001. The net was hung with trammels to match the 8" gill net, and fished in the same areas, and as described for the tangle nets. Observers collected the same set information and details about each fish brought on board as for the tangle nets.

RESULTS

We made 16 sets to capture 39 adult and 4 jack spring chinook salmon in the 5" tangle net and 58 adult and 2 jack spring chinook salmon in the 8" gill net. On average, the 5" gill net captured 4.2 adults per hour, compared to 5.7 adults per hour in the 8" gill net, but these were not significantly different (T=6, t=3, P>0.05). Adults captured in the 8" gill net were captured in better condition than those captured in the 5" gill net (Table 8). The immediate survival reflected this, with 10.3% of fish captured in the 5" gill net dying before release while none of those captured in the 8" gill net died before release.

Adults captured in the 5" gill net were captured by tangling (46%), mouth clamp (44%), gilling (5%) and wedging in the net (5%). Three of the four adults that died in the 5" gill net were captured with their mouths clamped shut, and the fourth was tangled in the gear. Adults captured in the 8" gill net were captured mainly by wedging in the net (83% of captures), with some gilled (7%) and the remainder tangled (10%).

Table 8. Initial condition of spring chinook salmon captured in the 5" and 8" gill nets. Immediate mortality is the number of spring chinook salmon that could not be revived for release.

Mesh Size		Condition at Capture					Total	Immediate Mortality (%)
		1 Lively	2 Lively, bleeding	3 Lethargic	4 Lethargic, bleeding	5 No visible movement or ventilation		
5"	Jacks	1	1	1	0	1	4	25.0
	Adults	20	0	9	0	10	39	10.3
8"	Jacks	1	0	1	0	0	2	0
	Adults	50	7	1	0	0	58	0

Both nets encountered shad, sturgeon, suckers and flounder. The only species captured in quantity was sturgeon, these were mainly juveniles, and the 5" gill net proved more effective than the 8" gill net (1,411 and 218 captured, respectively). No steelhead salmon were encountered during this part of the test fishery.

DISCUSSION

We were able to take advantage of a short opportunity to test the 5" gill net in tandem with the 8" gill net. While the 5" gill net was effective at capturing spring chinook salmon, we were concerned with the high initial mortality. During test fishing, the soak times were short, the fish from each net were handled in the same careful manner, and any fish needing revival was placed into a recovery box. It is therefore logical that the capture method is the likely cause of the increased mortality in the 5" gill net compared to the 8" gill net and the 3.5" and 4.5" tangle nets. This particular net was hung with trammels on both parts, with the idea that the trammels would increase the catch efficiency. Because both parts of the net had trammels, the increased mortality in the 5" gill net is not explained by this feature. After observing the capture of several thousand spring chinook salmon, we believe that the method of capture is very important to the long term survival.

Comparing the percentages in each category for each net shows how the increasing mesh size from 3.5" to 4.5" to 5.0" results in a larger proportion of the fish being captured by mouth clamping (Table 9), and a general trend towards more fish being captured by gilling and wedging. Mouth clamping proved detrimental to the immediate survival of the spring chinook salmon – of the 29 adults killed during the test fishery, 13 (45%) had been captured by mouth clamping. Our results also showed that capture by gilling and wedging (i.e. the methods of the 8" gill net), while not detrimental to immediate survival, were detrimental to the long-term survival.

Table 9. Percentage of fish captured by each method for each size mesh. N is the total number of fish captured in each net type.

Capture Type	3.5" net	4.5" net	5.0" Net	8.0" Net
Gilled	1.6%	0.3%	5%	9.1%
Mouth Clamped	4.3%	14.9%	43.6%	0%
Rolled	6.4%	2.6%	0%	0.2%
Tangled	87.8%	81.0%	46.2%	2.5%
Wedged	0%	1.2%	5%	88.2%
N	188	348	39	836

The web of our 5" gill net stretched to 5.25" (it is typical for gill net web to stretch, particularly when wet), and we suspect that this may be crossing the threshold between nets that truly function as tangle nets and nets that function as gill nets (hence the low rate of tangling in the 5" gill net). While our sample was small, it was clear from our test that the 5" gill net did not capture fish in the same manner as the 3.5" and 4.5" tangle nets, so the post-release survival rates from those nets should not be applied to the 5" or larger meshed nets. It is likely that the post-release survival rate for these mid-sized nets lies somewhere between the rates estimated for the tangle net and for the gill nets. Based on these observations, if the objective is to maximize the survival of unmarked spring chinook salmon, we recommend a maximum mesh size of 4.5".

PART 3 - FEASIBILITY OF USING A FLOATING TRAP FOR LIVE CAPTURE OF SPRING CHINOOK SALMON AND COHO SALMON

METHODS

The trap net we tested on the Columbia River was originally designed to capture coho salmon (*Oncorhynchus kisutch*) on the Naselle River. It consisted of a mouth formed by two 150= long vertical wings designed to funnel fish toward the middle section, or the “heart” of the net. The heart was formed from side and bottom panels equipped with three center baffles to entrap fish and encourage their movement toward the cod end of the trap-net. The cod end was constructed with 2.5@ coated nylon knotless web and measured 10= wide, 17= long, and 10= deep. The remainder of the net was constructed with 3.5@ nylon web, except for the wings which were 8” nylon web. The entire net was suspended from a polypropylene float line and weighted with a 50 lbs/100= lead line. The overall length of the net was 309= and its maximum depth was 15=.

For this test, the trap net was modified with: (1) a baffle that could be closed to prohibit fish from exiting the cod end; (2) a floor in the cod end that could be lifted to crowd captured fish for easier removal; (3) a welded aluminum frame attached to the cod end float line to maintain its shape and to prevent it from collapsing while being towed; (4) jiggers at the base of the wings to further encourage fish movement toward the cod end; and (5) an additional 150= extension for each wing. The wing extensions were too cumbersome and were removed after two days of fishing.

A single boat was used to deploy the trap net. The cod end was launched by hand from the deck while the wings were fed over the rail from deck-mounted hydraulic gill net spools. Two boats were used to tow the trap net and to keep the mouth open. Each wing was attached to a boat by a line. In most instances, the net was towed just fast enough to maintain shape its shape against the current. At the conclusion of the set, bringing the boats together closed the mouth and the net was spooled onto one boat until the cod end was reached. The fisher in the second boat used a dip net to remove fish from the cod end. The trap net was deployed during all tidal phases, with the mouth facing seaward to maximize encounters with fish moving upstream. Species, condition at capture, sex, and presence or absence of an adipose fin were recorded for each salmon before release.

We contracted two local fishers to fish the floating trap net on the lower Columbia River between river miles 31 and 47 in the spring and between river miles 14 and 23 in the fall of 2001 (Figure 1). It was fished on 6 days in the spring between May 7th and May 14th, targeting spring chinook salmon and 5 days in the fall between September 4th and September 12th, targeting coho salmon, averaging three sets per day. Fishing occurred between 0700 h and 1900 h. Set lengths, defined as the elapsed time between when the first part of the trap net went into the water and when the last part was retrieved, ranged from 29 to 156 minutes with the average set length being about 82 minutes. Deployment generally took fewer than 5 minutes.

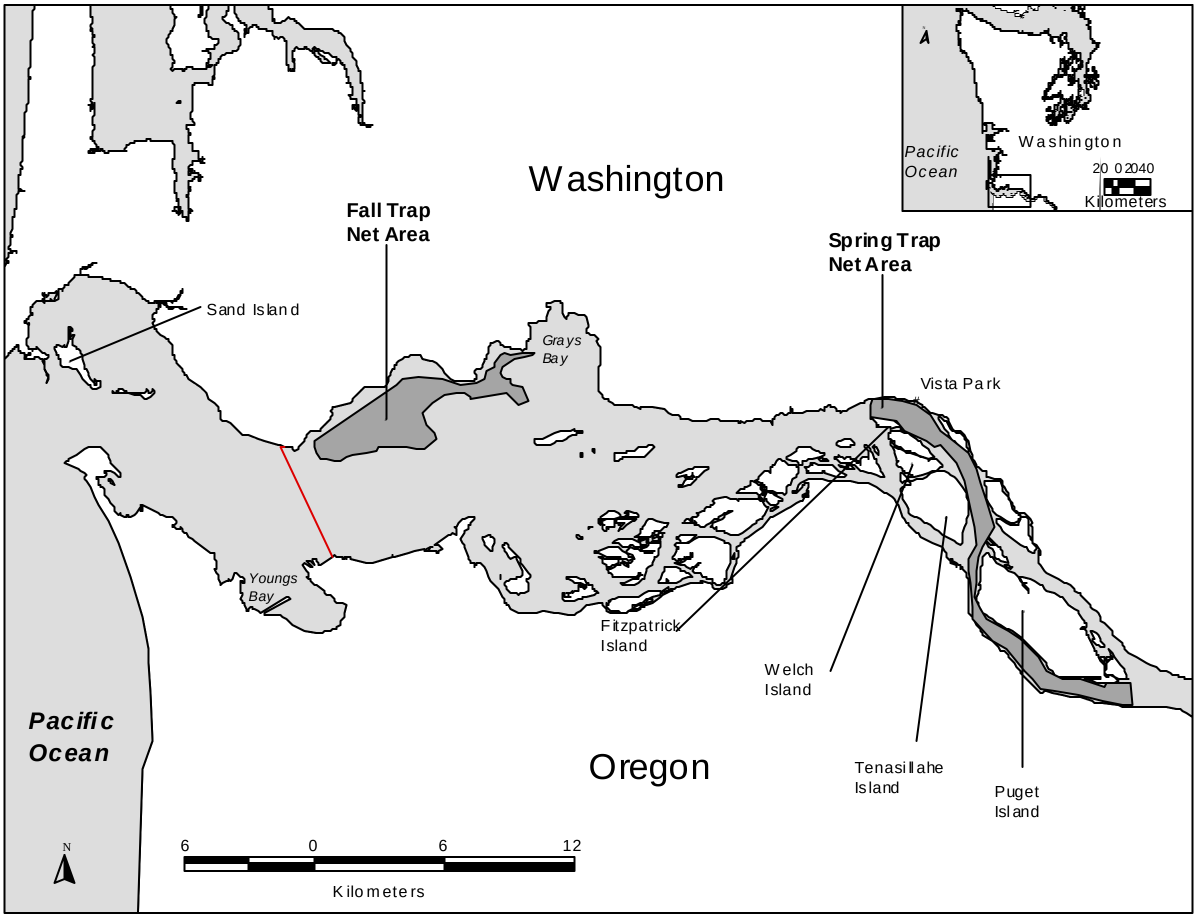

Figure 9. Test fishing locations for the floating trap net in spring and fall 2001.

We fished the trap net under a wide variety of conditions ranging from shallow nearshore sites with fast moving water, to deep offshore sites with weak current. Throughout both the spring and fall, water clarity was high, possibly due to drought related low flows. We fished only during daylight hours and when no commercial harvests were occurring within the test fishing areas.

RESULTS

No fish were captured in the spring. Historic run times, fish counts at Bonneville Dam (Figure 5), and the relative success of concurrent sport and test fisheries at up- and downriver sites suggest that most of the salmon had already transited the test fishing area by the second week of May. Repairs and modifications to the trap-net took longer than expected. Thus, we were unable to fish during peak run time in the spring.

During the fall test fishing period, we captured 11 coho salmon and 1 chinook salmon. Of the coho salmon captured, all were adipose fin clipped (hatchery origin), 7 were male and 1 was female (sex data from 3 fish were not obtained). The chinook salmon was of unknown origin. All were in excellent condition at time of capture and released immediately, unharmed. Coho salmon were known to be abundant in and adjacent to the test fishing area based on high capture rates in the sport fishery and frequently observed jumpers. Both coho salmon and sturgeon were seen jumping in the mouth of the trap-net during sets when no fish were captured. One observer estimated over 300 sturgeon jumps in the fishing area and inside the mouth of the trap-net during a single set; however, no fish were captured. Non-target species (white sturgeon, *Acipenser transmontanus* and starry flounder, *Platichthys stellatus*) were captured in low numbers and also released unharmed.

DISCUSSION

Low abundance of salmon in the test fishing area during the spring trial precluded an evaluation of trap net effectiveness in that fishery. However, low capture rates in the fall, during a time when salmon were abundant in the test fishing area, suggests that the trap net is largely ineffective for that fishery. Similar trap net designs have been fished in Canada and have been marginally successful with pink salmon, but have had difficulty harvesting other species of Pacific salmon. Efforts to improve the efficiency of these nets have focused on closing the mouth of the trap net quickly to prevent escape, reducing the visibility of the net material near the cod end, and reducing the weight (drag) of material used in construction. All of these modifications are aimed at reducing the ability of the fish to detect the net.

Thus far, all fishing has occurred during daylight. Future trap net experiments should include fishing at night. If avoidance reactions are visually cued, then greater efficiency may be achieved by fishing after dark. Further, towing too hard often results in a distortion to the intended shape of the trap net. Design modifications that permit greater tow speeds without compromising shape or structural integrity may improve encounter rates. Success of the floating trap net in harvesting Pacific salmon has yet to be achieved. Conceivably, additional time and resources dedicated to design improvements could increase encounter rates and improve efficiency.

PART 4 - FEASIBILITY OF USING TANGLE NETS FOR LIVE CAPTURE OF COHO SALMON

In this study we explore the feasibility of using a tangle net to harvest coho salmon selectively on the Columbia River. Fishers were paid by the sale of target stocks that they harvested. Catch efficiency and immediate mortality were examined to determine if economic feasibility and live capture and release of non-target stocks could coexist in this particular fishery.

METHODS

Six fishers participated in a test fishery using small mesh gear (3.5@ to 4.5@). Net lengths were restricted to 900' and were not allowed to soak for longer than 30 min per set. Soak time was defined as the time from when the first float entered the water to the time the first float was removed from the water. Total soak time, as listed in Table 1, was defined as the time from when the first float entered the water until the last float was removed at the end of the set. Eleven nets, designated A through K, were used. The nets varied in overall dimension, color, mesh size, web type and hang ratio (hang ratio = total length of stretch mesh: total length of float line). Two of the nets were fished after sundown by one fisher, otherwise, all fishing occurred during daylight between 6 Sep and 19 Oct 2001. Observers from WDFW were on board each fishing vessel to collect environmental and biological data. Each fisher had good local knowledge of the test fishing areas and was restricted to 8 h of fishing.

Fisher 1 fished during the late evening and early morning of 6 and 7 Sep in area I (Figure 10) with two nets. Both nets were 450' long, 28' deep, with green mesh. One was constructed from 3.5" multi-filament web hung at a ratio of 3:1 (Net A) and the other, which was originally used to capture sockeye, was constructed from 4.5" two-strand web hung at 2:1 (Net B). This fisher had a market for a limited volume of very high quality fish. As a result, he kept only the best fish, and returned some fish to the water that could legally have been retained. Fisher 2 fished on 7 Sep in area II and used a net that was 900' long, 17' deep, and was constructed from 4" green multi-strand web hung at 2:1 (Net C). Fisher 3 fished on 13 Sep in area I using two nets. Both were 28' deep and hung at a ratio of 3:1. Net D was 510' in length and constructed from 3.5" green multi-strand web. Net E was 390' long and constructed from 4.5" pink multi-strand. Fisher 4 fished on 14 Sep in area III using two nets. Both were 450' long, 28' deep, and hung at 2:1. Net F was constructed from 3.5" green multi-strand that was strung top to bottom approximately every 12' (at every other float). Net G was constructed from 4.5" blue-grey multi-strand strung top to bottom approximately every 6' (at every float). Fisher 5 fished on 13 Oct in area IV with nets F (see previous description) and H. Net H was constructed from 4.5" monofilament web, strung top to bottom approximately every 25', and was otherwise the same as net F. Fisher 6 fished on 19 Oct in area IV with three nets. Each net was 300' long and 28' deep. Nets I and J were constructed from 3.5" green and 4.5" blue-grey multi-strand, respectively, and were hung at 3:1. Net K was constructed from 4.5" green monofilament hung at 2.4:1.

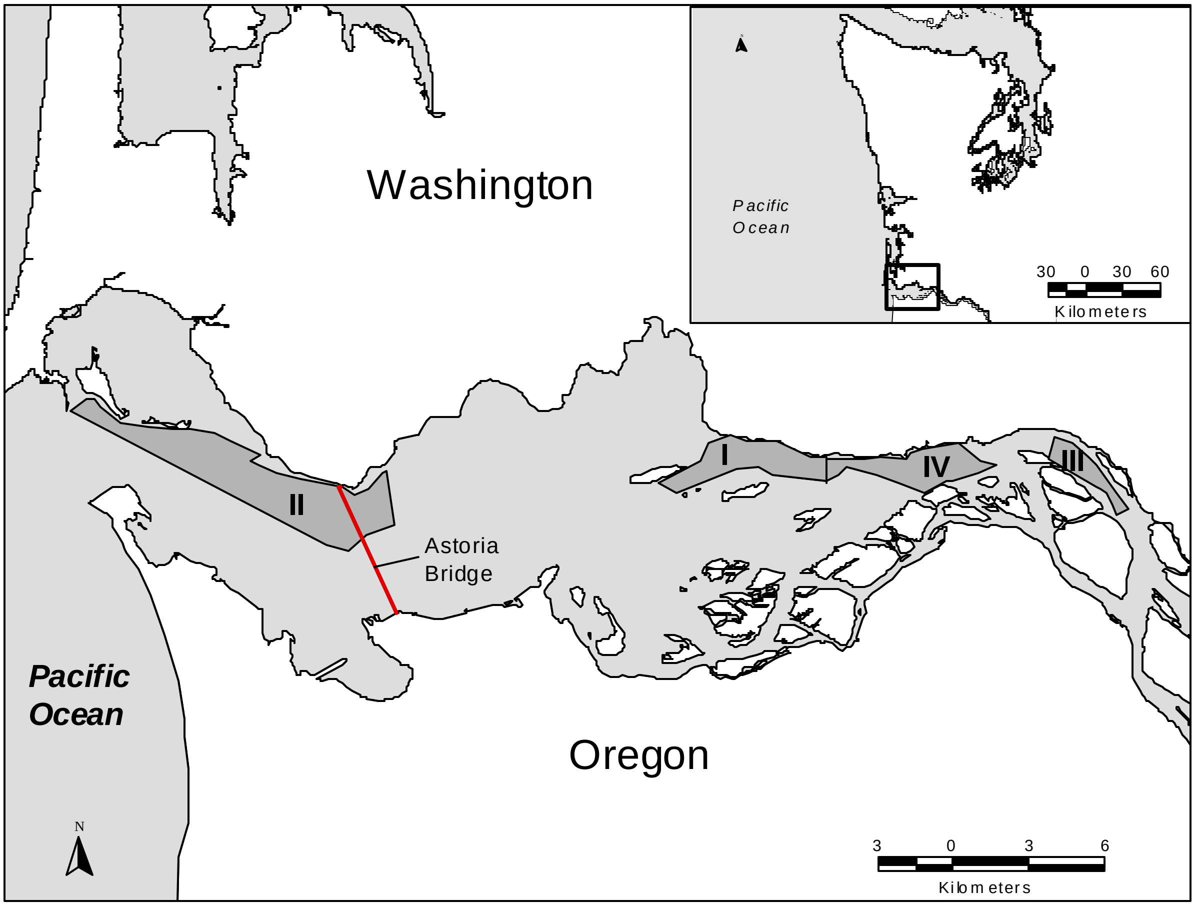

Figure 10. Fishing areas for evaluating tangle nets for live capture of coho salmon in fall, 2001.

Fishers were allowed to retain and sell all chinook salmon and marked coho salmon, identified by the absence of the adipose fin. All sturgeon, steelhead, and unmarked coho salmon were returned to the water. Steelhead and unmarked coho salmon received condition scores at time of capture as follows: 1 (vigorous and not bleeding); 2 (vigorous and bleeding); 3 (lethargic and not bleeding); 4 (lethargic and bleeding); or 5 (no movement or apparent ventilation). All steelhead and unmarked coho salmon receiving scores of 1 or 2 were immediately released into the water. A working recovery box was required on board each vessel. Steelhead and unmarked coho salmon receiving scores of 3 or higher were held in the box until their condition improved or they died. All dead fish were returned to the water.

RESULTS

A total of 892 coho salmon were captured over the course of six fishing periods (Table 10). Of these, 84% (748) were marked. Twenty-four (17%) of the unmarked coho salmon died before release. Also captured were chinook salmon, steelhead salmon and sturgeon. Bright chinook salmon were identified by their nickel bright color, the presence of loosely attached scales, and little apparent sexual dimorphism. Tule chinook salmon, on the other hand, had a brassy hue with firmly attached scales and clearly distinguished sexes with well-developed gonads. Jacks are small (less than 56 cm.) male chinook salmon that mature and return to spawn at age two. Twenty-one steelhead were captured and all were returned to the water in excellent condition. The sturgeon were also released in excellent condition.

Table 10. Number of fish captured and total soak time for each net configuration (see text for description of each net).

Species captured	Net Configuration											Total
	A	B	C	D	E	F	G	H	I	J	K	
Coho, marked	70	49	61	231	23	100	33	85	16	33	47	748
Coho, live, unmarked	15	7	11	49	7	7	5	8	2	4	5	120
Coho, dead, unmarked	1	3	3	11	0	2	0	1	1	1	1	24
Chinook, bright	7	3	1	11	2	0	0	0	0	0	0	24
Chinook, tule	14	8	1	7	1	4	0	0	0	0	0	35
Chinook, jack	10	3	3	2	0	3	1	0	0	0	0	22
Steelhead, marked	2	0	3	5	0	4	1	0	0	0	0	15
Steelhead, unmarked	1	0	1	1	1	0	1	0	0	1	0	6
Total soak time (min)	333	355	290	413	340	741	334	271	170	204	263	

DISCUSSION

Current full fleet fisheries on lower Columbia River targeting fall-run coho salmon allow the sale of all coho salmon, including those of non-hatchery origin. Although the fishery is temporally adjusted to avoid wild coho salmon, there remains a substantial overlap between wild and hatchery origin runs. Our results suggest that a mark-selective coho fishery using tangle nets could be feasible if the mark rate remains high, and deserves further exploration where particular runs require protection.

Live capture techniques have other advantages unrelated to conservation. For instance, fisher 1 sorted his catch for a specific, high quality market. If fish are captured live, the unmarketable or unprofitable fish can be returned to the water unharmed rather than sold at a loss or killed. Individual fishers have also expressed interest in developing a high profit market for live Pacific salmon, which could be realized using the tangle net.

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