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THE PACIFIC SALMON COMMISSION
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LONG-TERM RESEARCH PLANS FOR COASTWIDE PACIFIC CHINOOK STOCKS

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CHAPTER 1. INTRODUCTION

The purpose of this report is to: 1) summarize current monitoring and research activities dealing with coastwide chinook stocks of interest to the Pacific Salmon Commission (PSC); 2) identify missing or incomplete information needed for assessment of chinook stocks; and 3) recommend data collection and research programs that the Chinook Technical Committee (CTC) believes are most important in improving our ability to assess chinook stocks and harvest management. In some cases, entirely new programs will be required, while in others, further analysis of existing information may be sufficient. This report will provide the Commission with direction for data gathering and research on chinook stocks. The report should also provide information to assist the various government agencies in allocating research funds. The report is written at the request of the Standing Committee on Research and Statistics and will be used with similar reports from other technical committees to review the status of salmon knowledge and to recommend areas where new or additional information is needed.

Long-term goals established by the U.S./Canada Pacific Salmon Treaty (PST) include achieving optimum salmon production and providing each Party (Canada and the U.S.) benefits equivalent to the salmon production originating in its own waters while at the same time providing for security and long-term stability of the Parties' fisheries. In fulfilling these obligations, the Parties are requested to cooperate in management, research, and enhancement. In the first several years under the PST, the Parties have cooperated in management efforts through exchange of management plans and through negotiating harvest sharing regimes. In order to manage stocks more effectively and to allow maximum harvest of surplus stocks while ensuring adequate spawning escapements, more knowledge is needed about the abundance, productivity, and distribution of individual stocks and their relationships with each other. This will require the Parties to expend more time, effort, and money on research into both natural and enhanced productivity. Without additional research, the Parties will be limited in how they can allocate and manage the resource.

One goal of the PST is to "attain by 1998 escapement goals established in order to restore production of naturally spawning chinook stocks." Chinook stocks and spawning escapements from the Oregon coast to Southeast Alaska declined from the 1950's through the years immediately prior to the PST and concern was expressed in the PST that chinook stocks were "substantially below goals set to achieve maximum sustainable yields". A rebuilding program based on harvest restrictions was initiated in 1984. During the first 6 years after the start of this rebuilding program, 40% of the naturally spawning indicator stocks that were originally depressed have either reached goal or are increasing at a rate to allow reaching goal by 1998, 18% showed initial increases but later decreases in escapements, and 42% have either shown no response to the rebuilding program or such varied escapements that no assessment can be made. In order to understand what is happening to the 60% of the indicator stocks not responding to the rebuilding program, more information is needed on their stock-specific productivity and their distribution and exploitation in the different fisheries. Additionally, the interim escapement goals developed for most stocks at the beginning of the rebuilding program need to be evaluated and improved. For both short-term goals of achieving target escapements and long-term goals of maximum sustainable production and harvest, careful planning of programs designed to address them must be undertaken.

The PST recognizes the importance of collecting and sharing data on salmon stocks. With regard to all salmon stocks, the PST states (Article IV, paragraph 3) that "each year the State of origin shall submit preliminary information for the ensuing year to the other Party and to the Commission, including:

(a) the estimated size of the run;
(b) the interrelationship between stocks;
(c) the spawning escapement required;
(d) the estimated total allowable catch;
(e) its intentions concerning management of fisheries in its own waters; and
(f) its domestic allocation objectives whenever appropriate."

To provide this information, it is necessary to have forecasting abilities, knowledge of migration patterns and productivity of individual stocks, accurate measures of spawning escapement, and appropriate escapement goals. Currently, forecasts of chinook salmon returns are imprecise and such categories as above average, average, and below average are often used in predicting returns for the following year. Catch distributions are known for many hatchery stocks since many of these stocks are tagged; but, only limited knowledge exist about the distribution of wild stocks. Catch distributions for most wild stocks are inferred from associated hatchery stocks. Escapement goals have been established for most, but not all, of the regularly monitored stocks; however, in many cases the goals have been set based on past observations of escapement levels rather than on spawner-recruit analyses that would provide a maximum or sustainable harvest escapement goal. In Chapter 2, the data that are routinely collected by the various management agencies and research pertinent to PST management or stock assessment are summarized for chinook stocks. Major chinook salmon management regions under the PST are shown in Figure 1.

The PST (1990 Annex IV, chapter 3, Paragraph 1.d) charges the CTC with:

1) evaluating management actions for their potential effectiveness in attaining objectives of rebuilding and maintaining stocks,

2) evaluating annually the status of chinook stocks,

3) developing procedures to evaluate the progress being made in rebuilding these stocks,

4) recommending strategies for effective utilization of enhanced stocks,

5) recommending research required to implement the rebuilding program effectively, and

6) exchanging information necessary to analyze the effectiveness of management measures in satisfying conservation objectives.

This charge has been met by the CTC in part by development of

1) an escapement analysis based on escapement trends of natural stocks,

2) exploitation rate analyses based on coded-wire-tag recoveries of indicator hatchery stocks in the various fisheries, and

3) a simulation model, referred to as the chinook model, designed to evaluate the effect of alternative management actions on rebuilding of chinook stocks.

Results from the analyses and the model are given in an annual report from the CTC each fall and in briefing papers as requested by the Commission during the annual negotiating meetings. The Commission

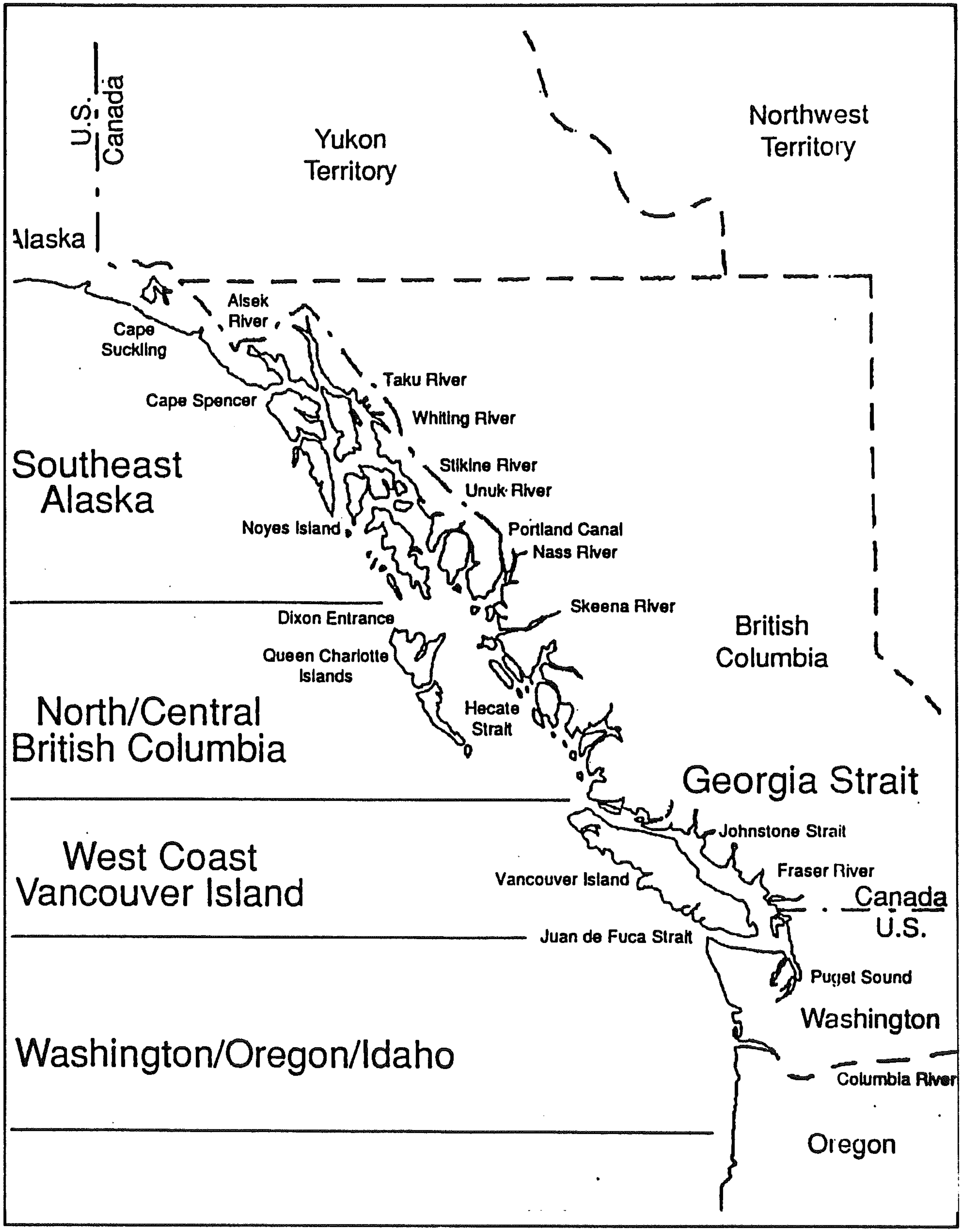

Figure 1. Major chinook salmon management regions under the Pacific Salmon Treaty.

also requires that the Parties provide interception estimates of all salmon species. As there is currently no stock identification program available for chinook salmon that could identify all stocks in a mixed stock fishery, these estimates are derived from the chinook model. Data that are needed to run these analyses and the chinook model are described in Chapter 3. In addition, data quality and the assumptions used are reviewed and areas where improvements could best be made are identified.

In Chapter 4, a summary is provided of the information and research needs based on PST requirements and on current analyses conducted by the CTC. Improvements to existing programs and new programs are identified that would improve current analyses and address important aspects of chinook production that are not now being addressed.

While each CTC annual report has made reference to poor quality data and has given recommendations for improvement, little attention has been paid to these comments by the PSC community. It is hoped that this report and the follow-up review to be conducted by the Standing Committee on Research and Statistics will receive more attention. The lack of reliable data in some areas and the complete lack of data in other areas, forcing the CTC to make simplifying assumptions for current analyses and modelling efforts, restricts the quality of CTC stock and fishery assessments.

CHAPTER 2. CURRENT AND RECENT MONITORING AND RESEARCH PROGRAMS

Pacific Salmon Treaty obligations to meet harvest sharing arrangements and to monitor rebuilding status of chinook stocks require monitoring of pertinent fisheries and stocks. Monitoring is the act of routinely gathering information such as catches and escapements. In addition, research activities are necessary to determine parameters such as hatchery stock survival, incidental mortality, and wild stock productivity. This may be done on a short term basis employing special tagging, sampling, or other activity. In this chapter, the monitoring and research activities of agencies involved in Treaty activities are reported by geographic area.

ALASKA

The Alaska Department of Fish and Game (ADF&G) manages Alaska's chinook fisheries to abide by Treaty and Alaska Board of Fish (Board) regulations. ADF&G conducts monitoring and research programs necessary to the management of chinook stocks. The National Marine Fisheries Service (NMFS), Auke Bay Laboratory, also conducts some research on chinook stocks in Southeast Alaska. Enhancement activities on chinook salmon are conducted by several different organizations within Southeast Alaska.

The chinook catch in Southeast Alaska is regulated by an all-gear ceiling as stipulated by the Treaty. In addition to the ceiling catch, Alaska is allowed additional catch of hatchery produced chinook salmon (add-on). Therefore, it is important to monitor the fisheries inseason to calculate the add-on and to ensure the ceiling is not exceeded. In addition, there are internal allocations that are stipulated by the Board requiring that catches be distributed by gear type.

MONITORING PROGRAMS

Catch and Effort Monitoring. Commercial landings of all salmon species are tallied from fish tickets supplied by ADF&G as a receipt for each sale. Processors are required to establish the district for the catch (see Figure 2 for fishing districts). Space on the fish ticket is provided for recording only one district for each sale. Troll landings often consist of fish caught from more than one district. When this happens, either two or more fish tickets are completed or the district with the majority of the catch is recorded. Salmon landings from net gear are often recorded down to the subdistrict.

Chinook salmon are normally tallied individually by the processor as they grade the fish; however, in the few cases where only weights are reported, the number of individuals is found by dividing the weight by the average weight per fish for that district and week.

A large portion of the troll catch is landed at remote buying stations rather than at processing plants. Fish and fish tickets are later picked up by a tender and delivered to the processing plant where the fish tickets are batched and finally sent to the Sitka area office for entry. As a result, troll fish ticket data are not available for use inseason. To estimate the catch to date during the season, ADF&G conducts

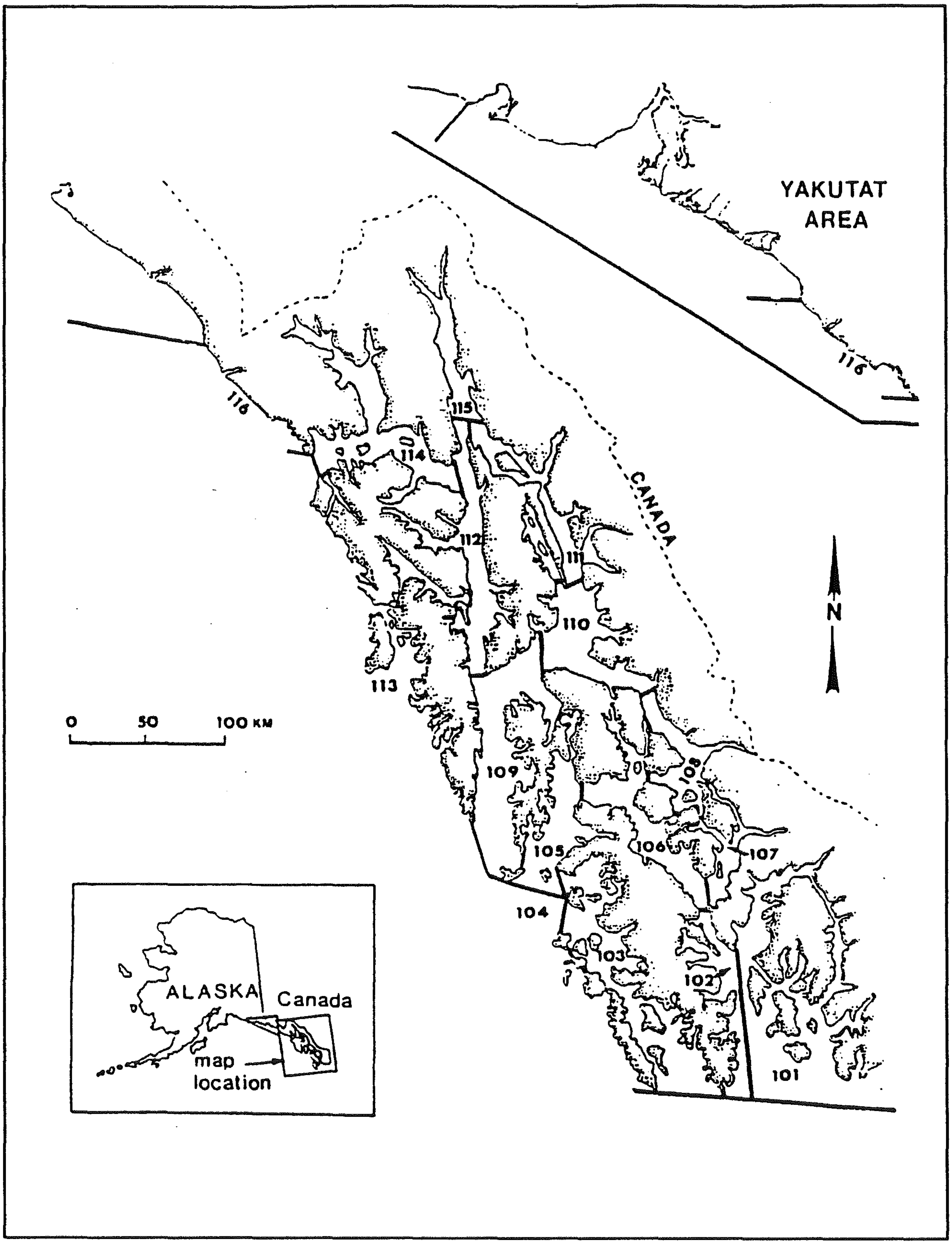

Figure 2. Commercial fishing districts in Southeast Alaska.

confidential interviews with skippers from randomly selected troll vessels as landings are made. Average catch-per-day-per-vessel estimates for both chinook and coho salmon are determined by district. For ease of use, the 25 districts that have troll harvest are summed into six major areas in Southeast Alaska. This is combined with inseason vessel counts by area obtained from aerial overflights to estimate the total catch to date. The resulting catch estimate is used by management to ensure that the final end-of-season catch does not exceed that set for the troll fishery.

The total annual net catch of chinook salmon is limited by the Board to 20,000 fish (excluding add-on). There are no chinook salmon directed net fisheries. Net fisheries typically occur in discrete districts during discrete openings of only a few days and the fish are landed at the end of the opening. Chinook salmon totals from net gear are relatively easily obtained each week from the fish tickets.

Sport fishery final catch estimates are determined from mail-out surveys and are usually not available until a year after the season (Mills 1991). Most subsistence catches are taken by rod and reel and are, therefore, tallied with sport catches. A preliminary estimate of the sport catch is made from creel surveys conducted in limited areas (Neimark 1985). In the past, there was no allocation for the sport fishery; slowly increasing effort from year to year kept the chinook catch relatively stable. To determine the allowable troll catch for the year, a forecast of the sport catch for the year was subtracted from the all-gear ceiling along with the net allocation. A new ruling (February 1992) by the Board allocates 83% of the allowable chinook (catch ceiling minus the 20,000 net allocation) to the troll fisheries and the remaining 17% to the sport fishery. This now means that the sport catch of chinook must be monitored or estimated in season in order to manage the fisheries to meet this allocation ruling. Precision and accuracy in the inseason estimates of sports catch have deteriorated recently due to the changing nature and distribution of the fishery. The creel surveys have been improved to give better inseason estimates of catch and to increase sampling for coded wire tags in 1992 and future years.

There are no estimates of directed effort on chinook salmon in mixed stock fisheries. Total recreational effort is estimated from results of the mail-out survey, but this includes effort for all species.

Chinook age and sex data are collected in the net fisheries, while only age data are collected in the troll fishery.

Escapement Monitoring and Estimation. In 1971 a stock assessment program was begun in Southeast Alaska for chinook salmon in which statistics from catches and escapements were monitored. Eleven stocks (Figure 3), representing about 88% of the total expected production from the 34 systems, were chosen as indicator stocks. By 1977 escapement survey methods for each indicator system were fairly well standardized. A detailed description of the survey methods and sites may be found in Mecum and Kissner (1989). There are 34 recognized chinook production systems in Southeast Alaska (including transboundary rivers) and 11 of these are surveyed on an annual basis (Table 1).

Monitoring the chinook escapement of the 11 indicator stocks is done on an annual basis and results are published in the Fisheries Data Series of the Division of Sport Fish, ADF&G (see Pahlke 1991). For the Alsek, Taku, and Stikine transboundary rivers, the stocks monitored spawn on the Canadian side of the border. Tributaries of the Alsek, Taku, and Stikine are counted using weirs operated by the Canadian Department of Fisheries and Oceans (DFO). Six tributaries on the Taku drainage are monitored using aerial surveys conducted by ADF&G. The Chilkat and Unuk River are also transboundary rivers but the stocks spawn primarily on the U.S. side of the border and the aerial surveys are all conducted on U.S. stretches of the rivers. On the remaining transboundary river, the Chickamin, all chinook spawning is

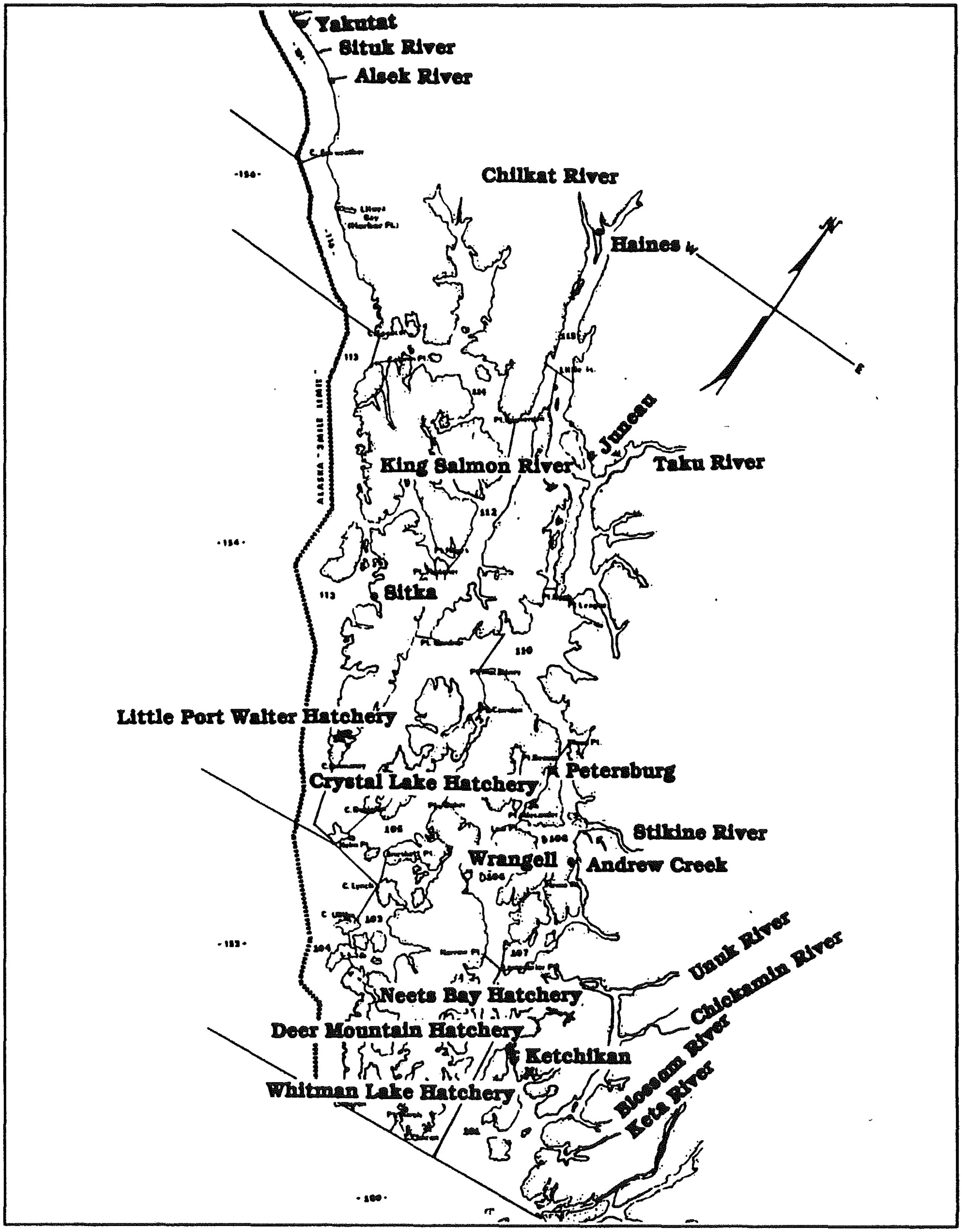

Figure 3. Location of escapement and exploitation indicator stocks in Southeast Alaska.

Table 1. Escapement survey summary for Southeast Alaska and transboundary chinook indicator stocks.

Stock	Survey Method	Expansion Factors	Jacks Counted	Age/Sex/Length	Hatchery Influence
Situk	weir 1928-1955, 1976-present	none needed	yes	limited data	none
Alsek	weir (DFO) at Klukshu since 1976; also aerial surveys of 3 systems (not used in indicator count)	none needed, goal is for Klukshu only	only adults counted	age and sex data collected	none
Chilkat	aerial or foot surveys of two index systems; 1991 & 1992 tagging; review of appropriateness of index systems underway.	survey expansion factor 1/0.80; tributary expansion factor 1/0.28; both under review.	only adults counted on surveys	from 1991, age and sex data collected	limited back plants of tagged fry since 1985
Taku	helicopter surveys of 6 index streams are summed for indicator escapement; weir on Nakina (not used in indicator count), other streams surveyed on irregular basis.	survey expansion factor 1/0.75; no tributary expansion, goal is for index systems only.	only adults counted on surveys, jacks counted at Nakina weir	yes, at Canyon Island and Nakina weir	none
Stikine	Little Tahltan weir (DFO) since 1985; helicopter surveys since 1975; 2 other systems aerial survey (not used in indicator count)	none needed, goal is for Little Tahltan only	jacks and adults counted at weir	age and sex data collected	none
Andrew	weir 1976-1984, foot survey 1985-1989, helicopter survey 1990	Foot and aerial survey expansion factor 1/0.625	jacks and adults counted at weir	some historical data available	none; but used as brood stock for local hatchery for planting elsewhere
King Salmon	weir since 1983; helicopter surveys since 1975 below and above weir	none needed	jacks and adults counted at weir	yes	egg takes for Snettisham hatchery since 1979 (~35 fish)
Blossom	helicopter surveys since 1974	survey expansion factor 1/0.625	only adults counted	none	none
Unuk	aerial or foot surveys of 6 tributaries	survey expansion factor 1/0.625	only adults counted	from 1991, age and sex data taken	used as brood stock by local hatcheries
Chickamin	aerial or foot surveys of 8 tributaries	survey expansion factor 1/0.625	only adults counted	limited data	used as brood stock by local hatcheries
Keta	helicopter surveys since 1974	survey expansion factor 1/0.625	only adults counted	none	none

thought to occur on the U.S. side of the border and surveys are conducted on the U.S. side only.
In Alaska, chinook escapement surveys are conducted cooperatively by ADF&G Sport Fish and Commercial Fisheries staff and are usually done as foot or helicopter surveys. Individual adult chinook are counted. Usually two or three surveys will be done for each index area during the time of maximum returns to the spawning grounds. The largest of the counts made will be used as the escapement estimate. An expansion factor is generally applied (see Table 1) to account for percentage of escapement in the surveyed area not seen by the counter. The factor generally used, 0.625, was determined through comparison of survey counts with weir counts. The Chilkat River is currently under review through a radio-tagging program operated by ADF&G Division of Sport Fish.

The Situk River chinook stock is the only chinook stock in Southeast Alaska currently managed to achieve a specific escapement goal by monitoring the escapement inseason. A weir near the mouth of the river is used to count escapement. For the remainder of Southeast Alaska chinook stocks, escapements are evaluated on a postseason basis.

Stock Composition Estimation. There is no regular monitoring for stock composition other than that of tagged hatchery fish.

Sampling for Coded Wire Tags. Monitoring coded wire tags in the catch is done for two purposes: 1) to substantiate the Alaska hatchery contribution to the catch and 2) to provide data on all tagged stocks for use in exploitation rate analysis by the Chinook Technical Committee (CTC). Catches from commercial fisheries are sampled for coded wire tags at the processing plants; the goal is to sample 20% of each gear/area/time strata fishery catch. Sport fish catches have been sampled at a somewhat lower proportion, 10 to 15%. Revision of the program in 1992 should result in a higher proportion sampled. While expansion factors for the sport fishery tag recoveries are made, they are not supplied to the coastwide database at the Pacific States Marine Fisheries Commission (PSMFC).

Tagging Indicator Stocks. All enhanced chinook releases in Southeast Alaska are represented by coded-wire-tagged fish. The proportion tagged is generally calculated to provide sufficient recoveries with a 20% recovery sampling rate for 90% confidence intervals that include deviations no larger than 10% of the estimated contribution.

Tagged hatchery stocks from Deer Mountain, Whitman Lake, Neets Bay, and Little Port Walter Hatcheries (Figure 3) are used by the CTC in their exploitation rate analyses to represent the Alaska spring stock group (see Figure 3 for hatchery locations). Deer Mountain, Whitman Lake, and Neets Bay, all in District 101, provide an adequate representation of the more southerly Alaska stocks; however, they do not provide a good index for our more northerly wild stocks: Andrew Creek, King Salmon, and Chilkat River. It is hoped that returns from the Crystal Lake Hatchery can be used as an indicator of Andrew Creek chinook. Little Port Walter Hatchery (Figure 3) is a federal facility and its outplants to not necessarily represent any naturally spawning chinook stock. Currently there are no tagged indicator stocks to represent the three major transboundary river stocks or the Situk River stock in either the CTC chinook model or the exploitation rate analysis (see page 74, CTC 1990b).

Taku wild stocks were tagged from 1977 to 1983 and results from these studies have given estimated exploitation rates for the stock (Kissner 1985, CTC 1990a). Stikine wild stocks were tagged from 1978 to 1981; however, returns were insufficient to allow data analysis. Currently there are no transboundary wild stocks that have been continuously tagged for use as indicator stocks in the CTC annual exploitation rate analysis. ADF&G has plans to tag Taku and Unuk wild stocks, but funding has not yet been forthcoming. The Taku chinook stocks are rebuilding successfully and soon there will be pressure to fish these rebuilt stocks more heavily. Information on where these stocks are found in the coastal waters is needed so they can be targeted or protected, as the need arises. There is some earlier tagging information from the Taku River; thus, if tagging were reinstated, this stock could be added to the coastwide chinook model to provide harvest and production estimates for Transboundary stocks.

Tagging Other Stocks. There is no annual program for tagging other stocks. See the research section for short-term tagging projects.

Monitoring Hatchery Returns. Tagged-to-untagged ratios are determined at all hatcheries. Standardized reporting; however, for CTC purposes is not consistent in all years. Due to tag lose and fish mortality from tagging, tagged-to-untagged ratios should be made when the fish return rather than at release.

Disease Monitoring. Disease profile histories are maintained on all Alaska hatchery chinook stocks, on all chinook hatcheries, and on egg takes from wild stocks. These data are used by FRED Division of ADF&G to evaluate the use of eggs from a stock or hatchery at alternate locations.

Forecasting. The hatchery add-on is forecasted each year in order to provide management guidelines in determining the length of the chinook retention summer troll fishery. An important component of determining summer troll season length has been the forecasting of the sport harvest of chinook salmon. This will no longer be necessary for determining the troll season length since the sport allocation is fixed. But the need now arises to follow the sport catch inseason to ensure that the sport allocation is not exceeded.

If abundance-driven alternative management models for chinook stocks are implemented, more reliable methods to predict abundance, both preseason and inseason will be needed. In order to find new approaches to forecasting chinook abundance in Southeast Alaska, more work needs to be done using: catch-per-unit-effort (CPUE) data (which may involve determining methods to measure fishing effort, e.g., in the winter troll fishery), test fishing programs, and analysis of June fisheries. Current methods of measuring effort in the troll fishery are inadequate, being based on landings rather than amount of time fished. In the past, the winter troll fishery has not provided a useful predictor of abundance.

Inseason Abundance Monitoring. Since management is based on remaining below a set ceiling, there is no need to determine abundance inseason.

RESEARCH PROGRAMS

Catch Estimation Techniques. The sport fish catch estimation and sampling program was revised in 1992.

Escapement Estimation Techniques. Sport Fish Division is conducting mark/recapture studies of chinook salmon on the Chilkat River. Coded-wire-tagging is done for smolts and radio tagging is done on adults. The purpose is to look at escapement distribution in the drainage, determine if the index streams that have been monitored in the past are representative of the entire system, and determine the distribution of the stock.

Radio telemetry field work on chinook salmon in the Taku River was completed in 1990 by NMFS, Auke Bay Lab. Radio telemetry has been an effective technique for studying salmon in large, turbid rivers where access and visibility are limited, as it provides detailed information that can not be obtained using other methods. The work in the Taku River was designed to provide data on stock composition, run timing of the various stocks, movement patterns, and information needed to evaluate escapement estimates from aerial surveys of established index spawning areas. Preliminary results were presented at a symposium in Japan (Eiler et al. 1990) and a project completion report should be out shortly (Eiler et al., *in prep.*).

ADF&G conducted a mark-recapture program in conjunction with the Taku radio-tag program to document the proportional distribution of spawning chinook and correlate with aerial survey results. As a result, four more survey areas were included in the aerial survey program.

Escapement Goals. Escapement goals for the 11 indicator stocks in Southeast Alaska, with the exception of the Situk River, are all interim goals based on past observed levels of escapement. ADF&G routinely re-evaluates all the goals to determine maximum sustainable and/or optimal escapement goal levels. This was done for the Situk River in 1991 based on spawner-recruit analysis (McPherson, *in prep.*). The Transboundary Technical Committee has agreed to re-evaluate the goals for the Alsek, Taku, and Stikine using cohort spawner-recruit analyses in 1995 (TTC 1991). Because initial analyses show much variability in the data, many years of returns will be needed to identify relationships.

Parameter Estimation. Studies were conducted during the years 1986 to 1987 to determine the mortality rates of chinook from nonretention fishing (Wertheimer 1988; Wertheimer et al. 1989). The results gave estimates of incidental mortality of both legal and sublegal sized chinook caught in the commercial troll fisheries. The extent of incidental mortalities in the various fisheries continues to be a concern. Better estimates of incidental mortality are needed as well as methods for reducing incidental mortalities in our fisheries.

Harvest rates of between 9 and 32% have been estimated based on tagging of the Taku stock between 1977 and 1988 (CTC 1990a).

Tagging was conducted on Unuk and Chickamin stocks between 1983 and 1988 (Hubbartt & Kissner 1987). The final significant return of tags is expected in 1992. These data will be used to estimate the exploitation rates on both these stocks. As these two stocks are inside rearing stocks, higher exploitation rates, especially on immature fish, is expected.

Alsek River chinook smolt were coded-wire-tagged between 1988 and 1990 with the intention of determining where this stock is harvested and, if possible, the exploitation rate on that stock. Adult returns are expected back starting in 1992. Preliminary ecological studies on juvenile chinook salmon in the Alsek River suggest that rapid geological changes in the Dry Bay area at the mouth of this river may be affecting stock rebuilding efforts in this system (Celewycz 1988).

Abundance and Distribution. Coded-wire-tagging of juvenile chinook salmon on the Unuk and Chickamin Rivers began in 1983 and continued through 1988 (brood years 1982 through 1986). The final significant return is expected in 1992. During 1991 and 1992, spawning ground recovery effort was concentrated on Cripple Creek, a principal spawning tributary of the Unuk River.

In other studies, Orsi (1988, 1989) has documented seasonal marine migration patterns of juvenile chinook from Alaskan and non-Alaskan sources into waters of Southeast Alaska.

Stock Composition. NMFS, Auke Bay Laboratory, is developing a genetic stock identification (GSI) baseline using electrophoresis on samples from wild and hatchery chinook salmon populations in Southeast Alaska and the Yakutat area. GSI samples are collected from chinook spawning areas to determine the potential for using this technique to determine stock composition from mixed-stock catches. This information is coordinated with information from populations to the south and north collected by other laboratories so eventually a coastwide (including Asia) baseline will be available.

Research using DNA markers is also in progress at laboratories in Juneau (University of Alaska), Anchorage (U.S. Fish & Wildlife Service), Seattle (NMFS), and Nanaimo, B.C. (DFO). Stock composition studies on chinook salmon using parasite markers are in progress at Auke Bay Laboratory (NMFS), Biological Station (DFO) in Nanaimo, B.C., and in Japan (Japan Fisheries Agency). This technique shows good potential for developing regional stock composition estimates and can be used in conjunction with genetic and scale methods to obtain more precise estimates.

Assessment and Refinement of Coded-Wire-Tag Methods. ADF&G is working on improving its estimation of hatchery contributions in various fisheries using coded-wire-tag analysis. Formulas for determining variances of these estimates are developed and presented in the ADF&G (1992) Add-On Report. Earlier work by Clark and Bernard (1987) produced variance estimates for the coded-wire-tag estimates.

Effects of Harvest Regulations. Reviews of size limits in commercial fisheries and bag limits for sport fisheries have been conducted. Studies using drift gillnets have looked at the possible effect of night closures on reducing chinook catch. Results are as yet inconclusive for the areas studied.

Alternative Marking Techniques. Long-term studies on genetic marking in pink salmon are in progress at the University of Alaska (Juneau). This study, and another on chum salmon in Puget Sound, have shown that the frequency of a rare allele can be increased dramatically in a population by selective breeding. Studies continue to find marks that show no long-term negative effects in the population from increasing the frequency of the chosen rare allele. It is hoped that this technique could be applied to chinook salmon in certain situations.

Enhancement. Presently there are 15 chinook enhancement facilities in Southeast Alaska, including individual hatcheries and associated off-site release projects. The Chinook Plan Team for Southeast Alaska reviews the activities and release permits for all hatcheries. The number of hatcheries and special enhancement projects has increased in recent years relative to the numbers of smolts released; contributions of chinook hatchery fish to the fisheries has also increased (McGee et al. 1991). The effects of enhanced chinook on wild stocks was recently discussed at a workshop on "Biological Interactions of Natural and Enhanced Stocks of Salmon in Alaska" held in Cordova, AK, November 10-15, 1991. As summarized by Heard (1992), there do not appear to be major problem areas of adverse hatchery stock/wild stock interactions with chinook salmon in Southeast Alaska for management purposes. Potential areas of concern include recovery of small numbers of adult hatchery chinook in nonnatal areas, including a few recoveries in natural chinook systems and the development and use of the most appropriate brood stocks for specific hatcheries.

Homing and straying of two stocks of chinook salmon transplanted to the Little Port Walter experimental hatchery was studied by Hard and Heard (*in press*), over a 9-year period. In this study, 98.9% of all maturing chinook salmon recovered at or near potential spawning areas were judged to have homed to the natal release site.

Miscellaneous Research. Other chinook research in Southeast Alaska involves a variety of enhancement studies including effects of smolt size at release and rearing densities on survival and adult production (Denton 1987, Martin & Wertheimer 1989) and development of a model for predicting smolt to adult survival for hatchery produced yearling smolt (Thrower, *in review*). Murphy et al. (1989) studied habitat utilization by juvenile chinook in the Taku River and Hard et al. (1989) documented geographic variation in red- and white-fleshed chinook salmon along the western North American Coast.

In 1985 an observer program was started to look at incidental mortalities in the troll and purse seine fisheries (Seibel et al. 1988; Rowse 1990). The size and condition of released fish was noted. The same encounter rates were assumed during nonretention fishing as during retention fishing; then mortalities were estimated as 13.1% for troll caught chinook greater than 28 inches and 28.1 % for chinook less than 28 inches. For seine gear, 42% of the released chinook were dead, 25% injured, and 33% uninjured.

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CANADA

The Canadian Department of Fisheries and Oceans manages Canada's west coast salmon fisheries, conducts research and stock assessments, maintains information systems, and enhances salmon production through the Salmonid Enhancement Program (SEP). Chinook fisheries are managed for conservation of stocks, native food fisheries, and allocations among other users including limitations agreed to under the Pacific Salmon Treaty. Some monitoring and/or research may be conducted under contracts, through Canadian universities, and recent increased co-management involvement of Native organizations.

Chinook harvest occurs in ocean mixed-stock troll, Native and sport fisheries, incidental catches in net gears targeting on other species (with the exception of two terminal gill net fisheries), and freshwater Native and sport fisheries. Annual all-gear harvests in marine waters of north and central British Columbia (Statistical areas 1-10 for nets and 1-11 & 30 for troll; see Figure 4) are managed to a total catch ceiling stipulated by the Treaty and between gear allocations determined domestically. Terminal harvests of Skeena River chinook in specified statistical sub-areas and catch in the early season large-mesh gillnet fishery in Bella Coola were recently excluded from the all gear catch total for north and central B.C. In southern B.C., catch ceilings are stipulated for the west coast Vancouver Island troll fishery (areas 21-27) and the troll and sport fisheries in the Strait of Georgia (areas 13-19A,28 & 29). Catch sharing in the Straits was determined domestically. Net fisheries in southern British Columbia target on sockeye, pink, and chum salmon but incidentally harvest chinook salmon. Harvest rates on chinook in these fisheries are controlled through area closures and fishing effort; Treaty pass-through obligations are respected in these fisheries. Chinook harvests in the Strait of Georgia, Johnstone Strait, and southern Queen Charlotte Sound have been further reduced to conserve chinook from the Lower Strait of Georgia stock. Sport fisheries in Juan de Fuca Strait, the west coast of Vancouver Island, and Johnstone Strait are not managed for Treaty stipulations; other than the general obligation on interceptions.

MONITORING PROGRAMS

Catch and Effort Monitoring. Records of each sale of salmon (sales slips) are the official source of catch information for all commercial fisheries in British Columbia. Sales slips are generated each time a fisher sells catch to a processor or buyer but may not be filed when the fish are landed. The sale slips are entered into a central database and subsequently published in the annual catch statistics for the Department. The sales slips record weight and numbers of fish caught by species and grade, area of catch, number of days fished, date of landing, boat name, and vessel identification number. Frequently, only the total weight of a landing by species and grade are recorded on a sales slip. In these cases, the number caught is estimated as the ratio of total weight and average weight (within the species, grade, catch strata). Average weight is from biological sampling data, when available, or from slips within that strata which recorded total weight and numbers caught. There are no estimates of directed effort on chinook salmon in mixed stock fisheries.

To obtain timely receipt of sale slips, DFO personnel and contractors collect sale slips at major landing ports throughout B.C. Field crews are stationed in Prince Rupert, Masset, Namu, Port Hardy, Winter Harbour, Tofino, Ucluelet, Campbell River, French Creek, Nanaimo, Steveston and Vancouver. These locations amount to the majority of all salmon landings. Following collection and entry, the sale slips are error checked through a series of computer programs before input in the catch database. Rejected records are investigated by Departmental personnel and reentered. The majority of the annual catch (approximately 95%) is recorded in the database by late fall but annual statistics are not finalized until the following summer.

Commercial troll fisheries. Sales slips provide the final postseason catch data; however, they are inadequate for inseason catch estimation due to the time lag between catch and sales slip compilation. This lag is due to: a) the time between catch and the completion of a sales slip. This lag can range from one day for day-boats, 3 to 10 days for ice boats and 10 to 60 days for freezer boats; and b) the time between the sales slip completion and entry into the database.

To achieve Pacific Salmon Treaty and domestic allocation goals, certain species are now managed to catch ceilings and/or quotas. Ceiling or quota management requires the ability to reliably estimate catch inseason. The InSeason Catch Monitoring Program (ISCMP) was developed in 1983 to provide timely catch estimates for commercial troll fisheries. Three data sources used by this program were: current sales slips, catch sample data consisting of CPUE and average weights, and regional effort estimates. The collection methods and uses of this information are described below.

CPUE and average weights are obtained from the Mark-Recovery Program (MRP). The MRP is a coastwide program designed to sample all commercial fisheries for adipose fin clips and biological data at a minimum of 20% of the catch by gear type, catch region and week. Troll sampling is restricted to ice and day-boats which have fished within the catch region that trip. Average daily catch by species is estimated from the number of fish landed by species, provided by MRP staff, and the number of days

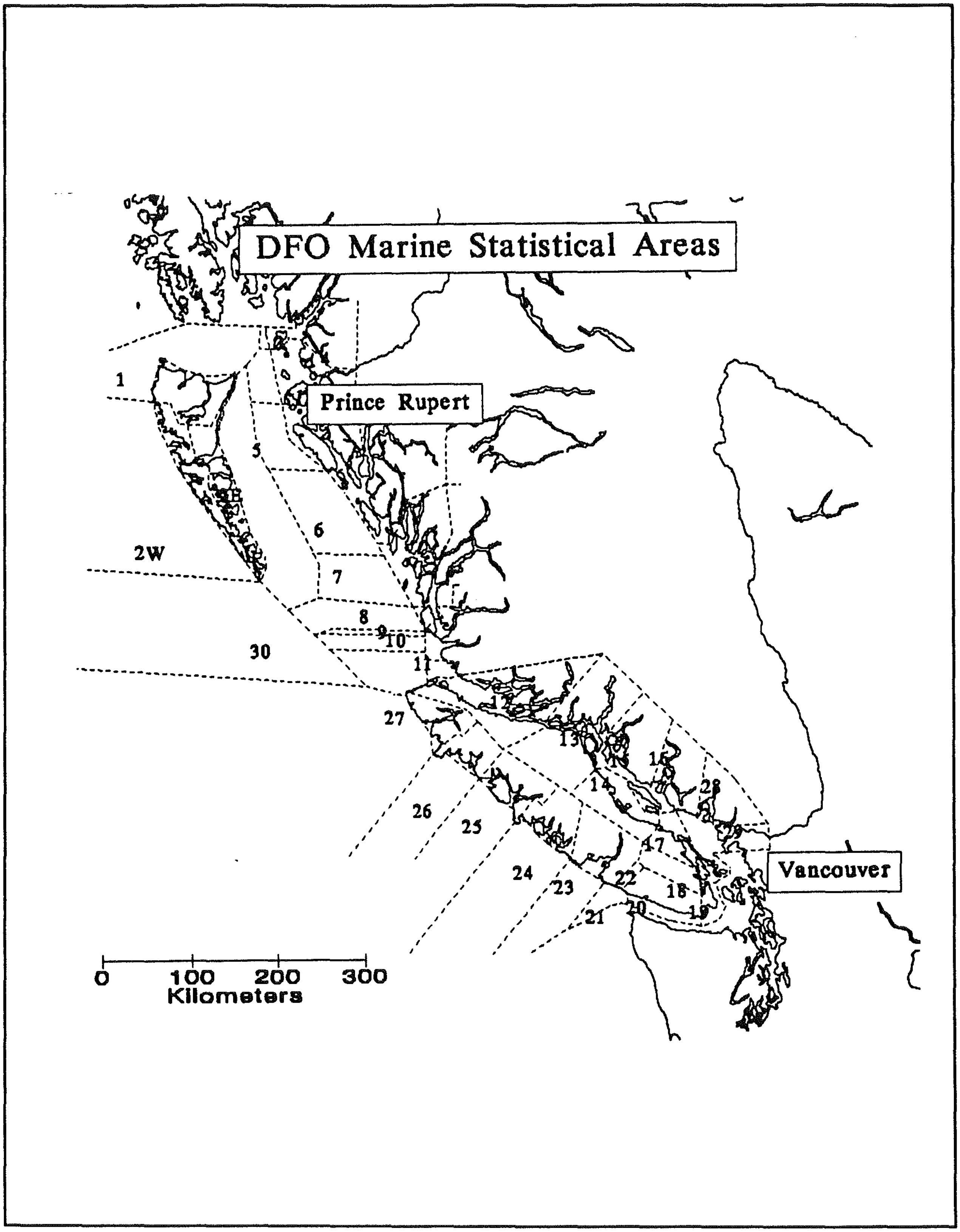


Figure 4. Marine statistical areas used in DFO reporting of catch statistics.

fished by area, obtained from fisher interviews. MRP samplers also record the total weight, by species and grade, used to calculate an average weight. These data are transmitted at least once per week by telephone or courier for entry into the ISCMP database.

Gear counts in the Strait of Georgia, west coast of Vancouver Island and North/Central coast troll fisheries are obtained from overflights. Gear counts in the west coast of Vancouver Island fishery (outside portions of statistical areas 21-24) are supplemented by twice daily radar counts conducted by the Canadian Coast Guard station at Ucluelet. Flights are normally conducted once or twice per week off the west coast of Vancouver Island, once per week in the North Coast and at least twice per week in the Strait of Georgia.

Sales slip weights are used to estimate weekly catch by catch region, gear type, weekly period and species. These weights are merged with the average weights obtained from the regional sampling program to produce estimates of pieces caught. Sales slip catch estimates are back-dated to estimate catch as it occurred and not the catch by landing date.

An independent catch estimate is derived from the sampling programs, where catch is the product of CPUE and effort. The independent estimates are usually lower than the sales slip totals; however, they are important during short duration fisheries or at the start of the season when sales slip totals are unreliable. To correct the negative bias, a "combined" catch estimate is calculated after several weeks of the fishery. Regression relations are derived between sales slip catch estimates (for weeks that contain complete accounting of the sales slips) and the "independent" catch estimate. Resulting regression parameters are used to correct biases in the "independent" estimates.

After all catch estimation techniques have been run, the troll catch estimates are reported in a weekly bulletin for each catch region. The catch estimates reported in the bulletin are often a combination of sale slips, independent and combined estimates. Sales slip catch estimates are reported for the weeks which are believed to be complete. Independent or combined estimates are used for the most current weeks.

CPUE is also estimated by interviewing fishermen on the fishing grounds ("hail" data) or through the use of charter vessels. Such data may or may not be verified by onboard inspections. These data are important in estimating daily CPUE in short duration fisheries or in fisheries approaching a catch ceiling. CPUE estimates are combined with effort counts to estimate daily catch.

In 1988, DFO began surveying the west coast of Vancouver Island companies which process 80 to 85% of the troll caught salmon. The buyers are contacted at the beginning of each week during the fishery to collect their total landings to date. This information provides a check on the ISCMP.

Commercial net fisheries. With the exception of the early season Bella Coola gill net fishery and the Barkley Sound gill net fishery, net fisheries in British Columbia are not directed at chinook salmon. In passthrough fisheries such as the Johnstone Strait sockeye, pink or chum fisheries, chinook catch is monitored inseason by hails and postseason by sales slips. Incidental chinook catches have been regulated through effort limitations (assuming a direct relationship between effort and catch) and limitation of juvenile chinook catch per seine set. Independent estimates of chinook catch by size class in southern B.C. net fisheries (1985 to 1990) were determined by the Biological Sciences Branch of DFO. Effort (days open, vessels reporting a landing, and vessels observed per day) is documented in annual postseason reports and in published DFO Fisheries and Aquatic Sciences Manuscript or Technical reports.

In chinook directed fisheries, estimated inseason catch is the product of average CPUE (hails plus subsets of sales slips) and effort (boat-days estimated from aerial or boat-based gear counts). Postseason catch is from sales slips. Mark incidence in the catch is determined by the coastwide MRP. Chinook catch by subarea in the Terminal Exclusion Area of Statistical Area 4 (Skeena River) is also estimated as above, although this catch occurs incidentally during sockeye and pink salmon gill net fisheries. Final catch estimation procedures for terminal exclusion areas have been described in previous documents.

For the Fraser River commercial net fisheries, a system has been in place since 1989 to identify surplus returns of early run chinook. Inseason abundance is monitored by an inriver test fishery. When identified, the surplus is harvested by increasing fishing time in the Native fishery (+1 day/week) and the commercial gill net fishery (a 12-hr inriver opening). To date, abundances have been below surplus levels.

Inseason catch and effort estimates in the Fraser fisheries are initially derived from vessel counts and on water hails of catch. Near the end of each opening, preliminary catch estimates are compiled by contacting the main processors for preliminary sales slip tallies and estimates of the proportion of the total slips that they represent. Final catch and effort values are compiled postseason from sales slips. Landings are reported by statistical subareas although the accuracy at this level of resolution is questionable. Sales slips underestimate the harvest of chinook in the late season (September to December) fisheries because fishermen take home a substantial proportion of their catch. These fish are frequently not reported on sales slips. At present, there is no sampling to estimate the magnitude of this bias.

Recreational fisheries. The Strait of Georgia sport catch, effort and biological information are estimated by a creel survey program in the area from the southern end of Vancouver Island near Victoria to just north of the Campbell River. Before 1980, catch and effort was estimated by fishery officers and small creel surveys. The lack of statistical rigor and consistency associated with these methods as well as the rapid growth of the recreational fishery led to the initiation of the Strait of Georgia creel survey. The creel survey has two elements: angler interviews and aerial overflights (English et al. 1986). Angler interviews provide CPUE data, daily activity patterns and biological samples, including the adipose fin clip incidence. Aerial overflights provide study area boat counts at the daily effort peak. These data are combined to provide monthly estimates of total effort, in boat-trips, and total catch of salmon and groundfish. In its simplest form, estimated catch is the product of estimated total effort and CPUE. The creel survey was designed to provide annual catch estimates for the Strait of Georgia with 95% confidence limits with no more than 5% error.

In 1991, a creel survey similar to above replaced fishery officer estimates in Queen Charlotte Sound and Johnstone Strait (Statistical Area 12 and upper Area 13) (Collicutt et al. 1992). In 1992, the study period was expanded from July and August to May through August. The current design does not permit inseason catch estimation.

Since 1984, a creel survey has been conducted in the Barkley Sound and Alberni Inlet, inside the surf line of statistical area 23, to estimate the catch of Robertson Creek and Somass River chinook. Since 1989, the study period and area were July 15 to September 30 inside Barkley Sound and Alberni Inlet. The study is designed to estimate catch and effort with a coefficient of variation of less than 10%, requiring interviews from at least 6% of the effort and two overflights per week. In 1992, the survey was expanded to include Statistical Area 24 and the outside portions of Statistical Area 23 (separate estimates are to be prepared for the new area)and the Alberni Inlet survey commenced on June 15 to estimate sockeye catch. Published reports are unavailable for the Barkley Sound creel survey; however, consultant reports are available for 1990 and 1991. The Somass River, which enters upper Alberni Inlet, also supports a substantial chinook sport fishery which is currently unassessed. Native comanagement funding may provide creel surveys in other WCVI areas in 1992 and subsequent years, including Nitinat (statistical areas 21 and 22) and Nootka Inlet (Statistical Area 25).

Monitoring of sport fisheries in marine areas off the Fraser River (Statistical Area 29) is included in the Strait of Georgia creel survey. Chinook sport fishing in Howe Sound (Statistical Area 28) is closed. Angling for chinook adults in the Fraser River was also closed in 1980; however, since 1984, fisheries have been reopened if escapements were increasing faster than expected or the stock was being enhanced, and either the harvest could be restricted to a single stock or the harvest of a mixed stock aggregate was insufficient to impact the rebuilding program. In most cases these fisheries were opened for limited periods, limited to harvest ceilings set at a maximum of 5% of the terminal return, and effort and catch were monitored by structured assessment studies (Schubert 1988, 1989, 1990, 1992; Schubert and Whyte 1992). These programs have largely depended upon funding from employment programs, native comanagement initiatives, or volunteers from local Rod and Gun clubs. The percent of the fisheries monitored has declined from 100% in 1984 to only 15% in 1992.

Most sport fishery effort and catch estimates from Northern and Central B.C. have been provided by fishery officers or periodic creel surveys of the major fisheries. With the rapid expansion of recreational fishing, however, creel surveys similar to the Strait of Georgia survey have been implemented at the Skeena River mouth (Statistical Area 4) and in Kitimat Arm (Statistical Area 6-1; terminal fishery for Kitimat Hatchery chinook). In the major fisheries at Rivers Inlet, Hakai Pass and Lanagara Island, CPUE is estimated from log books maintained by the resorts and effort is estimated from boat surveys. Hails are used to verify the log book statistics. The utility of these data are limited due to inconsistent methodologies and the inability to evaluate accuracy and precision.

Native fisheries. In north and central British Columbia, the majority of the native fisheries are conducted in nontidal waters. Most fisheries have no set quotas and are managed to provide sufficient quantities for personal needs. Local fishery officers have no set methodology for estimating the native catch, but estimates are usually presented by week and specific fishing areas in-river.

In Southern B. C. (excluding the Fraser River), native fisheries harvest chinook in a number of predominantly small terminal areas. Permits are also issued for marine fisheries along the WCVI and in Johnstone Strait, but the catch and effort in these fisheries is poorly documented. Effort and catch estimates are provided by fishery officers using a variety of subjective techniques; however, catch in some fisheries may be significant. In 1991, the Somass River fishery was monitored by tribal employees. Every few days, an estimated 60% to 90% of the fishermen were hailed for catch (total chinook and sockeye) and effort (hours fished). Gear was counted every few days from boat surveys. Estimated catch was the product of average catch per fisherman and total number of nets. In the future, this type of catch monitoring will likely be conducted by most bands with substantial net fisheries. Biosampling of mark incidence, age, and sex is not conducted in these fisheries.

Catch estimates in the Cowichan River are determined through a Native co-management program utilizing local guardians to observe catch and effort by gear type. Catch in non-sampled times and areas are extrapolated based on sampled periods. In recent years, catch has been sampled for mark rates and coded-wire tags collected through a co-operative program to monitor wild and enhanced chinook escapement into the Cowichan River.

Catch estimates in the Squamish River were derived from inspections of nets two or three times per week and estimation of catch for the season by (catch/gillnet-day * # days fishing * # of nets). The fishery is managed by the Native band but catch estimation continues to be conducted by the Department of Fisheries and Oceans.

The Fraser River fishery, until recently, was managed for subsistence and ceremonial purposes, with fishing time set to permit reasonable access to the resource (generally 3 to 4 days/week). Since 1977, fishing time during the early chinook return has been restricted to one day/week as a conservation measure. However, the 1989 clockwork process (described above) established a mechanism to identify and harvest surplus returns. Although surpluses were not identified in 1990 to 1992, additional fishing time was permitted during the early run.

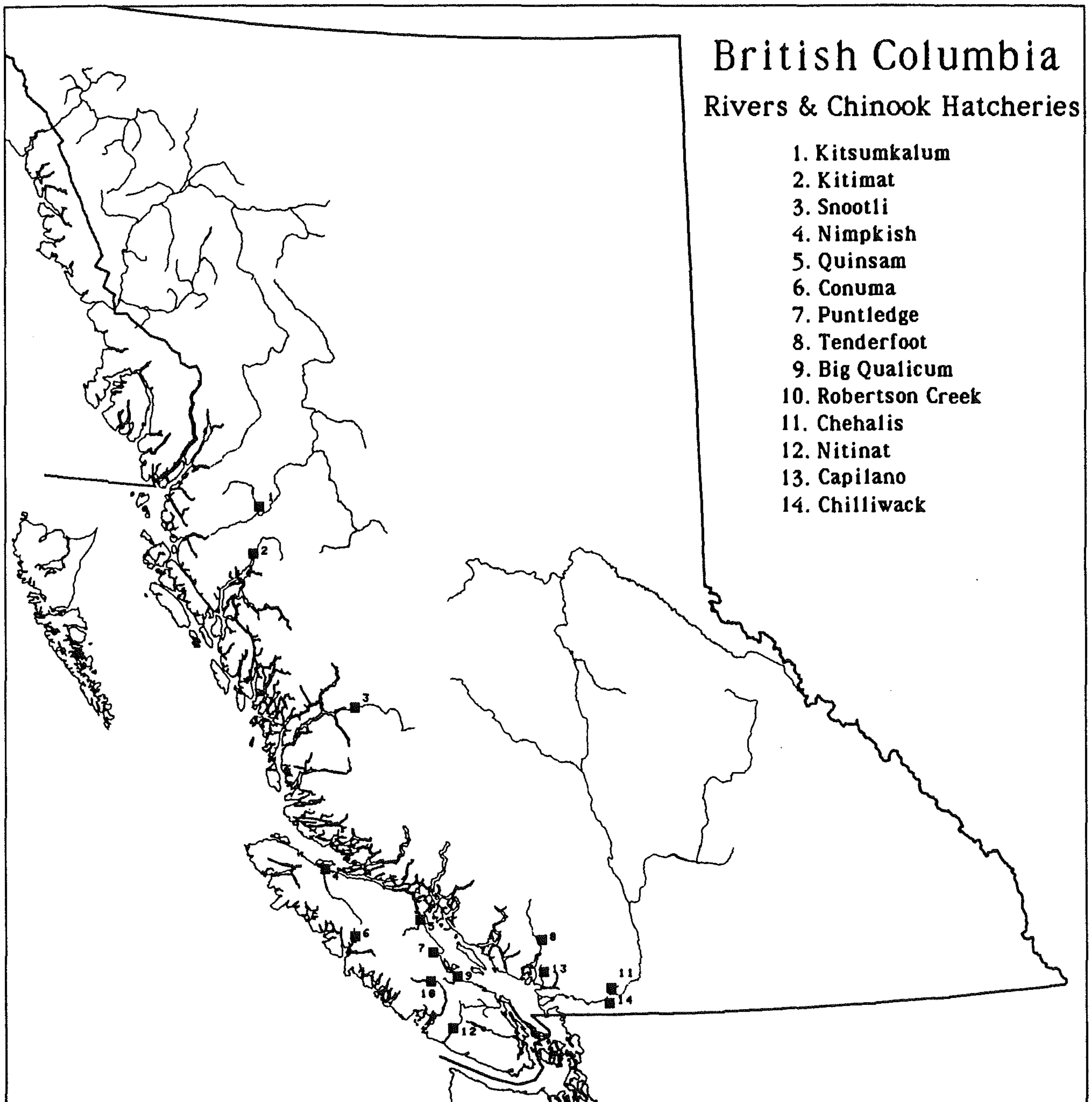
The Fraser River native fishery is monitored by fishery officers using a variety of site-specific techniques and levels of intensity; annual reports summarize results (e.g., Macdonald 1992). Monitoring is most intensive in the lower river where assessment of summer sockeye fishing normally entails two patrols per 3- to 4-day opening, with net counts and CPUE estimated during each patrol. Before July and after early September, monitoring is less structured or intensive, with no patrols in some areas and only one patrol per week in others. Estimation accuracy and precision for spring and fall run chinook catch is, therefore, probably poor. Furthermore, in the catch is not sampled for adipose clips and the native community does not participate in the Head Recovery Program.

In 1992, native comanagement programs resulted in the implementation of a more structured catch monitoring program in the fisheries from the Fraser River mouth to Sawmill Creek (lower Fraser Canyon). In addition, native fisheries on the Nass and Skeena Rivers are also involved in comanagement contracts to more carefully assess the catch and effort. Native groups have been contracted to estimate effort and catch, and to recovery the heads of adipose-clipped fish; the role of fishery officers has been changed to an audit function.

Escapement Monitoring and Estimation. In British Columbia, annual estimates of naturally spawning escapement are provided for most stocks primarily by fishery officers using a variety of foot, boat or aerial survey techniques. To evaluate rebuilding, the naturally spawning stocks were aggregated into 14 stock aggregates, with stock selection in each aggregate based on two criteria: a) the existence of a continuous annual escapement record since 1975; and b) no or minimal enhancement, i.e. the enhanced component of the escapement did not influence escapement trends. Location of the stocks is indicated in Figure 5. Survey methods for these stocks are described in Tables 2 to 4.

When the chinook rebuilding program began, a number of chinook stocks were selected for intensive monitoring of escapement and exploitation rate. Only five indicator stocks remain, three primarily as exploitation rate indicators (Robertson Creek, Big Qualicum and Quinsam rivers) and two as escapement indicators (Harrison and Kitsumkalum rivers). Several programs were eliminated when the lack of terminal recoveries of coded wire tags in Native fisheries precluded exploitation rate estimates; other tagging programs proved to be too expensive. Methods used and results are documented annually (see report list in Documentation Section below). Escapement estimation procedures for the exploitation rate indicator stocks are described below.

a) Big Qualicum River hatchery chinook are counted through a weir and the vast majority returned to the hatchery rack. All rack returns are examined for adipose fin clips and most are then sampled for coded wire tags.



Rivers which, for clarity were not labelled but which are also major producers include: Kitimat R. (where hatchery #2 is located) Quinsam/Cambell R. (#5), Conuma R. (#6), Squamish R. (#8), Somass/Sproat R. (#10), Harrison R. (#11), Nitinat R. (#12), and Alsek R. (in northern transboundary region outside border of map).

Figure 5. Major chinook rivers in British Columbia and chinook hatcheries (■) which are mentioned in this text.

Table 2. Escapement survey summary for the Canadian South Coast Division (Statistical Areas 12-27) chinook indicator stocks.

Indicator Stock Group	Surveyed Populations	Survey Method	Expansion Factors	Jacks Counted	Age/Sex/Length	Hatchery Influence
Lower Strait of Georgia Fall Chinook	Cowichan	1976-79 fence and mark-recapture; 1988-91 fence and swim surveys; other years walk, swim, and redd counts	peak counts from swim surveys expanded to unsampled portions of spawning area	counted, sampled, & reported separately	data available 1976-79 & 1989-91	yes - since 1979; enhancement production expanded recently
	Nanaimo	walk, swim, helicopter	peak counts from swim surveys, expansions vary between years depending on survey area and conditions	counted for brood stock only	data available 1979-80 & from brood stock	yes - since 1979
	Big Qualicum Enhanced	fence	none needed	counted, sampled, & reported separately	1959 - onward	yes - Big Qualicum Hatchery
WCVI Fall Chinook	WCVI Natural *	walk, swim &/or aerial surveys	variable, undocumented	not counted	available from some brood-stock sampling	yes, varying degrees but significant in 4 of the populations
	Somass and Stamp R. Enhanced	mark recapture &/or fishway counts since 1984	none needed	counted, sampled,& reported separately	mid-1970 onward	yes - Robertson Creek Hatchery
Upper Strait of Georgia Fall	Upper Strait of Georgia Natural **	walk, swim, aerial	variable, undocumented visibility highly variable in glacial systems	not counted	limited to brood stock	Minor - Nimpkish only
	Quinsam & Campbell R. Enhanced	mark-recapture 1984 onward	none needed	estimated, sampled, & reported separately	mid-1970 onward	yes - Quinsam Hatchery

* Rivers included in the WCVI Natural indicator stock group are the: Kennedy, Gold, Burman, Tahsis, Kaouk, Tahsish, and Marble. Enhancement activities significant in the Kennedy, Gold, Tahsis, and Marble rivers. Returns from enhancement activities mix with natural production for spawning.

** Rivers included in the Upper St. of Georgia indicator stock group are the: Devereux, Kakwieken, Wakeman, and Kingcome (mainland side of Johnstone Strait) and the Nimpkish River on Vancouver Island.

Table 3. Escapement survey summary for the Canadian Fraser River Division (excluding transboundary and Yukon Rivers) chinook indicator stocks.

Indicator Stock Group	Surveyed Populations	Survey Method	Expansion Factors	Jacks Counted	Age/Sex/Length *	Hatchery Influence
Upper Fraser River	Dome Creek	Weir	none	yes	yes	small facility
	Stuart/Nechako	Helicopter survey	undocumented	no	yes	small facility
	Balance of stocks **	Aerial, foot or boat	variable, undocumented	no	none	major facility: Quesnel Hatchery but survivals poor
Middle Fraser River	Upper Cariboo	Weir	none	yes	sex data only	Quesnel Hatchery
	Balance of stocks ***	Aerial, foot or boat	variable, undocumented	no	none	Quesnel & Pitt River hatcheries (several locations)
Thompson River	Bonaparte	weir	none	yes	yes	Spius Creek Hatchery
	Deadman	weir	none	yes	yes	small project
	Salmon	weir	none	yes	yes	Eagle River Hatchery
	Eagle	weir	none	yes	yes	Eagle River Hatchery
	North Thompson	helicopter, redd counts	variable, undocumented	no	none	Clearwater R. Hatchery
	Balance of stocks ****	aerial, foot or boat	variable, undocumented	no	none	several locations
Harrison River	Harrison River	Mark recapture since 1984	none	no	yes	yes, but minor contribution Chehalis & Chilliwack Hatchery
Squamish River (S/A 28 Howe Sound) - indicator stream for Lower St. Georgia stock	Cheakamus	Mark recapture and carcass weir	none	yes	yes	Tenderfoot Hatchery involved in each stream
	Squamish, Ashlu Mamquam, & others	visual surveys	variable, undocumented	no	none	

* Note: age, length and sex data are available for all enhanced stocks; however, most samples are probably not representative.

** Bowron, Willow, MacGregor, Slim are enhanced.

*** Cottonwood, Swift, Westroad, Chilcotin, Chilko, Quesnel, Cariboo are enhanced.

**** Nicola, Spius, Coldwater, Clearwater, N. Thompson, Raft, and lower and middle Shuswap are enhanced.

Table 4. Escapement survey summary for the Canadian North and Central B.C. (Statistical Areas 1-11) indicator stocks.

Indicator Stock Group	Surveyed Populations	Survey Method	Expansion Factors	Jacks Counted	Age/Sex/Length	Hatchery Influence
Queen Charlotte Island	Yakoun River	partial count via pink salmon weir & visual counts of spawners	peak count spawners expanded to total; expansions variable & undocumented	partial counts	none	none, see footnote *
Nass River	Meziadin River	partial fishway count & visual counts	fishway count used but known not to be total count of run	yes	yes	none
	Other Nass R. (12 streams)	visual surveys	variable depending on survey conditions	not counted	none	none
	Other Area 3 (3 rivers)	visual surveys	undocumented	not counted	yes, from Kincolith	Kincolith, small project
Skeena River	Babine system	fence counts & visual counts below fence	none but some variation in duration of fence count period	yes	yes	several small projects
	Kitsumkalum R.	mark-recapture since 1984	none needed	no	yes	Deep Creek, small project
	65 others (11 consistently monitored)	aerial, foot or boat visual surveys	variable, undocumented	no	none	several small projects
Kitimat Inlet	Kitimat system, Dala, Kildala	visual estimates and broodstock collections	closely observed but process undocumented	no	from brood stock only	Kitimat Hatchery
	Others (Area 6 Index - Kitlope, Kemano, etc.)	aerial &/or foot visual surveys	variable, undocumented	no	none	none
Bella Coola	Bella Coola River	repeated swims &/or aerial surveys,	program & expansions documented annually; but vary between years	no	from brood stock & dead pitch	Snootli Hatchery
	Others (Area 8 Index - Dean, Kimsquit, etc.)	visual counts only	variable, undocumented	no	none	none

Indicator Stock Group	Surveyed Populations	Survey Method	Expansion Factors	Jacks Counted	Age/Sex/Length	Hatchery Influence
Rivers Inlet	Wannock River	adult mark/recapture in recent years	none needed	no	from brood stock & dead pitch	Snootli Hatchery for Wannock R. only
	other major stocks - Kilbella, Chuchwalla rivers	visual counts and carcass sampling	inconsistent, undocumented	no	from brood stock only	yes, but very small production
Smith Inlet	Docee & Nekite Rivers	visual counts, aerial surveys sometimes	inconsistent, undocumented	no	none	none

* Hatchery activity for 1986-88 only, chinook eggs from Quinsam Hatchery were transplanted to Pallant Creek Hatchery on Queen Charlotte Island. Through 1992, marked and unmarked returns from these brood years have been caught in terminal fisheries off Queen Charlotte Island. There is no natural run of chinook to Pallant Creek. Enhanced chinook returns are counted at the hatchery fence.

b) Robertson Creek and Stamp River chinook have been enumerated in three ways: mark recapture programs were attempted in 1984 to 1985; a video camera was used at the Stamp Falls fishway in 1986 to 1988; and, since 1989, visual counts are made as the fish pass through the fishway. Mark incidence is estimated from carcasses recovered during foot surveys, at a carcass weir, and at the hatchery rack. Hatchery rack counts are subtracted from the fishway count; the mark rate and the coded-wire-tag composition from river recoveries (foot survey and carcass weir) are then applied to the balance to estimate the coded-wire-tag return in the naturally spawning population.

c) Quinsam River chinook escapement and the number of adipose fin clips is estimated from the hatchery rack count and from a Petersen estimate of escapement in Quinsam and Campbell rivers.

d) KitsumKalum River chinook escapements are estimated by sex and age using a mark-recapture study (this population has yet to be incorporated in the exploitation rate analyses).

Escapements for the Harrison River escapement indicator stock are estimated by sex and age using a mark-recapture study. At current coded-wire-tag application rates and adult sampling levels, it is not possible to accurately estimate the number of tags recovered by tag code by sex and age strata in the escapement.

In the future, native comanagement programs in B.C. will provide increased effort for determining chinook escapement, estimates of hatchery and wild components and biological sampling of chinook escapements. For example, in 1992 on the west coast of Vancouver Island, programs are being developed to index chinook escapements in statistical areas 22 (Nitinat River) and 24 (Clayoquot Sound).

Stock Composition Estimation. No specific programs are conducted on a regular basis.

Sampling for Coded Wire Tags. Coded-wire-tag recoveries are obtained from both active sampling and voluntary recoveries. All commercial fisheries are sampled as part of the coastwide mark recovery program. The objective is to sample all commercial fisheries at a minimum of 20% of the catch by gear, week and catch region. This objective has been achieved for most time and area strata, although troll sampling is restricted to ice and day-boats which have fished that trip within the catch region. There are presently no programs to evaluate the rate of sampling error (i.e., missed marks).

Mark incidence is estimated by period and area by creel surveys of major sport fisheries (Strait of Georgia, Kitimat, Johnstone Strait and Barkley Sound). The recovery of coded wire tags relies on voluntary head recovery; consequently, there is no control over sample size or the spatial distribution of the samples, and bias may exist by size class.

With the exception of a number of Fraser River sport fisheries (discussed above) and portions of the 1992 Fraser River Indian fishery, few inriver fisheries are sampled for mark incidence or coded wire tags. Sampling of the Indian fishery is expected to improve with the implementation of comanagement programs.

Tagging Indicator Stocks. The Big Qualicum, Quinsam, Kitsumkalum, and Robertson Creek indicator stocks are coded-wire-tagged at each hatchery. Each stock is tagged with a minimum 200,000 coded-wire tags per year.

Tagging Other Stocks. All other chinook tagging in British Columbia occurs at hatcheries; there is currently no wild stock tagging with the exception of wild smolts produced in the Big Qualicum river. There are two basic strategies used in Canadian chinook enhancement: a) catch supplementation, where juveniles are released from a hatchery and all adults which escape the fisheries return to the hatchery for use as brood stock or rack sales. None spawn naturally; and b) catch and escapement supplementation, where brood stock is taken from naturally spawning populations, incubated in a facility and released into the stream of origin. Resulting adults contribute to both harvest and the natural spawning population. Coded-wire-tagging strategies are documented in a report by the Mark Committee of the Data Sharing Committee. The Salmonid Enhancement Program (SEP) routinely tags all large hatchery production groups (greater than 500,000). The minimum production mark group is 75,000; however, tag lot sizes vary with production strategy or anticipated survival rate. Other experimental groups, tagged at levels determined by study design and funding, use the production group as a control and may be useful for distribution and exploitation rate analyses.

Monitoring Hatchery Returns. Returns to production facilities are enumerated at the rack. Returns are sampled for marks during sorting and heads are recovered from all marked fish. All returns are now double sampled for missed marks, and random checks are carried out by independent samplers. These measures virtually eliminated the missed mark problem. In cases where enhanced returns spawn naturally, estimates are made of the total spawning escapement and the mark rate in natural spawning stocks. Estimation procedures are not rigorous, usually involving visual escapement estimates by hatchery staff, with mark incidence estimated from carcasses recovered during foot surveys, brood stock collection or at carcass weirs. All coded-wire-tag recoveries and a representative sample of unmarked returns are sampled for size, sex, and, in some cases, age. When the mark rate, the coded-wire-tag composition, or escapement estimates are unavailable, these parameters are estimated by using the coded-wire-tag catch in the mixed stock fisheries and the exploitation rate from nearby stocks with similar timing and ocean distributions. Terminal catches are subtracted from the escapement estimate. These estimates, however, are maintained only in a "soft escapement" database maintained by SEP.

Disease Monitoring. Disease screening of natural and enhanced stocks is conducted by the Fish Health and Diagnostics program of the Biological Sciences Branch, Pacific Biological Station, Nanaimo, B.C.

Forecasting. The only forecasting for chinook salmon is sibling regression of older age returns versus younger ages from a brood year. Sibling regression models have been developed for coded-wire-tag groups from Robertson Creek, Big Qualicum, and Quinsam Hatchery stock.

Since 1989, a troll test fishery has been conducted off the west coast of Vancouver Island to estimate preseason chinook and coho abundance and to collect size, sex, and age data. Typically, three boats fish off the southwest coast and two boats off the northwest coast for about three weeks in May. In 1992, a sixth vessel was deployed in the southwest to tag and release chinook salmon.

Inseason Abundance Monitoring. Gill net test fisheries for chinook on the WCVI are conducted in statistical areas 21 (Nitinat Lake outlet), 22 (Nitinat Lake), 23 (Alberni Inlet) and, for the first time in 1992, in Area 25 (Nootka Sound/Tlupana Inlet). The purpose of these fisheries is to index abundance and run timing, and to sample for mark incidence, age, sex, and size. No reports have been published.

For the Fraser River, inseason escapement has been indexed since 1980 by a gill net test fishery near Albion in the lower part of the river. The test fishery is conducted daily by commercial gill net vessel with standardized gear, fishing site, and time (based on tide stage) (Schubert et al. 1988). Test fishing occurs from April through October and operates 7 days/week, except during commercial fisheries. The test fishery provides daily estimates of chinook CPUE and biological samples (length, weight, sex, flesh colour, scales and adipose clips). Test fishery precision may be limited because: a) the fishery operates over a seven month period which encompasses most stages of the rivers hydrography, catchability probably varies over this period; and (b) stock composition by time period and stock-specific rate of travel requires further study.

Since 1956, a sockeye and pink salmon gill net test fishery has been operated in the Skeena River. The test fishery does not cover the early portion of the chinook run; however, there is a good relationship between the index and total escapement (Farlinger et al. 1990). Recently, however, as the total return of chinook to the Skeena has increased substantially, the relation has been poorer. Biological samples are collected from the test fishery catch and catch inspected for coded-wire-tagged chinook salmon.

A test fishery for sockeye and pink salmon is conducted daily on the lower Nass River from approximately the first week in June to the last week in July. The test fishery has operated with little change from the original program since its inception in 1963. It is operated about 16 km upstream from the commercial fishing boundary. An index of chinook abundance and timing is calculated each year. Since the timing of the test fishery does not cover the duration of the chinook run and the net is not designed to capture or retain chinook the catch data is of limited value even as an index.

RESEARCH PROGRAMS

Catch Estimation Techniques. The reported catch of chinook salmon in southern B.C. seine fisheries was investigated between 1985 and 1990 (Johnstone Strait, St. of Georgia, and Juan de Fuca). Catch of large (> 5 lb) chinook salmon was consistent with reported catches but observed catches of small chinook (3 to 5 lb) and jacks (<3 lb) were substantially underestimated by sales slip reporting (Nagtegaal et al. 1988, 1990). Further, the reported catch of "small" chinook consisted of any chinook <5 lb, not chinook between 3 to 5 lb as defined by the small category.

Escapement Estimation Techniques. Shardlow et al. (1987) examined alternative visual estimation techniques and the effect of observer experience in a known population of chinook and coho salmon above the weir on the Big Qualicum River. Coho research at the Pacific Biological Station has been comparing visual survey methods for index sections of rivers with mark-recapture methods and weir counts (Irvine et al. 1992, English et al. 1992). The key streams for chinook salmon have been experimental in the sense of developing marking designs suited to each river and chinook population. The application of radar technology to salmon enumeration was investigated for several years and a prototype fish counter developed (contact B. Riddell, DFO).

Escapement Goals. Canadian escapement goals are interim management targets which are to be evaluated as spawning escapements increase and resulting production is monitored. One objective of the chinook key streams is to evaluate their escapement goals. Each key stream involves a coded-wire-tagged group to estimate catches and quantitative escapement estimation procedures have been established for each stream. Further, the Cowichan productivity study is intended to estimate the productivity and exploitation rate of this largely natural chinook population in the lower Strait of Georgia. This program commenced in 1988 and will continue at least through 1998.

Parameter Estimation. Studies have been conducted to determine the encounter rates of sublegal chinook salmon in the troll fisheries and to estimate incidental fishing mortality.

Encounter rates of sublegals. Encounter rates of sublegal chinook salmon in troll fisheries were monitored through a coastwide logbook program conducted by the trollers and Salmon Assessment program of the Biological Sciences Branch. This program began in the early 1980s but was terminated in 1989. This program provided the only large scale sampling of encounter rates; however, a smaller scale test fishery continues to monitor the WCVI troll fishery (South Coast Division, Fisheries Branch, Nanaimo, Shardlow et al. 1991).

Incidental fishing mortality studies. Means to reduce the incidental catch of juvenile chinook and coho salmon and to reduce the mortality of large chinook have been investigated. Alternative mesh sizes, configurations, and colour for seine bunts were investigated during 1990 and 1991; and the feasibility of catch-and-release of chinook salmon from seine nets has been investigated 1990 to 1992 (completion in August 1992). The latter program employs sonic tags to track chinook after release to avoid the uncertainty about recovery and returns rates associated with standard external tags (reports in preparation, contact B. Riddell, DFO). Wilson and Andrew (1987) report studies of gill net hang ratio and its influence on salmon catch rates. In the Fraser River, the legal maximum hang ratio is 3:1 but in this study the incidental catch of chinook salmon was significantly less at a hang ratio of 2.5:1.

Abundance and Distribution. Wild chinook smolts emigrating from the natural system of the Big Qualicum drainage have been enumerated and coded-wire-tagged for the past 2 years. Relative survival of hatchery and wild chinook from the Cowichan River will be monitored as part of the Cowichan productivity study. Daily growth patterns on otoliths will be used to identify hatchery and wild smolts.

Stock Composition. Several programs are developing methods for identifying stocks of chinook salmon. Electrophoretic sampling of populations throughout British Columbia has been on-going since about 1987. Most of these samples have been collected and processed through collaborative programs between the DFO, the NMFS, and the stock identification laboratory of the Washington Department Fisheries (WDF) (contact B. Riddell, DFO, for more information). Results of these surveys are included in the coastwide chinook baseline. This information has not been routinely applied to mixed-stock fishery applications but the spring 1992 troll fishery along the west coast of Vancouver Island was sampled. Research at the Pacific Biological Station in Nanaimo is investigating the use of nuclear DNA in identifying chinook stocks (contact R. Withler or T. Beacham, DFO).

Assessment and Refinement of Coded-Wire-Tag Methods. Emphasis has been on examining the accuracy of coded-wire-tag data and on developing measures of precision for this data (Schnute et al. 1990, Schnute 1992). Elemental marking research in Canada was initiated to develop a permanent mark for investigating coded-wire-tag data (Dr. T. Mulligan, Pacific Biological Station, Nanaimo; or K. Pitre, S.E.P., Vancouver). Research has been directed at identifying elements to mark scales with, how to mark the fish, and how to detect the mark. Detection capability held up this work but has now been resolved. Examination of mark recovery rates were referred to above. This investigation demonstrated that significant numbers of marks can be missed even when sampling at hatchery racks. Procedures to double check sampling have apparently eliminated this problem.

Effects of Harvest Regulations. The seine fishery investigations referred to above provided detailed information on the dynamics of these fisheries and the catch of chinook salmon by seine set. These data were the basis for recommending effort reductions in proportion to the harvest rate reductions required for chinook conservation. In the Strait of Georgia, hooking mortality studies on chinook and coho salmon were implemented to provide mortality rates specific to recreational fishing. Further, these programs now collect length-at-age data for the total population of chinook and coho vulnerable to sport and troll gear being used to collect samples. The latter was needed to evaluate size distributions relative to recent changes in size limits in sport and troll fisheries.

Alternative Marking Techniques. The use of elemental marking and identification of hatchery versus wild chinook via daily growth rings on otoliths have both been referred to above.

Enhancement. The possible interaction of hatchery and wild chinook is being investigated in the Cowichan River, southeastern Vancouver Island. Chinook spawning escapements to this river were very depressed in the mid-1990s. As part of a recovery plan for chinook in the lower Strait of Georgia, hatchery production of chinook in the Cowichan River was substantially increased. Relative survival of the hatchery and wild chinook is being monitored through coded-wire-tagging and identification of chinook based on daily growth rings in the otolith. Smolt production and total adult returns to the river are being estimated (project leader is B. Riddell).

Miscellaneous Research. Several additional research programs of interest are listed here.

Marine mortality of chinook. Three large research programs are investigating the early marine distribution and survival of hatchery and wild chinook salmon. Predator response and predation rates have been studied for the Big Qualicum chinook. Distribution, predation rates, and survival of Robertson Creek chinook has been investigated for several years in Barkley Sound. Distribution, seasonal growth, and predation on chinook in the Fraser River plume is also being investigated.

Database development. Extensive effort through the 1980s was directed to developing electronic databases for salmon stock assessment and documentation of these databases. Historical databases at the Pacific Biological Station have now been established for commercial catch, salmon spawning escapements, SEP releases of marked (coded-wire-tagged and fin-clipped) and unmarked salmonids, coded-wire-tag recoveries and sampling in commercial and sport fisheries coastwide. System documentation and access software has been documented for each system. Other databases in the Pacific Region include Native catch, Recreational catch, Strait of Georgia creel survey, and biological sampling by the MRP (since approximately 1980), and the historical database and archive of aging materials (scales, otoliths, fin rays). Historical records of effort (boat counts, days open) and hailed catch are maintained by each regional division of Fisheries Branch, and annual records of the ISCMP are maintained by the Salmon Services Unit of Fisheries Branch. Examples of annual fishery reports are listed in the Documentation Section below.

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PUGET SOUND

Chinook salmon in Puget Sound are harvested by sport, troll, and net gear in a number of directed and incidental fisheries (Figure 6). Sport fisheries occur throughout Puget Sound, troll fisheries occur in the Strait of Juan de Fuca, and directed net fisheries occur in terminal areas in which a harvestable surplus exists. The harvestable number of fish in a net fishery is typically computed by subtracting the escapement objective from a preseason or inseason estimate of abundance.

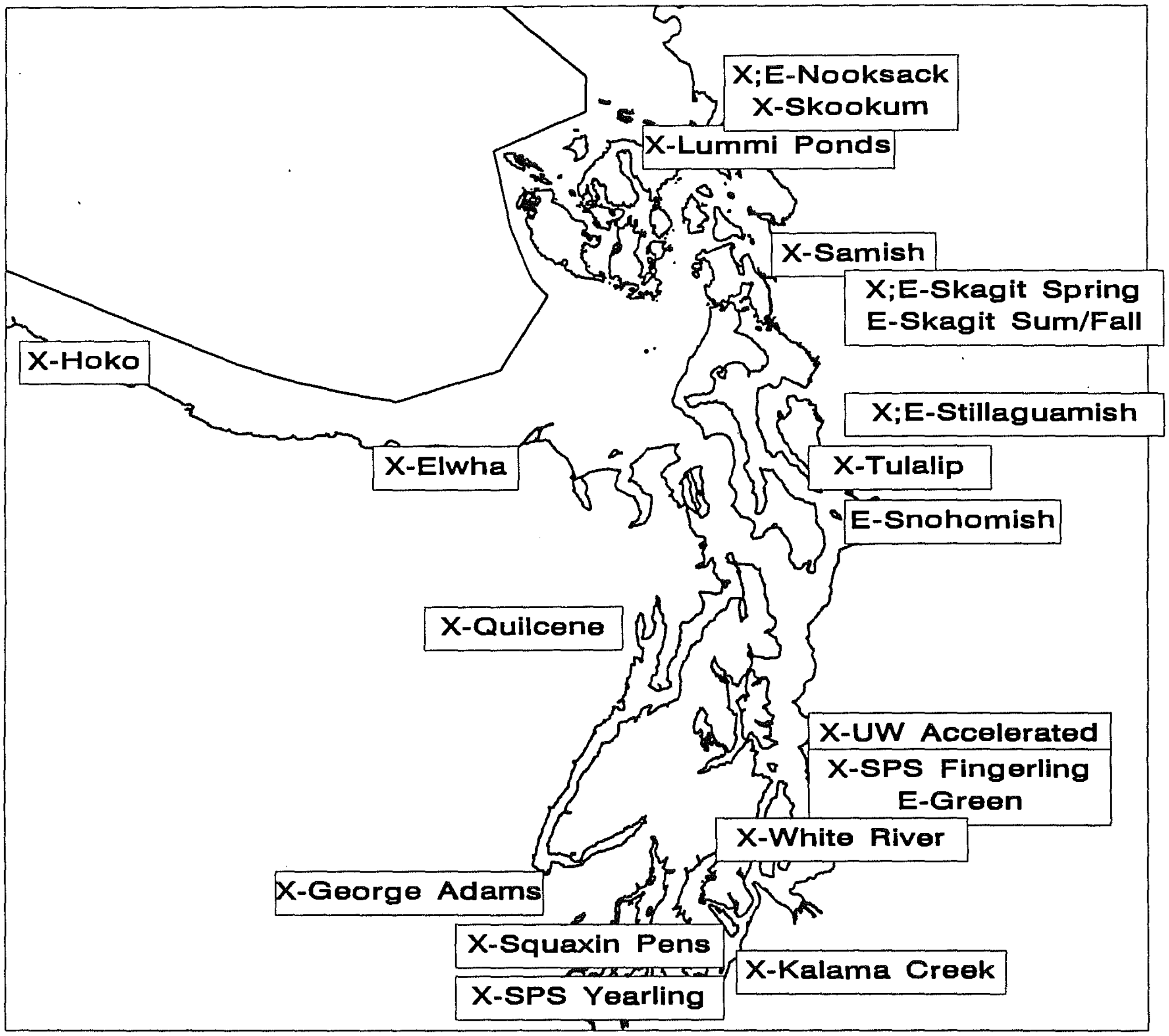

Figure 6. Location of major fishing areas in the Puget Sound area and of rivers and hatcheries where chinook indicator stocks are found.

Summer/fall chinook stocks predominate in Puget Sound although a few spring stocks exist as well. Four of the major summer/fall stocks managed for natural production are the Skagit, Snohomish, Stillaguamish, and Green River. The largest spring stocks are located in the Nooksack River and the Skagit River.

MONITORING PROGRAMS

Catch and Effort Monitoring. Inseason and postseason programs are currently in place in Puget Sound to estimate the catch and effort in troll and net fisheries. The catch in the Puget Sound sport fishery is estimated from a punch card survey. Each of the catch estimation programs is summarized below.

Commercial catch sampling programs. Inseason estimates of the commercial catch in Puget Sound rely upon the WDF Auxiliary Fish Catch Record System (AFCRS) (Sims and Wines 1992). The AFCRS uses both field samplers and tickets received from buyers to monitor the catch. Field samplers collect fish ticket information directly from dealers at dock offices, buying stations, or from buyer boats, and send the information via facsimile or telephone to the AFCRS office. Tickets which have not been tallied in the field by samplers (identified by the lack of a punch in the ticket) are added to the AFCRS when they are received. The rapidity at which the catch is added to the AFCRS depends upon the time of the year and the catch region, but for Puget Sound as a whole in 1991, 44% of the chinook catch was reported within one day of the landing, 76% within 3 days of the landing, and 96% within 7 days of the landing (Sims and Wines 1992).

Postseason estimates of catch are computed from fish tickets. State and tribal laws require the completion of a fish ticket any time a salmon is sold commercially. Once the catch data have been recorded on a ticket, it must be reviewed, edited, keypunched, and verified before it is incorporated into the final compilation of catch statistics (NWIFC 1987). The extensive verification and review process can require up to two years to complete.

Scale samples are taken from the catch in terminal net fisheries. The objective of the sampling program is to obtain 200 samples per week from each management area in which fishing occurs. Approximately 12,000 to 18,000 scales are collected per year. The age data obtained are available in a database; however, the sample data are not currently used to estimate the age composition of the catch.

Puget Sound troll catches are sampled for scales in conjunction with the genetic stock identification program. Data are currently maintained in a different database than the net fishery samples.

Sport catch punch card survey. The following summary was obtained from a WDF report (WDF et al. 1992). Since 1964, the WDF has used a punch card system to annually estimate the number of salmon harvested by sport anglers in Puget Sound. Anglers fishing for salmon are required to carry a punch card and to record on the card the location and date of any salmon caught and kept during a calendar year.

WDF attempts to sample 4% of all punch cards issued to estimate the number of salmon harvested. However, the actual sampling fraction is usually about 2.5% because some anglers do not return their punch cards, even when requested by follow-up surveys. Since 1981, WDF has annually reduced the punch card estimates of the number of salmon harvested by the marine sport fishery in Puget Sound based on evidence indicating that the punch card system consistently overestimates this harvest. This bias is assumed to be partly the result of successful anglers returning their punch cards at a higher rate than less successful anglers. Therefore, the punch cards used to estimate the sport harvest are not a representative sample of the angler population.

To address concerns about the accuracy of the punch card estimates, a joint program was initiated by WDF and the western Washington treaty tribes. The program, called the Sport Catch Estimation Study, conducted creel surveys in 16 area-month sample cells annually during the years 1987 through 1990. Results from the study indicate that the punch cards provide an unbiased estimate of the catch in Area 5 (located in the Strait of Juan de Fuca) but are biased high by approximately 46% for other areas of Puget Sound. Estimates of the sport catch for the years 1987 to 1990 have incorporated the area specific bias factors. Methods to apply the bias factor in previous years are under development. Currently, a 20% bias factor is assumed for all areas for the years 1981 to 1986. No bias correction factor is applied for years prior to 1981.

Species composition of the catch is estimated from sampling conducted at ports throughout Puget Sound. The intent of the sampling program is to obtain samples from each punch card area on a weekly basis. The percentage of the estimated catch sampled is typically less than 10%, but the percentage varies widely depending upon the area and time of year. Scales are collected from all fish sampled (approximately 18,000 per year).

Escapement Monitoring and Estimation. Estimates of natural spawning are obtained for all systems in Puget Sound (see Figure 6 for location of indicator stocks). Estimates are based on foot, float, or aerial counts and vary widely in quality. The methods utilized are briefly summarized in Table 5 for the CTC escapement indicator stocks in Puget Sound. The methods used for other stocks in Puget Sound, and greater detail for the escapement indicator stocks, may be found in Ames and Phinney (1977) and Smith (*in prep.*).

Escapement goals for the Snohomish, Green, and Skagit River fall stocks are the average escapement estimated for the years 1965 to 1976 (Ames and Phinney 1977). The escapement goal for the Stillaguamish River is the average escapement in the years 1973 to 1976 (Ames and Phinney 1977). The escapement goal for the Hoko River is based on an assumed optimum density of 12 redds per mile of stream and 3 fish per redd (Ames and Phinney 1977).

Carcasses have been sampled for scales in many systems since 1987. However, the data are not currently stored in a database and are not used to estimate the age composition of the escapement.

Skagit River spring and summer/fall. Estimates of the escapement to the mainstem Skagit River, Sauk, Cascade, and Suiattle are primarily based on counts of redds obtained from aerial surveys or foot surveys in index areas (Smith *in prep.*). In 1991, 2 to 4 surveys were conducted per stream section during the spawning period. Surveys are not conducted during the latter portion of the run in odd years because of intermingling of chinook and pink redds. In order to estimate the proportion of the redds which are missed during the aerial surveys, aerial counts and foot surveys are conducted on the same day at a number of index areas. Once the redd count data have been adjusted for the percent of the redds seen, a curve is fit using an assumed date for the start of spawning, the adjusted redd count data, an assumed date for the peak of spawning, and an assumed date for the completion of spawning. The curve is then used to estimate the total number of redds by adding the predicted number of redds (obtained from the fit curve) at 21-day intervals (assumes redds will be visible for 21 days) (Ames and Phinney 1977). The cumulative number of redds is then multiplied by 0.95 to account for false redds and by 2.5 (Ames and Phinney 1977) to account for the total number of fish per redd. Escapement to smaller tributary streams

Table 5. Escapement survey summary for Puget Sound chinook indicator stocks.

Stock	Survey Method	Expansion Factors	Jacks Counted	Age/Sex/Length	Hatchery Influence
Skagit River Spring	see Skagit Summer/Fall	see Skagit Summer/Fall	yes	age only	yes
Skagit River Summer/Fall	Aerial, foot counts of redds.	1. 2.5 fish per redd (Ames and Phinney 1977) 2. 21-day visibility period (Ames and Phinney 1977) 3. 0.05 false redds per counted redd (Ames and Phinney 1977) 4. aerial counts adjusted for missed redds based on foot surveys in index areas	yes	*	yes
Stillaguamish River Summer/Fall	Aerial, foot, boat counts of redds.	1. 2.5 fish per redd (Skagit) 2. 21-day visibility period (Skagit) 3. 0.05 false redds per counted redd (Skagit)	yes	*	supplementation program
Snohomish River Summer/Fall	Aerial, foot, boat counts of redds and live fish.	1. 2.5 fish per redd (Skagit) 2. 21-day visibility period (Skagit) 3. 0.05 false redds pre counted redd (Skagit)	yes	*	yes
Green River Fall	Aerial counts of redds.	1. 2.5 fish per redd (Skagit) 2. factor of 2.6 to account for spawning areas not quantified (unknown source) 3. aerial counts adjusted for missed redds based on foot surveys in index areas	yes	*	yes and supplementation program
Hoko River Fall	Foot and boat counts of redds.	1. 2.5 fish per redd (Skagit)	yes	age and sex only	supplementation program

* Scale samples taken from escapement but estimates of the age composition of the escapement are not currently available.

is estimated by multiplying the peak redd count by 0.95 (to account for false redds) and 2.5 (to account for multiple fish per redd). Although carcasses in spawning areas in the vicinity of the Skagit Hatchery are sampled for coded wire tags, no attempt is made to adjust the natural escapement estimate for the presence of hatchery origin fish.

Stillaguamish River summer/fall. Two techniques are used to estimate the escapement for the Stillaguamish River (Ames and Phinney 1977). For the mainstem of the Stillaguamish River and river miles 9.6 to 30.0 in the North Fork, the methodology used is identical to that previously described for the Skagit River except that actual counts were used to define the peak date of spawning. Escapement to the South Fork and tributary streams is estimated by multiplying the peak number of redds by a factor of 2.5 to account for the number of fish per redd.

A natural stock supplementation project exists on the Stillaguamish River. Each year, brood stock are collected in the river, spawned, and the resulting progeny reared and tagged at the Stillaguamish Hatchery. Brood stock removed for the project are included in the estimate of natural escapement. However, no attempt is made to separate production resulting from supplementation from production resulting from natural spawning.

Snohomish River summer/fall. Four general methods are used to estimate the escapement to tributaries to the Snohomish River are summarized below:

1) In the mainstem Skykomish and the South Fork Skykomish, the method previously described for the Stillaguamish River is used to estimate the escapement.

2) In the mainstem Snoqualmie, the number of visible redds is estimated by weekly aerial surveys. Surveys may not be conducted late in the year (mid-October) because of the limited visibility resulting from high water conditions. A visible redd curve is plotted and the area under the curve integrated with the result divided by the assumed 21 days a redd is visible. This result is multiplied by 0.95 to account for false redds and by 2.5 to account for multiple fish per redd.

3) In the Wallace River, the estimated escapement is equal to the total number of carcasses counted. Carcasses are marked after counting to prevent repeat counting on subsequent surveys.

4) In the Sultan River and the South Fork Tolt, the estimated escapement is equal to the cumulative number of redds multiplied by a factor of 2.5 (to account for multiple fish per redd) and 0.95 (to account for false redds).

5) In the Tolt River and the Raging River, the escapement is estimated by multiplying the peak number of redds by the ratio of the total Snoqualmie escapement to the peak number of redds in the Snoqualmie.

Although carcasses are sampled for the presence of coded wire tags, no attempt is made to adjust the estimate of natural escapement for the presence of hatchery origin fish.

Green River fall. Escapement to the Green River is estimated from a combination of aerial counts, float counts in index and supplemental areas, and foot surveys.

Escapement to the mainstem of the Green River is estimated through a four step process.

1) The escapement to the index area (river miles 41.5 to 43.0) is estimated by multiplying raft counts of unique redds by a factor of 2.5 to account for multiple fish per redd.

2) The escapement to the supplemental area (river miles 35.0 to 41.5) is estimated by multiplying the peak number of redds counted by the ratio of the total escapement in the index area to the peak number of redds in the index area.

3) The escapement to sections of the river with an aerial survey (river miles 29.6 to 47,0 and 56.0 to 61.0) is estimated by multiplying the peak number of redds observed in 6 flights by a correction factor to account for redds not seen from the aerial survey (estimated from areas with both an aerial survey and a float survey). The corrected number of peak redds is then multiplied by the ratio of the escapement in the index site to the peak number of redds in the index site.

4) The sum of 1), 2), and 3) is then multiplied by a factor of 2.6 (the ratio of linear miles of spawning habitat available to the spawning habitat surveyed) to account for spawning areas not counted via either an aerial or a float survey.

Escapement to Newaukum Creek is estimated from foot surveys in an index area (river miles 0.0 to 1.0) and a supplemental area (river miles 1.0 to 3.9). Escapement in the index area was estimated by multiplying the number of unique redds by a factor of 2.5 to account for multiple fish per redd. Escapement to the supplemental area is estimated by multiplying the peak number of redds by the ratio of the escapement to the index area to the peak number of redds in the index area.

Escapement to Soos Creek is estimated based on the cumulative number of carcasses observed plus the number of live fish counted on the final survey date.

Although carcasses are sampled for the presence of coded wire tags, no attempt is made to adjust the estimate of natural escapement for the presence of hatchery origin fish.

Hoko River fall. Foot and float surveys are used in the Hoko River to count spawning redds (LaRiviere 1991). During each survey, new redds were marked to prevent double counting. The escapement to the river is estimated by multiplying the total number of redds counted by a factor of 2.5 to account for the presence of multiple fish per redd.

A natural stock supplementation project exists on the Hoko River. Each year, brood stock are collected in the river, spawned, and the resulting progeny reared and tagged at the Hoko Hatchery. Brood stock removed for the project are included in the estimate of natural escapement. However, estimates of the production resulting from supplementation are available but not currently utilized.

Stock Composition Estimation. The stock composition of catches from sport and troll fisheries in the Strait of Juan de Fuca have been estimated using protein electrophoretic analysis (i.e., GSI) by WDF since 1986. Results are published in annual reports (e.g., Marshall et al. 1991). The time and area strata sampled have varied, but typically the troll fishery has been sampled from January to June and the sport fishery in the months of July and August. In 1992, the standardized GSI database contained genetic data for 196 stocks from Sacromento, California, to Southeast Alaska.

Sampling for Coded Wire Tags. Coded-wire-tag recoveries are obtained from both sampling crews (used for commercial, hatchery, and sport catch sampling) and voluntary recoveries (from the sport fishery). Consistent with the coastwide standard, the objective of the commercial sampling program is to sample 20% of the catch. However, analysis of the catch/sample data for the years 1985 through 1991 indicates that an average of 31% of the sampling strata were sampled at a rate of less than 20% and that these undersampled strata accounted for an average of 35% of the catch.

The number of coded-wire-tag recoveries in the Puget Sound sport fishery is estimated from recoveries obtained from sampling crews and from voluntary recoveries. The sampling rate for voluntary recoveries is not directly measured, but is instead computed indirectly by means of an awareness factor. The awareness factor is defined as the probability that a sport fishermen will turn in the head of an adipose-clipped fish to a designated voluntary recovery site (JTCDS 1989). The awareness factor is computed using the formula

$$A = \frac{V}{\frac{R}{S} x \,(C - S)}$$

where
V = number of voluntary recoveries,
R = number of clipped fish in survey sample,
S = number of fish in survey sample, and
C = catch in fishery.

The primary responsibility of the sampling crews is to obtain estimates of the incidence of clipped fish in the sport catch (the ratio of R to S in the equation above). There is currently not an explicit objective for the sampling rate in the sport fishery. Instead, one sampler is assigned to each of the four catch regions in Puget Sound and samples as many fish as possible. Sampling rates are in the range of 0% to 20% with an average of approximately 10%. With the inclusion of voluntary recoveries, the sample rate is estimated to be approximately 30%.

Tagging Indicator Stocks. Natural and hatchery production of chinook salmon from Puget Sound is currently represented by 15 Exploitation Rate Indicator stocks. Tagging is conducted via complementary programs of WDF, the U.S. Fisheries and Wildlife Service (USFWS), and western Washington treaty tribes. Stocks currently tagged are listed below by run type.

Spring:
- Nooksack Hatchery
- Skookum Creek Hatchery
- Hupp Springs Hatchery
- Quilcene Hatchery
- Skagit Hatchery

Summer/Fall:
- Stillaguamish River (wild brood stock collection program)

Fall:

- Lummi Sea Ponds
- Samish Hatchery
- Tulalip Hatchery
- Green River Hatchery
- Grovers Creek Hatchery
- Kalama Creek Hatchery
- George Adams Hatchery
- Lower Elwha Hatchery
- Hoko River (wild brood stock collection program)
- Squaxin Island Pens

As requested by the CTC, the Exploitation Rate Indicator Stock Program for Puget Sound has recently undergone an extensive review (Scott et al. 1992). The authors indicated that "only 4 (Samish River, Green River, Grovers Creek, and George Adams) of the stocks...are providing data of the quality required for the fishery harvest rate index." Problems identified included 1) estimates of the escapement of tagged fish are lacking, are of poor quality, or have not been provided to the PSMFC, 2) survival of tagged fish has been poor or tagging levels have been too low to provide sufficient fishery recoveries, and 3) budget cutbacks have reduced agency ability to maintain both adequate tagging and high quality escapement sampling programs.

Tagging Other Stocks. Other stocks are not tagged on a regular basis.

Monitoring Hatchery Returns. Escapement is enumerated at all hatcheries and scales are sampled throughout the return to enable estimation of age composition.

Disease Monitoring. A team of pathologists makes regular trips (every 3 to 4 weeks) to each WDF facility to inspect all fish on station and screen for a number of diseases. At USFWS facilities, there is routine disease screening during rearing as well as prior to release. The health of fish at tribal facilities is screened on a monthly basis by a team of pathologists from the Northwest Indian Fisheries Commission (NWIFC). The NWIFC pathology laboratory is also participating in the Investigation of New Animal Drug using erythromycin for the treatment of bacterial kidney disease.

Forecasting. Preseason forecasts of abundance (Puget Sound net catch plus escapement) are prepared for all stocks in Puget Sound and presented in Stock Status Reports published jointly by WDF, NWIFC, and the Puget Sound treaty tribes. The forecasts are typically not age specific and are calculated based on recent year average runs or average return rates. Average prediction errors are typically in the range of 15 to 25%.

Inseason Abundance Monitoring. Catch levels for most terminal net fisheries are based upon inseason estimates of abundance. The inseason estimates typically rely upon a relation between commercial catch or CPUE and terminal run size. In 1991, inseason estimated were used for the following summer/fall stocks or stock aggregates: Nooksack/Samish, Skagit, Green, Chambers Bay (south Puget Sound), Nisqually River, Deschutes River (south Puget Sound), and Hood Canal (WDF et al. 1991).

RESEARCH PROGRAMS

Catch Estimation Techniques. A five year program to evaluate the methods used to estimate the sport catch in Puget Sound has recently been completed. Additional information may be found in the Puget Sound Catch and Effort Monitoring section of this report.

Escapement Estimation Techniques. No pertinent research is being done on this.

Escapement Goals. In conjunction with the escapement indicator stock program, the escapement goal for the Hoko River is under review. The review will compare the assumptions and parameters used to develop the goal with data collected from the indicator stock program.

Parameter Estimation. Two efforts are currently underway to develop statistical methods to compare the survival rates and catch distribution of coded-wire-tag groups. Pascual and Hilborn (1992) have developed methods to apply generalized linear models to test for differences between stocks, brood years, or hatcheries. Newman and Comstock (1992) have developed statistical procedures for testing hypotheses concerning fishery contribution rates based on recoveries of coded wire tags.

Preliminary results are available from an ongoing study designed to estimate the mortality of fish released from sport fishing gear (Natural Resource Consultants 1991). A total of 67 chinook were captured using sport fishing gear, transferred to a net pen, and mortalities observed for a period of approximately 24 hours. Six chinook (9%) died during the observation period. An experiment with an improved sample design and increased sample size will be conducted in 1992.

Abundance and Distribution. No pertinent research is being done on this.

Stock Composition. No pertinent research is being done on this.

Assessment and Refinement of Coded-Wire-Tag Methods. WDF has investigated the rate at which coded wire tags are shed after tagging and the naturally occurring incidence of missing adipose fins (Blankenship 1990). Wand detectors are undergoing field testing by the WDF to determine if the hand held device can reliably detect the presence of a coded wire tag under field conditions (PSMFC Subcommittee on Mass Marking, *in prep.*).

Effects of Harvest Regulations. No pertinent research is being done on this.

Alternative Marking Techniques. Research has been conducted to assess the feasibility of inducing distinctive otolith banding on chinook fingerling using 5 day periods of feeding and starvation. Volk et al. (1990) reported that the feeding regime produced areas of high and low density within a well defined otolith region and caused less than 2.5% mortality.

The WDF is also investigating the potential for using a laser to produce a mark on juvenile chinook. The laser destroys skin pigments, producing a clear area which is visible with the naked eye (PSMFC Subcommittee on Mass marking, *in prep.*).

Enhancement. A new technique for rehabilitating natural production will be evaluated in the Dungeness River. In order to maintain genetic diversity and limit the number of brood stock collected, fry will be collected from a number of redds and reared in a hatchery prior to release back into the river.

Miscellaneous Research. None.

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WASHINGTON COAST

The Washington State Department of Fisheries (WDF) manages Washington's chinook stocks cooperatively with treaty Indian tribes and Federal entities. Major fishing areas are shown in Figure 7. The Pacific Fisheries Management Council (PFMC) establishes total allowable catches of chinook and coho in the ocean areas off Washington, Oregon, and California, including the area between Cape Falcon, Oregon, and the U.S./Canada border, based upon predicted impacts on stocks of concern (PFMC 1992). WDF monitors the ocean fisheries off its coast so as not to exceed the quotas established for commercial and recreational fisheries.

The following is a brief description of those Washington coastal chinook stocks that receive management attention, and how they are managed (Anonymous 1991). Five natural chinook stocks on the Washington coast are managed for a specific harvest rate with an escapement floor. These are: <u>Queets Spring/Summer</u>, <u>Queets Fall</u>, <u>Hoh Spring/Summer</u>, <u>Hoh Fall</u>, and <u>Quillayute fall</u>. These stocks are managed to achieve a maximum total inriver harvest rate of 0.30 to 0.40 (depending on the stock), provided escapements do not fall below the floor. Inriver harvest occurs in both treaty Indian gill net fisheries and recreational fisheries. Initial gill net fishing schedules (number of fishing days per week) are set using preseason run-size forecasts. For some stocks, inseason run-size updates are made part way through the season, based on catches from the early weeks of the fishery. These updates are used to manage the remainder of the season. When needed, regulations are implemented during chinook directed fisheries to minimize impacts on depressed coastal coho stocks. All other chinook stocks on the Washington coast (Quinault spring/summer, Quinault fall, Quillayute spring and summer, Grays Harbor spring, Grays Harbor fall, and Willapa) are managed for a fixed escapement goal.

MONITORING PROGRAMS

Catch and Effort Monitoring. The following Washington catch and effort monitoring programs are currently in place:

Ocean sampling programs. The WDF Ocean Sampling Program (OSP) performs sampling of the Washington ocean recreational bottomfish, halibut, sturgeon, albacore, and salmon fisheries as well as commercial salmon troll fisheries (Moore et al. 1991). Because the ocean salmon fisheries are managed for quotas, OSP gathers data used to develop daily or weekly estimates of catch and effort. Washington state law requires that all commercial salmon landings be recorded on a standard WDF fish ticket, to be filled out by the buyer. State law requires that these fish tickets be mailed to WDF within 24 hours of landing; they are then entered into the WDF Auxiliary Fish Catch Recording System (AFCRS). In practice, there is often a delay in receiving tickets and data in AFCRS are up to two weeks out of date.

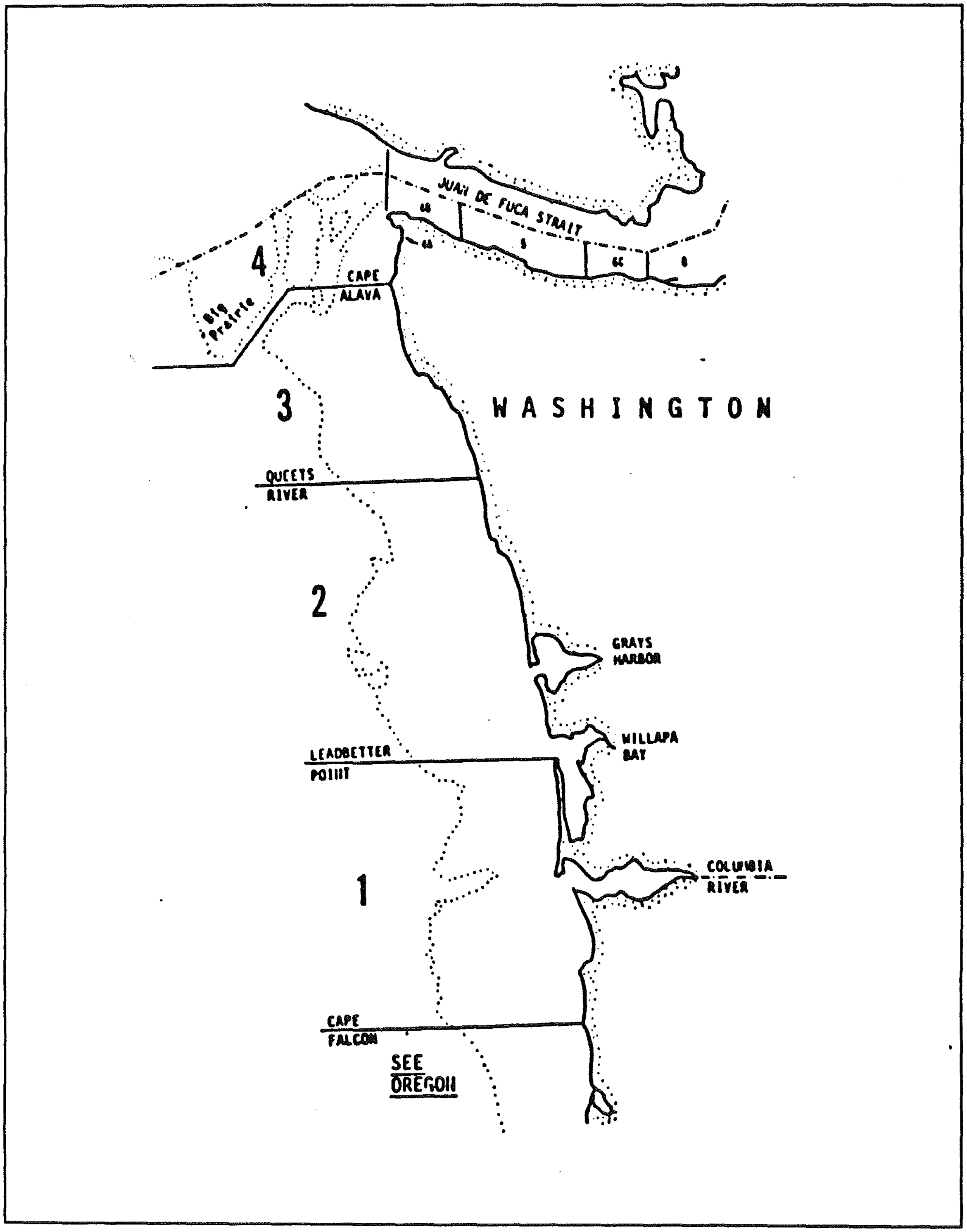

Figure 7. Major fishing areas off the coast of Washington.

For inseason monitoring of each troll fishery, OSP relies on the AFCRS for landing estimates until the fishery is predicted to be within two weeks of closing. At this time, the program switches to a "key buyer" system. During key buyer periods, the program attempts to collect all fish ticket information daily from every buyer in a given port, and uses this information to generate real-time catch estimates. After the season, final commercial catch and effort estimates are made using the WDF fish ticket data system. Catches are reported in both numbers of fish and numbers of pounds, and effort is reported in number of days fished (boat-days). No distinction is made between chinook directed effort and effort directed at other species.

For inseason monitoring of recreational fisheries, OSP conducts daily counts of all boats leaving the ports (port exit counts) to estimate effort, and obtains creel census data from returning boats to estimate catch (Lai et al. 1991). Because catch success differs between private and charter fishing boats, separate catch and effort statistics are calculated for each. At the landing site, samplers randomly select a portion of the incoming charter and private boats and conduct interviews. The samplers record: trip type (e.g., salmon, halibut, sturgeon, nonfishing), fishing area, boat type (i.e., charter or private), number of anglers onboard, and catch by species. These data are expanded by the daily port exit counts and used to produce catch estimates. Effort is measured both in number of boat trips and in number of angler trips. Although there is a recreational punch card system in place that includes Washington ocean areas, OSP recreational catch and effort estimates are considered superior and are used postseason instead of punch card estimates.

There is no significant catch of chinook (< 100 fish) in Washington ocean net fisheries.

Freshwater sampling programs. Sport catch on the coastal rivers is not currently monitored inseason. Postseason catch estimates are made using the WDF punch card system. Final sport estimates are generally not available until two years after the fishery. Commercial gill net catch is monitored inseason by tribal fish ticket systems. After the season, these numbers are reconciled with the WDF fish ticket catch numbers to produce final catch estimates for each river.

Escapement Monitoring and Estimation. Natural spawning escapements are estimated for the following chinook stocks: Queets spring/summer, Queets fall, Hoh spring/summer, Hoh fall, Quillayute summer, Quillayute fall, Grays Harbor spring, Grays Harbor fall, and Willapa Bay fall (Figure 8). The Willapa Bay fall stock is managed for hatchery production and is not used as a CTC escapement indicator stock.

For the Washington coast, redds are used as the measure of spawner abundance since redds can be observed with greater reliability than fish on coastal streams that have frequent freshets and associated turbid water conditions. The general methods used to estimate coastal escapements are described below:

- Weekly foot surveys are performed on index streams within the system.
- Redds are marked and cumulative counts are made within the index areas.
- Information on stream flow, visibility, numbers of live and dead fish by sex and numbers of jacks are also collected.
- During peak spawning times, additional surveys are performed in supplemental areas.
- Redd counts in the supplemental areas are expanded for the season using data from associated index areas.
- Index and supplemental redd data are converted to redds per mile and then expanded over unsurveyed areas considered usable by chinook.

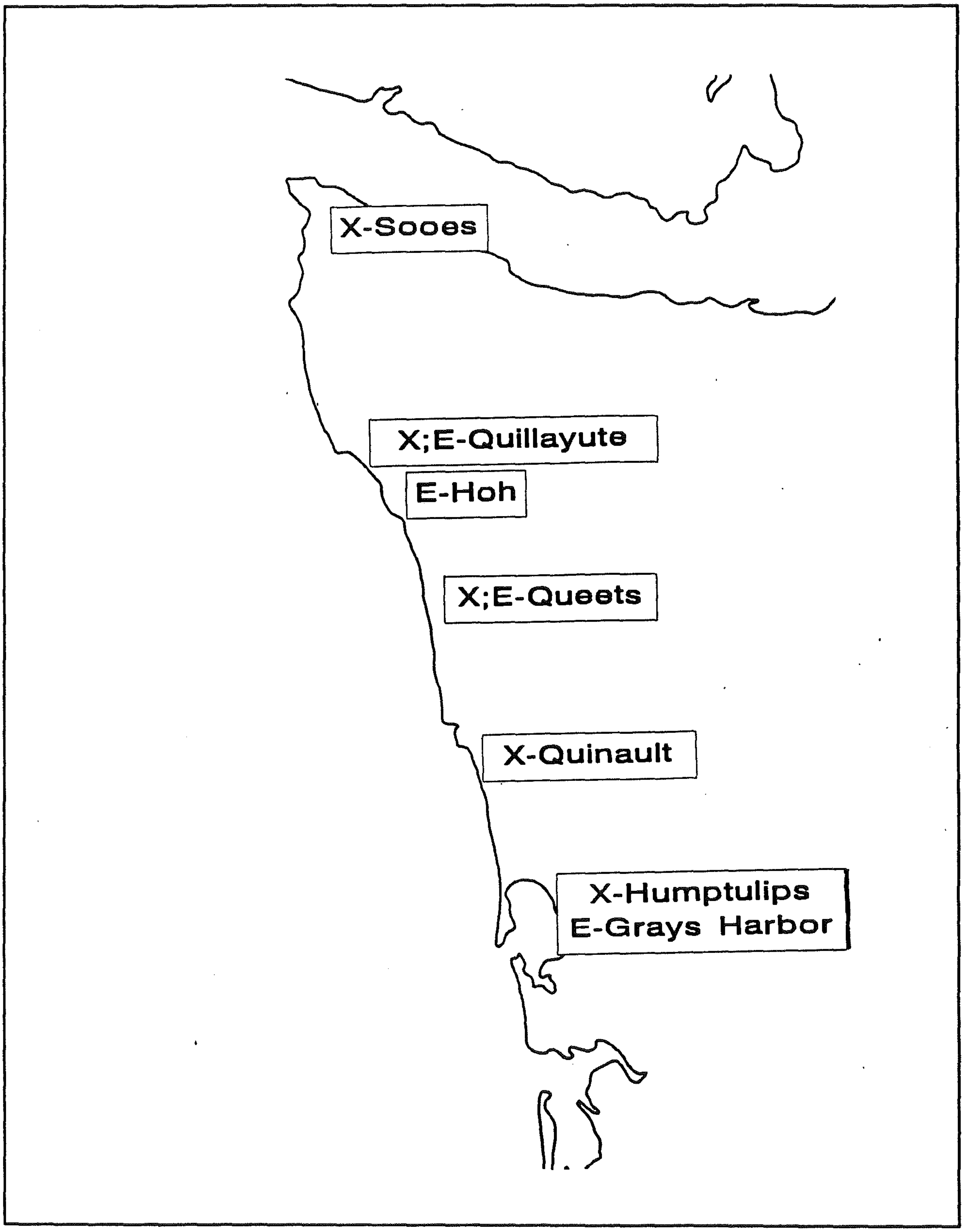

Figure 8. Location of the chinook escapement indicator stocks on the Washington coast.

- Specific unsurveyed areas are associated with representative index or supplemental areas.
- An average of 2.5 chinook per redd is used to calculate total spawners.
- No variance estimates are calculated.

Typically, WDF and tribal workers make independent escapement estimates for each watershed. Any differences are reconciled through a series of discussions before final estimates are generated. Additional information regarding the methods used for each of the Escapement Indicator Stocks may be found in Table 6.

Stock Composition Estimation. WDF produces yearly GSI stock composition estimates of catches in ocean troll fisheries.

Sampling for Coded Wire Tags. The following Washington coded-wire-tag monitoring programs are currently in place:

Ocean sampling. WDF's OSP performs sampling for coded wire tags in ocean commercial and recreational fisheries. Sampling rates are generally high, well above the agreed upon minimum of 20% for most fisheries (e.g., 33 to 60% in 1989) (Markey et al. 1991). One exception to this is the ocean treaty Indian troll fishery in Westport, which has been consistently sampled below the 20% level (12% in 1989). This undersampling occurs because the landings in this fishery are small and occur unpredictably. Analysis of the catch/sample data for the troll fishery in the years 1985 through 1991 indicates that an average of 33% of the sampling strata were sampled at a rate of less than 20% and that these undersampled strata accounted for an average of 26% of the catch.

The scale and length sampling goal in ocean fisheries is a 20% minimum subsample of the total number of chinook sampled (WDF 1992). Small fisheries are sampled at a higher rate. These sampling goals have generally been exceeded for ocean fisheries.

Freshwater sampling. On the Quillayute, Queets, Hoh, and Grays Harbor systems, chinook sampling for age, length, and coded wire tags occurs in the commercial fishery. The sampling goal is 20% of the commercial catch in Grays Harbor, 30% on the Quillayute and Queets, and 67% on the Hoh. The actual sample levels generally exceed these goals. Expansion factors for commercial catches from the Hoh River have not been reported to PSMFC at this time. Sampling of ceremonial and subsistence (C&S) catch occurs when that catch is made available to samplers.

Tagging Indicator Stocks. North Washington coastal summer and spring/summer production is represented by the Quillayute River summer brood stock program. Brood stock are collected from the Bogachiel and Soleduck Rivers, reared, tagged, and released in the Soleduck River. The brood stock collection program has been in place since 1987; tagging of the 1985 and 1986 brood years relied upon fish that returned to the hatchery. The utility of this program is compromised by problems with potential brood stock contamination by spring run fish, poor escapement estimation, and insufficient tagging.

North Washington coastal fall production is represented by CTC indicator stocks at the Makah National Fish Hatchery, the Quinault National Fish Hatchery, and the Queets River brood stock program. Currently, none of these programs provides an adequate indicator stock due to poor escapement estimation, low survival, insufficient tagging, and lack of base period data. Options for improving data or developing an alternative indicator stock for this region are under consideration.

Table 6. Estimation techniques for escapement indicator stocks from the Washington Coast.

Stock	Survey Method	Expansion Factors	Jacks Counted	Age/Sex/Length	Hatchery Influenced
Queets River Spring/Summer	foot counts of redds	2.5 fish per redd	yes	age only	none
Queets River Fall	foot counts of redds	2.5 fish per redd	yes	age only	yes and supplementation program
Hoh River Spring/Summer	foot counts of redds	2.5 fish per redd	yes	age only	none
Hoh River Fall	foot counts of redds	2.5 fish per redd	yes	age only	yes
Quillayute River Summer	foot counts of redds	2.5 fish per redd	yes	age only	yes and supplementation program
Quillayute River Fall	foot counts of redds	2.5 fish per redd	yes	age only	yes
Grays Harbor Spring	foot counts of redds	2.5 fish per redd	yes	age only	none
Grays Harbor Fall	foot counts of redds	2.5 fish per redd	yes	age only	yes

South Washington coastal fall production is represented by the Humptulips hatchery stock. As with the North coastal stocks, the utility of Humptulips as an indicator stock is hampered by poor survival and unreliable escapement estimates.
Good quality escapement estimates are lacking for almost all existing Washington coastal indicator stocks. Escapement of most stocks is estimated at the hatchery rack, with no organized effort made to sample for hatchery strays. Since, in many cases, straying is know to be a substantial problem, escapement estimates are considered unreliable. For the Queets brood stock program, redd counts are used to get a total escapement estimate, and sampling is performed to determine the proportion of tagged fish. These estimates have not yet been reported to the PSMFC and their accuracy and precision is unknown.

Tagging Other Stocks. No regular tagging of other stocks is being done.

Monitoring Hatchery Returns. At both WDF (Humptulips) and USFWS (Makah and Quinault) facilities, every adult fish returning to a hatchery is sampled for an adipose fin clip. If an adipose fin clip is present, then the fish is sexed, the fork length is measured, and the snout is removed. Because there is 100% sampling for tagged fish, the tagged to untagged ratio can be calculated for fish returning to the hatchery. However, due to straying, total escapement estimates for tagged fish are generally not available. As such, the tagged to untagged ratio for the total return is not available.

Disease Monitoring. A team of pathologists makes regular trips (every 3 to 4 weeks) to each WDF facility to inspect all fish on station and screen for a number of diseases. At USFWS facilities, there is routine disease screening during rearing as well as prior to release.

Forecasting. Preseason run-size forecasts are made for Queets spring/summer, Queets fall, Hoh spring/summer, Hoh fall, Quillayute spring, Quillayute (all run types), Grays Harbor spring, and Grays Harbor fall chinook stocks. Preseason forecasts are generally derived from recent year average run sizes or some combination of recent year average run sizes and cohort analysis. For some stocks, preseason forecasts are not very accurate, and are only used to set initial seasons. Inseason run-size updates are made for Queets fall, Hoh spring/summer, Hoh fall, Quillayute spring, Quillayute (all run types), and Grays Harbor fall chinook stocks. For these stocks, actual catch levels are set based on these inseason updates, which are derived from catches in the early weeks of the gill net fisheries. Some inseason updates are considered fairly accurate, while others do little to improve on the preseason forecast.

Inseason Abundance Monitoring. None

RESEARCH PROGRAMS

Catch Estimation Techniques. The WDF OSP recreational catch sampling program was recently evaluated, with variances calculated for catch and effort estimates. Estimates from all ports were found to be extremely good, with coefficients of variation less than 0.05 (Han-Lin Lai, unpublished data).

A WDF Biometrician is currently undertaking a statewide review of all Washington sampling programs, with the intent of improving efficiency and reducing costs, while achieving adequate levels of accuracy and precision. The review will cover programs that sample for: catch and effort, biological data, and coded-wire-tag recoveries.

Escapement Estimation Techniques. Several projects have been performed for both chinook and coho (for which the same escapement estimation technique is employed), aimed at validating the escapement estimation methodology. Some small scale experiments have involved transporting hatchery fish near spawning condition into stream reaches above anadromous barriers, then comparing escapement estimates with known numbers of spawners. Other more extensive projects have involved trapping fish, counting them, and passing them upstream of a weir or fish ladder. The results have generally demonstrated high accuracy of the method on small to medium sized streams where information on the total mileage of used habitat is fairly good. Estimation is much more difficult in mainstem habitat, and it is assumed that estimates in these areas are much less accurate.

Escapement Goals. Currently, five of the Washington coastal natural chinook stocks are managed on a harvest rate/escapement floors basis. One objective of this management system is to provide sufficient variation in escapements to define a spawner recruit relationship. The spawner recruit relationship could then be used to estimate the optimum escapement.

Parameter Estimation. No pertinent research is being done on this.

Abundance and Distribution. The Queets River fall chinook brood stock tagging program is designed to provide catch distribution and harvest rate data that are representative of natural fall stocks from the north Washington coast. Studies have been completed comparing the characteristics of tagged and naturally produced fingerlings in the Queets River. Naturally produced fingerlings were found to have a size distribution similar to that of tagged fish reared at the hatchery, and the date of release for hatchery fish is specifically designed to coincide with the outmigration of the natural stock.

Stock Composition. No pertinent research is being done on this.

Assessment and Refinement of Coded-Wire-Tag Methods. As described above, a WDF Biometrician is currently undertaking a statewide review of the coded-wire-tag sampling program.

Effects of Harvest Regulations. No pertinent research is being done on this.

Alternative Marking Techniques. WDF, in cooperation with Northwest Marine Technology, has been investigating the use of fluorescent microtags as visible mass marks for salmon. There are two parallel techniques presently available, one using fluorescent tags and the other using fluorescent silicone. An experiment is currently being performed with Grays Harbor coho to test the utility of these tags. If returns of both the hatchery and natural stock are sufficiently high, it may be possible to test a limited selective fishery on the marked coho in 1993.

Enhancement. No pertinent research is being done on this.

Miscellaneous Research. The U.S. Fish and Wildlife Service is performing an extensive review of the Grays Harbor watershed, as an initial step in developing a restoration plan (J. Hiss, pers. comm.).

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COLUMBIA RIVER

Since 1969 management of Columbia River fisheries has been under federal court jurisdiction. Fish management plans were developed in 1977 and 1985. The purpose of the Columbia River Fish Management Plan (CRFMP) is "to provide a framework ... to protect, rebuild, and enhance upper Columbia River fish runs while providing harvests for both treaty Indian and non-Indian fisheries" (U.S. District Court 1988, p.2). The CRFMP specifies commercial season timing, catch limits, and maximum incidental impacts for anadromous fish runs of the upper Columbia River (above Bonneville Dam). Figure 9 shows the major chinook fishing areas and the location of the natural spawning and hatchery indicator stocks on the Columbia River.

Spring chinook entering the Columbia River include stocks destined to spawn in the lower river (mostly Willamette River stocks) and stocks heading upriver (above Bonneville Dam). The lower river spring chinook stocks are managed for hatchery production. The majority of current production from upriver spring chinook stocks is also from hatchery production. The lower river fisheries are designed to target Willamette stocks, allowing for run timing differences between lower river and upriver stocks. In recent years, the incidental commercial catch of upriver spring chinook has been very small due to the depressed state of the upriver run (TAC 1991). Allowable harvest of the upriver run is managed according to the CRFMP. The last target commercial fishery for upriver spring chinook was in 1977. Tributary fisheries are managed by the respective state agencies. The Snake River component of the upriver spring chinook run has been listed as threatened under the Endangered Species Act (ESA).

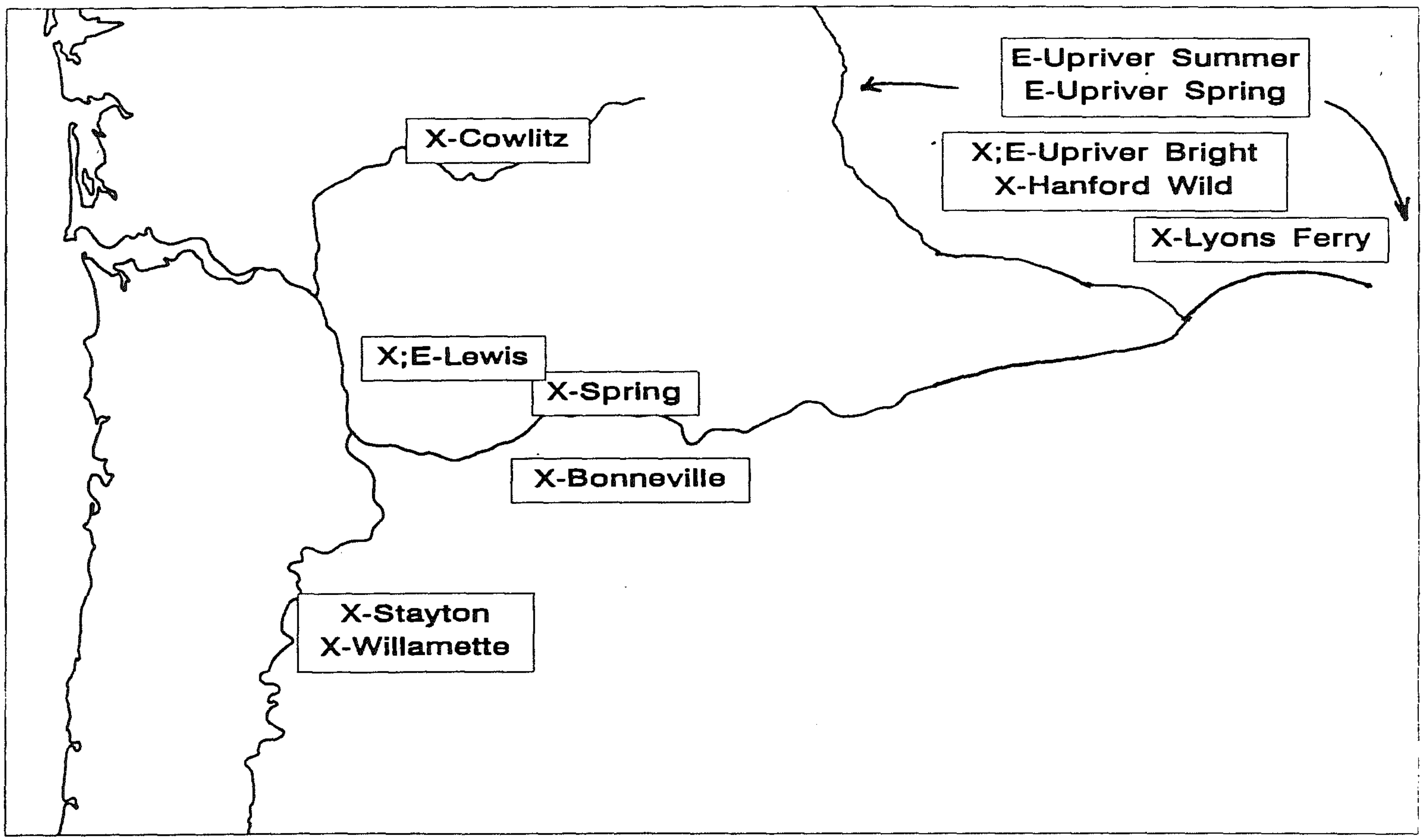

Figure 9. Fishing areas and location of naturally spawning and hatchery indicator stocks on the Columbia River.

Summer chinook have not been targeted commercially in the Columbia River since 1964 due to very depressed run sizes. Summer chinook originate above Bonneville Dam and are from both natural and hatchery production, with a slight predominance of hatchery fish at present. The Snake River component of the summer chinook run is also listed as threatened under the ESA.

Fall chinook are the primary run harvested commercially inriver. They are managed as 5 stocks based on area of origin: Lower River Hatchery (LRH), Lower River Wild (LRW), Bonneville Pool Hatchery (BPH), Mid-Columbia Brights (MCB), and Upriver Brights (URB). The LRH stock is comprised of hatchery populations below Bonneville Dam. The LRW stock is produced mainly in the Lewis River, with smaller components from the Cowlitz and Sandy Rivers. The upriver fall chinook run is comprised of stocks returning above Bonneville Dam including BPH, URB, and a portion of the MCB production and is subject to treaty allocation requirements. The BPH stock is produced at Spring Creek National Fish Hatchery in the Bonneville Pool and is managed solely for hatchery escapement. The URB stock, including Deschutes River and Snake River fall chinook, is mainly natural production from the Hanford Reach and is managed for an escapement goal of 40,000 adults past McNary Dam. The Snake River fall chinook component of upriver brights has been listed as threatened under the ESA. The MCB stock is a bright hatchery stock reared and released in several locations below McNary Dam.

Tagging of exploitation indicator stocks for upriver spring chinook stocks and Snake River summer chinook stocks began only recently in the mid-1980s and a full brood cycle of recoveries is not yet available for analysis. Snake River fall chinook from Lyons Ferry Hatchery and the large wild component of Columbia Upriver bright fall chinook from the Hanford Reach have only been tagged for 7 and 5 years respectively. Lower river hatchery spring chinook and hatchery tule and upriver bright fall chinook have had tagging since the mid-1970s.

Reliable estimates of terminal run sizes and inriver harvest rates are readily available over a long time series for several stock groups because of a long history of dam counts, coded-wire-tag and catch data from inriver fisheries (TAC 1991). Exploitation rates for Columbia River chinook stocks in ocean fisheries are less well defined, especially for upriver spring chinook stocks and Snake River summer chinook stocks.

MONITORING PROGRAMS

Catch and Effort Monitoring. Catch estimation techniques for the Columbia River are well established, although the reliability of estimates in some fisheries is unknown.

Commercial catches in the lower river fisheries are identified as being from one of five areas (Zones 1 to 5). Catches above Bonneville and up to McNary Dam (Zone 6) are being identified according to pool (e.g., the Bonneville pool upstream of Bonneville Dam). Inseason Columbia River commercial catches are tracked by sampling key buyers by telephone on a daily basis during the season. Weights of landed catches are accumulated for all major buyers, and then expanded by 5% to account for fish sold to small or unknown buyers. Average weight data are available from a random sampling program which scans 20% of the catch for coded wire tags, and obtains subsamples of scales, tissue for GSI, etc. Catch in numbers of fish is estimated from the average weight data and the estimates of pounds of fish bought from the key buyer interviews. This inseason technique usually results in catch estimates very close (+/- 5% to 10%) to postseason estimates, which use the average weight data and the poundage on the fish tickets to determine catch in numbers. WDF and the Oregon Department of Fish and Wildlife (ODFW) each check their fish tickets for identifiable errors in species caught, areas fished, etc., and have their data compiled by the beginning of the calendar year following the fishing season. By May, the data are merged into a single database by ODFW for use by both states and the PSMFC.

Effort monitoring of the Zone 6 net fisheries is performed by weekly flights overhead to count the number of nets fishing. Combined with catch data, this effort information provides a catch rate that aids managers in developing fishing season regulations.

All recreational catches in the Columbia River are subject to a punch card system where sport fishermen voluntarily turn in a record of their catch (usually when they buy the next year's fishing license) to any fishing license vendor or the fisheries department. The punch cards are therefore not available for a year or more. The official postseason punch card estimates for the mainstem Columbia River below McNary Dam are of limited usefulness because each state develops estimates for only its own fisherman, and these estimates are often not complete until 2 years after the season.

Creel census surveys have been established to provide better weekly, monthly or season catch estimates for major sport fisheries, especially for the Buoy 10 sport fishery. Landings are sampled regularly on both the Washington and Oregon sides of the river, and the data are jointly collated to provide estimates throughout the season. There is greater confidence in the creel census data than in the punch card data; therefore, the creel census data, where available, are generally used by managers, even postseasonally. Creel census data do not provide estimates for all areas and times.

Catch accounting and reporting of C&S fisheries are a responsibility of the participating tribes. In the past, inseason and postseason accounting of catch has not been as comprehensive as for other Columbia River commercial and recreational fisheries, because the fishery is highly dispersed temporally and spatially. Recently, a creel census was initiated and data for these fisheries are improving.

Escapement Monitoring and Estimation. Four Columbia River chinook stocks are currently used in the CTC escapement assessment. These include upriver spring chinook (TAC 1991), upriver summer chinook (FCO/WDF 1971), upriver bright fall chinook (TAC 1982) and Lewis River wild fall chinook (McIsaac 1990). A summary of the escapement survey methods used are presented in Table 7.

Estimates for the CTC escapement assessment of these stocks are developed from counts at Bonneville and McNary Dams, adjusted (reduced) for impacts of fisheries occurring upstream from the enumeration point. Escapement of spring and summer chinook are estimated at Bonneville Dam by expanding fish counts taken for 50 minutes per hour by 1.2 and by assuming there is no night passage. The escapement of upriver bright fall chinook is estimated in the same way, but at McNary Dam. A CRITFC escapement estimation study is currently being conducted for Deschutes River upriver bright fall chinook. Spring and summer chinook escapement into the Wenatchee River tributary of the upper Columbia River is being estimated using video tape technology (Hatch et al. 1992).

Since Columbia River returns are a mixture of hatchery and naturally produced fish, an estimate of the natural component of the return is preferable to the total dam count for evaluating the response of naturally spawning chinook to Treaty management actions. Upriver spring and summer chinook returns currently are predominately hatchery fish, whereas the fall chinook escapement at McNary Dam is predominated by natural spawners from the Hanford Reach area. For upriver spring chinook, an estimate of natural chinook escapement is developed from coded-wire-tag analysis, passage loss estimates and upstream fishery and hatchery returns. Upriver summer chinook and bright fall chinook are currently

Table 7. Estimation techniques for Columbia River escapement indicator stocks.

Stock	Survey Method	Expansion Factors	Jacks Counted	Age/Sex/Length	Hatchery Influence
Upriver Springs	Bonneville Dam Count	actual counts are made 50 minutes each hour; counts are multiplied by 1.2 to estimate total passage (COE 1991). It is assumed there is no fish passage between 20:00 and 04:00 hours.	yes	yes	large
Upriver Summers	Bonneville Dam Count	same as for Upriver Springs	yes	yes	large
Upriver Falls	McNary Dam Count	same as for Upriver Springs	yes	yes, but from catch	small
Lewis River Wild	Peak Carcass Counts	peak counts (both live and dead fish) are expanded by a factor of 5.27 to estimate total spawners (Hymer 1990)	yes	yes	very small

still aggregated as a total count of hatchery and natural fish but would benefit from separate estimates of the natural components. All Snake River hatchery produced chinook will be marked beginning with brood year 1991 releases, and returns of wild and hatchery produced fish can be enumerated separately at Snake River dams beginning with 1995 and 1996 returns.

For exploitation rate indicator stocks, escapement estimates for tagged fish is needed. Sampling rates are low (roughly 5%) for Hanford Reach spawners, and tagging goals have not been met in recent years due to difficulties in collecting fish. Exploitation rate estimates would be improved if the escapement sampling rate or tagging rate were increased.

Age composition and length-at-age data are collected for upriver spring (Fryer et al. 1992a) and summer (Fryer and Schwartzberg 1992) chinook at Bonneville Dam. However, sex determination at this point in their upstream migration is not possible for most stocks. Fall chinook age and length data are collected in conjunction with random catch sampling for coded wire tags. In addition, age and sex composition and length data are collected on the spawning grounds and at hatcheries for a number of individual stock components for upriver spring, summer and fall chinook and for lower river stock components.

Stock Composition Estimation. Since fisheries in the Columbia River are terminal in nature, there are no interceptions of chinook not produced in U.S. waters.

Stock composition estimates of Columbia River mixed stock fisheries used in run reconstruction analysis are determined by several techniques. These include coded-wire-tag analysis, GSI analysis, and visual stock identification (VSI) according to skin color, in addition to differential run timing and area of origin factors.

VSI sampling is used to distinguish Willamette spring chinook from upriver spring chinook inseason. GSI sampling is used to obtain inseason stock composition estimates for spring chinook fisheries to distinguish Willamette River, upper Columbia River and Snake River spring chinook stocks (ODFW and WDF 1992). VSI at Bonneville Dam is used to separate tule and bright fall chinook inseason. GSI can also separate tule and bright fall chinook.

Coded-wire-tag data from both commercial and test fisheries are also used for inseason stock composition of fall chinook. Daily and seasonal total dam counts, GSI data, coded-wire-tag data, and VSI sampling of the fish passing the observation windows also provide information for run reconstruction. Run reconstruction is used to further develop postseason stock composition estimates.

Sampling for Coded Wire Tags. Tag recovery programs are in place for all major Columbia River fisheries and escapements. Fisheries are sampled for coded wire tags at a target rate of 20% with the actual rate often substantially exceeding this target in the commercial gill net fisheries. However, the target goal is not always achieved in the sport fisheries due to temporal and spatial spread of small impacts. A funding proposal to increase the level of sampling in the mainstem Columbia River sport fisheries has recently been approved to address this situation. In addition, naturally spawning fish are sampled for coded wire tags in spawning ground surveys where natural fish are tagged and in natural spawning areas adjacent to hatcheries to get as complete a recovery of tags as possible (Hymer 1990).

Tagging Indicator Stocks. A number of stocks are coded-wire-tagged on an annual basis for use in the exploitation rate analysis. Spring Creek fall chinook, lower river hatchery fall chinook (Cowlitz and Stayton Pond), Lewis River wild fall chinook, Priest Rapids fall chinook, Hanford Reach wild fall chinook, Willamette system spring chinook and Lyons Ferry fall chinook have a long enough historical record of tagging to be useful in current exploitation rate analyses. Wells summer chinook were previously an exploitation rate indicator stock but have not recently been used due to changes in hatchery practices producing a stock more similar to fall chinook. It should be determined whether their ocean distribution remained constant before they continue to be used as an exploitation indicator stock. If not, a new source of data representing Columbia River upriver summer chinook should be developed. Tagging of upriver spring chinook and Snake River summer chinook has been ongoing to represent these stock components. Several more years of recovery data are necessary before these stocks can be incorporated into the exploitation rate analysis. Coded wire tags are being applied at the rate of approximately 200,000 tagged fish per release group except that Idaho was tagging at the rate of approximately 300,000 fish per stock to account for the higher juvenile passage mortality experienced by their stocks. Tagging rates of indicator stocks in Idaho were increased beginning with brood year 1991 fish as a result of the need to mark all hatchery-produced chinook in the Snake River basin.

Tagging Other Stocks. Hatchery production is usually represented by some coded-wire-tagged fish as a basis for monitoring and evaluating hatchery practices. Endangered Species Act (ESA) concerns and wild broodstock management needs necessitated marking all Snake River hatchery-produced fish beginning with brood year 1991. Snake River management agencies requested a variance from coastwide marking protocols to allow marking all hatchery produced chinook with an adipose fin clip without coded-wire-tagging (indicator stocks would still be coded-wire-tagged). The variance was denied and, due to the absence of a suitable alternative mass mark, the majority of fish were adipose-fin-clipped and coded-wire-tagged. The result was an increase in coded-wire-tagging levels in the Snake River in 1991. Without an acceptable alternative mass mark to be used in the future, coded-wire-tag releases will increase further in future years since brood year production in 1991 was well below capacity at Snake River hatcheries.

Monitoring Hatchery Returns. Direct returns to major Columbia River hatcheries are reported by number, age, and sex. At most hatcheries, all returns are examined for coded-wire-tagged fish with adipose fin clips and mark ratios are recorded. Hatchery returns to the river mouth are developed using coded-wire-tag analysis and run reconstruction techniques. Escapements of hatchery outplants and hatchery straying rates are developed as time and interest allows.

Disease monitoring. Hatchery fish health is routinely monitored in the Columbia River system. Transmission of diseases is considered when reviewing proposals to transfer fish from one hatchery to another or outplant.

Forecasting. Preseason estimates of terminal run size to the Columbia River for spring and fall chinook are based upon age- and stock-specific forecasts of annual ocean escapement. The returning year class of each chinook stock group is estimated using relationships between successive age groups in a cohort. The databases for these relationships were constructed by combining age- and stock-specific estimates of escapement and inriver catch since the 1970s. Stock identification in the Columbia River mixed stock fisheries is determined by sampling catch and escapement for coded wire tags, GSI, and VSI data. Age composition estimates are based on available scale samples from catch and escapement, and length frequency distribution when scales are unavailable. Preseason estimates of tributary returns are also made using similar techniques to allow for preseason planning of known stock fisheries.

Preseason estimates of summer chinook are based on a running average of the previous three years of returns (PFMC 1992). To develop an age composition database, a sampling program was initiated in

1990 to trap and collect age and length frequency data for upriver summer chinook at Bonneville Dam. Catch sampling data on this depressed stock are nonexistent because fisheries have been very restrictive and/or nonexistent for many years. It is also difficult to gather age data from the escapement because a large percentage of the run is naturally produced. It is hoped that the summer chinook age at maturity information will allow better preseason estimation of run size and stock composition as the database is developed.

Postseason estimates of run size to the mouth of the Columbia River incorporate catch, escapement, and stock- and age-composition data from catches, as well as data from spring and summer chinook age composition and length-at-age monitoring at Bonneville Dam.

Inseason Abundance Monitoring. Daily fish counts over each mainstem dam are entered into the Army Corps of Engineers CHROMS database for retrieval by fish management agencies the next day. Test fishing data provide some index of relative abundance but are used mostly for stock composition.

RESEARCH PROGRAMS

The following summary of research is limited by the authors' (USFWS and CRITFC) knowledge of only their own organization's projects. There is no doubt a great deal more research being conducted by individual tribes, ODFW, WDF, Washington Department of Wildlife, Idaho Department of Fish and Game (IDFG), NMFS, PSMFC, Columbia Basin Fish and Wildlife Authority, Army Corps of Engineers, USFWS, Bureau of Land Management, academic institutions, and independent consulting agencies. A list of talks to be presented for the 1992 annual public review of projects funded by Bonneville Power Administration (BPA) is included under Miscellaneous Research to give some idea of current research by other agencies, and includes additional studies on many of the following research categories.

Catch Estimation Techniques. Not in our knowledge.

Escapement Estimation Techniques. Several innovative research projects on escapement enumeration and identification are underway in the Columbia River and its tributaries. CRITFC studies include research on video taping fish passage through counting windows in dams, and underwater video taping of fish passage through fish ladders or weirs (Hatch et al. 1992). In addition to allowing repeated counting of the video tapes and estimates of observer variability, these methods allow enumeration up to 24 hours a day and reduce the labor needed for continuous census through by using time lapse exposures. In conjunction with these studies, techniques for using computer technology to pre-edit the video tapes to remove blank sequences during which no fish passage occurs are being researched, and would further reduce the labor necessary to review tapes.

A pilot study examining the feasibility of using discriminant analysis of morphometric measurements from video tape images to identify stock composition of escapement is also in progress at CRITFC, as is a small pilot test on detectability of fluorescent filament visual identification tags (provided by Northwest Marine Technology). It is possible that the length-at-age composition data from monitoring programs could be used with morphometric measurements to provide age composition of escapement.

Techniques for estimating noncatch mortality such as interdam loss are under continual refinement depending on data availability and resolution.

Several studies are currently addressing wild stock productivity on an individual stream or subbasin basis for both upriver spring and summer chinook. The Columbia River InterTribal Fisheries Commission (CRITFC) is conducting a feasibility study to design and identify possible locations for a weir to monitor escapement and hatchery straying of summer chinook salmon into the lower Secesh River.

Monitoring activities for natural escapements in Idaho systems will be increased as part of the Idaho Supplementation Studies program.

Escapement Goals.

Four Columbia River chinook escapement goals are currently used in the CTC escapement assessment. These include goals for upriver spring chinook (TAC 1991), upriver summer chinook (FCO/WDF 1971), upriver bright fall chinook (TAC 1982) and Lewis River wild fall chinook (McIsaac 1990).

The escapement goal of 120,000 adult upriver spring chinook at Bonneville Dam used during the Treaty negotiation process was established by two methods with similar results: 1) spawner-recruit methodology plus hatchery brood stock requirements (with recruits measured in terms of Columbia river mouth returns), and 2) the number of fish needed to seed each production area at 50% (i.e., attain half the juvenile carrying capacity) and attain full hatchery production. A goal for the natural component of the escapement was developed from the 70% natural at the time, resulting in a goal of 84,000 adult fish for natural upriver spring chinook (CRITFC 1987).

The escapement goal of 85,000 adult summer chinook at Bonneville Dam was established in 1963 using spawner-recruit analysis (with recruits measured in terms of Columbia River mouth returns, FCO/WDF 1971).

The escapement goal of 40,000 adult upriver bright fall chinook past McNary Dam is based on limited spawner-recruit information (with recruits measured in terms of Columbia River mouth returns), and upon observed stable production over a ten year base period (1964 to 1973), subsequently adjusted for lost Snake River habitat. This ten year period was selected because it represented a fairly recent period of relatively strong escapements and returns to the Columbia River. Hatchery production is part of this escapement but the majority (approximately 80% in recent years) is from naturally spawning chinook. An interim goal of 45,000 adults past McNary Dam has been used by Columbia River managers in 1990 to 1992 to account for increased production at Priest Rapids and Lyons Ferry hatcheries.

An escapement goal of 5,700 has been estimated for Lewis River wild fall chinook, based on a spawner-recruit analysis of the 1964 to 1982 brood years (McIsaac 1990). For 16 of these years, only data on parent spawners and escapement of recruits were available. For 1977 to 1979 brood years, there were estimates of both catch and escapement of recruits, providing the ratio of total recruitment to recruit escapement. Total recruitment of the earlier brood years was estimated by applying this ratio to earlier recruit escapements.

Spawning escapement goals for naturally spawning Snake River spring, summer, and fall chinook are currently being developed by Columbia River management agencies. These goals are being developed in conjunction with the development of ESA recovery programs for the stocks.

Parameter Estimation. Much research addressing productivity from individual subbasins or streams is going on within the Columbia Basin, especially in conjunction with the development of Integrated System Plans (NPPC 1990).

In the CTC analysis of exploitation rates, incidental mortalities are calculated on an age- and fishery-specific basis for commercial net and recreational fisheries in the Columbia River. Total catch is multiplied by the proportion of the fish not vulnerable to the gear by age and then multiplied by an assumed mortality rate for the gear. Gear-specific mortality rates applied to net and recreational fisheries are 90% and 30%, respectively. Age-specific nonvulnerable proportions for the Columbia River net fisheries are the same as those used in the Puget Sound net fisheries. No independent sampling has been done to evaluate if these rates are appropriate for Columbia River fisheries.

No further adjustments are made for incidental mortality of sport fisheries due to regulations such as hook and release fisheries, however, mainstem Columbia River sport fisheries directed at upriver spring and summer chinook have been closed for many years in an effort to protect these depressed stocks. Mainstem fall chinook sport fisheries have generally been unrestricted in time and area, without hook and release regulations for species or stock, but have maintained daily bag limits.

Abundance and Distribution. Improved methods for stock identification and measuring escapement are necessary to gather data on individual components of the stock management units and determine if they are adequately managed as an aggregate.

A common assumption involved in using exploitation rates of tagged hatchery stocks to represent exploitation rates on natural stocks from the same area is that they have similar ocean distributions and vulnerability to fishing. Tag recoveries from wild Lewis River fall chinook showed a different distribution than hatchery reared fall chinook from the same area (McIsaac 1990). The recent tagging of upriver bright fall chinook in the Hanford Reach of the Columbia River along with the continuing Priest Rapids Hatchery marking program will also allow comparisons of ocean distribution and exploitation rates for a wild bright fall chinook stock and the adjacent hatchery stock that was used to represent it, as well as age-specific maturity rates. Research on distribution usually follows any adequate tag recoveries and is pursued by expanding tagging programs. Unfortunately, even 100% tagging is not enough to provide adequate recoveries and distribution data for some stocks suffering chronic rearing and outmigration mortalities. Especially for the upriver spring and summer stocks, there are inadequate tag recoveries to adequately assess stock distribution and fishery impacts.

Research is being conducted on straying rates and distribution of hatchery fish, such as those from the Umatilla River. In some years, water flow in the Umatilla has been almost nonexistent, and such conditions lead to mass straying of returning spawners. Radiotelemetry studies on fish passing Ice Harbor Dam are being conducted to garner insight on the migrational behavior of fish, including strays, and spawning ground surveyors endeavor to recover coded-wire-tagged fish.

Stock Composition. A great deal of research is being done on stock identification through electrophoretic analysis of tissue proteins. GSI data can now be used to identify lower river, upper Columbia River, and Snake River spring chinook, and to partition lower river spring chinook according to Cowlitz or Willamette origin. Snake River summer chinook can be distinguished from upper Columbia River summer chinook, but bias occurs in separating upper Columbia River summer and fall chinook. Snake River fall chinook are represented in the baseline by only Lyons Ferry Hatchery fish and cannot yet be reliably distinguished from upper Columbia River fall chinook (WDF 1991). Research continues on improving GSI baseline data sets and reducing the bias of such classifications.

Research is being conducted by CRITFC to see if the concentration of natural elements in scales or otoliths can be used for stock identification, based on the premise that there are chemical differences among watersheds. Similarly, stock identification based on scale pattern analyses is being performed (Fryer et al. 1992b).

Assessment and Refinement of Coded-Wire-Tag Methods. Most of the effort to refine coded-wire-tag data involves expanding the coverage of stocks represented to include all run types and more geographically distinct units. In addition, tagging of wild stocks, such as Hanford Reach fall chinook, allows a test of the assumption that wild stocks can be meaningfully represented by hatchery stock tagging.

Effects of Harvest Regulations. Not in our knowledge.

Alternative Marking Techniques. Studies involving the use of fluorescent filament and visual identification tags are being done in conjunction with an effort to mark all hatchery produced chinook from the Snake River Basin. Studies of the relative mortality associated with combinations of ventral fin clip, adipose fin clip, and coded-wire-tag marking are being done at Warm Springs National, Umatilla, Rapid River, and Pahsimeroi hatcheries.

Enhancement. Coded-wire-tag programs are being used for a number of hatchery programs to evaluate changes in hatchery production. Tagged groups are also routinely used to evaluate hatchery practices such as rearing density, feeding regimes, and release strategies.

In the Yakima and Klickitat basins, supplementation is being adaptively investigated to see if artificial production (incubation and rearing of eggs from natural brood stock), combined with extensive outplanting and acclimation, can enhance natural production of salmon while maintaining their genetic integrity and protecting the spawning and rearing habitats (Clune and Dauble 1991). The potential to increase juvenile production using artificial propagation to restore or augment natural populations is being investigated through Idaho's supplementation studies.

In the Umatilla Basin, historical runs of fall and spring chinook and coho are being reintroduced after being eliminated 70 years ago because of a lack of water. Agreements were reached to provide water for fish and projects are underway to reestablish and enhance natural and hatchery salmon runs, using artificial production and supplementation, flow enhancement projects, passage improvements for irrigation diversion dams (fishways), small irrigation diversions (screening), and channels, and riparian protection and rehabilitation including reestablishment of pools and instream structure in headwater streams (Boyce 1986).

In addition to harvest and propagation, many habitat factors are thought to have a substantial effect on escapement and productivity within the Columbia Basin, including mainstem migration corridor water velocities, water temperature and quality, and accessibility of spawning habitat. Changes of inriver conditions which improve survival are an important component of enhancement. The U.S. Army Corps of Engineers' Snake River System Configuration Study is designed to identify water management changes necessary to improve smolt and adult migration conditions. Research is being conducted on identifying factors involved in juvenile downstream survival and adult upstream passage and there are a number of projects to measure or improve inriver survival, including studies on juvenile passage and densities, and projects to improve smolt and adult survival. A study of the physical effects of drawing down lower Snake River reservoirs was completed at two of the dams in spring 1992. Some of these programs, where the use of coded wire tags is impractical because it requires sacrificing marked fish to recover the tags, are being evaluated through use of Passive Integrated Transponder (PIT) tags. However, contribution to ocean and inriver fisheries from these enhancement projects can only be inferred from studies also involving coded wire tags.

Miscellaneous Research. Columbia River salmon are the focus of considerable research at present.

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OREGON COAST

The Oregon Department of Fish and Wildlife (ODFW) has responsibility for managing the populations of chinook salmon originating from coastal streams for sustained long-term persistence while accommodating human use of these populations. The Oregon Fish and Wildlife Commission (OFWC) sets both sport and commercial angling regulations for near-shore (0 to 3 miles) estuarine and riverine fisheries. The Pacific Fisheries Management Council (FPMC) set both sport and commercial harvest regulation for offshore waters in the Exclusive Economic Zone (3 to 200 miles). Annually chinook catch is regulated to meet escapement goals by catch quotas or adjustments in allowable fishing time by area. Future regulations may include adjustments for threatened and endangered populations. Harvest quotas are developed using forecasts from preseason indices of stock abundance combined with expected fishing patterns. Harvest management in Oregon offshore waters is currently regulated by the: 1) relative abundance of Klamath, Rogue, Chetco, Elk, Tillamook Bay, and Columbia River chinook stocks; 2) allocation agreements with the Columbia River tribes; and 3) passthrough provision of the Pacific Salmon Treaty. Sport harvest of coastal stocks inriver is regulated on an individual population basis. Oregon catch areas as reported when landed in Oregon are shown in Figure 10.

Harvest managers distinguish 4 groups of aggregated populations originating from production in coastal Oregon rivers. The ocean harvest of the far north migrating group and the mid coast group occurs

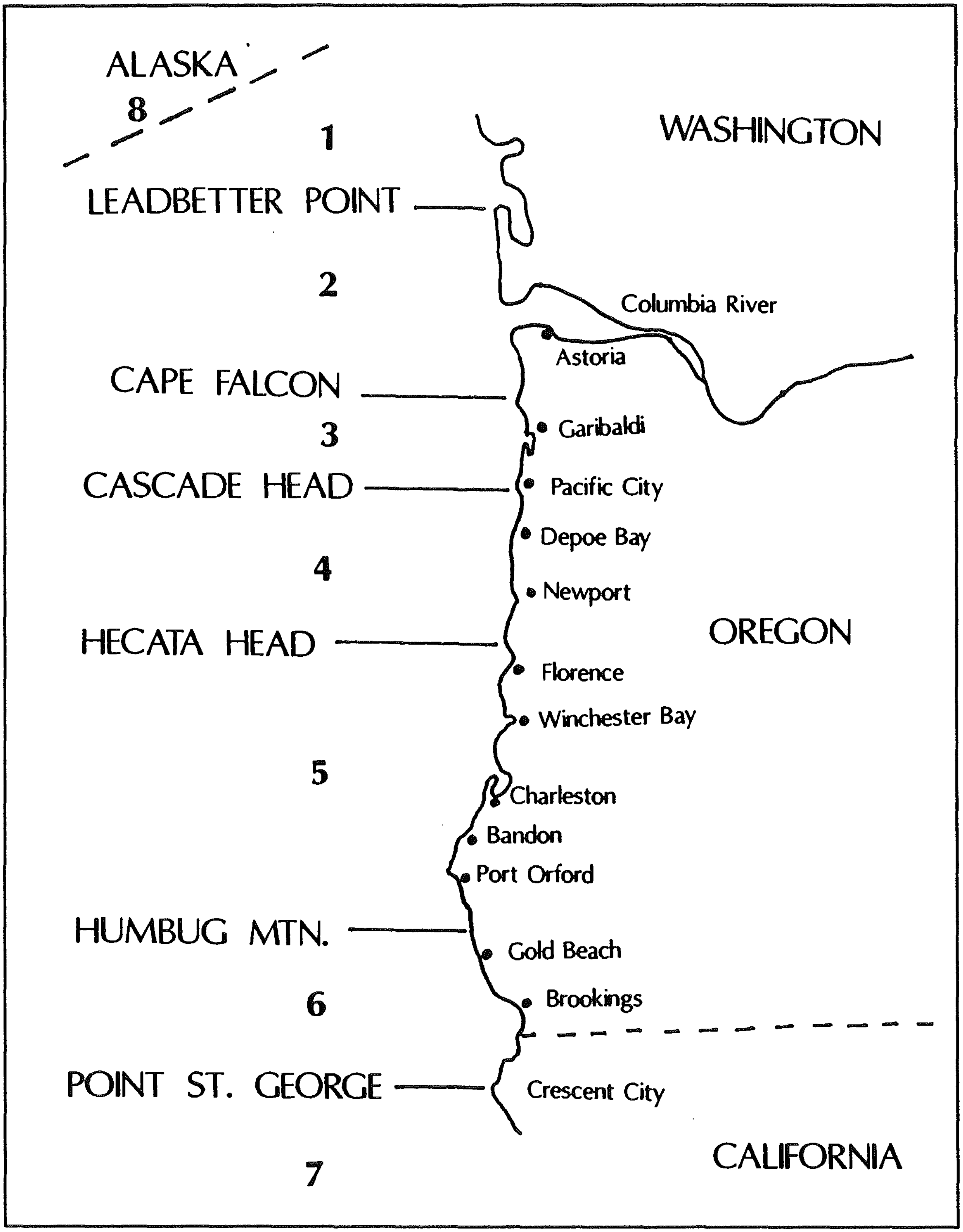

Figure 10. Oregon catch areas and major ports where commercial troll salmon are landed.

primarily in ceiling fisheries, while the other 2 groups (grouped as south migrating for this report) are taken only off Oregon and California (Figure 11).

Oregon offshore fisheries are monitored for catch so that catch quotas are not exceeded. Catches in coastal rivers are assessed through a voluntary "punch card" system and are not available until the end of the following calendar year. At present, spawning escapements are monitored for long term trends by foot surveys. However, two rivers have dams and actual counts of chinook passing upstream are taken at these obstructions. Postseason estimates of spawning fish density are presently determined to track long-term trends for some chinook populations, and are generally not sufficient to assist in annual harvest management. Exceptions to this are the Elk and Rogue Rivers, where abundance indices are used to develop harvest management in a near-shore late-season fishery and to assist in scaling harvest impacts on the Klamath stock in the general ocean chinook fishery. No net fisheries are conducted in Oregon offshore water nor in coastal estuaries or rivers south of the Columbia River.

MONITORING PROGRAMS

Catch and Effort Monitoring. All commercial troll landings are tallied from fish tickets as a receipt for each sale. Fish buyers are required to record landing information including total weight of catch by species, and grade, and the area of catch. Often landings may be from 2 or more fishing areas in which case the ticket is completed to indicate where the majority of the catch was thought to have occurred. Agency samplers are stationed at 13 landing sites from Astoria in the north (Columbia River) to Brookings on the southern coast. Sample data include the number of salmon by species, grade and weight. All fish missing an adipose fin have their snout removed for detection of coded wire tags. Estimates of the number of fish landed is derived by taking poundage from fish tickets and applying average weight data from the port sampling program. These data are usually 10 to 14 days in processing.

Because of the lag time between catch and fish ticket returns to the department and the need to manage fisheries on a quota system, ODFW has a "key buyer" sampling program to estimate catch on a timely basis and to allow for quota management. This program monitors daily or periodic troll landings at major fish buyers along the coast to provide assessment of catch to date. The total weights from the buyers fish tickets are divided by the average weight from sampling data to estimate the total number landed in the period. Landings are expanded to account for those buyers not contacted. Actual landings are known after the season when all fish tickets are finally received by ODFW.

Information gathered by ODFW on commercial ocean fisheries includes: vessel effort in boat days; catch in numbers; total weight; and average weight by fish size category. These data are determined for each fishing area in offshore waters, and by the port at which the fish were landed. Coded-wire-tag analysis yields catch composition by fishing area, and age structure of the catch.

Ocean sport fishery creel surveys are conducted at 10 ports along the coast of Oregon. Statistics from this program includes: catch by species, catch rates, number of angler trips, and stock composition by port and trip type. Recreational catch is estimated weekly by expanding catch per angler by angler trips for each port. Catch per angler, anglers per trip and coded-wire-tag samples are obtained through interviews with anglers returning to port docks by examining catch, and through charter office logbooks. Total boat counts are made by observing port entry channels and stratified by charter or pleasure vessel. Angler catch data are stratified by trip type (salmon, bottomfish, or tuna), boat type (charter or pleasure), and day type (weekend or weekday and holiday) to best estimate total sport catch and effort. See

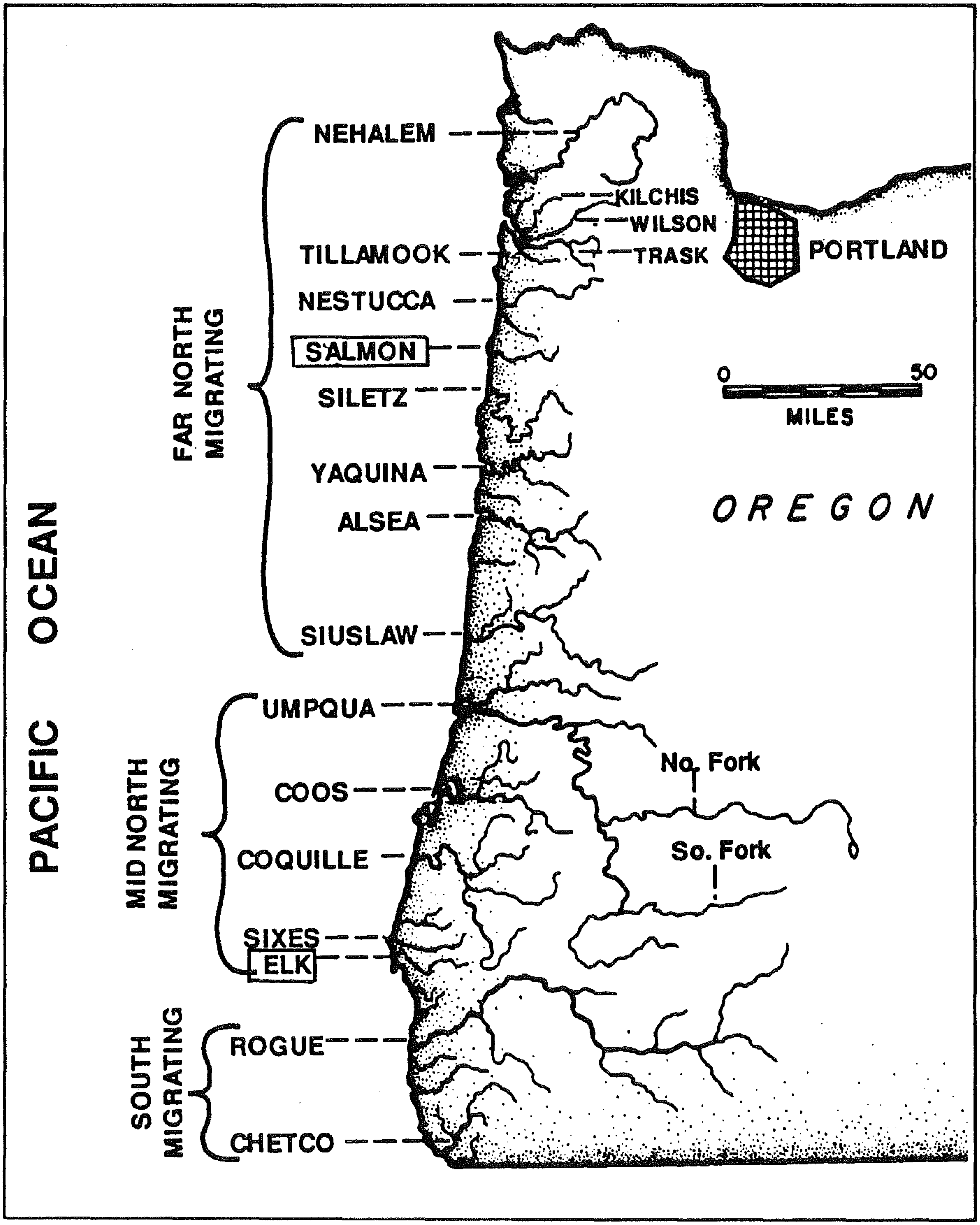

Figure 11. Oregon coastal rivers that are surveyed to determine the escapement of the Oregon chinook indicator stock. Exploitation rate indicator stocks are indicated by a box.

Schindler et al. (1992) for further details of the ocean sampling project.

Estuarine and riverine sport fishery data for most coastal rivers comes from voluntary "punch card" records, supplied by the anglers after the calendar year is concluded. Because these are voluntary records, a nonresponse factor is used to adjust the response numbers to arrive at the sport catch estimate. No coastwide freshwater catch coded-wire-tag sampling occurs. Rivers where PSC exploitation rate indicator stocks are returning are monitored intensely for catch, effort, and adipose fin clipped fish from which snouts are taken. See Boechler and Jacobs (1987) for details of the exploitation rate indicator stock recovery project.

Escapement Monitoring and Estimation. Natural populations of chinook salmon along the Oregon coast are aggregated into 4 stock groups for harvest management purposes. Only one of this group is presently designated a PSC escapement indicator stock. ODFW is currently proposing a second group be added as an indicator stock. Annual monitoring of 15 populations included in these 2 escapement indicator stock aggregates is done by foot and boat surveys (Table 8). ODFW has conducted stream surveys to monitor coastal chinook populations since the early 1950's. These surveys have been conducted annually on stream segments determined by local biologists. Between 1950 and 1975 most rivers were surveyed at a number of sites but between 1975 and 1986 most rivers were surveyed at only one site (Cooney and Jacobs 1992). Analysis has shown the single site results give higher spawner density counts and therefore may be biased. Since PSC support began, we have increased the number of survey sites in each river basin to obtain a more representative index. Presently, surveys are conducted in the fall and winter and include both multiple sites that will be surveyed annually (standard sites) and sites that may only be surveyed on that particular year (supplemental sites). The survey sites represent between about 3% - 37% of the major spawning mileage in each river basin. Each site is presently surveyed at 7 to 10 day intervals throughout the spawning season. However, not all surveys can be completed on schedule because of high water conditions. Weather, light incidence and annual personnel turnover may cause highly variable visual conditions among surveys and among years. Although surveys are meant to observe the spawning density of natural populations of chinook, hatchery releases in nearby areas do affect the index. To reduce this bias these surveys are grouped into hatchery influenced and noninfluenced survey sites. Hatchery influenced sites are designated as being within ten miles of a release site of fed (fingerling or smolt) hatchery reared chinook.

Information collected on all surveys include counts of live and dead chinook, numbers of adipose fin clipped and non adipose fin clipped fish. Additionally, six rivers are designated key streams for collecting age and sex data. The sex of fish are noted and scales are collected from carcasses on these streams for age determination. The unit of measurement for the annual spawning fish index is the maximum number of live and dead chinook counted on any single survey among all repeated samples at the site during the spawning season. This is designated as the "peak" count for that survey site for the year. Stock aggregate indices are then determined by summing all peak counts across all survey sites across all river basins in the stock aggregate, and dividing by the number of miles in these surveys to obtain the annual "peak chinook per mile" index.

Carcasses of spawned-out salmon encountered on all surveys are inspected for fin clips and snouts taken from adipose fin clipped fish. Coded-wire-tag recoveries from these fish are listed as "select" as they do not have an expansion factor associated with their recovery.

Stock Composition Estimation. Proportionate stock compositions and exploitation rates are constructed for fishery management areas using coded-wire-tag recoveries. This information is used by managers

Table 8. Escapement survey summary for individual populations composing the Oregon coastal chinook indicator stock group.

Stock Aggregate	Surveyed Populations	Survey Method	Expansion Factors	Jacks Counted	Age/Sex/Length	Hatchery Influence *
Far North Migrating	Nehalem	Foot	none	yes	yes	0 out of 17 sites
	Kilchis	Foot	none	yes	no	1 out of 2 sites
	Wilson	Foot	none	yes	yes	0 out of 2 sites
	Trask	Foot	none	yes	no	1 out of 1 site
	Taillamook	Foot	none	yes	no	1 out of 2 sites
	Nestucca	Foot	none	yes	no	2 out of 3 sites
	Salmon **	Foot	none	yes	yes	14 out of 14 sites
	Siletz	Foot, Boat	none	yes	yes	0 out of 4 sites
	Yaquina	Foot	none	yes	no	3 out of 3 sites
	Alsea	Foot	none	yes	no	0 out of 4 sites
	Siuslaw	Foot	none	yes	yes	0 out of 15 sites
Mid Oregon Coastal North & South Migrating	Coos	Foot	none	yes	no	1 out of 4 sites
	Coquille	Foot, Boat	none	yes	yes	1 out of 8 sites
	Floras	Foot	none	yes	no	0 out of 1 site
	Sixes	Foot	none	yes	no	2 out of 2 sites
	Elk **	Foot, Boat	none	yes	yes	16 out of 16 sites

* Hatchery influences include the number of sites subject to fingerling or smolt releases within 10 miles of the survey site. Unfed fry released are not considered to effect spawning ground counts. Number of influenced sites is compared to total number of survey sites in the basin (1990 surveys).

** This population is composed of naturally-spawning and hatchery-reared fish and is proposed as an exploitation rate indicator stock for the stock aggregate.

to regulate fisheries to minimize impacts on specific depressed stocks. For PSC exploitation analysis this information is used to allocate proportions of indicator stock impacts attributed to the Washington and Oregon catch area, a passthrough fishery.

Monitoring for Coded Wire Tags. Monitoring for presence of coded wire tags in the catch is done at all sampling sites along the coast, at fish buyers for commercial landings or at the marina docks and boat ramps for sport catches. Tagged fish are used to determine the area of catch of chinook stocks.

Presently, ODFW is able to meet the overall 20% catch sample standard. For the 1990 season mark sampling averaged 27% and 43% for ocean commercial and sport fisheries. However, this standard may not be met for certain strata, where large volumes of fish are landed. To obtain good stock composition estimates, additional criteria based on a minimum number of tag recoveries per area of interest is important. Estimated numbers of tags depends on the sample fraction, and few tag recoveries reduce the reliability of stock composition estimates.

Tagging Indicator Stocks. Two of the north migrating coastal chinook stock aggregates are represented by coded-wire-tagged hatchery fish, for exploitation rate analysis. Currently both of these hatchery groups contain at least 200,000 coded-wire-tagged fish with their production release. The Salmon River Hatchery, representing the far north migrating stock aggregate, releases only 200,000 fish making this group 100% marked. The Elk River hatchery, representing the mid-Oregon coastal aggregate, has 200,000 of the production release marked with coded wire tags. This is about 55% of the production from this hatchery.

Tagging Other Stocks. State hatchery evaluation projects often mark chinook releases from other coastal hatcheries at about 25 to 50% of production. These are marked for experimental purposes or to determine catch distribution.

Monitoring of Hatchery Returns. Tagged and untagged fish returning to rivers into which coded-wire-tagged fish were released are monitored for stock identification according to Table 9. When spawning fish surveys are conducted on rivers into which hatchery fish have not been released and adipose fin clipped fish are found, snouts are collected. These represent returning spawners that "stray" into streams other than their home stream. There are no expansion factors for these recoveries as no sampling fractions are available for the escapement surveys.

Disease Monitoring. Department pathologists are assigned several hatcheries to routinely monitor. Routine monitoring includes checking: 1) broodstock for presence of virus (IHN, IPN, EBIS); 2) rearing juveniles for pathogens and physiological condition; 3) all groups of fish prior to release for pathogens; or 4) whenever hatchery personnel notify pathologists that abnormal loss is occurring. Some stations have known chronic disease problems and fish at these facilities may be under routine prophylactic treatments. Most prophylactic treatments tend to be for BKD, although some stations with chronic cold water disease also receive prophylactic treatment.

Experiments have been underway for several years to determine the mode of transmission of IHN virus and develop methods to successfully rear virus-free progeny of infected parent broodstock. In most but not all cases, vertical transmission does not occur; proper treatment and isolation of eggs can result in virus free progeny and continuation of the production from infected broodstock.

Table 9. Monitoring of hatchery returns for tag returns in coastal watersheds.

STOCK AGGREGATE Stock	Recovery Area and Type * Hatchery Rack	Fishery	Spawning Ground
FAR NORTH MIGRATING POPULATIONS			
Trask - Springs	Yes-E	No	No
Trask - Falls	Yes-E	No	Yes-S
Nestucca - Falls	Yes-E	No	Yes-S
Salmon R - Falls	Yes-E	Yes-E	Yes-E
Alsea - Falls	Yes-E	Yes-E	Yes-S
MID OREGON COASTAL NORTH & SOUTH MIGRATING POPULATIONS			
Umpqua - Springs	Yes-E	No	No
Umpqua - Falls	Partial	No	No
Coos - Falls	Yes-E	No	Yes-S
Coquille - Falls	Yes-E	No	Yes-S
Coquille - Springs	No	No	Yes-S
Elk - Falls	Yes-E	Yes-E	Yes-E

* type: S = select or observed recovery only, no expansion factor associated with the recovery; or E = sampling of population designed to provide expansion factor.

Forecasting. No forecasting of the far north migrating stocks are made. Of the mid Oregon coastal stocks, only the Elk River (hatchery enhanced) stock is forecast to allow a near-shore troll fishery to target on surplus production of this single population. General southern Oregon PFMC controlled fisheries are regulated based on forecasts of Klamath, Central Valley (California), and Rogue River chinook abundance.

Inseason Abundance Monitoring. None

RESEARCH PROGRAMS

Catch Estimation Techniques. An evaluation of the troll and sport sampling program was conducted in the mid 1980s, and recommendations have been implemented (Buckman 1986).

Escapement Estimation Techniques. Presently, analysis of historic and contemporary spawning survey "peak" count data is underway. ODFW is attempting to relate "peak" counts to total estimated populations in three study streams and determine an appropriate expansion factor to convert peak counts to total spawners per mile of stream for the coastwide database, and to reevaluate index areas. In 1992 the agency will begin an exploitation rate indicator stock recovery project on the Elk R. to provide accurate ocean escapement accounting of the tagged mid Oregon coastal group. Several techniques will be tried to determine the most appropriate method to monitor the in-river run and estimate the number of each tagged year class returning to the Elk River. ODFW will compare a carcass mark-recapture technique and hydroacoustics to actually count the returning fish as they pass the sonar site.

Escapement Goals. Presently, ODFW uses an escapement index of 60 to 90 fish/mile as measured in "standard" index surveys as a goal for the coastal chinook populations. Recently, ODFW planning section has determined that at least 4 stock aggregate groups best describe these populations and we, therefore, need to develop appropriate escapement goals for these aggregated stocks (ODFW 1991). Furthermore, recent policies adopted by the Fish and Wildlife Commission regarding wild fish management dictate that each population needs to be carefully monitored. This will require that escapement goals be developed for each major population as specified in recent long-term planning efforts. Generally, a population is thought to include all chinook in each major river basin, although the Rogue and Umpqua rivers may contain several distinct populations. As results from the escapement survey analysis become available interim escapement goals can be developed from this information. If improved, statistically-designed escapement sampling is implemented, revision of the interim goals should be expected.

Parameter Estimation. Productivities of the coastal chinook have not been analyzed. Once the escapements are estimated a number of stock-recruitment functions may be useful to describe productivities of these stocks. No studies have been implemented to specifically determine incidental fishing mortalities associated with ocean or inriver fisheries.

Abundance and Distribution. The general assumption is made that coded-wire-tagged hatchery fish from the Salmon and Elk River Hatcheries are representative of their respective natural population aggregates. No information is available for several populations of coastal chinook regarding ocean catch distribution. Because Oregon chinook stocks are the southern limit of chinook that migrate into the ceiling fisheries, and some stocks never migrate to the north, it is important to define which stocks are relevant to PSC management. The undefined populations include some of the smaller populations of chinook in coastal river basins such as Nehalem River summer run chinook and various populations of spring chinook. These same populations are not well monitored for ocean escapement and better spawning escapement estimates are needed. A small population of fall chinook from the Umpqua River has been tagged for 3 years to define its distribution.

Stock Composition. Most harvest modelling is done using coded-wire-tag data. Presently, there is no standard catch monitoring program using GSI to determine stock composition, although past studies have used this technique. A study performed by California of landed catch in Oregon and California used GSI to determine stock origin (Gall et al. 1989).

Beginning with the 1992 summer fishery, ODFW will collect tissue samples from ocean fisheries for GSI analysis. These will be used to determine the stock composition in Oregon fisheries, with emphasis on the occurrence of Snake and Klamath River chinook stocks in ocean fisheries. NMFS, Seattle, will provide the 1992 stock estimates using the standardized coastwide GSI database (with 196 stocks or stock groups).

Assessment and Refinement of Coded-Wire-Tag Methods. ODFW is presently converting all landing data to area of catch as well as port of landing. Through cooperative work with the PSC Working Group on Coded-Wire-Tag Statistics, ODFW staff is developing variance estimates for coded-wire-tag recoveries, and sensitivity of coded-wire-tag sampling programs.

Effects of Harvest Regulations. A study was undertaken in 1990 to determine catch efficiency of different gear arrays for the troll fleet. It was shown that 4 spreads on the bottom could significantly increase catch of chinook while decreasing catch of coho (Lawson 1992). Effort response to regulations are routinely analyzed in the season setting process, and periodically adjusted in-season. Attributes such as weather conditions, changes in stock distributions and fleet efficiency, are variables that can influence catch and season length but are not usually evaluated routinely. Periodically when user groups wish to increase their efficiency we are called upon to analyze the effect of these variables. Generally historic data from log books or older studies are used to assist in these evaluations.

Alternative Marking Techniques. Tagging or marking fish is done for several objectives, one of which is harvest management. Harvest management goals to conserve natural stocks have recently spurred interest in finding marking techniques to identify large lots of hatchery fish. The following cooperative marking studies are underway in Oregon: 1) temperature induced branding of otoliths (WDF-ODFW); 2) comparing various body marks with the adipose fin clip and coded-wire-tag mark (BPA-ODFW); 3) testing tag loss of coded-wire-tagged fish. Several studies are in the planning or conceptual stage that will explore mass marking technology: 1) rare metal induced scale marks; and 2) laser branding. These studies are being conducted under regional guidance and are not confined to the Oregon coast.

Enhancement. Several studies have been completed that evaluated various aspects of fish propagation effectiveness and impacts on natural populations in the enhanced rivers. The Elk River study (Downey et al. 1988), found that: 1) age at maturity is sex linked and heritable; 2) date of return is heritable; 3) hatchery fish return both to natural spawning areas as well as to the hatchery of origin; 4) survival rate of cultured chinook varied by a factor of 10, despite all smolts being of apparently equal quality; 5) abundance of naturally produced chinook was not changed with the addition of large numbers of hatchery fish to the river system. The Lost Creek Dam evaluation (Cramer et al. 1985 and ODFW 1992) investigated various aspects of a water control structure and hatchery compensation on spring run chinook production. Findings include: 1) flow augmentation from stored water can reduce prespawning mortality of chinook, 2) water releases in winter are inherently warmer than preimpoundment temperatures and cause premature emergence of fry, and mortality if not compensated for, 3) presence of hatchery fish stimulates fishing pressure, and because wild fish do not migrate into the hatchery they suffer higher exploitation rates than hatchery fish. Presently most evaluation of fish propagation and wild fish is occurring in the Columbia River basin.

ODFW is conducting studies to determine the effect of various aquatic habitat alteration techniques for increasing salmon production (Nickelson et al. 1992). Instream structure from large woody debris and winter habitat structure that protects fish from peak flow events are found to assist smolt production.

Miscellaneous Research. None.

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CHAPTER 3. DATA REQUIREMENTS FOR ANNUAL ANALYSES

The Chinook Technical Committee (CTC) annually reviews the rebuilding progress of coastwide chinook stocks through several different types of analyses, including assessment of escapement levels and trends of naturally spawning stocks, exploitation rate estimation based on data from tagged chinook stocks, and modelling of fishery effects based on catch, exploitation rate, and escapement data. The quality of all these analyses are, however, limited by the quality of the data available. This chapter describes the analyses conducted by the CTC and lists major assumptions and data limitations of each.

ESCAPEMENT ASSESSMENT

DESCRIPTION OF THE ANALYSIS

The escapement assessment evaluates changes in spawning escapements of naturally spawning chinook stocks distributed from Oregon north through Southeast Alaska. Escapement information is compiled for 42 indicator stocks or stock groups. Collectively, these stock groups are suppose to represent the array of naturally spawning chinook stocks occurring coastwide and, individually, the stock groups are suppose to represent the total spawning within a narrower geographic region. Fluctuations and trends in escapement are used to assess the progress of the indicator stocks in reaching their respective spawning escapement goals. Not all stocks coastwide have established escapement goals. For those stocks with escapement goals, a determination is first made as to whether the stock has reached its goal and, if not, an assessment of progress toward the goal is made. The assessment is based on 1) a comparison of the average escapement during the base period with the average during the rebuilding period, 2) deviations of recent escapements from a linear escapement trend from the base period time and average escapement to the goal level at the rebuilding target date, and 3) apparent trends in escapements since implementation of the Pacific Salmon Treaty (PST).

The goal of the rebuilding program as stated in the PST (Annex IV, chapter 3, paragraphs 1(a)(ii) and 3(b)) is to have naturally spawning chinook stocks, as measured by indicator stocks, achieve their escapement goals by target dates, 15 years after start of conservation measures. The target dates for transboundary and Southeast Alaska stocks is 1995 and for the remaining coastwide stocks, 1998. The CTC was instructed to monitor the rebuilding of the indicator stocks and to report on the prospect of achieving the goals by the target dates. Since productivity of individual stocks is unknown, simple linear schedules were used to measure progress in escapements from the base period to the target date.

ASSUMPTIONS OF THE ANALYSIS

Major assumptions of the escapement analysis are summarized here.

1. The spawning escapement goals provided by management agencies are realistic and biologically achievable.

2. The escapements reported include only naturally spawning chinook.

3. For stocks without escapement goals, the escapement levels are currently below desired level (i.e., an increase in mean escapement and a positive trend indicate rebuilding).

4. The escapement data for each stock are collected in a consistent manner among years and the measurement (survey) error for a stock is less than the improvement increment (base level to goal level) that is to be monitored.

5. Spawning escapement trends will not be masked by variations in brood year survivals.

6. Rebuilding progress can be assessed against a straight line from the base period escapement level to the escapement goal at the target date.

7. The entire estimated escapement spawns (i.e., no fishery or other removal operates after the escapement estimate is made).

DATA LIMITATIONS IN CURRENT ANALYSIS

The results of this analysis can only be considered as an imprecise assessment of rebuilding due to limitations in the spawning escapement data for most indicator stocks. Chinook escapement data are seldom collected in a scientific manner, precision of estimates is unknown, and surveys in many cases have not been conducted consistently among years. The extent of these problems varies between regions but, in general, inadequate attention and resources have been directed to collecting escapement data suitable for stock assessment. Most escapement counts rely on visual index methods and are, therefore, subject to large interannual variation caused by varying visibility due to weather conditions and survey timing and maximum spawning timing not always coinciding due to variable timing of spawning returns. Other acknowledged problems that occur in some systems include: unaccounted for enhanced fish in the natural spawning areas; poor documentation of estimation methods resulting in inconsistency over time; uncertainty about the representativeness of indicator stocks for their geographic regions; and unestimated harvest occurring above the location of escapement enumeration. Another concern involves comparing escapement trends of single stocks (e.g., Southeast Alaska indicator stocks) against those of aggregate stock groups (e.g., most Canadian indicator stocks). It is not expected that an aggregate of stocks would respond in the same way as a single stock; variability in rebuilding patterns would be expected within the stocks within an aggregate and this variability might either dampen or exaggerate the rebuilding response.

Given all these problems and the wide variety of escapement survey methods used, fluctuations in annual escapement estimates may be more reflective of measurement error than of actual escapement variation. This could explain why no trend can be discerned in some indicator stocks. Another source of variability in escapements is the variability in brood year survival strength; other CTC analyses suggest that brood year survival is highly variable. This complicates the assessment of whether apparent rebuilding progress is due to harvest controls or to changes in brood year survival.

Most spawning escapement goals used in the escapement assessment are not based on biological analyses. Rather, goals have been derived from historical average values, policy decisions, or assessments of available spawning habitat. The uncertainty that these goals represent optimal sustainable production limits the ability of the escapement assessment to correctly determine rebuilding rates towards maximum or sustainable production. Further, escapement goals are not always adjusted when changes in escapement monitoring occur. Escapement goals based on historical levels observed when using foot surveys are not appropriate for escapement estimates later made using mark-recapture studies, since the two escapement methods do not produce equivalent escapement estimates.

EXPLOITATION RATE ANALYSES

DESCRIPTION OF ANALYSES

For fisheries operating under PST ceiling management to contribute to the successful rebuilding of the stocks of concern, a reduction in the exploitation rates on those stocks by those fisheries must be observed. The CTC estimates, using cohort analysis, a time series of age and fishery specific exploitation rates for those chinook stocks with suitable coded-wire-tag data. Six types of exploitation rate analyses have been employed by the CTC in its annual report. The theory and procedures employed in these analyses are described in CTC (1988). An additional analysis on passthrough fisheries has been included in the 1991 annual report.

Fishery Indices. Stock and age specific exploitation rates in a fishery are combined across the indicator stocks to develop indices of fishery impact changes under PST chinook management regimes relative to a 1979-1982 base period. The index for any given year is computed by dividing the fishery exploitation rate for that year by the base period average exploitation rate. Therefore, a fishery index less than 1.0 represents a decrease in exploitation from the base period while a fishery index greater than 1.0 indicates an increase. The relative magnitude of the change is the difference of the index from 1.0.

Fishery indices are presented for both reported catch and total (reported catch plus incidental loss) mortalities, both expressed in terms of "adult equivalents." Adult equivalence is defined as the probability that a fish of a given age would return to its river of origin in the absence of fishing. The total mortality index provides a consistent means of representing changes in unreported mortalities associated with regulatory measures, such as size limits and nonretention periods.

Stock Indices. Stock indices are used to present information on the annual impact/changes of fisheries on a specific stock relative to a selected base period (catch years 1979 to 1982). An index of 1.0 indicates no change from the base period; an index greater than 1.0 indicates that impacts have increased compared to the base period; an index less than 1.0 indicates that impacts have decreased relative to the base period.

Three types of stock indices are estimated. One index presents the impacts of all fisheries operating under PST ceilings. The second index presents impacts of all Canadian fisheries not operating under

PST ceilings. The third index estimates the impacts of all U.S. fisheries not operating under PST catch ceilings.

Brood Year Exploitation Rates. Within specific stocks and brood years, estimates of the cumulative impacts on all ages (within a cohort) by all fisheries and by only ocean fisheries are presented. Brood year exploitation rates are expressed in adult equivalents and presented for reported catch and total (catch plus incidental mortalities) fishing mortality. Rates are expressed as a proportion of the total fishing mortality plus escapements.

Survival Rate Estimates. Stock survival estimates are computed for exploitation rate indicator hatchery stocks using coded-wire-tag release and recovery data. A time series of survival estimates is calculated as the total fishing mortality plus escapement of fish of a given age divided by the number of tagged fish released for the brood. Separate estimates are computed for ocean age 2 and 3 fish. These estimates are used instead of a single estimate based on total survival in order to include recent brood years in the analysis and provide indications of short-term abundance expectations. On average, the age 3 estimate provides a better index for total survival; however, the age 2 estimate projects survival for an additional brood year.

Stock Catch Distribution. The distributions of reported catch and of total mortalities for each exploitation rate indicator stock are presented for 9 fishery categories: one for each of the sets of 4 fisheries operating under a PST ceiling and one for each gear type of Canadian and U.S. fisheries that do not operate under PST ceilings. Distributions are presented as percentages of both the reported catch and the total fishing mortality (expressed in terms of adult equivalents). Distributions are computed only for those calendar years that have coded-wire-tag recovery data for at least 3 brood years.

Stock Contribution Indices. Indices of contributions for major stock groups to the Southeast Alaska troll, the North/Central B.C. troll, the West Coast of Vancouver Island troll, the Strait of Georgia troll and sport, and the Washington/Oregon ocean troll and sport fisheries are used to illustrate relative changes in stock contributions. Contribution indices are computed for the Upriver Bright, Robertson Creek, Somass River, Spring Creek, Oregon Lower Columbia Tules, Washington Lower Columbia Tules, Willamette, Quinsam, and Big Qualicum stocks. Contributions are calculated by expanding the estimated fishery coded-wire-tag recoveries at age by one of the 3 following methods: a) the ratio of terminal (escapement plus terminal catch) coded-wire-tag recoveries to stock-specific terminal returns at the same age; b) the ratio of escapement coded-wire-tag recoveries to stock-specific escapement returns at the same age; and c) marked to unmarked release ratio for the hatchery. The estimated contributions of each individual stock were compared to that stock's average contribution during the 1979 to 1982 base period. Stock contribution indices provide information to aid in the interpretation of changes in exploitation rates; for example, these data illustrate how substantial increases in abundance of some stocks do not automatically result in reduced exploitation rates because of decreased abundance of other stocks.

Passthrough Exploitation Rates. The CTC has proposed a working definition of passthrough fisheries which follows from the modelling analyses done by the ad hoc (pre-Treaty) CTC to establish the PST management regime (CTC 1991). The proposed passthrough index compares the adult equivalent catch in a nation's passthrough fisheries of a depressed stock with the adult equivalent catch which would have occurred with base period (1979 to 1982) exploitation rates (or for some Canadian net fisheries, base period exploitation rates reduced by 25%).

ASSUMPTIONS AND INTERPRETATION

Assumptions for the cohort analysis and other procedures utilized in the exploitation rate analyses are summarized below. Detailed discussions of assumptions and parameter values may be found in CTC (1988).

Cohort Analysis. The cohort analysis is the computational procedure used to reconstruct a cohort from coded-wire-tag recovery data. All subsequent analyses rely upon parameters estimated from the cohort analysis. The primary assumptions of the cohort analysis are:

1. Fishery and escapement coded-wire-tag recovery data are obtained in a consistent manner from year to year. Many of the analyses rely upon indices which are computed as the ratio of a statistic in a particular year to the value associated with a base period.

2. For age 2 and older fish, natural mortality is constant for each age class in each year.

3. All stocks within a fishery have the same size distribution for each age and the size distribution at age is constant between years.

4. The distribution of sublegal-sized fish is the same as that of legal-sized fish.

5. Incidental mortality rates per encounter are constant within each fishery.

6. In the absence of an independent estimate of incidental mortality loss during nonretention periods, the procedure for estimating the mortality of coded-wire-tagged fish of legal size assumes that the stock distribution remains unchanged from the period of legal catch retention.

7. All fisheries are accounted for.

Fishery and Stock Indices. The temporal and spatial distributions of stocks in and between fisheries are assumed to be stable from year to year.

Survival Rate Indices. Fishery exploitation, incidental mortality, and stock maturation rates are assumed to be constant from year to year.

Stock Contribution Indices. Coded-wire-tagged fish are assumed to have the same temporal and spatial distributions as the untagged fish they are intended to represent.

Incidental Mortalities. The following assumptions are inherent in the procedures used to estimate incidental mortalities:

1. For a given stock, the geographic and temporal distributions are similar for legal- and sublegal-sized fish.

2. Assumptions 3 to 6 listed for the Cohort Analysis.

3. Estimates of nonretention mortalities for Alaskan fisheries use reported incidence of legal- and sublegal-sized fish where available. Similar procedures would be used elsewhere if the data were available.

4. When the number of chinook nonretention (CNR) days is used to estimate incidental mortalities, the relative encounter rate of legal-sized fish is assumed to be 34% of the rate during the period when legal-sized fish are retained (value applied to all CNR periods in fisheries). This assumption is based upon reported incidence of legal-sized fish in the Southeast Alaska chinook nonretention troll fishery.

Reported Catch Versus Total Mortalities. Fishery and stock indices are computed for both reported catch and total mortality. Management strategies have changed considerably for fisheries constrained by PST catch ceilings since implementation of the Treaty. Regulatory changes include size limit changes and periods of chinook nonretention. These changes are not reflected in coded-wire-tag recovery data, yet are crucially important for assessment of total fishery impacts. Procedures to estimate these incidental mortality losses and incorporate them into the Exploitation Rate Analysis were described in Supplement B of CTC (1988).

DATA LIMITATIONS IN CURRENT ANALYSES

Data limiting the current analysis have been discussed in Chapter 2 in the regional presentations of the Exploitation Rate Indicator stock programs, Escapement Indicator Stock programs, coded-wire-tag sampling programs, and catch estimation programs. Several significant limitations are repeated below:

1. Representative indicator stocks have not been established for many stock groups. These stock groups include: Transboundary spring, North/Central B.C. spring and summer, Fraser River summer and fall, Skagit summer/fall, Snohomish summer/fall, Columbia River summer, and Upper Columbia River spring.

2. Estimates of nonlanded fishing mortality are not available for any fisheries;

3. Estimates of coded-wire-tag recoveries are not available for north B.C., central B.C., and West Coast of Vancouver Island sport fisheries.

4. Estimates of recoveries in Southeast Alaska sport fisheries are available but have not been reported to the Pacific States Marine Fisheries Commission (PSMFC).

5. The estimated recoveries of coded wire tags in the Puget Sound sport fishery have typically not been reported to the PSMFC by July of the following year. This precludes analysis of exploitation into Puget Sound sport fishery in the annual assessment of the CTC.

CHINOOK MODEL

DESCRIPTION OF THE MODEL

The chinook model provides a common bilateral basis for evaluating the impacts of PST management actions on the chinook rebuilding program. Results from the model are also employed to estimate chinook interceptions. The data, assumptions, and algorithms incorporated into the model represent the best estimates of the CTC. The chinook model is deterministic; there is no attempt to incorporate stochastic elements into any of the parameters used in the model.

The chinook model uses an iterative process of estimating chinook population parameters, given certain management strategies, that results in chinook catches and escapements that most closely represent those actually seen. Management strategies may include catch ceilings, quotas, harvest rate adjustments, nonretention regulations, size limit changes, and enhancement activities. Computations are performed on an annual basis (calendar year). This time step is the largest that can be used and still achieve the objectives for which the chinook model is intended.

ASSUMPTIONS AND INTERPRETATION

The following are some of the most important assumptions that underlie the chinook model.

1. The only changes to harvest rates over time are those that result from the management actions that are being modeled.

2. The stock distribution and fishing patterns are identical from year to year.

3. The proportion of the catch which may be attributed to stocks not represented in the chinook model remains constant over the rebuilding period.

4. Exploitation patterns on hatchery coded-wire-tag release groups are representative of those on the natural stocks which they represent.

5. Impacts of management actions on indicator stocks reflect impacts of management actions on the natural stocks of concern.

6. The stock productivities and optimum escapements do not change over the rebuilding period.

7. All age 4 and older fish taken by net fisheries are mature.

DATA LIMITATIONS IN MODEL USE

The CTC is confronted with the following data limitations when using the chinook model:

1. Estimates of nonlanded fishing mortality are not currently available for any fishery;

2. Estimates of the exploitation rates on many Canadian stocks are of poor quality because of the lack of estimates of coded-wire-tagged fish in the escapements during the base period;

3. Estimates of the productivity of many stocks are likely biased because of inaccurate estimates of escapement or the terminal run and because escapement goals are poorly defined;

4. Estimates of the age composition of the terminal run or escapement are not readily available for many stocks; and

5. Natural mortality rates are unknown.

REFERENCES

Chinook Technical Committee (CTC). 1988. 1987 Annual Report. Pacific Salmon Commission. Report TCCHINOOK (88)-2.

Chinook Technical Committee (CTC). 1991. 1990 Annual Report. Pacific Salmon Commission. Report TCCHINOOK (91)-3.

CHAPTER 4. RESEARCH NEEDS

WHY MORE RESEARCH

Extensive amounts of information on chinook salmon have been collected, but frequently the resolution of these data has been inadequate for the more complex questions dealing with stock specific assessment and coastwide management. For example, fishing mortality on a stock may be determined for terminal fisheries, but it is seldom known over all fisheries unless the juveniles in the stock were tagged. Another example is spawning escapement data which are usually collected as an index measure of trend or annual variation. These escapement indices are not comparable to catch, unless the index has been expanded to total spawning escapement, and should not be used to determine total returns or production. When an expansion has been used, it is seldom based on rigorous scientific data. Age and sex data from spawning escapements have been only sporadically collected (currently only sampled regularly for about half our indicator stocks), but these data are essential to determine chinook productivity (i.e., production of returns per spawner).

To a large extent, chinook data limitations are associated with high costs (due to remoteness, environmental variability, etc.) and difficulty of collecting the data due to the complex life history of this species (e.g., multiple ages at maturity and extended vulnerability to fisheries). In addition, chinook salmon are extensively exploited in mixed-stock ocean fisheries, both international and domestic, and satisfactory methods have not been developed to determine specific catches for untagged stocks in these fisheries. Consequently, effective stock assessment and stock-specific management have been very limited on a coastwide basis, resulting in large numbers of severely depressed spawning populations (at the time of signing the Treaty), the loss of less productive populations, and the legacy of poor data upon which to base our present assessment work. In attempts to increase potential catches and at the same time preserve selected chinook stocks, extensive harvest regulations and investments in enhancement were made. Now, after several years of implementation of these two solutions, there is uncertainty about their effect on sustaining catch and increasing production. Within the Pacific Salmon Treaty (PST) process, these data inadequacies were evident:

a) When escapement goals were needed at the beginning of the chinook rebuilding program, there were few biologically determined goals and some goals were chosen without knowing if they were even biologically sustainable given current habitat conditions;

b) Productivity is not known with certainty for individual stocks and numerous assumptions were required to estimate productivity and sustainable exploitation rates;

c) The amount of harvest reduction needed to rebuild individual stocks is not known and we must proceed on a trial basis;

d) Direct measures of total interceptions are not available and we must rely on inferences from tagged stocks which are primarily hatchery stocks.

The Chinook Technical Committee (CTC) has developed several methods to conduct their annual assessments of stock status and fishery impacts. However, as indicated in Chapter 3, each method is limited by data inadequacies. To conduct more comprehensive assessments, a basic set of required data per stock has been identified:

i) numbers of spawners by age and sex;
ii) stock specific catch and total mortality by fishery, age, and sex;
iii) environmental data on variables affecting freshwater and marine survival (needed for forecasting and understanding limits to production); and
iv) measures of the sampling error associated with catch and escapement data.

There are very real practical problems associated with the collection of these data. Without a greater realization of the need for more accurate data and, following that, a commitment to better and consistent data collection, we will not be able to answer the increasingly complex questions that are asked about responsible utilization of chinook resources. The costs of poor data will only become more and more evident, obvious examples being: extinction of some chinook populations; loss of harvest opportunities, particularly as fisheries become increasingly regulated to conserve smaller or less productive stocks; and increased disruption to traditional fisheries. Without improved information, controversy over the utilization and conservation of the resource will increase and resource benefits to both Parties will be lost.

DATA NEEDS TO ADDRESS TREATY PRINCIPLES

Commitments under the PST require extensive information if we are to adequately address the principles of preventing overfishing, achieving optimal production, and equity. These information needs are discussed here.

OPTIMUM PRODUCTION & PREVENTION OF OVERFISHING

Preventing overfishing is defined as providing the spawning escapement needed to maximize the sustainable yield from a population. The minimum information required for such an assessment was referred to above. However, on a coastwide basis, determination of optimum production will also require an understanding of interactions between species and stocks for space and other resources, habitat limitations on production in both freshwater and marine environments, and effects of fishery utilization patterns on production. Numerous studies come to mind when considering the complexity of this principle, for example:

1) determining the productivity of individual naturally spawning chinook populations, including identifying

    a) the role of the freshwater environment for rearing and migration,

    b) the influence of the estuary and marine environments on the survival of year classes, and

    c) the extent of annual variability in these factors;

2) measuring genetic diversity among stocks and the influence of diversity on production;

3) determining the effect of hatchery production on wild stock production and what mixture of enhanced and wild production is advisable;

4) understanding the effects of current and alternative harvest patterns on optimal yields; and

5) determining the effect of spawning distribution and behavior on the rebuilding rates of individual populations.

At present, complete information necessary to determine stock productivity is not available for any individual chinook stock! For a few stocks, enough information has been available to apply stock-recruitment type analyses to estimate productivity parameters, but even these had to involve some major assumptions about age structure in catch and/or escapement and about the error structure of these data. And none include environmental factors, which are known to produce variability and annual production. Current analyses are also based on only a short time series of years while, to reliably determine relationships in the biological data and between the biological and environmental data, several generations of data are needed. The few long-term studies that exist have only recently begun; results are several to many years away. These studies need to be protected against budget cuts in future years in order to make the data collected useful. It will take several generations of data to determine productivity and optimal harvest levels. To meet the challenge of determining biologically sound spawning escapement goals and optimum production levels, a serious commitment to improve data collection and to focus research will be essential.

EQUITY

Addressing the principle of equity requires estimating the interception of each Party's chinook salmon by the other Party (ignoring for now the issue of catch valuation) and the level of each Party's chinook production. Theoretically, interceptions could be known if we had accurate stock assessments of all chinook stocks or at least had accurate stock identification programs for each of the mixed-stock fishery catches. Practically, however, this information is not available and interceptions have been estimated by associating total chinook returns to geographical areas with tagged indicator stocks recovered within each area. The indicator stocks, mostly hatchery stocks, are assumed to be representative of distribution patterns and exploitation rates on other stocks in the area. At present, the chinook model developed by the CTC for harvest rate studies is used to generate the annual estimates of interceptions, with the exception of the Alaskan catches of transboundary chinook stocks.

Several data limitations and analytical assumptions associated with the chinook model could result in serious errors in these interception estimates, including:

1) Differences exist in the accuracy of escapement and/or terminal run-size estimates between the Parties (underestimates, relative to other stocks, of escapements lead directly to underestimates of interceptions of the stock);

2) Exploitation rates and distribution patterns of hatchery chinook are assumed to be representative of the associated naturally spawning chinook;

3) Stocks from some production areas are not included in the model (e.g., transboundary stocks);

4) In most cases, model stocks are assumed to be representative of the stocks actually harvested from the area; and

5) Not all catches are reported and sampled for coded wire tags (e.g., WCVI sport catches, many subsistence and ceremonial catches).

Although these data limitations pose limits on the accuracy of interception estimates, in the absence of direct measures of interception, the estimates are a product of the best data we have available for chinook stocks. These estimates are a by-product of extensive model assessments conducted by the CTC primarily for the purpose of fishery performance evaluations. Tagging of all current indicator stocks must continue if we are to continue to produce comparable interception estimates in future years. However, to verify the current estimates, we should develop other estimation procedures involving new analyses of current data or direct sampling to provide new, independent data.

For the transboundary chinook stocks, a harvest rate analysis involving tagging studies from Taku chinook stocks is used. The harvest rate determined for the Taku stock is assumed as the harvest rate for the Alsek and Stikine stocks (the U.S. and Canada do not agree on the harvest rate to use). Stock specific harvest rate estimates are needed for these two stocks and estimates of chinook production from minor transboundary systems is needed to improve our estimates of these catches.

DATA NEEDS FOR CTC ASSESSMENTS

To address the assignments given the CTC under the Treaty (Annex IV, Chapter 3), specific evaluation procedures and tools have been developed and are described in Chapter 3 of this report. These assessment procedures are, of course, limited by all the data issues identified above. Information required to improve the assessments are considered below.

ESCAPEMENT ASSESSMENT

Indicator Stocks. Coastwide chinook rebuilding is assessed on the basis of 36 indicator stocks with escapement goals; several of these stocks are actually aggregates of several spawning populations. Aggregating populations may reduce the inter-annual variations in run sizes, but it probably also mixes populations of differing run types and productivity, thereby reducing the consistency of the surveys between years. Aggregating also introduces questions about the individual rebuilding progress of populations within the aggregate. Guidelines for defining indicator stocks and providing annual consistency in data collection are essential.

Basis of Goals. Escapement goals based on biological or habitat considerations are needed to provide more realistic rebuilding goals for the indicator stocks. The present goals were frequently established as interim management targets with the intention of gaining knowledge during the rebuilding program. To determine biologically based goals (e.g., the desired egg deposition or the number of females required), however, information beyond that of just annual escapement counts is needed (see next item).

Biological Data. Data on age, sex, size, and fecundity of spawners (and from the terminal catches) are essential to differentiate the effects of variation in brood year survivals from the effects of changes in exploitation patterns, to relate adult production to numbers in the spawning population, and to estimate the reproductive value of the population. However, consistently collected and reliable biological data from spawners is extremely limited for chinook stocks coastwide.

Hatchery and Wild Stock Mixtures. The mixing of chinook from an enhancement activity with naturally spawning chinook complicates the assessment of rebuilding naturally spawning chinook populations. Reliable estimates of the number of hatchery fish in the spawning population are necessary to correctly interpret the spawner-recruit relationship of the naturally spawning population and to determine the relative survivals and productivity of the enhanced and naturally spawning populations. An additional concern developing is the use of supplemental breeding programs to augment the productivity of depressed natural populations.

EXPLOITATION ASSESSMENT

Indicator Stocks. Coded-wire-tagged hatchery stocks are assumed to be adequate indicator stocks for the exploitation rates, distribution patterns, and maturation schedules of proximal natural chinook populations. This is a critical assumption in applying the various indices calculated in the exploitation rate assessment and should be tested for validity. Further, major geographic areas and stocks are not now represented in these analyses. Agencies should maintain the existing core indicator stocks, develop new indicator stocks for production not presently represented, and look for possible wild stocks to tag for comparison with associated hatchery stock tagging.

Catch Sampling/Estimation. Sampling for and expansions of coded-wire-tag recoveries in fisheries and escapement are fundamental to most chinook assessments presently conducted by the CTC. However, with increased requirements for conservation and accountability between users of the resource, marine and freshwater programs for coded-wire-tag recoveries should be re-evaluated. Several concerns have been identified which limit the accuracy and precision of estimates based on these essential coded-wire-tag data: low sampling rates in some catch strata (defined by area/gear/period), unsampled fisheries, use of voluntary returns of tags in sport fisheries, missed marks in escapement sampling, and unsampled portions of escapements. The issues of missed marks in sampling and the accuracy of the coded-wire-tag data have not been examined. A statistically defensible tag and recovery program was an agreement between the Parties in the Memorandum of Understanding of the PST; however, short comings in the program continue to be identified.

Total Fishing Mortalities. Accuracy of stock productivity and exploitation rate estimates are jeopardized by the existence of nonreported catches, poor catch estimation procedures in some fisheries, and the lack of area/time specific estimates of incidental fishing mortality. Previous CTC reports (e.g., chapter 2, CTC 1987) have documented the existence and potential extent of incidental fishing mortalities. These mortalities can be a significant portion of the total fishing mortality, but are not consistently monitored. Incidental mortalities change over time as regulations or fishing effort by gear changes. Further, the original assumptions about mortality rates are still used in the exploitation rate analyses. Complete reporting and documentation of fishing mortalities are required for accurate estimation of exploitation rates and distribution patterns.

Analytical Methods. Variances for the exploitation rate estimates are needed to determine the precision of those estimates. The development of statistical test is needed to compare distributions of tag recoveries between years and stocks.

CHINOOK MODEL

Stock Representation. Coded-wire-tagged stocks used in the chinook model are assumed to be representative of the coastwide production of chinook and the tagged stocks are assumed to be representative of the wild stocks associated with them. However, not all significant production areas are adequately represented in the model and tests of the representativeness of hatchery stocks for wild stocks have not been conducted. Further, many of the model stocks are aggregates of populations which may vary in run-timing, vulnerability to fisheries, accuracy of escapement estimates, age at maturity, etc. The representativeness of the stocks used should be evaluated and all significant production areas represented in the model.

Model Calibration. Calibration of the chinook model requires from stocks with terminal catches accurate terminal run size estimates to reconstruct ocean catches and to estimate cohort abundance. Accurate reconstruction of ocean abundance by age and area is necessary for evaluating fishery management options and actions and for examining interannual variation in marine survivals.

Stock Productivity and Marine Survival. Projections of future chinook abundance are required to examine when a stock may rebuild under various management strategies. However, there are few measures of biological productivity in chinook salmon upon which to base abundance projections. While productivity values are expressed as an average rate of return per spawner, actual production from the contributing brood years may vary greatly depending on the early marine survival. For example, survival from Robertson Creek hatchery chinook has varied by 100 fold (0.03% to 3.0%) over the past 20 years.

Rebuilding performance will be sensitive to variations in productivity and survival values. Studies to determine the true values of productivity and causes of marine survival variation (both magnitude and pattern) will be needed to understand chinook population dynamics but are unlikely to provide information useful in assessing the PST rebuilding program. Such studies are inherently long-term but are necessary to determine optimal production and appropriate harvest management plans. In the absence of this information, stock-specific production rates and average survival values are estimated during model calibration. Stock productivity is related to trends in spawning escapements and to brood year exploitation rates on associated indicator stocks. The accuracy of these productivity values is, therefore, impacted by the uncertainty in spawning escapement numbers, survey inconsistency, lack of biological data from escapements, age and sex composition, and any unreported catches or tag sampling problems.

Stock Composition. Projected stock distributions in the model are based on the distribution of tag groups representing a stock in the base period years (generally brood years 1975-1979). How the distribution of the catch of stocks will change following changes in fishing impacts is unknown and variation between brood year distributions cannot be accounted for in model projections. For example, present troll fisheries are presumed to exploit the same mixture of stocks (except for changes in the relative abundance) as in the base period even though substantial changes in fishing seasons (duration and timing) have occurred. Further, the stock composition of incidental mortalities is unknown. These assumptions may limit our evaluation of the effectiveness of harvest changes and mask causes of rebuilding variation among stocks.

Fisheries Dynamics. The model was designed for evaluating the effect of alternative regulatory strategies on chinook rebuilding. Our ability to predict these responses are obviously limited by the biological information available (discussed above), but the evaluations are also limited by the information available on fisheries. For example, in the model, a fishery could be managed by a fixed harvest rate (as opposed to a fixed catch ceiling) but realistically we are unable to translate this strategy into a management plan. Missing information that would limit this includes how to standardize fishing effort and project effort response, relations between catch per effort versus inseason abundance, species selectivity in different fisheries, and directed effort in mixed-species fisheries. Exploring the feasibility and effectiveness of new regulatory mechanisms will continue to be limited without greater emphasis on understanding fishery, as well as the stock, dynamics.

FUTURE ANALYSES

The Chinook Work Group has been asked by the Commission to look into alternative ways of managing coastwide chinook stocks. Effort has been put into developing alternatives based on stock abundance. Before any such alternative could be put into effect, a method would be needed to predict the abundance each year before the fisheries began. We need to explore various methods for predicting abundance.

RECOMMENDATIONS

To seriously address Treaty objectives and to provide annual assessments of chinook salmon, greater effort will be needed in the identification of necessary data and its collection, and greater commitment will be needed to long-term research projects. The biological data involved is complex and is collected against a background of natural variability and man-induced changes in the environment. Unfortunately, a legacy of past inadequacies results in a long list of information requirements for now and the future.

The CTC has attempted to develop a comprehensive list of information improvements and needs for existing and new programs. The list developed is presented in Table 10. Each member of the CTC was requested to rank these projects. Rankings were highly variable between respondents, but an overall ranking by project was determined based on the average of individual rankings. Then the CTC, at its October 1992 joint meeting, reviewed the top ranked projects, combined projects that were similar in nature, identified missing project area, and constructed a list of 14 top priority projects (Table 11). Given that these projects agreed upon by the CTC would encompass a significant monitoring and research commitment, the CTC chose to limit their recommended list of information needs to these 14 projects but do not mean to imply that information from any of the remaining projects listed in Table 10 is not needed.

It is worth noting that ten of the top 14 projects identified by the CTC involve improvements to existing programs or data collection. In other words, before new programs are initiated, a stronger core program of accurate and comparable data is essential for coastwide management of chinook salmon. Many of these projects require dedicated time from CTC members, to examine existing programs and to recommend change, rather than large sums of additional moneys or continued analyses of the existing information. However, some new programs are clearly required, such as studies to improve our knowledge of chinook population dynamics and to directly examine equity issues. New programs will also strengthen existing information systems by examining basic assumptions of present analyses and by improving the coverage of catch/sampling data to all chinook fisheries and of exploitation rate indicator stocks to include other chinook production areas and stock types. From the large list of possible new projects, the CTC focused on: applying genetic stock identification (GSI) information to estimate the stock composition in fisheries; initiating a few well designed programs to examine the productivity of natural and enhanced populations; and establishing programs to study fishery dynamics. In the case of GSI, extensive resources have already been invested in collecting a coastwide baseline database and it should now provide a useful tool for examining PST chinook issues. To understand the biological productivity of chinook is inherently a long-term study, but achieving the objectives of the PST requires that the Parties recognize this and invest in developing this basic understanding. A major issue for funding agencies will be the need to maintain a long-term commitment to these new biological programs. Studies of fishery dynamics are essential for evaluations of alternative management strategies and expected impacts on chinook rebuilding. The types of studies envisioned include examining effort responses to changes in quotas or seasons, standardizing effort or estimating directed effort, evaluating size limits, relating harvest rates to days fishing, etc.

The CTC recognizes that new biological programs could involve large amounts of new funds but believes that a careful examination of opportunities for study site selection and an integration of project objectives and funding sources can significantly reduce the new funds required. The CTC stresses, however, that new programs can not simply replace the core information systems since our established assessment procedures and the new programs are premised on these programs continuing and being strengthened. Extensive amounts of information on chinook salmon have been collected, but we continue to have a great deal to learn, particularly against a background of climate change and man-induced changes in the environment. Management agencies should recognize and acknowledge the limitations of existing information and find ways to maximize what we learn from these new programs and future management actions.

REFERENCE

Chinook Technical Committee (CTC). 1987. Chinook Technical Committee report to the November 1987 meeting of the Pacific Salmon Commission. Pacific Salmon Commission. Report TCCHINOOK (87)-5.

Table 10. Chinook long-term research survey and project listings.

Part I. Information needs for Existing Program activities:

1. Maintain a consistent set of Escapement Indicator streams which meet CTC quality standards.
2. Establish guidelines for identification of stock groupings for escapement indicator stocks.
3. Establish guidelines for the types and quality of escapement data to be collected.
4. Estimate return of enhanced chinook to escapement indicator stocks.
5. Maintain a consistent set of Exploitation Rate Indicator stocks which meet CTC quality standards.
6. Establish guidelines for identification of stock groupings for exploitation rate indicator stocks.
7. Establish guidelines for the types and quality of exploitation rate data to be collected.

Institute catch estimation and sampling programs in fisheries lacking these programs:

8. sport fisheries (e.g., WCVI sport),
9. personal use or take-home fisheries,
10. native fisheries.

Estimation of incidental mortalities:

11. encounters in fisheries,
12. stock composition of encounters,
13. applicable mortality rates.

Coded-wire-tag (CWT) information base:

14. meet minimum sampling standards for commercial fisheries,
15. examine feasibility of random sampling for sport fisheries,
16. examination of sampling design for escapements,
17. investigate reliability of recovery programs (missed marks, mark incidence,...),
18. exchange catch/sample expansion factors for Alaskan sport fishery recoveries.

Assessment of CWT data:

19. verify accuracy through alternative marks,
20. accuracy of total releases associated with tags,
21. accuracy and reporting of escapement sampling,
22. statistical properties (e.g., variance estimates).

Review of CWT expansion methods:

23. effect of pooling across strata and tag groups,
24. standardization of expansion factors for commercial fisheries,
25. standardization of expansion factors for sport fisheries,
26. reporting of data necessary for expansion of escapement recoveries.

Analytical tests to examine validity of assumptions:

27. constant annual spatial distributions of stocks,
28. similarity of distributions among CWT groups.

Recommended additional indicator stocks:

29. Upper Fraser R. spring and summers,
30. Central & Northern B.C. spring and summers,
31. Transboundary River stocks,
32. Upper Columbia R. summers,
33. Upper Columbia R. springs,
34. Washington coastal springs,
35. South Puget Sound yearlings,
36. St. of Georgia summer/falls,
37. West coast Vancouver Island,
38. Fraser R. fall - Harrison stock,
39. Central Oregon coastal falls.
40. Improving estimates of catch for commercial fisheries
41. Improving estimates of catch for sport fisheries
42. Improving estimates of catch for native fisheries
43. Improving estimates of catch for ceremonial and subsistence use
44. Improving estimates of catch for personal use

Part II. Information needs from New Program activities:

Quantitative estimates of production:

45. spawning escapement by sex and age,
46. juvenile production monitoring,
47. tagging of migrants for exploitation rates,
48. stock identification programs for catch by stock,
49. estimates of pre-spawn mortality.

Interactive effects on total chinook production:

50. inter-specific competition,
51. intra-specific competition,
52. hatchery x wild stock interactions,
53. supplementation programs (outplanting, etc.),

Habitat determinants of production:

54. identification and quantification of habitat factors limiting chinook production,
55. quantification of habitat impacts/stresses hindering rebuilding of natural stocks,
56. monitoring of environmental factors.

Coastwide production limitations:

57. marine carrying capacity,
58. climate change/trends,
59. between stock correlation analyses (e.g., survival variation, etc.).

Validation of interception estimates:

60. genetic stock identification programs,
61. mass marking programs in hatchery stocks,
62. stock specific marker studies (e.g., DNA probes),
63. stock identification for Transboundary R. stocks.

Development of analytical methods:

64. stock concentrations (fishery shaping analysis),
65. effort standardization, response, and determination of directed effort in multiple species fisheries,
66. estimation of abundance by area,
67. abundance forecasting.

Table 11. The top priority information needs identified by the Chinook Technical Committee and required to meet the objectives of the Pacific Salmon Treaty including current annual assessments. The projects are not ordered in any way related to priority. Reference numbers refer to the project numbers in Table 10.

Ref. #	Project	Project Description
1-4	Escapement Data	Establish guidelines for types & quality of escapement data collected for PST escapement indicator stocks; develop & maintain a consistently monitored set of stocks to evaluate spawning escapement trends among years and stocks.
5-7, 26	Exploitation Rate Data	Establish guidelines for types & quality of data collected for PST exploitation rate indicator stocks; develop & maintain a consistently monitored set of stocks to estimate exploitation rates by stock and brood year for evaluation of optimal production, equity, and fishery assessments.
8 & 10	Catch Data	Institute catch estimation, biological sampling, and tag recovery programs in fisheries lacking these programs, in particular; Native fisheries in Canada and sport fisheries (e.g., WCVI, freshwater fisheries, etc.)
11	Encounter Rates	Monitor chinook encounter rate in fisheries for the estimation of total fishing impacts (both incidental mortalities and reported catch); particularly in fisheries harvesting indicator stocks representing a depressed naturally spawning chinook population.
14	Commercial CWT Sampling	Maintain the essential CWT information base by establishing and maintaining minimum sampling standards for coded-wire tag recovery in commercial fisheries.
15	Other CWT Sampling	Improve the CWT information basis by examining the feasibility of random sampling for CWT in sport fisheries to examine comparability of sport, native, and commercial recovery programs, and potential biases in voluntary recovery programs (implement if feasible).
19	CWT Accuracy	Assess the accuracy of CWT data through the application of mass marking (otolith, elemental marks, etc.) of tagged stocks and recovery programs in terminal runs for examination of tag loss, differential mortalities of tagged and untagged fish, straying between stocks, etc.
27, 28, 67	CWT Distribution	Develop and apply analytical methods to compare spatial and temporal distributions of CWT groups for among year or stock comparisons and to predict abundance in fishery areas.
29-31, 38	New CWT Stocks	Establish additional exploitation indicator stocks to improve the geographic and stock type coverage of these indicators; the most important new indicators would be: the Harrison River falls, upper Fraser River springs & summers, North/Central B.C. springs & summers, and a Transboundary River indicator.
55	Habitat	Investigate habitat factors influencing chinook production in escapement indicator stocks that are not rebuilding.
60	Stock Composition	Monitor stock composition in fisheries using Genetic Stock Identification techniques to examine stock composition predicted by the Chinook Model, and therefore, to evaluate current interception estimates.
various	Sampling Errors	Examine sampling errors associated with catch and escapement estimation procedures to investigate the accuracy of CWT data, to evaluate how to improve these estimates, and for statistical evaluations of stock-recruitment relations in productivity studies.
various	Population Dynamics	Establish a core group of rigorously designed experiments to study the population dynamics of chinook salmon; particularly addressing biological productivity of chinook life history types and evaluating escapement goals, effects of the environment on survival, long-term production of hatchery stocks, and the interaction of enhanced & wild chinook populations.
new	Fishery Dynamics	Identify information needs and design monitoring programs to examine the dynamics of salmon fisheries for consideration of alternative management strategies.