FINAL

AMENDMENT 13

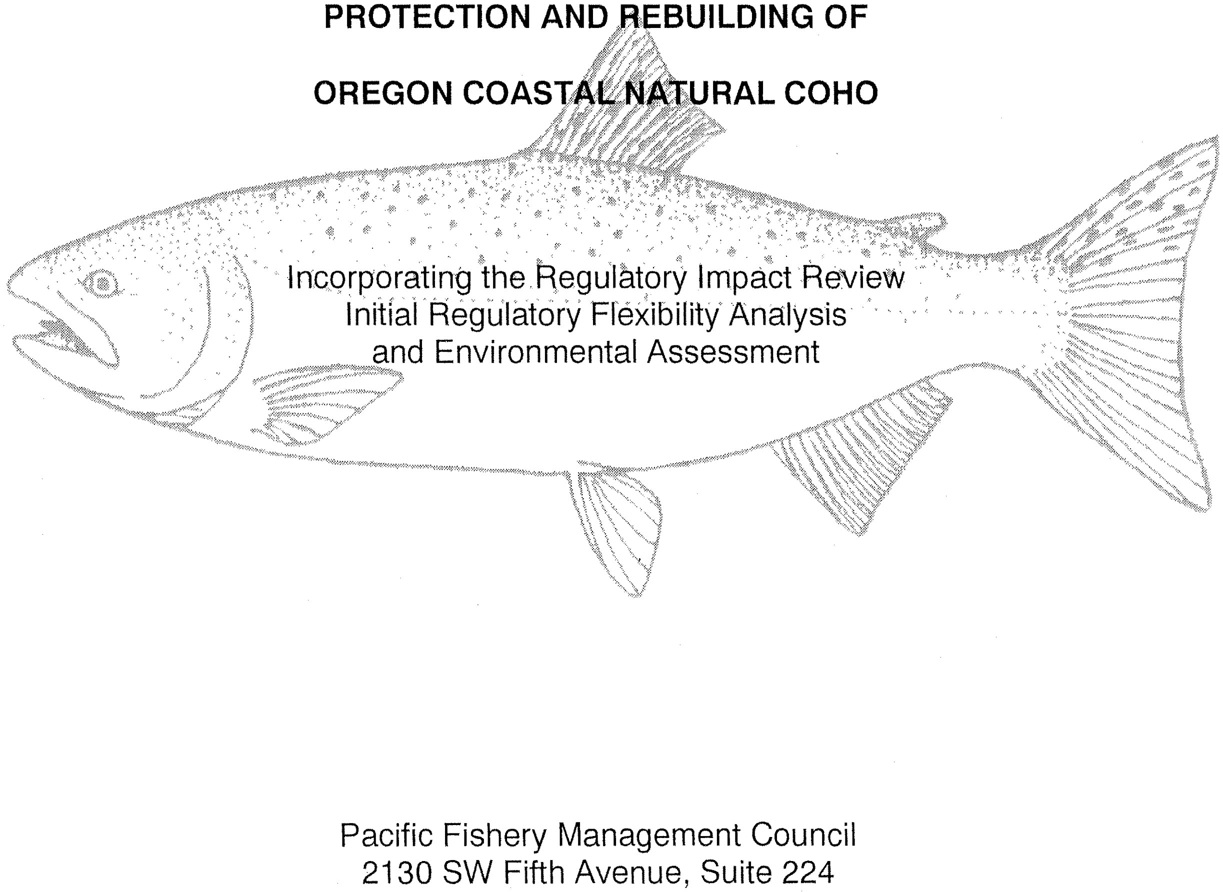
to the

PACIFIC COAST SALMON PLAN

FISHERY MANAGEMENT REGIME TO ENSURE

PROTECTION AND REBUILDING OF

OREGON COASTAL NATURAL COHO



Incorporating the Regulatory Impact Review
Initial Regulatory Flexibility Analysis
and Environmental Assessment

Pacific Fishery Management Council
2130 SW Fifth Avenue, Suite 224
Portland, Oregon 97201
January 1999

File w/ document

PACIFIC FISHERY MANAGEMENT COUNCIL

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January 13, 1999

Mr. William Stelle, Jr., Director
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Dear Will:

On November 5, 1997, the Council adopted Amendment 13 to the Pacific Coast Salmon Plan. The enclosed amendment document is submitted for your review and implementation for the 1999 salmon fishing season. (Under separate cover, 25 copies of the amendment document have been sent to the Northwest Regional Office, ten to the Southwest Region, and 25 copies to Headquarters.)

Amendment 13 revises the management goals for Oregon coastal natural (OCN) coho to increase the probability that this aggregate stock will recover from a long period of very low abundance. To accomplish this, the amendment uses the recently established stratified random sampling data which appear to more accurately estimate the true stock status, disaggregates the spawner goal into four geographically defined stock components to be more responsive to variations within the stock aggregate, and applies greater harvest restrictions than the current salmon management plan, based on parent abundance and projected marine survival. The Council believes these revisions significantly improve the probability of OCN coho recovery. Additionally, the Council is continuing to analyze its management approach for OCN coho, including the recently completed risk analysis by Oregon Department of Fish and Wildlife and National Marine Fisheries Service staff and a scheduled complete review of the amendment in the year 2000.

We have coordinated with your staff to assure that the Council's final amendment and associated documents are complete and ready for processing. Please call upon Dr. John Coon of the Council staff if you need any further clarification or assistance in implementing the Council's proposed amendments.

Sincerely,

Larry

Lawrence D. Six
Executive Director

JCC:rdh

Enclosure

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ACKNOWLEDGEMENTS

This document was prepared by the Council staff based on the proposed amendment developed by the Oregon Department of Fish and Wildlife (ODFW). In addition to Council staff, the primary amendment authors and contributors to its analysis include the following persons:

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LIST OF ACRONYMS AND ABBREVIATIONS

Council	Pacific Fishery Management Council
CWT	coded-wire tag
EA	Environmental Assessment
EIS	Environmental Impact Statement
EO	Executive Order
ESA	Endangered Species Act
ESU	evolutionary significant unit
FMP	fishery management plan
FRAM	Fisheries Regulatory Assessment Modeling
GCG	Gene Conservation Groups
IRFA	Initial Regulatory Flexibility Act
NEPA	National Environmental Policy Act
NPPA	Northwest Power Planning Act of 1980
ODFW	Oregon Department of Fish and Wildlife
OCN	Oregon coastal natural (coho)
OPI	Oregon Production Index (coho salmon stock index south of Leadbetter Point)
PFMC	Pacific Fishery Management Council
PSC	Pacific Salmon Commission
PSTA	Pacific Salmon Treaty Act of 1985
RIR	Regulatory Impact Review
SEIS	Supplemental Environmental Impact Statement
STT	Salmon Technical Team
SRS	Stratified Random Sampling

FISHERY MANAGEMENT REGIME TO ENSURE PROTECTION AND REBUILDING OF OREGON COASTAL NATURAL COHO

1.0 INTRODUCTION

This document, based on a proposal developed by the Oregon Department of Fish and Wildlife (ODFW), presents and analyzes the impacts of the proposed thirteenth amendment to the Pacific Fishery Management Council's (Council or PFMC) ocean salmon fishery management plan (FMP). The amendment considers a change in the management of Oregon coastal natural (OCN) coho salmon *Oncorhynchus kisutch* to utilize the most recent estimates of spawner escapements and abundance and to help ensure the protection and timely rebuilding of the stock.

1.1 Document Organization

This is an integrated document with regard to the assessments required for an FMP amendment. The description of the proposed amendment and its impacts in sections 2.0, 3.0 and 4.0 contain key elements necessary for a Regulatory Impact Review/Initial Regulatory Flexibility Analysis (RIR/IRFA) and draft environmental assessment (EA). Section 6.0 contains or references the information required for a structurally complete RIR/IRFA. Section 7.0 summarizes the relationship of this amendment to other existing laws and policies. Section 8.0 contains or references the information required for a structurally complete EA. Appendix A contains a technical description of the habitat-based assessment and modeling upon which the proposed alternative management is based. Appendix B contains harvest and abundance data for Oregon production index (OPI) area coho (all coho stocks present in the area south of Leadbetter Point, Washington), estimates of exploitation rates under the amendment alternatives and other supporting technical information. Appendix C is the Final Assessment of Risk Associated with the Harvest Management Regime of the Thirteenth Amendment to the Pacific Coast Salmon Plan. This risk assessment, completed in October of 1998, was prepared by staff of the ODFW and National Marine Fisheries Service (NMFS) in response to a stipulation for such an assessment in the Council's final adoption of Amendment 13.

1.2 Description of the Fishery, Required FMP Contents and Ongoing FMP Amendments

A description of the ocean fisheries under the *Pacific Coast Salmon Plan* (PFMC 1997) can be found in Chapter IV and Appendix D of the *Review of 1997 Ocean Salmon Fisheries* (Salmon Technical Team (STT) 1998), Appendix B of Amendment 10 to the Salmon Fishery Management Plan (PFMC 1990) and the *Proposed Plan for Managing the 1981 Salmon Fisheries off the Coast of California, Oregon and Washington* (PFMC 1981). A complete updating of the fishery description has been included in Appendix B of Draft Amendment 14 to the Pacific Coast Salmon Plan which was submitted for public review on January 11, 1999. Amendment 14 is a comprehensive review and updating of the current salmon FMP which, among other things, will make the salmon FMP consistent with the Magnuson-Stevens Fishery Conservation and Management Act of 1996. In particular, Amendment 14 will update the salmon management unit, overfishing definition, management objectives, and provide for a description of essential fish habitat (EFH). This comprehensive amendment also includes a supplemental environmental impact statement (SEIS) to update the previous SEIS completed in 1984. A description of the current salmon management unit, objectives and overfishing definition can be found in the *Pacific Coast Salmon Plan* (1997).

At the current time, no retention of coho salmon is allowed in the ocean fisheries south of Cape Falcon, Oregon, the primary area in which management of OCN coho occurs. Overall for both the recreational and commercial fisheries, OCN coho have generally contributed about 20 to 35% of the total ocean harvest of OPI coho on an annual basis during years in which coho retention has been allowed south of Cape Falcon.

The initial nonretention requirement for coho south of Cape Falcon took effect in commercial fisheries in 1993 and in recreational fisheries in 1994. Therefore, the majority of allowable harvest impacts on OCN coho presently occur as hook-and-release mortality during fisheries directed at chinook salmon stocks. If coho abundance increases, it may be possible to allow directed recreational coho harvests to resume south of Cape Falcon. Directed commercial fisheries are unlikely in the near future.

Until 1994, hatchery and natural coho salmon provided the bulk of recreational ocean salmon harvest in ocean fisheries from south-central Oregon to the Canadian Border (Humbug Mountain to Cape Flattery). Table 1 (from STT 1998) provides a display of the participation by charter and private fishing vessels and their harvest in recent years off Washington and Oregon. When coho retention was allowed, the OCN coho stock contributed most greatly to the harvest off Central Oregon and to a much lesser extent to fisheries off California and Washington (STT 1998). In 1990, there were 170 charter boats licensed for ocean fishing in Oregon and 273 in Washington. In 1997, those numbers had dropped to 122 in Oregon and 209 in Washington.

Coho salmon have also been an important component of the commercial harvest off Oregon and Washington until about 1992. Table 2 provides a summary of the number of licensed commercial salmon fishing vessels in ocean waters off Oregon and Washington in recent years, along with the chinook and coho harvest (from STT 1998).

TABLE 1. Ocean recreational salmon fishing effort and catch (in thousands) from charter and private boats off Washington and Oregon (from Table IV-11; STT1998).

Year or Average	Angler Trips		Chinook Catch		Coho Catch	
	Charter	Private	Charter	Private	Charter	Private
			OREGON			
1981-1990	51.1	186.2	6.6	27.8	59.3	132.6
1990	55.3	191.2	5.1	21.5	61.6	139.1
1991	40.3	149.7	1.9	12.5	68.9	190.2
1992	30.0	135.4	2.7	9.9	46.2	139.6
1993	13.4	66.9	0.9	5.6	16.2	43.1
1994	1.4	25.5	0.5	5.5	-	<.05
1995	4.6	31.2	0.3	6.4	4.0	7.9
1996	5.6	38.3	1.2	10.1	3.0	4.2
1997	3.9	26.4	1.5	6.2	2.4	3.6
			WASHINGTON			
1981-1990	77.8	64.7	29.3	11.9	95.7	73.3
1990	65.0	94.4	16.6	13.0	90.9	113.6
1991	43.7	69.6	5.0	7.3	80.2	111.6
1992	38.2	56.8	11.8	6.6	48.5	62.6
1993	40.2	68.9	5.8	6.9	52.8	62.3
1994	-	-	-	-	-	-
1995	17.9	30.0	<0.05	0.4	26.1	37.4
1996	15.3	23.5	<0.05	0.2	24.5	24.4
1997	12.5	15.1	1.7	2.3	12.5	12.8

TABLE 2. Summary of commercial non-Indian salmon vessel numbers and landings (number of fish) in Oregon and Washington in recent years (from Tables I-4, I-5, A-13, D-13 and D-14 of STT 1998).

Year	Number of Vessels Landing Salmon	Chinook	Coho
	OREGON		
1981-1990	2,261	274,000	360,000
1990	1,557	232,000	122,000
1991	1,217	75,000	307,000
1992	649	110,000	50,000
1993	612	82,000	2,000
1994	371	25,000	-
1995	476	215,000	-
1996	456	177,000	<50
1997	453	150,000	-
	WASHINGTON		
1981-1990	1,295	53,000	102,000
1990	897	31,000	90,000
1991	811	29,000	54,000
1992	604	44,000	18,000
1993	474	30,000	14,000
1994	1	-	-
1995	96	<50	25,000
1996	90	-	18,000
1997	51	6,000	-

1.3 Need and Purpose for Action

1.3.1 Proposed Action

This proposed amendment resulted from an intensive effort by the State of Oregon under the Governor's Coastal Salmon Restoration Initiative, developed to help restore coastal salmon populations and prevent the need for federal Endangered Species Act (ESA) listings. The amendment proposes to manage OCN coho salmon on the basis of exploitation rates, not spawner escapement objectives. The determination of appropriate exploitation rates is based on the habitat production potential, incorporating the effects of both freshwater and marine environments, and relies heavily on a habitat-based assessment and modeling of OCN coho production. Thus, the primary goal of the amendment is to assure that fishery related impacts will not act as a significant impediment to the recovery of depressed OCN coho and to more uniformly rebuild each component population subgroup to a higher level.

1.3.2 OCN Coho Management Background

The term OCN coho designates a stock aggregate comprised of the naturally produced coho salmon from Oregon coastal streams. This stock aggregate constitutes the largest proportion of naturally produced coho salmon caught in ocean salmon fisheries off Oregon and California. In that regard, OCN coho have been important contributors to the ocean harvest and generally have set the allowable coho harvest rate for combined natural and hatchery production in any given year for the area south of Cape Falcon, Oregon.

The OCN coho stock is part of the aggregate of hatchery and naturally produced coho south of Leadbetter Point, Washington which is referred to as the OPI area.

During the early to mid-seventies, just prior to the time the Council was created, the OCN abundance was estimated to range from near 700,000 to over a million fish (Table 3) and OPI area abundance of all coho stocks ranged from over 2 to nearly 4.5 million fish. Total marine harvest of all coho stocks in the OPI area during that time ranged from about 1.5 to nearly 4.0 million fish (Figure 1 and Appendix B, Table B-1). However, a combination of high harvest rates, deteriorating marine survival conditions and freshwater habitat degradation have greatly reduced the present abundance of OCN and OPI coho (see Chapter IV of the Oregon Coastal Salmon Restoration Initiative 1996 and PFMC 1992). Despite significant reductions in total marine and freshwater harvest impacts beginning in the mid 1980s, OPI area coho stocks have remained depressed in the face of continued poor marine and freshwater survival. Marine harvest of coho in the OPI area was completely closed in 1994 and no retention of coho has been allowed in the marine fishery south of Cape Falcon, Oregon since that time.

The Council first established an aggregate OCN coho spawner escapement goal in 1981 which called for meeting specific spawner objectives which would rebuild the stock and result in achievement of a long-term goal of 200,000 index spawners (Table 3). This goal was further articulated in the Council's framework salmon plan amendment (PFMC 1984) and called for the annual goal to be 200,000 adults by 1987. With continued depression of the stock, the Council implemented a sliding scale approach to the spawner goal in Amendment 7 (1987). This allowed some reduction in the long-term goal at certain low stock sizes to address the negative socioeconomic impacts created by declining fisheries. However, as marine survival deteriorated and drastic reductions in abundance occurred in the early 1990s, the Council implemented Amendment 11 (1993) which re-established the 200,000 OCN coho spawner goal, but allowed incidental harvest, or harvest impacts, of up to 20% at stock abundances below 250,000 coho--as long as the chosen rate would not jeopardize the survival of the stock. Without some incidental harvest impact, the entire ocean fishery would have to have been closed.

In the face of continued poor marine survival conditions, low freshwater production, and listings of Pacific coast coho stocks under the ESA, the Council has found it necessary to consider the need to further amend the salmon plan management objectives for OCN coho to ensure recovery of the components of this aggregate stock.

2.0 MANAGEMENT ACTIONS CONSIDERED

2.1 Status Quo

Under the status quo, the OCN coho stock is managed as an aggregate for the entire Oregon coast with one overall spawner escapement goal. The goal, found in Section 6.1.1 of the *Pacific Coast Salmon Plan* (PFMC 1997), is to meet an aggregate density of 42 naturally spawning adults per mile in standard index survey areas (considered equal to 200,000 index spawners). At OCN stock sizes that are less than 125% of the annual numerical escapement goal (less than 250,000 coho), an exploitation rate of up to 20% will be allowed for incidental impacts of the combined troll, sport and freshwater fisheries. At projected OCN spawner escapements of 28 or fewer adults per mile, an exploitation rate of up to 20% may be allowed to provide only minimum incidental harvest to prosecute other fisheries, provided the rate chosen will cause no irreparable harm to the OCN stock.

It should also be noted that if a species is listed under the Federal Endangered Species Act, the fishery impact limitations are as provided in a Biological Opinion resulting from a Section 7 consultation with NMFS to avoid jeopardizing the species. The OCN coho stock consists of two evolutionarily significant units (ESUs), Oregon coast and southern Oregon/northern California, which are currently listed as threatened. In recent years prior to the listing of the OCN components, NMFS recommended a limited aggregate OCN coho exploitation rate as a surrogate to protect evolutionarily significant units (ESUs) of coastal coho proposed for listing in 1995.

TABLE 3. Aggregate OCN coho spawner and stock abundance data in index and stratified random sampling (SRS) numbers, rivers and lakes combined, in thousands of fish (except for adults per mile and recruits per spawner).

Adult Return Year	OCN Spawners [a/]					Total OCN Stock Abundance [b/]				Recruit per Index Spawner [c/]
	Goal [d/]		Index [e/]		SRS	Index Estimate		SRS Estimate		
	Adults	Adults per mile	Adults	Adults per mile	Adults	Pre-season	Post-season	Pre-season	Post-season	
1970	-	-	249.5	-	-	-	664.1	-	-	2.85
1971	-	-	324.0	-	-	-	1450.7	-	-	7.86
1972	-	-	127.7	-	-	-	669.8	-	-	3.17
1973	-	-	162.3	-	-	-	734.6	-	-	2.94
1974	-	-	133.3	-	-	-	703.6	-	-	2.17
1975	-	-	159.1	-	-	-	673.7	-	-	5.28
1976	-	-	162.1	-	-	-	1288.5	-	-	7.94
1977	-	-	67.8	-	-	-	476.3	-	-	3.57
1978	-	-	76.7	-	-	-	379.6	-	-	2.39
1979	-	-	173.8	-	-	-	645.2	-	-	3.98
1980	-	-	110.7	-	-	-	358.1	-	-	5.28
1981	175.0	-	73.0	18	-	-	357.8	-	-	4.66
1982	172.0	-	132.6	32	-	-	323.9	-	-	1.86
1983	140.0	-	58.8	14	-	-	236.7	-	-	2.14
1984	135.0	-	208.7	44	-	-	290.5	-	-	3.98
1985	175.0	-	190.9	45	-	302.6	316.0	-	-	2.38
1986	143.0 [f/]	-	190.8	42	-	304.0	291.4	-	-	4.96
1987	200.0	-	82.5	19	-	476.0	197.1	-	-	0.94
1988	200.0	-	160.8	33	-	480.3	352.9	-	-	1.85
1989	200.0	-	144.5	28	-	446.2	315.5	-	-	1.65
1990	161.0 [g/]	-	104.0	15	20.9	321.0	263.9	-	75.7	3.20
1991	200.0	-	135.5	24	36.4	421.9	255.5	-	84.2	1.59
1992	135.0 [e/]	-	138.6	25	39.3	265.7	256.6	77.1	90.1	1.78
1993	142.0 [e/]	-	168.0	29	54.5	283.3	251.9	82.2	98.6	2.42
1994	-	26	130.5	27	43.7	140.9	134.1	49.3	45.2	0.99
1995	-	38	131.3	26	52.4	219.0	159.0	60.0	65.5	1.15
1996 [h/]	-	32	212.1	43	88.1	181.3	236.5	63.2	102.9	1.41

a/ Prior to 1985, index spawners were calculated using complete OCN spawning habitat mileage (streams and lakes combined) and based on a coastwide average adult-spawners-per-mile value observed for streams. Index estimates since 1984 are calculated by individual coastal river basins with adult-spawners-per-mile values calculated for each basin separately. A spawner escapement methodolgy study based on SRS has been in effect since 1990. The SRS methodology indicates that actual escapements are less than projected by the standard spawner index.

b/ Calculated as: ocean escapement/(1-OPI ocean harvest rate).

c/ Postseason index abundance estimate divided by parent index adults; except peak index spawner counts have been used for 1970-1972.

d/ Council goal initially established in 1981 to rebuild OCN stocks and amended in 1987 (Amendment 7) to provide a range of 135,000 to 200,000 coho. The goal was amended again in 1993 (Amendment 11) to 42 adults per mile on standard index surveys. Amendment 11 also allows up to a 20% exploitation rate at stock abundances of less than 250,000. The rate chosen must not cause irreparable harm to the stock.

e/ Adults-per-mile were adjusted to remove hatchery fish for 1985-1995. No hatchery strays were identified in 1991.

f/ Salmon framework amendment rebuilding goal of 170,000 was modified by the Council for optimum yield considerations.

g/ Reflects sliding scale portion of Council framework amendment spawning goal in Amendment 7.

h/ Preliminary.

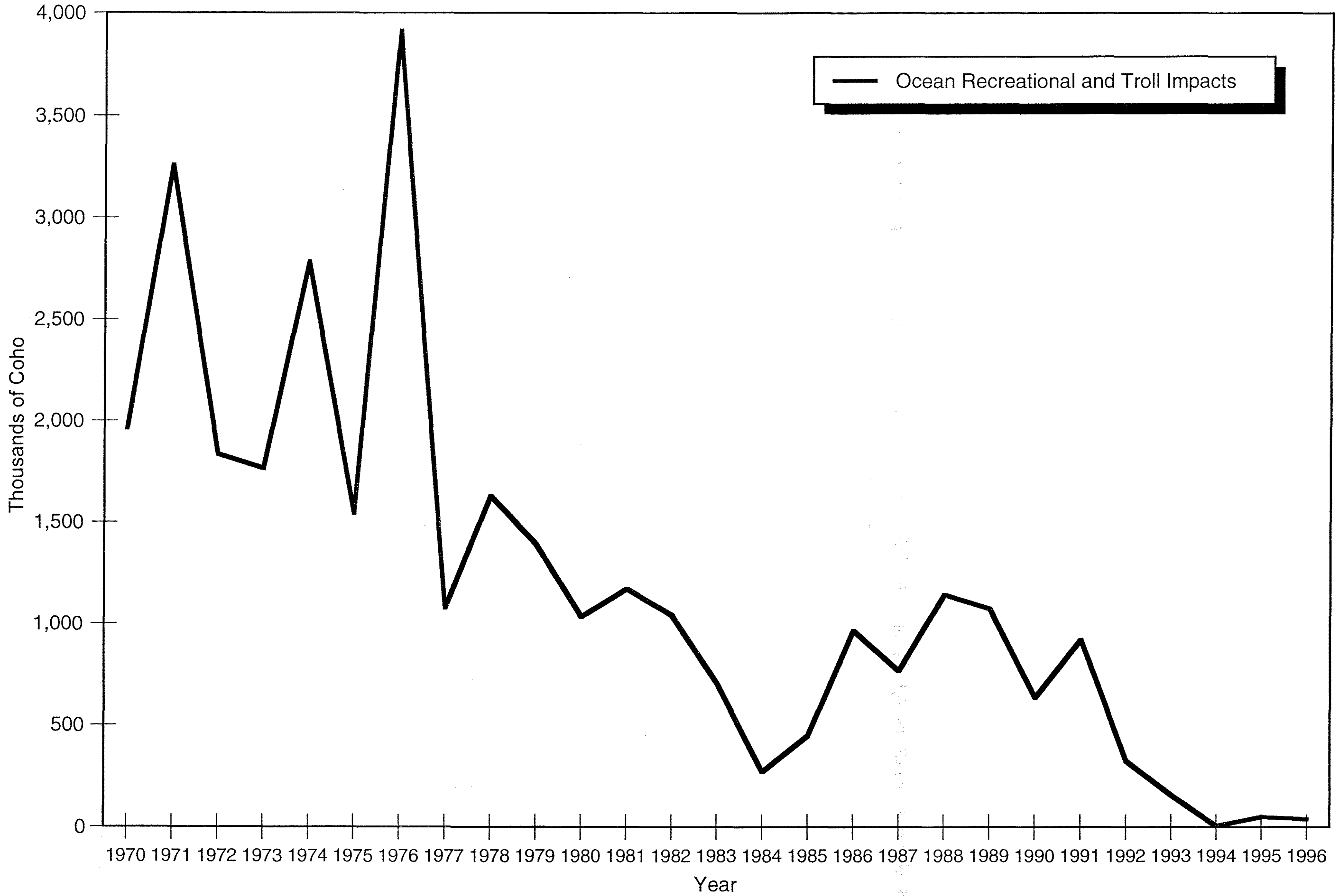

FIGURE 1. Marine fishery impacts on OPI area coho salmon (catch plus hook-and-release mortality in thousands of fish).

2.2 Alternative 1 - Habitat-based, Fishery Impact Limit with Spawner Rebuilding Criteria at 50% and 75% of Full Seeding

2.2.1 Overview and Description of Components to Achieve Management Objectives

The objectives of Alternative 1 are to: (1) set management targets for the total harvest exploitation rate for OCN coho that significantly reduce the impact of fisheries on the recovery of depressed OCN stock components and (2) promote stock rebuilding on a more consistent basis while still allowing very limited access to harvest abundant salmon stocks during critical rebuilding periods. Any increase in fishery impacts from the lowest allowable levels under this alternative (15% or less) are contingent upon demonstrated progress in achieving spawner rebuilding criteria by parent broods and improvements in ocean survival conditions for the returning adults.

To achieve its objectives, Alternative 1 makes several significant changes from the current management regime for OCN coho. To better address identified disparities among various components of the overall OCN coho aggregate stock, Alternative 1 subdivides the current OCN aggregate (with one overall spawner escapement goal) into four separate geographically defined components (see Figure 2). For the first time, Alternative 1 would directly consider variations in habitat production potential in setting the annual spawner objective. This is accomplished through the incorporation of (1) the estimated production potential parameters for the freshwater habitat derived from a Habitat-Based Life Cycle Model developed by Nickelson and Lawson (1996) and (2) an estimate of potential marine survival conditions for the returning adults. In addition, a brood's parent and, at higher allowable harvest levels, grandparent spawner abundance would have to be considered in arriving at the final allowable exploitation rate. Allowable total harvest impacts on OCN coho under this alternative would be limited to a range that includes the recent historic low levels of 1994-1996 (11 to 13%) to a ceiling which, in the most abundant years, allows a 35% exploitation rate (i.e., almost two-thirds of OCN coho would go to spawner escapement).

To successfully implement Alternative 1, intensive monitoring will be necessary and is part of the Oregon restoration process. The monitoring must include tracking juveniles and adults in freshwater as well as determining ocean fishery impacts.

In consideration for the uncertainties that exist in this proposed management regime and the potential for new information to affect basic assumptions critical to the proposal's success, **all measures proposed in this alternative would be subject to a comprehensive, adaptive review by the year 2000.** To incorporate the best science, the methods of estimating the technical parameters used in this proposal may change without plan amendment, if approved by the Council following a technical review and recommendation for change by the Scientific and Statistical Committee.

2.2.1.1 Stock Disaggregation

For management purposes, the OCN coho stock will be divided into four separate components, divided geographically as follows (see Figure 2):

1. Northern - Necanicum River to Neskowin Creek
2. North-Central - Salmon River to Siuslaw River
3. South-Central - Siltcoos River to Sixes River
4. Southern - Elk River to Winchuck River

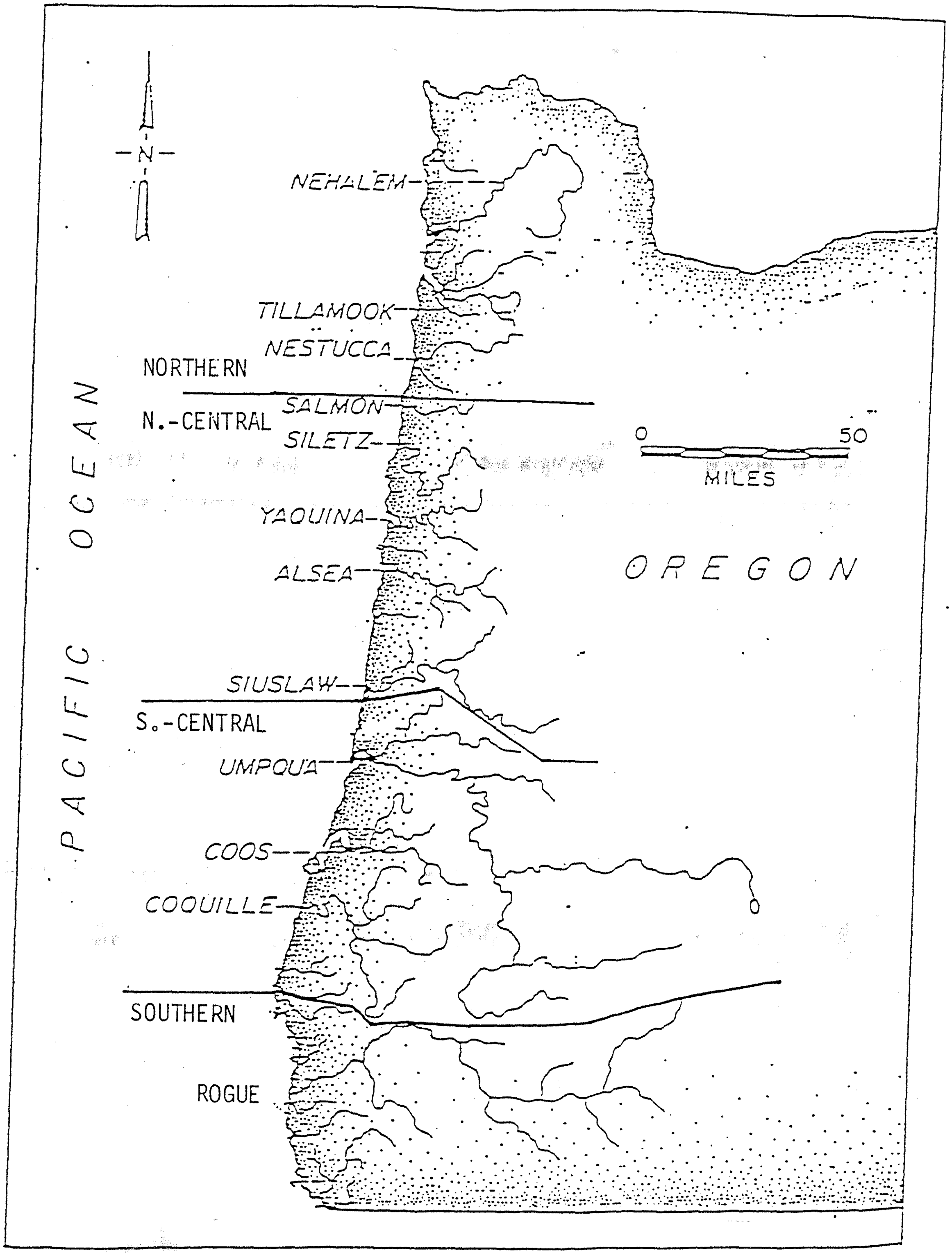

FIGURE 2. OCN coho stock component management units.

The determination of these particular components is based on a combination of available genetic, coded-wire tag (CWT) and other data used to describe biologically-based clusters. These four groupings do not identically correspond to the preliminary Gene Conservation Groups (GCG) identified in *The 1995 Biennial Report on the Status of Wild Fish in Oregon* (ODFW 1996). The preliminary northern mid-coastal Oregon GCG was split into the first two components listed above and the preliminary Umpqua GCG was combined with the adjacent preliminary southerly GCG to form the third component. However, given the limitations of some of the data, as well as the ability to track fishery impacts and make total abundance estimates, slight modifications of the original GCGs were warranted.

Within the limits of our current understanding and available information, each stock component will be managed at an overall annual harvest exploitation rate that is sensitive to present spawner abundance criteria based on the productive capacity of its freshwater environment and the expected marine survival for the returning adults.

Minor modifications to the definition of the stock components may be made after a Council review. However, a basic change to the concept of four components would require plan amendment.

2.2.1.2 Spawner Rebuilding Criteria

Two spawner rebuilding levels are proposed as triggers in the fishery management regime to guide harvest rate decisions. These levels are derived from the freshwater habitat-based model of Nickelson and Lawson (1996). In developing estimates of spawners needed to achieve full seeding, this model incorporates measures of variability in the quality of the freshwater habitat and uses estimates of survival between life stages where numerical indicators have been measured in Oregon study streams or other relevant research. Under the model's assumptions, the number of spawners necessary for full seeding of the freshwater habitat is higher under favorable marine survival conditions than at less favorable levels. A detailed description of the model is contained in Appendix A.

For each stock component, the lowest stock rebuilding level (Level #1) represents one-half the estimated adults needed to achieve full seeding of the high quality habitat that is productive during conditions of poor ocean survival. The higher spawner rebuilding criteria (Level #2), which dictates when the highest levels of fishery impacts are allowed, is simply 50% greater than Level #1 (i.e., 75% of full seeding of the high quality habitat). The Level #2 rebuilding criteria assures that significant progress is being made in rebuilding before the fishery impacts are increased.

The proposed spawner abundance criteria are comparable to adult estimates based on the stratified random survey (SRS) methodology that has produced reliable spawner estimates north of Cape Blanco since 1990. The SRS methodology was initiated in the Rogue River basin beginning with the 1996-97 spawning season. The recent year average spawner abundance and proposed spawner rebuilding criteria are provided in Table 4. Tables A-2 through A-4 in Appendix A provide a detailed display of the production potential and full seeding estimates at three levels of marine survival for major streams within each stock component.

If, under future review, the best science indicates new estimates of full seeding, the Level #1 and Level #2 rebuilding criteria could be modified without plan amendment to reflect the same proportional relationship (50 and 75% of full seeding).

2.2.1.3 Marine Survival

Marine survival of OCN coho can vary significantly from brood to brood. This alternative apportions the adult marine survival rates into low, medium and high categories which, along with parent abundance, help determine the appropriate fishery exploitation rate each year that will allow stock rebuilding progress. Adult recruits-per-spawner values for OCN coho north of Cape Blanco, under less than full seeding rates, have been categorized as near 1 in years of poor marine survival, 2-5 for medium survival and greater than 5 under high marine survival conditions. Generally, marine survival rates for OCN adult coho of less than 5% would be considered low and those of 10% or greater would be in the high category. Since data for marine survival rates for wild fish is not available, Alternative 1 proposes to utilize the smolt-to-jack survival rates of hatchery produced coho as the best present predictor to determine high, medium and low adult marine survival categories. If better predictors are determined in the future, they would replace the jack predictor after review and approval by the SSC and Council. Minor modifications to the designated categories to reflect the best science also could be made without plan amendment.

TABLE 4. Recent average number and range of spawners compared to Alternative 1 rebuilding criteria for OCN coho stock components in SRS numbers.[a/]

	Number of OCN Adult Spawners			
	Actual 1990-1996		Rebuilding Criteria	
Stock Component	Average	Range	Level 1 (50% of full seeding at low marine survival)	Level 2 (75% of full seeding at low marine survival)
Northern	4,300	2,200-9,300	10,900	16,400
North-Central	11,100	5,600-18,800	27,500	41,300
South-Central[b/]	31,200	13,100-56,200	25,000	37,500
Southern[c/]	3,400	200-5,400	2,700	4,100
Aggregate	50,000	21,100-89,700	66,100	99,300

a/ Spawner estimates in the Rogue River from 1990-1995 were not made using the SRS methodology. The SRS methodology will be conducted in 1996-1997, and comparisons to traditional counting results can be made at that time.

b/ Includes both rivers and lake systems.

c/ Number of OCN spawners in the southern sub-aggregate represent only those estimated for the Rogue River, since counts are not made in the other (minor) areas. The use of only the Rogue River to measure the interim escapement objective for the southern-most OCN stock component, albeit by far the dominant river in the area, is based on the presumption that it correlates with the populations in the balance of the area.

Figure 3 displays the smolt-to-jack and subsequent smolt-to-adult survival rates for combined Columbia River and Oregon coastal hatchery coho for adult return years 1970-1996. Jack survival rates less than 0.09% are categorized as low, those from 0.09-0.34% as medium and those over 0.34% as high. A linear regression of the adult hatchery coho survival rates on the jack survival rates indicates that the predicted hatchery smolt-to-adult survival levels show a generally strong relationship between the jack survival and adult survival categories (Figure 3 and Figure B-1 in Appendix B for regression relationship; $r^2 = 0.85$).

Table 5 displays the data used to develop and establish the accuracy of the proposed marine survival categories using hatchery jack survival rates to identify high, medium and low marine survival rates for OCN adult coho. The relationship between OPI hatchery and OCN adult coho survival rates are not precisely known, and wild recruit-per-spawner values are somewhat dependent on parent spawner level. Therefore, neither quantity is singly reliable as a predictor of rebuilding potential in underseeded conditions at different marine survival levels. However, an evaluation of the success with which the hatchery jack survivals predict either the correct marine survival category for wild adult recruits per spawner or the OCN coho smolt-to-adult survival (under the assumption that it is double that of hatchery coho), shows that hatchery jack survival correctly predicts adult survival in all 27 years displayed in Table 5. Separately, under the proposed divisions, hatchery jack survival correctly categorizes wild recruit per spawner values in 19 of 27 years (under predicted in 2 years and over predicted in 6 years). For OCN adult survival based on the assumption that it is double that of hatchery adults, the jacks correctly predict adult marine survival in 21 of 27 years (1 under prediction and 5 over predictions).

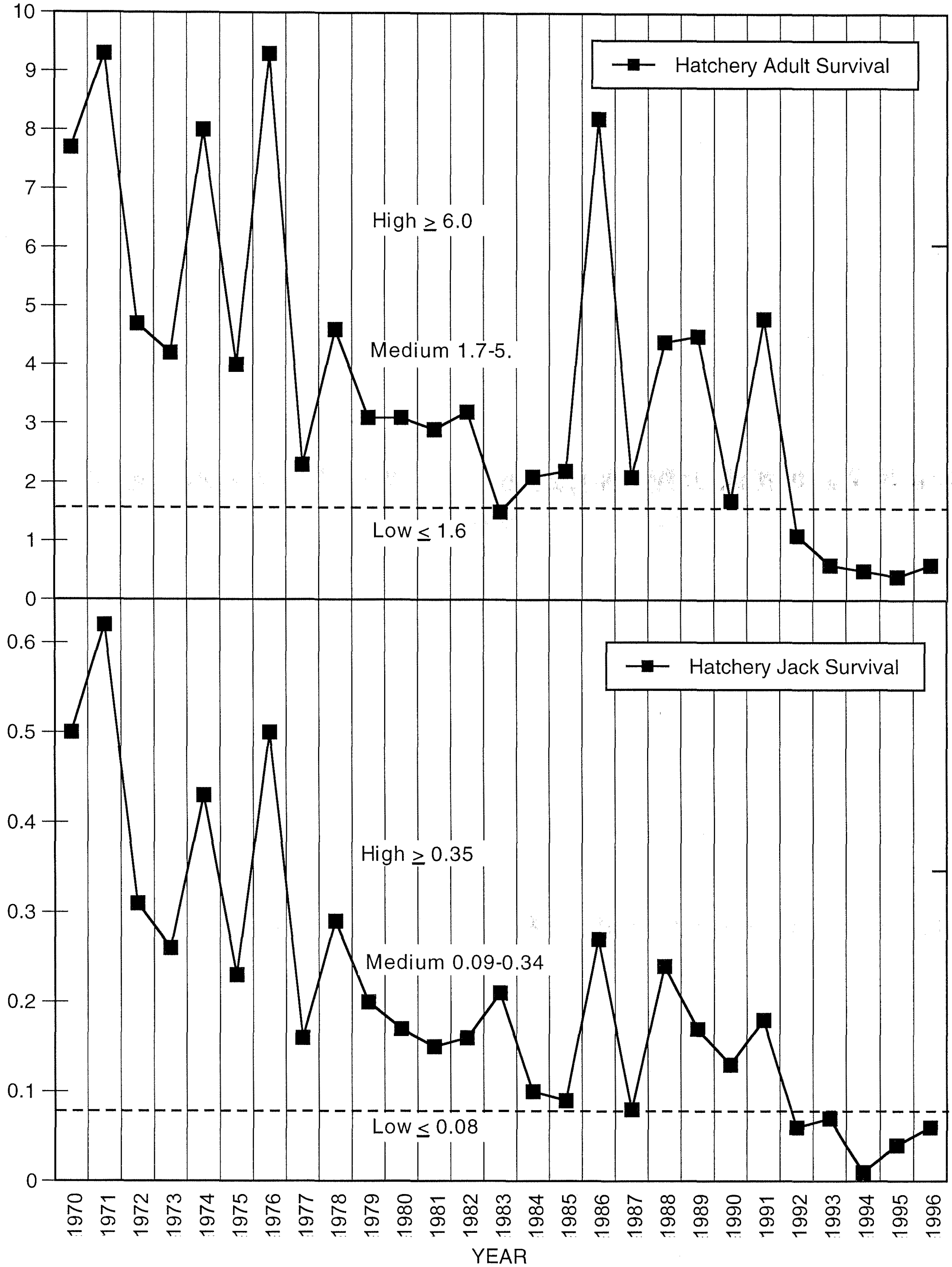

FIGURE 3. Comparison of smolt to jack and smolt to adult survival rates and marine survival categories for Columbia River and Oregon coastal natural coho (adult marine survival categories taken from regression of adult survival on jack survival - see Appendix B).

TABLE 5. Prediction of marine survival categories from combined Columbia River and Oregon coastal hatchery coho smolt-to-jack survival rates (1970-1996). Numbers for smolts are in millions; jacks and adults in thousands.

Adult Return Year (t)	Smolts (t-1)	Jacks (t-1)	Jack Survival	Adults (t)	Adult Survival	Wild Recruit per Spawner[a/]	Do Jacks Accurately Predict Adult Marine Survival Category?[b/] High (>5% or >5)	Medium (2.5-5% or 2-5)	Low (<2.5% or <2)
HIGH ADULT MARINE SURVIVAL (Predicted by Smolt-to-Jack Survival >0.34%)									
1971	28.8	179.4	0.62%	2679.1	9.3%	7.86	Yes	-	-
1970	32.4	162.2	0.50%	2503.8	7.7%	2.85	Yes	(W)	-
1976	34.0	171.5	0.50%	3149.2	9.3%	7.94	Yes	-	-
1974	33.6	144.2	0.43%	2678.9	8.0%	2.17	Yes	(W)	-
				Averages:	8.6%	5.21			
MEDIUM ADULT MARINE SURVIVAL (Predicted by Smolt-to-Jack Survival of 0.09-0.34%)									
1972	33.3	103.7	0.31%	1578.3	4.7%	3.17	-	Yes	-
1978	35.5	103.2	0.29%	1617.7	4.6%	2.39	-	Yes	-
1986	29.0	77.6	0.27%	2381.7	8.2%	4.96	(H)	Yes	-
1973	35.3	91.4	0.26%	1498.8	4.2%	2.94	-	Yes	-
1988	35.0	85.1	0.24%	1556.4	4.4%	1.85	-	Yes	(W)
1975	32.6	76.2	0.23%	1314.6	4.0%	5.28	(W)	Yes	-
1983	32.7	68.2	0.21%	504.5	1.5%	2.14	-	Yes	(H)
1979	37.1	72.5	0.20%	1160.8	3.1%	3.98	-	Yes	-
1991	37.2	68.7	0.18%	1802.9	4.8%	1.59	-	Yes	(W)
1989	36.0	60.8	0.17%	1620.0	4.5%	1.65	-	Yes	(W)
1980	34.2	57.6	0.17%	1065.2	3.1%	3.20	-	Yes	-
1977	33.5	53.7	0.16%	759.6	2.3%	3.57	-	Yes	(H)
1982	37.3	61.3	0.16%	1196.1	3.2%	1.86	-	Yes	(W)
1981	32.3	48.7	0.15%	938.6	2.9%	4.66	-	Yes	-
1990	35.9	46.7	0.13%	594.2	1.7%	3.20	-	Yes	(H)
1984	30.9	31.7	0.10%	646.1	2.1%	3.98	-	Yes	(H)
1985	30.0	26.0	0.09%	657.4	2.2%	2.38	-	Yes	(H)
				Averages:	3.6%	3.11			
LOW ADULT MARINE SURVIVAL (Predicted by Smolt-to-Jack Survival <0.09%)									
1987	39.5	32.8	0.08%	817.1	2.1%	0.94	-	-	Yes
1993	39.7	27.2	0.07%	222.8	0.6%	2.42	-	(W)	Yes
1992	42.1	25.6	0.06%	472.8	1.1%	1.78	-	-	Yes
1996	29.5	17.3	0.06%	174.3	0.6%	1.41	-	-	Yes
1995	32.3	11.8	0.04%	134.8	0.4%	1.15	-	-	Yes
1994	39.5	5.1	0.01%	202.7	0.5%	0.99	-	-	Yes
				Averages:	0.9%	1.45			

a. FromTable 1 (postseason index abundance estimate/parent index spawners); except 1970-1972 data are from peak spawner counts.

b. The jack prediction is considered correct if adult marine survival fits the same category as the jack marine survival based on meeting either the hatchery smolt-to-adult survival **or** the wild recruit-per-spawner category values. The categories are as follows.

Adult hatchery survival levels: high is >5%; medium is 2.5-5% and low is <2.5%

Wild recruits per spawner: high is >5; medium is 2-5 and low is <2

If the two adult marine survival estimates differ by category, the marine survival category that would have been designated singly by wild recruits-per-spawner or hatchery smolt-to-adult survival rate are indicated by "(W)" and "(H)", respectively.

2.2.2 Proposed OCN Coho Management Objectives

The matrix below in Table 6 illustrates the proposed allowable total stock exploitation rate for each OCN coho stock component. The allowable rate is determined by the spawning abundance of the parents and grandparents of the returning adults and upon the marine survival expectations for the current maturing brood.

The total stock impacts (exploitation rate) represent all fishing related mortality, including marine and freshwater fisheries for both retention and catch-and-release fishing. Allowable stock exploitation rates range from a low of less than 15% (under conditions like 1994-1996) to a high of up to 35% if two generations of spawner rebuilding has been demonstrated and marine survival is high enough to expect continued improvements in spawner escapement for a third generation. A cap of 35% in total stock impacts is proposed regardless of high parental spawning levels or projected favorable ocean conditions, so as to test the effects of high spawner levels. A limitation of up to 15% remains in effect even at the two highest tiers of parent escapement if ocean conditions are not favorable, so as to preserve rebuilding progress achieved to that point.

TABLE 6. Determination of the allowable total fishery exploitation rate under Alternative 1 for each OCN coho stock component.

	SMOLT TO ADULT MARINE SURVIVAL[a/]		
	Low	Medium	High
PARENT SPAWNER STATUS[b/]	ALLOWABLE TOTAL FISHERY IMPACT		
High Parent spawners achieved Level #2 rebuilding criteria; grandparent spawners achieved Level #1	≤15%	≤30%	≤35%
Medium Parent spawners achieved Level #1 or greater rebuilding criteria	≤15%	≤20%	≤25%
Low Parent spawners less than Level #1 rebuilding criteria	≤15%	≤15%	≤15%
Parent spawners less than 38% of Level #1 rebuilding criteria	≤10-13%		

Stock Component Rebuilding Criteria:	**Level #1** (50%)	**Level #2** (75%)
Northern	10,900	16,400
North-Central	27,500	41,300
South-Central	25,000	37,500
Southern	2,700	4,100
Total	66,100	99,300

a/ See the discussion of marine survival under Section 2.2.1.3.

b/ In the event that a spawner criteria is achieved, but a basin within the stock component is identified to have a severe conservation problem, the next tier of additional harvest would not be allowed in mixed-stock fisheries for that component, nor additional impacts within the basin (see Table A-3 in Appendix A for a list of stream basins within stock components).

Under the lowest category of parent spawner status and marine survival, the matrix allows up to a 15% harvest impact, unless the parental spawner abundance of a stock component is well below the Level #1 rebuilding criteria. In the event parent spawners are less than 38% of the Level #1 rebuilding criteria (similar to the aggregate levels of recent years), harvest impacts would be held at no more than 10-13%, the levels maintained in 1994-1996. If parent spawners decline to even lower levels than seen in recent years, rates of less than 10% would be considered, recognizing that there is a limit to further bycatch reduction opportunities.

Each of the four OCN coho stock components will be managed in marine fisheries as a separate stock to the extent that the best scientific information allows. Because of apparent similarities in the marine distribution of the four components, little flexibility is expected in marine fishery intensities among the components. If some components begin rebuilding faster than others, but data are not available which allows the marine harvest of OCN coho components at different rates, opportunities for increased ocean harvest may be constrained by the weakest component. In the forseeable future, the northern stock component can be expected to dictate low harvest levels in marine fisheries for all components. Any management flexibility for increased fisheries on any strong OCN component will be essentially in freshwater or estuarine areas in the near future. In these areas, ODFW will base fishing opportunity on the status of populations in individual basins within a stock component and directed fisheries on natural coho will be allowed only when spawners are expected to be at or above the full seeding level for high quality habitat. Actual seasons would be based on the presence of fin-clipped hatchery fish, public comment and other basin-specific factors.

2.2.3 Monitoring and Evaluation

This alternative will require an intensive monitoring program implemented by ODFW to measure overall management effectiveness towards the goal of increasing OCN spawner levels and consequent juvenile and adult progeny. The proposed monitoring program integrates several inventory methods:

1. <u>Surveys of summer and winter juvenile abundance</u> to obtain a juvenile benchmark of full seeding and a strong relationship between summer pre-smolt and winter/spring smolt populations. Such data could be used to measure utilization of freshwater rearing habitat in each stock component.

2. <u>Intensive surveys of adult abundance</u> using the SRS protocols to obtain appropriate confidence estimates around spawner estimates in each of the four stock components. This monitoring will be used as the primary method to evaluate several of the key assumptions about the results of limitations on fishing.

3. <u>Fishery impacts monitoring</u> with surrogate CWT groups of genetically similar hatchery fish within each sub-aggregate. Double-index groups will be used in selective fishery applications.

4. <u>Comprehensive monitoring sites</u> on streams representing broad management categories for individual population systems to develop an understanding of complete population dynamics (i.e., to monitor incoming adults, rearing juveniles, and outgoing smolts, as well as ocean rearing immatures (from double-index tagging).

5. <u>Physical surveys of spawning and rearing habitat</u> to calibrate a realistic absolute number of juvenile and adult fish at such benchmarks as full seeding, so that ultimate escapement goals can be developed.

Monitoring program activities are currently funded at the annual levels listed below by a combination of ODFW and federal agency expenditures:

Monitoring Coordination	$68,000
Spawner Surveys	$670,000
Life History Monitoring (Smolt and adult trapping and estimation of survival rates)	$680,000
Habitat Surveys	$604,000
Fishery Monitoring	$772,000
Total	$2,794,000

A very important feature of this proposal is a comprehensive evaluation mechanism on a pre-determined schedule. This proposal is intentionally open to critical information that may emerge prior to the scheduled evaluation; however, a full evaluation is proposed to occur promptly during 2000 when 10 years of SRS spawning data will be available (in addition to other important information). This comprehensive evaluation is proposed to include other Oregon State agencies, neighboring state and tribal agencies, the federal government and interested public. Review targets will include at least the following in an effort to appraise the appropriateness of the spawner escapement rebuilding criteria and fishery management regime relative to achieving the desired improvement in OCN health. All features of this proposal are subject to change at the scheduled evaluation.

1. Relationship of parents to adult recruits at various marine survival rates.

2. Results of juvenile monitoring, such as egg to fingerling to smolt survival rates, summer and winter carrying capacity estimates, and relationship of parents to smolts in each stock component.

3. Relationship of fishery impacts on stock/population sustainability at various freshwater and marine survival rates.

4. Estimates of fishery mortality by several individual strata.

5. Boundaries between the three tiers of allowable take in fisheries.

6. Results of run reconstruction exercises (FRAM model and SRS/Standard).

7. SRS assumptions about viable spawning habitat.

2.3 Alternative 2 - Habitat-based, Fishery Impact Limit with Spawner Rebuilding Criteria of Full Seeding

Alternative 2 would be the same as Alternative 1, except the rebuilding criteria would have only one level--full seeding at the low marine survival level as displayed below in Table 7. Also, under the lowest category of parent spawner status and marine survival, the matrix allows up to a 15% harvest impact, unless the parental spawner abundance of a stock component is well below the full seeding level. In the event parent spawners are less than 50% of full seeding, the harvest impacts would be held at no more than 10-13%, the levels maintained in 1994-1996. If parent spawners decline to even lower levels than seen in recent years, rates of less than 10% would be considered, recognizing that there is a limit to further bycatch reduction opportunities.

TABLE 7. Determination of the allowable total fishery exploitation rate under Alternative 2 for each OCN coho stock component.

PARENT SPAWNER STATUS[b]	SMOLT TO ADULT MARINE SURVIVAL[a] — Low	Medium	High
	ALLOWABLE TOTAL FISHERY IMPACT		
High Parent and grandparent spawners achieved full seeding	≤15%	≤30%	≤35%
Medium Parent spawners achieved full seeding	≤15%	≤20%	≤25%
Low Parent spawners less than full seeding	≤15%	≤15%	≤15%
Parent spawners less than 50% of full seeding	≤10-13%		

Stock Component Rebuilding Criteria:	**Number of Spawners for full seeding**
Northern	21,700
North-Central	55,000
South-Central	50,000
Southern	5,400
Total	132,100

a/ See the discussion of marine survival under Section 2.2.1.3.
b/ In the event that a spawner criteria is achieved, but a basin within the stock component is identified to have a severe conservation problem, the next tier of additional harvest would not be allowed in mixed-stock fisheries for that component, nor additional impacts within the basin (see Table A-3 in Appendix A for a list of stream basins within stock components).

2.4 Other Alternatives

Prior to the current amendment process, the Council considered modifying OCN coho management by converting the extensive index data base, which establishes the current spawner goal of 200,000 adults, to SRS numbers which are believed to more accurately reflect the actual OCN coho population. However, due to the depression of the OCN coho stock, only a limited range of data is available to use in estimating a precise conversion. Waiting to get a robust data set could take many more years. Given this problem, the uncertainty of accurately estimating maximum sustainable yield (MSY) and the fact that the status quo does not specifically consider component stock management and habitat production potential, conversion of the index data was not included as a part of this amendment consideration.

The alternative management concepts considered in this document were presented to the Council after being developed in an extensive public and state agency process headed by the Governor's Office of the State of Oregon while completing the coastal salmon restoration initiative. No other detailed management alternatives were offered or adopted during the Council's scoping or review of the preliminary draft amendment.

Within the two alternatives to status quo management there are many possible variations in the selection of specific management criteria which could result in additional alternatives. However, due to the great deal of uncertainty and complexity in OCN management, evaluating all of the various permutations would likely be more confusing than helpful. One of the main purposes of the alternatives being considered is to develop better information and certainty in OCN management. If the Council adopts one of the amendment alternatives, it is likely that better informed decisions can be made in the future as to various beneficial modifications to the adopted management structure.

3.0 IMPACTS OF THE MANAGEMENT ALTERNATIVES

Status quo management of OCN coho allows fishery harvest and mortality to take all fish in excess of a spawner escapement goal of 200,000 index adults, except at low stock sizes when a harvest impact rate of no more than 20% is allowed to protect stock recovery while allowing access to other available salmon stocks. This spawner goal is based on what was believed to be the best estimate of MSY as determined from standard adult index survey estimates. However, recent studies using SRS methodology indicate that the index surveys overestimate the actual spawner escapement to a very significant degree and cast doubt on the present management objective, especially in view of the persistent and continued decline of the stock and its consideration under the ESA.

The proposed fishery impact rates of Alternatives 1 and 2 represent significant relief to OCN coho compared to historic rates (Table 8) and the potential rates currently allowed under status quo (Table 9). Alternatives 1 and 2 establish harvest impact ceilings that allocate more recruits to spawning than to fisheries in every year. At low stock sizes, Alternatives 1 and 2 limit the total harvest impact to no more than 15% or at very low stocks sizes to no more than 13%. Alternatives 1 and 2 appear to provide more protection against further stock losses and a higher probability of larger long-term spawner escapements for OCN coho than the status quo. Alternative 2 is identical to Alternative 1, except that it requires a higher level of stock rebuilding criteria (number of parent spawners) before the harvest rate can increase above 13% or above 15%. In the near future, Alternative 2 would tend to allocate more fish to spawning than Alternative 1 if marine survival reached medium or high levels (Table 9 and also see Figure 4 in Section 6.3).

Table 10 displays the results of hindcasting the allowable harvest impact rates under status quo and the two alternatives for the years 1992-1997 in SRS numbers (prior to 1990, all accounting was in terms of index numbers). This period was one of consistently low OCN coho abundance and the allowable harvest rates projected under status quo management are no more than 20%. Under both alternatives, the allowable harvest rate would have been no more than 15%. The actual Council-adopted exploitation rates during this period ranged from 11 to 42%.

3.1 Ecological Impacts

Alternatives 1 and 2 propose management which is based directly on estimates of freshwater habitat production and marine production potential for OCN coho as defined within four stock components. While there is danger that some estimates upon which the management is based may contain significant error, the alternatives also provide for the generation and collection of data which should help our understanding and modeling of the dynamics of natural coho salmon production in the OPI area and improve our management ability in the long-term.

Both Alternative 1 and 2 appear to have greater ecological benefits for OCN coho than status quo management. They not only assure greater numbers of spawning adults at nearly all abundance levels, but the stock component goals assure a more uniform distribution of spawners and production throughout the OCN coho freshwater habitat which should make for a more resilient and diverse population. The unequal distribution (low numbers in the two northern components) has been a consistent problem for several years. This problem is displayed in the variation of spawner replacement rates among the component stocks in Table 11 and in comparing the average spawners with the spawner rebuilding criteria in Table 4.

TABLE 8. Estimated historic fishery impact rates by time period on Oregon coastal natural coho, 1890-1996.[a/]

Years	Estimated Fishery Impact Rate
1890-1929	40%
1930-1939	55%
1940-1949	55%
1950-1959	70%
1960-1969	70%
1970-1983	80%
1984-1986	35%
1987-1992	55%
1993	35%
1994-1996	7-12%

a/ From evaluation of the following ODFW documents and consolidated data sets:

Cleaver, F.C. 1951. Fisheries Statistics of Oregon. Oregon Fish Commission, Contrib. 16.

Jacobs, S.E. 1994. An assessment of historic and contemporary abundance and catch for Oregon coastal natural coho salmon by time period, 1890-1993. Unpublished data. Oregon Department of Fish and Wildlife. Ocean Salmon Management Program.

Lawson, P.W. 1992. Estimating time series of Oregon coastal natural coho salmon ocean harvest rates and recruitment. Oregon Dept. of Fish and Wildlife, Ocean Salmon Management Program unpublished report. Newport.

Mullen, R.E. 1981. Oregon's commercial harvest of coho salmon *Oncorhynchus kisutch* (Walbaum), 1892-1960. Oregon Dept. of Fish and Wildlife, Info. Rpt., No. 81-3.

Alternatives 1 and 2 more clearly set specific limits to harvest impacts at low OCN coho stock abundances than status quo management, both in the selection of harvest rates and by the disaggregation into four stock components. These limits should help assure the protection of the four OCN stock components during decline and assist in their rapid recovery when environmental conditions improve. The protection from fisheries offered by Alternatives 1 and 2 is similar to or greater than that provided to salmon currently listed under the federal ESA.

At high abundance levels, the alternatives significantly increase the number of spawning fish. If the status quo spawner goal truly represents the MSY level, the additional spawners may not be beneficial. However, the SRS data indicates that it is likely that status quo management underestimates the real number of spawners needed for MSY. In addition, recent studies have reported on the importance of nutrient transport to the upper stream reaches through the carcasses of spawning fish. This transport has been greatly reduced for many years.

TABLE 9. Comparison of projected total allowable exploitation rates under the proposed alternatives. (See Appendix B for details of rationale for each alternative).[a/]

Adult Return Year	Amendment Alternative	Allowable Exploitation Rate for Marine Survival Conditions		
		Low	Medium	High
1998	Status Quo - Aggregate	≤10-13%	≤20%	-
	1 - Northern	≤10-13%	≤10-13%	
	North-Central	≤15%	≤15%	-
	South-Central	≤15%	≤15%	
	Southern	≤15%	≤15%	
	2 - Northern	≤10-13%	≤10-13%	
	North-Central	≤10-13%	≤10-13%	-
	South-Central	≤15%	≤15%	
	Southern	≤15%	≤15%	
1999	Status Quo - Aggregate	≤20%	≤35%	≤50%[b/]
	1 - Northern	≤10-13%	≤15%	≤15%
	North-Central	≤15%	≤15%	≤15%
	South-Central	≤15%	≤30%	≤35%
	Southern	≤15%	≤20%	≤25%
	2 - Northern	≤10-13%	≤15%	≤15%
	North-Central	≤10-13%	≤15%	≤15%
	South-Central	≤15%	≤20%	≤25%
	Southern	≤15%	≤20%	≤25%
2000	Status Quo - Aggregate	≤20%	≤35%	≤50%[b/]
< Level #1	1 - Northern	≤10-15%	≤15%	≤15%
	North-Central	≤10-15%	≤15%	≤15%
	South-Central	≤15%	≤15%	≤15%
	Southern	≤15%	≤15%	≤15%
< full seeding	2 - Northern	≤10-13%	≤15%	≤15%
	North-Central	≤10-13%	≤15%	≤15%
	South-Central	≤15%	≤15%	≤15%
	Southern	≤15%	≤15%	≤15%
2000	Status Quo - Aggregate	≤20%	≤30%	≤50%[b/]
≥Level #2	1 - Northern	≤15%	≤20%	≤25%
	North-Central	≤15%	≤20%	≤25%
	South-Central	≤15%	≤30%	≤35%
	Southern	≤15%	≤30%	≤35%
≥Full seeding	2 - Northern	≤15%	≤20%	≤25%
	North-Central	≤15%	≤20%	≤25%
	South-Central	≤15%	≤20%	≤25%
	Southern	≤15%	≤20%	≤25%

a/ The projected range of rates for Alternatives 1 and 2 can be clearly determined at this time through the year 2000 (with some small uncertainty for Alternative 1 in 2000 at low parent spawner levels). Projections for Status Quo are quite certain at low marine survival in all years. At medium and high marine survival the projections for Status Quo contain significant uncertainty.

b/ Even with a significant general increase in OCN coho, protection of listed ESUs (Central California and northern Oregon/southern California) would likely preclude a rate as high as 50%.

TABLE 10. Comparison of the Council-adopted aggregate OCN preseason exploitation rate target with the hindcasted preseason targets under status quo and proposed alternative OCN management.[a]

		Status Quo			Alternatives 1 and 2				
		OCN Preseason Prediction[b]							
Adult Year	Adopted Preseason Exploitation Rate	SRS	Index	Allowable Exploitation Rate[c]	Smolts (t-1)	Jacks (t-1)	OPI Smolt to Jack Survival Rate	Marine Survival[d]	Allowable Exploitation Rate[e]
1992	0.42	77.1	212.2	≤0.20	42.1	25.6	0.061%	Low	≤0.15
1993	0.26	82.2	226.3	≤0.20	39.7	27.2	0.069%	Low	≤0.15
1994	0.11	49.3	135.7	≤0.20	39.5	5.1	0.013%	Low	≤0.15
1995	0.12	60.0	165.2	≤0.20	32.3	11.8	0.037%	Low	≤0.15
1996	0.11-0.13	63.2	174.0	≤0.20	29.5	17.3	0.059%	Low	≤0.15
1997	0.11	86.4	237.8	≤0.20	31.6	20.7	0.066%	Low	≤0.15

a/ The current FMP management objectives for OCN coho were implemented in 1994.
b/ Preseason SRS abundance converted to index accounting based on the postseason 1990-1996 average ratio between both accounting methods.
c/ Aggregate exploitation rates for OCN coho at abundances of less than 250,000 adults must be 20% or less.
d/ Smolt to jack survival rates less than 0.09% are rated as low, 0.09-0.34% medium and above 0.34% as high.
e/ Allowable aggregate exploitation rates are 15% or less under both alternatives. However, because of low parental escapement (less than 38% of the rebuilding criteria in Alternative 1 and less than 50% of the criteria in Alternative 2), the following stock components would have been constrained to an exploitation rate of 10-13% or less for the following years.

	Alternative 1	Alternative 2
Northern:	1993, 1995 and 1997.	1993, 1995 and 1997
North Central:	1993, 1994, 1996 and 1997.	1993, 1994, 1995, 1996 and 1997
South Central:	none.	1993, 1994, 1995
Southern:	1994 and 1996.	1994 and 1996

TABLE 11. Estimates of OCN coho spawner abundance and replacement rates (spawner abundance from Appendix A, Table A-3).

Stock Component	1990	1991	1992	1993	1994	1995	1996	1990-1996 Mean
Northern	2,200	9,300	2,400	4,500	4,100	3,700	3,400	4,300
		Spawner Replacement Rate:		2.05	0.44	1.54	0.76	
North Central	5,600	6,700	15,400	7,800	9,700	13,600	18,800	11,100
		Spawner Replacement Rate:		1.39	1.45	0.88	2.41	
South Central	13,100	20,300	21,900	42,100	29,900	34,800	56,200	31,200
		Spawner Replacement Rate:		3.2	1.47	1.59	1.33	
Southern	2,800	800	1,900	200[a]	5,300	4,200	5,400	3,400
		Spawner Replacement Rate:		0.1[a]	6.63	2.21	13.75[a]	
Aggregate	23,700	37,100	41,600	54,600	49,100	56,600	83,700	49,500
		Spawner Replacement Rate:		2.3	1.32	1.36	1.53	

a/ Poor estimate.

3.2 Social and Economic Impacts (see Section 6.3 for additional detail)

It is extremely difficult to estimate and compare specific social and economic impacts of status quo and the proposed alternatives over any future period. This is due to the complexity of the proposed management alternatives, the variability and limits to our knowledge of the population dynamics of coho salmon, uncertainty with regard to management actions dictated under ESA listings, and the large degree of uncertainty in future environmental conditions which are critically important to coho production. Section 6 discusses these issues in more detail and provides a characterization of the potential longer-term socioeconomic impacts.

In the recent past, OCN coho harvest impacts have been held to about 11-13% due to chronic low abundance, increasingly poor marine survival conditions and the proposed listing of OCN stock components under the ESA. Over the next two to three years, the difference in fishery harvest impact rates would likely range from near zero to as large as the difference between somewhat more than 20% for status quo compared to 10-15% under the alternatives. In the long-term, implementation of proposed Alternatives 1 or 2 would result in a very constrained fishery management regime for OCN coho when compared to historic harvest levels (Table 8). However, if the OCN stock were successfully rebuilt and marking of hatchery reared coho proved to be successful in allowing high exploitation rates on the hatchery component while mixed with natural stock, the reduction in future fisheries would be mitigated and gains might even be possible in the long-term average annual harvest. It is also possible that without the increased spawning allowed under the alternatives, the future survival of OCN coho may not be assured.

3.3 Administrative Impacts

The proposed alternatives represent some of the most complex and data intensive management approaches that the Council has ever considered for its salmon FMP. This complexity may add additional workload to the Council's preseason salmon management and methodology review processes, and require extensive support from ODFW staff. However, the guidance in the alternatives is more specific than in the current FMP and most of the parameters which set the allowable harvest rate can be determined in advance of the Council's March meeting. This could simplify the development of options in March during years of low OCN coho abundance.

The proposed alternatives contain numerous quantitative criteria which determine the final harvest management. With so many specific criteria, it is impossible to predetermine if they will fit each year's management situation as intended. Also, there will be extreme pressure on reviewing or reassessing the data if the rebuilding criteria or marine survival category are near a break point with regard to allowed harvest rate. Experience has shown that in some years the management directed by the various criteria may result in an illogical situation which may require emergency action by the Council.

3.4 Compliance with the National Standards

The Council's status quo management of OCN coho and the proposed alternatives appear to meet the basic tenets of the 10 National Standards of the Magnuson-Stevens Fishery Conservation and Management Act. The difference between status quo and the alternatives is the degree or way in which they meet the standards.

Both status quo and the alternatives attempt to manage for optimum yield and prevent overfishing. While it is now questionable if the status quo spawner goal accurately estimates the MSY level, the harvest impact rate currently used by the Council is based on SRS numbers in the fishery impact models. Alternatives 1 and 2 are clearly more conservative than status quo management and are unlikely to exceed an MSY harvest rate. The alternatives would provide data from which to better determine an MSY estimate for long-term management.

4.0 COUNCIL RECOMMENDATION

4.1 Council-Adopted Alternative

The Council recommends implementation of Alternative 1 with minor modifications to Table 6 as presented below in Table 12. The modifications include edits to Footnote b and the addition of Footnote c which incorporates some of the criteria formerly listed within the "Low" Parent Spawner Status cell of Table 6 (additions to the language in Alternative 1 are in bold type).

TABLE 12. Council-adopted, allowable harvest impact rate criteria for OCN coho stock components.

	SMOLT TO ADULT MARINE SURVIVAL[a]		
	Low	**Medium**	**High**
PARENT SPAWNER STATUS[b]	**ALLOWABLE TOTAL FISHERY IMPACT**		
High Parent spawners achieved Level #2 rebuilding criteria; grandparent spawners achieved Level #1	≤15%	≤30%	≤35%
Medium Parent spawners achieved Level #1 or greater rebuilding criteria	≤15%	≤20%	≤25%
Low Parent spawners less than Level #1 rebuilding criteria	≤15% ≤10-13%[c]	≤15%	≤15%

Stock Component Rebuilding Criteria:	**Level #1** (50%)	**Level #2** (75%)
Northern	10,900	16,400
North-Central	27,500	41,300
South-Central	25,000	37,500
Southern	2,700	4,100
Total	66,100	99,300

a/ See the discussion of marine survival under Section 2.2.1.3.

b/ In the event that a spawner criteria is achieved, but a ***major*** basin within the stock component is ***less than ten percent of the full seeding level***, the next tier of additional harvest would not be allowed in mixed-stock fisheries for that component, nor additional impacts within that particular basin (see Table A-3 in Appendix A for a list of ***major*** basins within stock components ***and Table A-2 in Appendix A for the spawners needed for full seeding at three percent marine survival).***

c/ This exploitation rate criteria applies when parent spawners are less than 38% of the Level #1 rebuilding criteria, ***or when marine survival conditions are at an extreme low as in 1994-1996 (<0.06% hatchery smolt to jack survival).***

The provisions in Footnote b were designed to protect weak portions of a stock component when there are serious disparities in the coho abundance levels of various major river basins within the component. Under Alternative 1, Footnote b did not contain a clear definition of what constituted "a severe conservation problem" or a "basin". The modifications to footnote b provide (1) a specific standard at which harvest impact increases for a stock component are prohibited--"less than 10% of full seeding in any major river basin", and (2) a reference in Appendix A to identify the full seeding level for each major basin.

Footnote c contains the triggering criteria of Alternative 1 (38% or less of full seeding) to limit the allowable harvest impact rate to 10-13% or less. In addition, Footnote c specifies that this harvest limitation also applies when marine survival conditions are at an extreme low as in 1994-1996.

4.2 Relation of the Adopted Alternative to State Management

The amendment alternative adopted by the Council meets the criteria developed by the State of Oregon in the *Oregon Coastal Salmon Restoration Initiative* (now commonly referred to as the Oregon Plan) and the terms of the Memorandum of Agreement between the State of Oregon and NMFS to collaborate in salmon restoration. The state restoration initiative is a unique approach to addressing salmon stock recovery which emphasizes the role of state agencies and voluntary efforts to address the major factors depressing the salmon populations.

4.3 Council Response to Technical Concerns

During the Council's consideration of the proposed amendment, several entities and individuals expressed strong support for the concept of the adopted alternative, but also some genuine concern for various technical aspects upon which achievement of the amendment's objectives depend. The thrust of these comments and the Council's response are characterized below.

The STT stated that the proposed amendment represents a significant step in the direction necessary to conserve important components of the OCN coho stock aggregate. The SSC reported its strong support for the concepts embodied in the amendment which provide a framework for sound management and restoration of the OCN coho runs. Both advisory bodies then went on to express their serious reservations about certain technical aspects of the adopted alternative which are important to its successful implementation. Those aspects included the need for a risk assessment (i.e., how likely is the amendment to achieve its goals), additional evaluation of the differences in the impacts of the alternatives over a longer time period with regard to achieving full seeding and maintaining the viability of the ocean fisheries, modification of present fishery assessment models to allow direct management of the four stock components, and the arbitrary choice of some parameters which guide the allowable stock harvest impact.

The Council understands that the concepts and technical modeling behind the adopted alternative are relatively new, quite complex and have not been extensively tested. Therefore, to answer concerns expressed by the Council's technical advisors and to help guide implementation of the amendment, ODFW and NMFS staff have developed an assessment of the level of risk involved in rebuilding OCN coho under the status quo (Amendment 11) and proposed management regime (Amendment 13). The complete risk assessment is contained in Appendix C and makes the following conclusions:

> Amendment 13's low allowable exploitation rates will permit recovery and full seeding of high-quality habitat within several generations if marine survival improves. Modeling indicates that the probability of achieving full seeding of available habitat is higher under Amendment 13 than Amendment 11, particularly with medium and high marine survival. The overall risk (to stock recovery) associated with Amendment 13 is lower than the risk associated with Amendment 11, although both management regimes show low risk at medium to high marine survivals. On average, Amendment 11 management effectively capped escapements at levels near the 200,000 goal. In contrast, the Amendment 13 harvest rate based management regime permits escapements to increase above escapement goals defined under Amendment 11. This feature of Amendment 13 gives managers the adaptive flexibility to tap the full potential of less productive freshwater spawning and rearing habitat when marine survivals are high.
>
> It is clear, however, if poor marine survival persists for many generations, no harvest management regime alone will restore OCN coho.

In recommending the adopted alternative, the Council clearly understands that the new management approach is a work in progress which is scheduled for a full review in 2000; just two years after implementation (management in 1998 under an ESA jeopardy standard was identical to the proposed alternative). Of special emphasis in this review will be a further assessment of (1) how well the amendment provides for significant rebuilding toward full seeding and (2) a detailed review of the selection of break points in the parent spawner and marine survival criteria which set the allowable harvest impact rates. In the interim, the Council believes the adopted alternative provides an improved approach to the management of OCN coho which increases the probability of restoring the stock over the approach contained in the current salmon FMP.

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6.0 REGULATORY IMPACT REVIEW

6.1 Introduction

A Regulatory Impact Review (RIR) is required by National Marine Fisheries Service (NMFS) for all regulatory actions that either implement a new fishery management plan (FMP) or significantly amend an existing FMP. The RIR provides a review of the problems and policy objectives prompting regulatory proposals, ensures a systematic and comprehensive evaluation of the major alternatives in order to enhance public welfare in the most efficient and cost effective way, and provides a comprehensive review of the impacts associated with the proposal. The RIR also provides information from which to determine if a proposed regulatory action is likely to be economically significant, information required for NEPA on the expected economic impacts on the human environment, and a basis for determination of significance under the Regulatory Flexibility Act.

6.2 Description and Analysis of the Proposed Action and Its Impacts

A description of the fishery, need for action and policy objectives prompting this regulatory proposal are provided in Sections 1.2 and 1.3. The management actions considered are specified in Section 2.0.

6.3 Cost-Benefit Analysis

Summary: Costs--minimal costs until abundances increase; if abundances increase, a short term cost from reduced harvests; if stocks would have rebuilt under status quo and rebuilding under the chosen alternatives **is not** sufficiently greater than the rebuilding that might have occurred under status quo, there may be **lower** harvests over the long-term.

Benefits--if an ESA listing which would otherwise have occurred is avoided, there would be benefits from the avoidance of constraints on the fishing and broader economy which would result from such listings; if an ESA listing would not have occurred but the rebuilding under the chosen alternative **is** sufficiently greater than the rebuilding that might have occurred under status quo, there may be **higher** harvests over the long-term.

NOTE: The state of Oregon will be expending $2.5 million annually in monitoring coordination, spawning surveys, life history monitoring, habitat surveys, and fishery monitoring. According to ODFW, these expenditures will occur regardless of whether or not the Council adopts one of the alternatives to status quo (personal communication from McIsaac, 1997). Therefore, they are not included as part of this cost-benefit analysis.

6.3.1 Characterization of Costs

Under the alternatives, the costs, if they are incurred, will be in the form of foregone harvest opportunities. The costs will most likely be incurred only if conditions improve enough to allow some increase in coho abundance. At recent abundances, the alternatives do not mandate policies that are substantially more conservative than what has been practiced under status quo (Table 10), though some variations may occur as a result of disaggregation (see the last three paragraphs of this section). If, under status quo, abundances would have stayed at recent levels but the Council would have started allowing harvests at the maximum harvest rate allowed under the current FMP (20%), then the proposed alternatives would result in an immediate harvest reduction relative to that higher rate. However, assuming that recent year management practices would have continued, in general, costs would not likely be incurred until abundances increase. When higher abundance levels first occur, the proposed alternatives would result in lower harvests than status quo. The lower harvests mandated by the alternatives would use the opportunity provided by an increase in abundance to attempt to rebuild, or more rapidly rebuild, than under status quo.

Characterization of the costs is difficult because of the complexity of the amendment and uncertainty regarding the models which may be available for implementing it. Under status quo, each abundance level has a single maximum harvest. Under the proposed alternative, there are six possible harvest rates which may apply at any abundance level depending on previous events occurring in the fishery. Additionally, the single OCN stock is divided into four components and a different harvest rate may apply to each component. Thus for each alternative, there are 24 possible comparisons to be made against a single status quo OCN abundance. Moreover, for a single aggregate OCN abundance there are a seemingly infinite number of alternative distributions of the stock among its four components. And finally, if a given set of conditions is assumed, the effect on stock rebuilding and harvest depends to some degree on the development of models to handle the components individually. In this analysis, an attempt will be made to provide some sense of the quantitative differences among the alternatives. In order to provide this quantitative characterization, simplifying assumptions will have to be made.

As one illustration of the impact of the alternatives on harvest (and hence escapement), the following assumptions are made:

1. Marine survival conditions are high.

2. Similar abundance, harvest, and spawning level were achieved for the parent and grandparent spawners. For example, if it is possible to achieve Level #1 (Alternative 1) spawning under the specified abundance, then that abundance and spawning level was achieved by both the parent and grandparent spawners.

3. The Council will set its harvest rates to achieve the previous levels achieved by the parent and grandparent spawners.

4. The distribution of OCN components in harvest and escapement is exactly proportional to distribution among the parent spawner status criteria. For example, the full seeding criteria of the high quality habitat is 132,100. If there is an escapement of 132,100 fish, it is assumed that each component will exactly achieve this full seeding.

5. Abundance prediction and harvest models will perform perfectly.

Under these conditions, Figure 4 shows the maximum harvest allowable under each alternative at a given abundance level and provides a comparison to status quo (transformed to SRS numbers by the methods used in Table 10). The vertical distance between the 100% harvest line and each alternative represents the number of spawners. In general, under the above assumptions, the alternatives would provide lower harvests than status quo at a given harvest abundance (assuming that under status quo the Council started adopting the maximum allowed harvests). One exception to the generally lower harvests would occur in the abundance range of about 80,000 to 90,000 coho. However, such harvest levels may not be likely because of the effects of relaxing some of the above assumptions. Reduced OCN harvest opportunity at a given abundance may affect only the OCN coho, but could also affect access to other stocks in the ocean fisheries, depending on the constraints present in any particular year. The possibility that the alternatives could lead to higher abundance levels than would have occurred under status quo is discussed below in the section on benefits.

The following discussion outlines what might happen when some of the above assumptions are not met, beginning with Assumption 5 that models will perform perfectly. In 1995, the preseason estimate of total abundance was 38% above the post season estimate. Under Alternative 1, at an abundance level of 152,000 fish and high marine survival, high parent spawner status could be achieved for all components given Assumption 4 above. This would allow the maximum harvest rate (35%). However, a 38% overestimation implies a real abundance of 110,000 coho. Assuming the target harvest of 53,000 fish is achieved or exceeded (0.35*152,000), the actual spawning escapement would be no more than 57,000 coho. If the actual spawning escapement is accurately measured, the Council would determine that the spawning abundance was below the Level #1 (66,000 coho).

As a consequence of the above occurrence, three years later, regardless of ocean conditions and predicted abundance levels, the maximum allowable harvest rate would be 15% and, absent another plan amendment, it would be nine years before harvests of that brood could return to the 35% level. For this reason, it is likely that managers would seriously consider not managing for the maximum harvest rate, particularly when abundances are just sufficient to reach the next higher spawner status level.

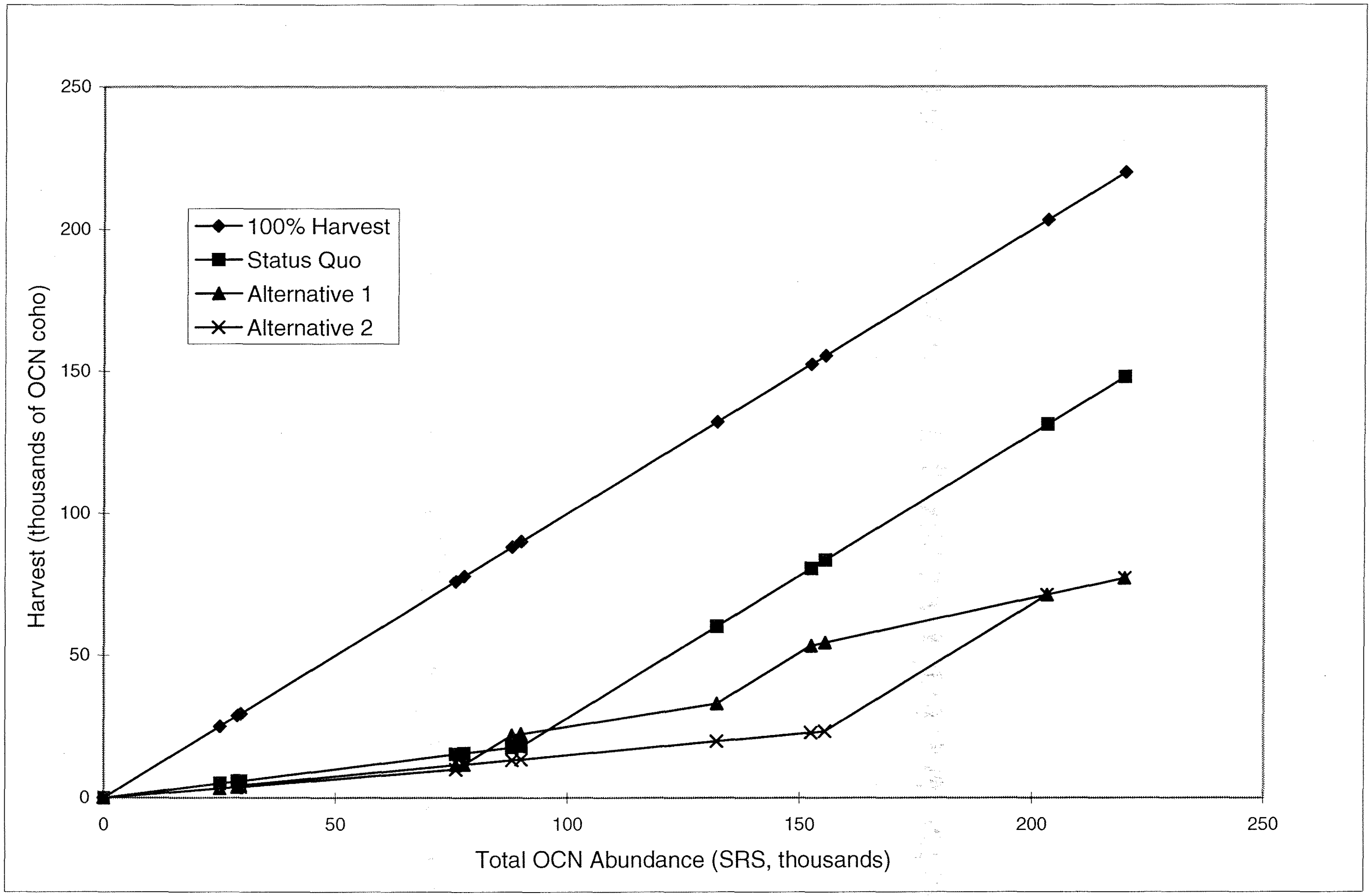

FIGURE 4. Maximum harvests under restrictive assumptions: high marine survival, similar abundance for two previous generations, harvest set to maintain spawner status level, total abundance distributed proportionally among components, and perfect models.

If Assumption 4 is relaxed but other assumptions maintained, situations may arise in which harvests under the alternatives somewhat exceed that shown by the lines shown in Figure 4. For example, at an OCN abundance of 125,000 fish with proportional distribution among components, all stocks could be harvested at up to a 25% harvest rate (given high marine survival conditions, Assumption 1). However, if the stocks were disproportionately distributed, with 10% more fish distributed to the south-central component than would occur under proportional distribution, the south-central component could be harvested at a 35% rate (given Assumption 2). Total harvest would then be 6,000 fish more than indicated in Figure 4. This situation is illustrated in the table which follows on page 28.

	Stock Component				
	Northern	North-Central	South-Central	Southern	Total
Abundance			(thousands of fish)		
Distribution 1 (Assumption 4 applies)	20	52	47	5	125
Distribution 2 (Assumption 4 relaxed)	16	42	63	4	125
Allowable Harvest Rates			(harvest rate)		
Distribution 1	0.25	0.25	0.25	0.25	
Distribution 2	0.25	0.25	0.35	0.25	
Harvest Opportunity			(thousands of fish)		
Distribution 1	5	13	12	1	31
Distribution 2	4	10	22	1	37
Status Quo					53
Harvest difference Between Alternative and Status Quo					(thousands and pecent)
Distribution 1					-21 (-41%)
Distribution 2					-15 (-29%)

At the 88,000 fish OCN abundance level, if 50% more fish were distributed to the south-central component than would occur under proportional distribution, the south-central component could be harvested at a 35% rate while the other components would be harvested at a 25% rate (given Assumption 2). This would result in a harvest of 6,000 fish more than is illustrated in Figure 4 for the 88,000 fish abundance level. However, as mentioned above, harvesting at maximum levels, given modeling uncertainties, could put future harvest opportunity at risk. If Assumption 4 is relaxed further, harvest under the alternatives could exceed status quo.

For example, if under Alternative 1, the two northern components failed to recover despite medium to high marine survival conditions and the two southern components achieved the highest parent spawner status, the harvest rates for those components could be 30-35% as compared to 20% under status quo. With high marine survival conditions and abundance levels of up to around 100,000 fish, more fish could be harvested under the alternatives than under status quo. Assuming that the northern stocks stayed at recent averages and were harvested at a 10% rate, harvest under the alternatives could exceed status quo by a maximum of about 7,000-8,000 fish at an abundance of 90,000 fish.

Figure 5 illustrates the maximum allowable harvests if only the south-central component recovered and all other components stayed at recent average levels and were harvested at a 10% rate. If some components begin rebuilding faster than others and if a harvest model is not developed which allows the ocean harvest of OCN coho components at rates different from one another, opportunities for increased ocean harvest may be constrained by the weakest component. When relatively strong components cannot be harvested in the ocean there may be opportunity for increased freshwater and estuary fisheries. Achieving the target harvest rate may depend on the ability of inside fisheries to take up the difference. These fisheries are thought to have low exploitation rates, usually under 10%. If a harvest model able to differentiate between components is developed, harvest rates for the aggregate are unlikely to exceed those which would have been allowed for the aggregate at a similar abundance level under status quo management except in extreme situations such as that just described.

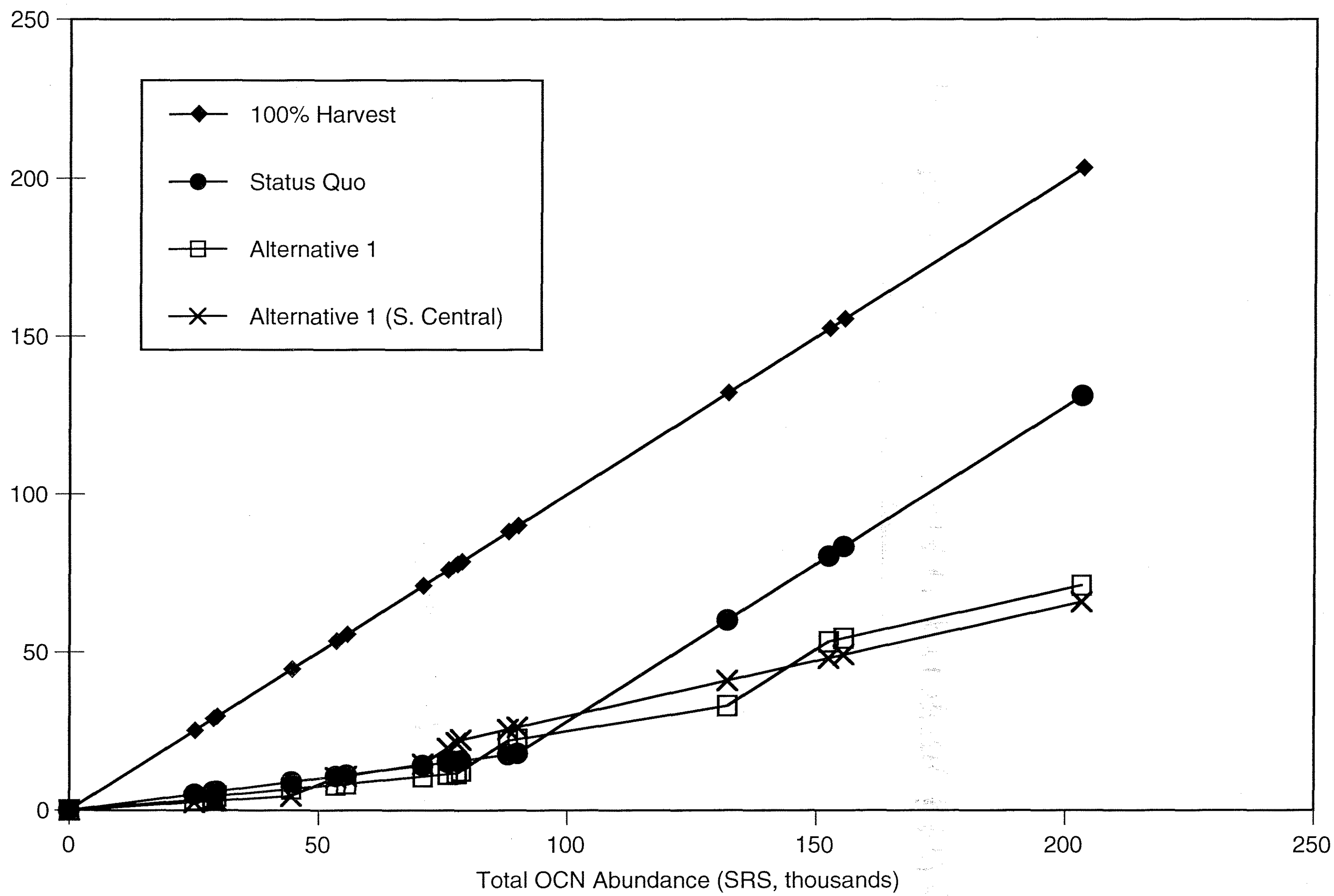

FIGURE 5. Maximum harvests under Alternative 1 assuming that only the south-central OCN component increases in abundance to above recent levels.

If abundances stay at recent levels and harvest rates are maintained in the 10-13% range, the disaggregation of the OCN complex proposed under the alternatives could alter the amounts of fish available for ocean harvest. For example, if harvest rates are determined to be uneven between stock components, and if it is determined that current models underestimate the exploitation rate on a particular component, then adjustments may have to be made to reduce all ocean harvests. In this case there would be reallocation to inside fisheries, but OCN harvests would only decline if inside fisheries were unable to take the additional fish available. Conversely, if improved models allow selective reduction of impacts on weak stock components then more OCN coho could become available for harvest. At current abundance levels most OCN ocean harvest impacts are allocated to incidental mortality, providing access to other fish stocks. No substantial directed fishery on OCN coho is anticipated for the near future.

Another of the assumptions is that abundances are similar to parent and grandparent spawners (Assumption 2). On the one hand, if parent or grandparent abundances were lower, harvest rates may be restricted to lower levels than illustrated in Figure 4. On the other hand, in the unlikely event of high grandparent and parent spawners, medium to high marine survival and a low abundance projection, harvest rates of 20-35% could be applied under the alternatives to status quo.

6.3.2 Characterization of Benefits

The benefits may take the form of avoidance of listing of the stock under the ESA, and so, avoidance of the attendant restrictions on the economy. The fisheries are only one of the factors contributing to the depressed OCN abundances. If the stocks would have recovered under status quo management, but at a slower rate, over the long term there may or may not be a benefit from the alternative management policies in terms of increased harvest, i.e., over the long term, harvests may be less or more than would have occurred under status quo. In part, the outcome depends on whether or not the abundances under the alternatives are larger than would occur under status quo, and, if so, whether they are enough larger to compensate for harvest rates that are lower than would occur under status quo. For example, under the assumptions used to generate Figure 4, to achieve a harvest level comparable to that provided at a status quo abundance of between 105,000 and 125,000 coho, abundances would have to be at least 27,000 and 60,000 coho higher than status quo under Alternatives 1 and 2, respectively. The horizontal distances between the lines in Figure 4 show the approximate magnitude of the improvement required to compensate for lower harvest rates with increased abundance. In determining whether there is a net benefit, a time preference would also need to be evaluated. For example, using the Office of Management and Budget recommended 7% interest rate, to compensate for foregoing 1,000 fish this year, a harvest of 1,225 more fish than would have occurred under status quo would be required three years from now; or 1,000 additional fish in three years and an extra 75 fish every 3 years for the next 12 years (assuming all other factors remain constant--price, average weight, success rates, etc.).

In addition to avoiding economic constraints which might be associated with a listing of coho under the ESA, the benefits from the potential recovery of the coho fishery could be substantial. There has been no commercial troll coho fishing south of Cape Falcon since 1992 and no recreational fishery coho retention since 1993. From 1976 through 1992 an average of $3.3 million a year of coho was landed in Oregon south of Cape Falcon (unadjusted for inflation). On average, this constituted 34% of the value of the total commercial troll salmon landings. In the mid-1980s as many as 2,300 vessels took part in the fisheries. In inflation adjusted terms, commercial troll coho landings in Oregon south of Cape Falcon contributed $9.7 million annually to personal income in coastal communities. From 1976 through 1993 an average of 175,000 recreational trips were taken each year between Cape Falcon and Humbug Mountain, Oregon. On these trips, 93% of the catch taken was coho. These trips generated an average $11.0 million annually in personal income for coastal communities (adjusted for inflation). Since 1994, an average of 10,000 trips have been taken each year with no coho retention. Considering the recreational ocean salmon fisheries for the entire Oregon coast, as many 320 charter vessels took part in the fisheries in the mid 1980s (PFMC 1997). If the coho stocks recovered, achieving these economic benefits in the ocean fisheries would depend on whether or not other stocks constrained ocean harvests.

6.4 Economic Significance of the Proposed Action

Executive Order (EO) 12866 plays an integral part in the RIR by providing criteria to determine whether a proposed regulation is a "significant action." Section 1 of the order deals with the regulatory philosophy and principles that are to guide agency development of regulations. The regulatory philosophy stresses that agencies should assess all costs and benefits of all regulatory alternatives. In choosing among regulatory approaches, the philosophy is to choose those approaches that maximize net benefits to society.

Under EO 12866, a significant regulatory action is one likely to:

(1) have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, productivity, competition, jobs, the environment, public health or safety, or State, local or tribal governments or communities;

(2) create a serious inconsistency or otherwise interfere with an action taken or planned by another agency;

(3) materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights and obligations of recipients thereof; or

(4) raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in EO 12866).

Based on the information reviewed or referenced above, the actions contemplated in these amendments are not likely to have a significant adverse effect with regard to the criteria listed in EO 12866 and so do not constitute a significant regulatory action.

6.5 Initial Regulatory Flexibility Analysis

Significance: The alternatives to status quo are being identified as potentially significant under the Regulatory Flexibility Act in the positive effect they may have on small entities by rebuilding stocks and avoiding the effects of an ESA listing. There may also be substantial negative effects at very high abundance levels. At high abundances, the proposed action may significantly constrain harvest as compared to status quo. For example, at an abundance of 400,000 coho under high ocean survival status and high parental spawner status, 57% fewer coho (188,000 fewer) would be harvested under either of the alternatives, as compared to status quo. On the other hand, it is uncertain whether or not these high abundance levels would again be reached without an alternative such as one of those proposed here; however, once the stock is recovered and at healthy abundance levels, it is possible that higher than rebuilding harvest rates may be sustainable. Current information is inadequate to determine what those sustainable rates might be. As rebuilding occurs additional information acquired will assist in determining appropriate harvest rates.

Duplication and overlap: There is no duplication, overlap or conflict with other Federal rules.

Projected reporting, record keeping and other compliance requirements: Under the Council's recommended alternative, the proposed rules would result in no new compliance requirements for small entities.

Development of the Alternatives: The draft IRFA solicited public comment on alternatives which would achieve the stated objectives while placing less of a burden on small entities and none were received.

The table which follows identifies the sections of the amendment pertinent to the conclusion of potential significance.

Statement, Description or Assessment	Section Reference
Entities affected	1.2
Need for Action	1.3
Description of Alternative Actions	2.0
Impact Summary	3.0
Ecological Impacts	3.1
Social and Economic Impacts	3.2; 6.3; 6.4
Administrative Impacts	3.3
Council Recommendation	4.0

7.0 RELATIONSHIP TO OTHER EXISTING LAWS AND POLICIES

7.1 Endangered Species Act and Marine Mammal Protection Act

The purposes of the Endangered Species Act (ESA) are to provide a means whereby the ecosystems upon which endangered and threatened species depend may be conserved, to provide a program for the conservation of such endangered and threatened species, and to take such steps as may be appropriate to achieve the objectives of the treaties and conventions created for these purposes. Section 7 of the ESA requires all federal agencies to ensure that any action authorized, funded or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species.

The purpose of the Marine Mammal Protection Act is to protect marine mammals and to prevent certain marine mammal species and stocks from falling below their optimum sustainable population.

Endangered or threatened species under the ESA that may be present within the Council management area include the following.

Endangered:

Snake River Sockeye Salmon
Upper Columbia River Steelhead
Umpqua River Sea-run Cutthroat Trout
Sacramento Winter Chinook Salmon
Southern California Coast Steelhead
Brown Pelican

Threatened:

Snake River Fall Chinook Salmon
Central California Coho Salmon
Oregon Coast Coho Salmon
Central California Coast Steelhead
Lower Columbia River Steelhead
Steller Sea Lion
Snake River Spring/Summer Chinook Salmon
Southern Oregon/Northern California Coho Salmon
South-central California Coast Steelhead
Central California Valley Steelhead
Snake River Basin Steelhead

Additional coho stock listings may occur in 1999.

The alternative management proposed in this salmon amendment should have a positive affect on listed coho salmon stocks in the OPI management area and may help prevent other ESUs from being listed in the future. The NMFS Northwest Region is preparing a Biological Opinion on the effect of the salmon fisheries under the salmon FMP as amended by Amendment 13. The opinion will be completed before Amendment 13 or its implementing rule are approved.

7.2 Coastal Zone Management Act

The Council believes the proposed actions are consistent to the maximum extent practical with applicable state coastal zone management programs (see Appendix C of Amendment 11 to the salmon FMP for a full description of the state programs). The NMFS will correspond with the responsible state agencies under Section 307 of the Costal Zone Management Act to obtain their concurrence in this finding.

7.3 Northwest Power Planning Act

The Northwest Power Planning Act (NPPA) of 1980 placed great emphasis on protection, mitigation and enhancement of fish and wildlife and their habitat within the Columbia River Basin. The Columbia Basin salmon runs are historically important contributors to the ocean salmon fisheries within the Council's jurisdiction north of Cape Falcon, Oregon.

Proposed actions to accomplish the NPPA goals for fish and wildlife were adopted by the Northwest Power Planning Council in 1982 and amended in 1987 and 1992. The Council, NMFS, states and treaty Indian tribes have participated with the Northwest Power Planning Council in developing and carrying out the fishery provisions of the NPPA. The objectives of these fishery related activities were found to be generally consistent and compatible with the conservation and management goals of the salmon FMP.

The proposed salmon management action should have almost negligible impact on the current fish and wildlife program of the Northwest Power Planning Council.

7.4 Pacific Salmon Treaty Act

The Pacific Salmon Treaty Act (PSTA) of 1985 was established to implement the Pacific Salmon Treaty between the U.S. and Canada. The treaty provides for bilateral cooperation in salmon management, research and enhancement by establishing a bilateral commission with coastwide responsibilities for management of "intercepting" salmon fisheries. The PSTA provides for coordination with the Council-managed fisheries by requiring that at least one representative to the PSC's southern panel be a voting member of the Council and by requiring consultation with the Council in the promulgation of regulations necessary to carry out the obligations under the treaty.

The proposed actions are consistent with the management requirements of the PSTA.

7.5 Executive Order 12612 (Federalism)

Executive Order (EO) 12612 of October 26, 1987, provides federal agencies with guidance on the formulation and implementation of policies that have federalism implications. Federal agencies are to examine the constitutional and statutory authority supporting any federal action that would limit the policy-making discretion of the states.

The proposed action does not have sufficient federalism implications to require the preparation of a federalism assessment.

7.6 Federally Recognized Indian Fishing Rights

Several Indian tribes which fish in Council-managed waters or whose fisheries may be impacted by Council managed ocean fisheries possess federally recognized fishing rights. Ocean fishing tribes with treaty fishing rights include the Makah, Quileute, Hoh, and Quinault. Other tribes with fishing rights that may be impacted by Council management actions include Puget Sound, Columbia River and Klamath River Indian tribes.

The proposed action is consistent with federally recognized Indian fishing rights.

8.0 ENVIRONMENTAL ASSESSMENT

8.1 Introduction

This environmental assessment (EA) has been prepared according to 40 CFR 1501.3 and 1508.9, and National Oceanic and Atmospheric Administration (NOAA) Administrative Order 216-6 to determine whether an EIS is required for any major action that will have a significant impact on the quality of the human environment. An EIS is not required if the EA concludes there is no significant impact.

In 1977, the first Council-prepared ocean salmon fishery management plan (FMP), with accompanying Environmental Impact Statement (EIS), was approved and implemented. A new FMP/EIS was developed for the 1978 season. Since that time, the 1978 FMP has been amended 12 times.

From 1979 to 1983, the FMP was amended annually to establish management measures for each year's fishery and a Supplemental Environmental Impact Statement (SEIS) was prepared for each amendment. In 1984, a framework amendment was implemented and was accompanied by another SEIS. The framework amendment established a mechanism to implement preseason and inseason regulatory adjustments without an annual FMP amendment.

This proposed amendment would be the seventh amendment since implementation of the framework FMP. The issue contained in Amendment 13 was identified formally during a scoping session at the October 1996 Council meeting.

In November 1998, the Council also adopted Amendment 14 for public review. Amendment 14 is a comprehensive review and updating of the current salmon FMP which, among other things, will make the salmon FMP consistent with the Sustainable Fisheries Act of 1996. In particular, Amendment 14 will update the salmon management unit, overfishing definition, management objectives, and provide for a description of essential fish habitat (EFH). This comprehensive amendment also includes a SEIS to update the previous SEIS completed in 1984.

8.2 Agencies and Persons Consulted

Representatives of the following agencies were consulted in formulating the proposed action, considering alternatives and preparing this document.

Alaska Department of Fish and Game
Idaho Department of Fish and Game
Oregon Department of Fish and Wildlife
Pacific States Marine Fisheries Commission
U.S. Fish and Wildlife Service
California Department of Fish and Game
National Marine Fisheries Service
Pacific Fishery Management Council
Washington Department of Fish and Wildlife
U.S. Coast Guard

Copies of the draft amendment were sent to the other regional management councils. The proposed action does not overlap with any other council's jurisdiction.

8.3 Public Hearings and Comments

Public hearings on the proposed amendment were held on October 27, 1998 in Astoria, Oregon, October 28 in North Bend, Oregon and November 5 at the Council meeting in Portland, Oregon. The state of California also held a hearing on October 30. About 50 members of the public attended the hearings (including the comment period at the November Council meeting) and 12 provided testimony. The testimony primarily concerned understanding the complex alternatives, recommending more conservative management, or questioning if more protection could be obtained for the stock by listing it under the ESA than would be gained through either of the proposed alternatives. California commercial fishers were especially concerned that the amendment could limit their ability to access California chinook stocks while not requiring any constraints on other industries that have contributed to the depression of OCN coho stocks.

The Council received seven written comments for the amendment which were similar in nature to the testimony provided at the hearings.

8.4 Impact Assessment

The table below identifies the sections of the amendment which discuss the need for action and analyze the potential environmental impacts of the amendment alternatives. There are no significant negative environmental impacts of this amendment.

Statement, Description or Assessment	Section Reference
Need for Action	1.3
Description of Alternative Actions	2.0
Impact Summary	3.0
Ecological Impacts	3.1
Social and Economic Impacts	3.2 and 6.0
Administrative Impacts	3.3
Council Recommendation	4.0

With regard to the five criteria listed in Section 6.11 of NOAA Administrative Order 216-6, the proposed action has the following effects.

1. *The proposed action is not expected to jeopardize the long-term productive capability of any stocks that may be affected by the action.*

   The proposed action is more protective of the OCN coho stock than the current salmon FMP.

2. *The proposed action is not expected to damage ocean or coastal habitat.*

   The proposed action does not directly affect habitat and has no negative indirect impacts.

3. *The proposed action is not expected to have an adverse impact on public health and safety.*

   The proposed action is expected to be neutral with respect to health and safety.

4. *The proposed action is not expected to have an adverse impact on any marine mammal or endangered or threatened species.*

   The proposed action is generally consistent with harvest rates developed under Section 7 consultations for listed salmon species. There will be no change in marine mammal interaction and impacts under the proposed action.

5. *The proposed action does not have cumulative adverse impacts that could have an effect on target resource species or any related stocks.*

   There are no adverse cumulative impacts associated with the proposed action.

In addition to the five criteria listed above, the proposed action must be considered with regard to socioeconomic effects and controversy. Socioeconomic effects are reported in Sections 3.2 and 6.0. The socioeconomic impacts may or may not be significantly positive, depending on changes in the environment and their relationship to the ability of the OCN stock to recover to more harvestable levels.. The effects of the proposed action are not considered to be controversial.

The salmon management actions proposed by the Council will have no significant or adverse effect on flood plains or wetlands and trails and rivers listed or eligible for listing on the National Trails and Nationwide Inventory of Rivers.

8.5 Finding of No Significant Impact

For the reasons discussed and referenced above, it is determined that the proposed action is not a major action having significant effect on the quality of either the marine or human environment. Accordingly, preparation of an environmental impact statement is not required by section 102(2)(C) of the National Environmental Policy Act or its implementing regulations.

Assistant Administrator for Fisheries, NOAA	Date

APPENDIX A

A HABITAT-BASED ASSESSMENT OF COHO SALMON PRODUCTION POTENTIAL AND SPAWNER ESCAPEMENT NEEDS FOR OREGON COASTAL STREAMS

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INTRODUCTION

The Coho Salmon Management Plan (ODFW 1982) identified production goals and spawner escapement goals for wild coastal coho salmon (*Oncorhynchus kisutch*). Because of a number of factors, including unfavorable marine survival, the production goals have never been realized and the escapement goals have seldom been achieved. Much new information is now available about the factors affecting production of coho salmon and the effects of natural weather cycles on salmon production. The interactions between freshwater and marine survival of coho salmon are of particular interest to the development of realistic production and escapement goals for wild fish.

Research has demonstrated that the quality of freshwater habitat (particularly over-winter habitat) has a direct influence on freshwater survival rate. To be equally productive, salmon inhabiting a stream with poor quality habitat will require a higher rate of marine survival than salmon inhabiting a stream with good quality habitat. As a result of these interactions, marine survival can play a dominant role in determining the productivity and sustainability of coho salmon populations.

Because of these interactions between marine survival and habitat quality, extended periods of low marine survival, such as has occurred off Oregon since the late 1970s, will result in only the best freshwater habitats supporting viable coho salmon populations. In fact this is what has been observed: very few stream reaches with large spawner populations; most stream reaches with few or no spawning coho salmon (Cooney and Jacobs 1995). Therefore, when developing production and spawner escapement goals, both the quality of the freshwater habitat and the probable levels of marine survival must be taken into consideration.

METHODS

A model was developed to estimate production potential and spawner escapement needs that accounts for differences in habitat quality. Habitat quality determines the number of coho salmon smolts that a stream can produce as well as the efficiency with which those smolts are produced (*i.e.* survival rate)..

Estimates of smolt capacities and average survival rates at densities associated with maximum smolt production were derived for 11 large Oregon coastal basins and small direct ocean tributaries. Production potential and spawner needs were estimated for individual stream reaches (lengths of stream between changes in gradient or valley and channel form). Estimates were based on data in the Oregon Department of Fish and Wildlife (ODFW) Aquatic Inventory Database (Moore et al. 1995) and data from the Siuslaw National Forest (B. Metzger, Siuslaw National Forest, Corvallis, OR, personal communication, June 1996). Sampling rates ranged from 16% to 64% of the available coho salmon habitat in each basin.

Estimates of Smolt Production Capacity

Estimates of smolt production capacity were derived for individual stream reaches in two ways, depending on the level of inventory data available. For stream reaches where winter habitat data were available, the latest version of the habitat limiting factors model (HLFM Version 5.0) originally described by Nickelson et al. (1992a), was used to estimate smolt potential. This model estimates potential population abundance for the spawning, spring rearing, summer rearing, and winter rearing life stages of coho salmon by multiplying habitat-specific densities based on data from Nickelson et al. (1992b) by areas of individual habitat types derived from stream inventory data collected during summer and winter. It then estimates potential smolts by applying survival rates from each of these life stages to the smolt stage (Table 1). The estimates of potential coho salmon smolt capacity generated by this model have been shown to be closely related to actual smolt production when summer habitat was fully seeded with juveniles [approximately 1.5-2.0 parr/m^2 of pool; Nickelson et al. (1992b)](Figure 1). Suitable winter rearing habitat typically is in least supply in Oregon coastal streams compared with the other four types of habitat and thus limits smolt production (Table 1; Nickelson et al. 1992a, 1992b). Therefore we can use the HLFM and data from inventories of winter habitat to estimate the smolt capacity of many individual stream reaches.

Most stream reaches lack data on winter habitat because stream habitat typically is surveyed only during summer. Therefore, a multiple regression model was used to predict winter habitat capacity from summer habitat data and estimate smolt potential for these stream reaches. This model was developed from data for 74 stream reaches where both summer and winter habitat surveys have been conducted, and predicts smolt potential (as estimated by HLFM) from stream reach characteristics determined during summer stream habitat surveys. To account for differences in stream size, smolt potential was expressed as a density based on reach area derived from reach length and active channel width. Some variables were transformed to linearize the function or to normalize and equalize the variance. The regression model shown below explained 80% of the variation in the dependent variable:

[1] $C = (0.4000 - 0.0682\log_e W - 0.0332G + 0.1030B + 0.2020L)^2$,

where C is the predicted potential smolt density for the reach expressed as smolts/m^2, W is the active channel width of the reach in m, G is the gradient of the reach in percent, B is the number of beaver dams per km in the reach, and L is the arc sine square root transformation of the percent of pool in the reach. To test the predictive power of this model, the regression was fitted to five randomly picked subsets consisting of 75% of the data and then used to predict the remaining data in each case. Smolt capacities predicted by the multiple regression model were significantly correlated with smolt capacities estimated using the HLFM ($r = 0.874$, $p < 0.001$). To account for uncertainty at the upper end of this relationship, where few values occurred, maximum potential smolt density was capped at 1.15 smolts/m^2 (the density expected if the entire reach were made up of the best quality habitat).

Maximum smolt capacity (M) for each reach, expressed as a total number of smolts, was calculated by multiplying C by the total area of the reach (length multiplied by active channel width).

Over-Winter Survival

Observations of over-winter survival in several streams was positively correlated with potential smolt density (C) as estimated by HLFM. This relationship is key to the influence of habitat quality on coho salmon population dynamics. It was based on 30 observations of over-winter survival from 5 streams and 2 beaver ponds, and their potential smolt capacities estimated from winter inventory data using the HLFM (Figure 2). This relationship yielded the following equation:

[2] $S_{ow} = 0.1361 \log_e C + 0.487 + E$,

where S_{ow} is over-winter survival and E is an error term ($r = 806$, $p < 0.001$). Thus, C is not only an estimate of potential smolt density, but it is also an index of habitat quality that is related to juvenile survival. Because this equation produces survival rates ≤ 0 when $C < 0.03$ for a reach, all such reaches were assigned a survival rate of 2.5%, the lowest value observed.

Egg Deposition Needed to Produce Maximum Smolts

The egg deposition needed to produce maximum smolts (D_m) is synonymous with the concept of full seeding of the habitat, and was calculated from:

[3] $D_m = M / S_{smolt}$.,

where S_{smolt} is egg-to-smolt survival rate calculated for each reach by multiplying over-winter survival rate (S_{ow}) by egg-to-summer parr survival rate. To estimate D_m we assumed a constant egg-to-summer parr survival of 7.2% for all reaches. This value was the survival rate at the point of maximum parr production (full seeding) on a Ricker stock-recruitment curve (Ricker 1975) based on data for three Oregon coastal streams from Moring and Lantz (1975) and Hall et al. (1987).

Spawners Needed to Produce Maximum Smolts

Two assumptions were necessary to calculate the number of adults needed to produce the maximum number of smolts for a reach (A_m): 1) fecundity was assumed to be 2,500 eggs per female (Moring and Lantz 1975), and; 2) sex ratio was assumed to be 1:1. The value A_m was then derived from:

[4] $A_m = (D_m / 2{,}500) * 2$.

Production Potential in Terms of Adults

Production potential for a reach (PP) was estimated from:

[5] $PP = M * S_{mar}$

where S_{mar} is marine survival rate and M is maximum smolt capacity.

Production goals and spawner escapement needs were developed based on three levels of marine survival: 10, 5, and 3 percent. Therefore, three tiers of freshwater habitat would be capable of supporting coho production, corresponding to the three levels of ocean survival: high quality (3% marine survival), moderate quality (5% marine survival) and poor quality (10% marine survival). Each tier was defined as the habitat within a basin where the population would replace itself given that level of marine survival (i.e. $M * S_{mar} \geq A_m$).

Production potentials and spawner needs were calculated for each tier of habitat in a basin by summing reach estimates and dividing by the sampling rate. All production potentials were derived with the assumption of having fully seeded freshwater habitat and should be viewed as *potentially* achievable levels of production based on current modeling results.

Lake Systems

An alternative approach to assessing production potential and spawner needs was used for the major coastal Oregon lake systems: Siltcoos Lake, Tahkenitch Lake, and Tenmile Lakes. Production potential was estimated by doubling the sum of the highest escapements observed in each lake system during the past 2 decades based on the assumption that exploitation rate was 50% (the average for the period). It was also assumed that maximum production occurred with a marine survival of 10%.

The number of spawners (A_L) needed to achieve the production potential (PP_L) was estimated from:

[6] $A_L = PP_L / (S_{ma} * S_{ow} * 0.072)$

where S_{ma} is 10%, S_{ow} is 0.506, the value generated by Equation 2 at maximum smolt density, and 0.072 is egg to summer parr survival. In this analysis, the lakes were considered to provide the highest quality winter habitat and thus the maximum over-winter survival rate.

Assumptions

Implicit to the habitat quality component of the model are the assumptions that winter habitat is the primary bottleneck to smolt production in each stream reach, and that survival from egg deposition to summer parr is 7.2% for all reaches when at full seeding. These assumptions are necessary because we have inadequate information upon which to base a more detailed analysis that would account for all the factors influencing survival. For example, some stream reaches may experience high water temperatures that exclude coho salmon during summer but then provide rearing habitat when waters cool in the winter. Depending on their location relative to the possibility of immigration of juveniles from other areas for over-wintering, these reaches may be limited by summer habitat. Similarly, sedimentation and excess scouring can reduce egg survival. In lieu of such data we have made the above assumptions.

RESULTS AND DISCUSSION

Model Validation

This analysis appears to generate reasonable and believable results. The survival rates produced by this analysis fall within the range reported in the literature (Bradford 1995). Smolt production values also generally fall within the range actually observed in field studies (Skeesick 1970; Moring and Lantz 1975; Kadowaki et al. 1995; Johnson and Solazzi 1995).

The results from this analysis are consistent with the pattern of spawner distribution that we have observed in the stratified random spawning surveys since 1990. The spawning survey data exhibit a highly skewed distribution with a high proportion of streams having no spawners. This would be predicted by the habitat modeling that suggests that under recent marine survival rates, coho salmon in most stream miles would not replace themselves and therefore would have declined dramatically over the past 10-15 years.

Also, with the exception of the Coos, Coquille, and Rogue basins, there is a very good correlation between estimated habitat quality (See below) and the 1990-95 mean coho salmon spawners per mile (Figure 3). The three southern basins have experienced much higher spawner numbers in recent years than the northern basins, most likely the result of a combination of lower exploitation rates and better marine survival conditions (ODFW 1995).

Habitat Quality

The analysis indicates that habitat quality for coho salmon in coastal basins is heavily biased toward poor habitat. Coastwide, only 22% of the coho salmon habitat is of sufficient quality to sustain populations if current marine survival (estimated to be about 3%), were to continue for an extended time. This proportion varies by basin (Figure 4), ranging from 5% in the Tillamook Bay basin to 43% in the Yaquina River basin.

A large part of the recovery process of coho salmon involves improvements in the habitat conditions in fresh water. An increase in the number of smolts going to the ocean in the current low ocean productivity will increase the number of recruits and spawning escapement if harvest rates remain low in the short run. If smolt survival increases, a larger number of smolts migrating from improved freshwater habitat will speed the rebuilding process no matter what increase in ocean survival occurs.

Potential Production and Spawner Needs

The potential number of adult coho salmon that could be produced from each major coastal basin was estimated for marine survival rates of 3%, 5%, and 10% (Table 2). The production is derived from habitats of high, moderate, and poor quality corresponding to stream reaches where the population would at least replace itself with marine survivals of 3%, 5%, and 10%, respectively.

Table 2 also includes the estimated number of spawners needed for maximum smolt production in each basin when marine survival is 3%, 5%, and 10%. The number of spawners needed varies considerably with marine survival because as marine survival increases, the amount of productive freshwater habitat increases. Thus, as a population progresses through time and experiences climatic cycles of high and low marine survival (Beamish and Bouillon 1993; Hsieh et al. 1995) the population size and distribution within a basin will expand and contract. Similarly, the number of spawners needed to fully seed the productive habitat will expand and contract.

It is important to keep this new understanding of coho salmon population dynamics in mind when setting spawner escapement goals for the purpose of managing fisheries. For example, setting an escapement goal that will provide full seeding of the habitat that is productive during a period when marine survival is 10% will be unachievable during a period of 3% marine survival. Conversely, setting an escapement goal that will provide full seeding of the habitat that is productive during a period when marine survival is 3% will be meaningless during periods of higher marine survival.

One solution to this problem is to manage fisheries based on exploitation rates, not escapement goals. The Oregon Department of Fish and Wildlife's proposed harvest strategy (ODFW 1997) takes this approach. This approach avoids the use of escapement goals per se, but rather establishes spawner rebuilding criteria that must be met before exploitation rate can be increased. This was necessary because coastal Oregon coho salmon populations have experienced an extended period of poor marine survival (estimated at 3% for the past decade) and spawner populations in most basins (Table 3) are below the levels needed for full seeding of high quality habitat (productive at 3% marine survival)(Table 2). Two levels of spawner rebuilding criteria were developed for four coastal regions based on 50% and 75% of the number of spawners needed for full seeding of the high quality habitat (Table 4). The approach that was developed (ODFW 1997) uses the latest understanding of the dynamics of coho salmon populations as influenced by the freshwater and marine environments.

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TABLE A-1. Example of application of the coho salmon limiting factors model (HLFM Version 5.0).

Stream: East Fork Lobster Creek
Stream inventories conducted in summer 1990 and winter 1990-91
Stream Length 3.8 km

Season	Seasonal capacity	Life stage	Potential smolts (Capacity*Survival Rate)	
Spawning	1 330 000	egg	266 000	
Spring	32 400	fry	9 800	
Summer	13 800	parr	6 900	
Winter	4 500	presmolt	4 100	Limiting habitat and smolt capacity

	Stream area (m^2) by habitat from inventories		Seasonal capacity by habitat type (Area*Juvenile Density)			
Habitat type	Summer	Winter	Spawning	Spring	Summer	Winter
Cascades	39	296		-	0	-
Rapids	4 398	10 307		6 200	600	100
Riffles	1 847	6 223		7 500	200	100
Glides	2 966	1 911		3 500	2 300	200
Trench pools	62	-		-	100	-
Plunge pools	667	1 167		1 000	1 000	300
Lateral scour pools	4 436	5 526		7 100	7 600	1 900
Mid-channel scour pools	-	-		-	-	-
Dammed pools	168	1 048		2 700	300	600
Alcoves	-	-		-	-	-
Beaver ponds	671	558		1 400	1 200	1 000
Backwater pools	442	529		3 000	500	300
Spawning Gravel		1 596	1 330 000			
		Total Capacity	1 330 000	32 400	13 800	4 500

Juvenile density (#/m^2) by habitat type

Habitat type	Spring	Summer	Winter
Cascades	0.0	0.2	0.0
Rapids	0.6	.01	0.01
Riffles	1.2	.01	0.01
Glides	1.8	.08	0.1
Trench pools	1.0	1.8	0.2
Plunge pools	0.8	1.5	0.3
Lateral scour pools	1.3	1.7	0.4
Mid-channel scour pools	1.3	1.7	0.4
Dammed pools	2.6	1.8	0.6
Alcoves	2.8	0.9	1.8
Beaver ponds	2.6	1.8	1.8
Backwater pools	5.8	1.2	0.6
Spawning Gravel	2 500 eggs/redd / 3m^2/redd = 833 eggs/m^2		

Density independent survival rates	
Egg to smolt	0.2
Spring fry to smolt	0.3
Summer parr to smolt	0.5
Winter presmolt to smolt	0.9

TABLE A-2. Estimates of coho salmon production potential and spawner needs for Oregon coastal basins.

Basin	Marine Survival	Habitat Quality				Spawners Needed
		High	Moderate	Poor	Total	
Nehalem	10%	79,900	32,300	26,600	138,800	46,100
	5%	39,900	19,200		59,100	31,700
	3%	24,000			24,000	17,500
Tillamook	10%	8,100	8,500	16,400	33,000	17,100
	5%	4,000	4,300		8,300	5,700
	3%	2,400			2,400	2,000
Nestucca	10%	8,100	13,100	7,700	28,900	11,200
	5%	4,000	6,500		10,500	6,400
	3%	2,400			2,400	1,800
North Coast Ocean Tribs	10%	2,500	8,800	2,100	13,400	5,200
	5%	1,300	4,400		5,700	3,900
	3%	800			800	400
Siletz	10%	18,200	8,000	2,800	29,000	9,200
	5%	9,100	4,000		13,100	7,400
	3%	5,500			5,500	4,300
Yaquina	10%	30,400	13,000	1,400	44,800	12,600
	5%	15,200	6,500		21,700	11,800
	3%	9,100			9,100	7,100
Alsea	10%	67,500	17,800	7,400	92,700	25,500
	5%	33,700	8,900		42,600	21,100
	3%	20,200			20,200	15,100
Siuslaw	10%	94,900	43,100	12,200	150,200	47,200
	5%	47,500	21,500		69,000	39,200
	3%	28,500			28,500	22,800
Mid Coast Ocean Tribs.	10%	24,600	17,300	9,000	50,900	18,300
	5%	12,300	8,700		21,000	12,400
	3%	7,400			7,400	5,700
Umpqua	10%	128,100	84,100	73,600	285,800	110,400
	5%	64,100	42,100		106,200	62,200
	3%	38,400			38,400	29,400
Coos	10%	29,500	20,600	4,000	54,100	17,100
	5%	14,800	10,300		25,100	14,600
	3%	8,900			8,900	7,200
Coquille	10%	25,600	31,600	23,500	80,700	33,900
	5%	12,800	15,800		28,600	18,900
	3%	7,700			7,700	5,400
Coastal Lakes	10%	36,000			36,000	8,000
	5%	18,000			18,000	8,000
	3%	10,800			10,800	8,000
Rogue	10%	22,800	35,000	49,000	106,800	30,105
	5%	11,400	17,500		28,900	14,200
	3%	6,800			6,800	5,400
Total Oregon Coast	**10%**	**576,200**	**333,200**	**235,700**	**1,145,100**	**391,905**
	5%	**288,100**	**169,700**		**457,800**	**257,500**
	3%	**172,900**			**172,900**	**132,100**

TABLE A-3. Estimates of coho salmon spawner abundance in Oregon coastal basins.

Group and Basin	Miles	1990	1991	1992	1993	1994	1995	1996 *a*	90-96 Mean
NORTH									
Nehalem	386	1,552	3,975	1,268	2,265	2,369	1,564	1,057	2,007
Tillamook	249	265	3,000	261	860	924	275	736	903
Nestucca	167	189	728	684	401	313	1,811	519	664
Direct Ocean Tribs.	97	191	1,579	209	983	485	319	1,043	687
TOTAL	**899**	**2,197**	**9,281**	**2,423**	**4,509**	**4,092**	**3,968**	**3,355**	**4,261**
NORTH-CENTRAL									
Siletz	118	441	984	2,447	400	1,200	607	763	977
Yaquina	109	381	380	633	549	2,448	5,668	4,577	2,091
Alsea	221	1,189	1,561	7,029	1,071	1,279	681	1,637	2,064
Siuslaw	514	2,685	3,740	3,440	4,428	3,044	6,089	8,827	4,608
Direct Ocean Tribs.	201	895	67	1,821	1,331	1,743	573	2,975	1,343
TOTAL	**1,163**	**5,592**	**6,732**	**15,371**	**7,779**	**9,713**	**13,619**	**18,779**	**11,083**
SOUTH-CENTRAL									
Umpqua	1,083	3,737	3,600	2,152	9,311	4,485	11,020	14,413	6,960
Coos	208	2,273	3,813	15,625	15,284	14,583	10,447	12,128	10,593
Coquille	331	2,712	5,651	2,116	7,384	5,035	2,116	16,169	5,883
Coastal Lakes *b*		4,393	7,251	1,986	10,145	5,841	11,216	13,493	7,761
TOTAL	**1,622**	**13,116**	**20,315**	**21,879**	**42,124**	**29,944**	**34,799**	**56,204**	**31,197**
SOUTH									
Rogue *c*		2,796	765	1,935	174 *d*	5,303	4,221	5,386	3,401
TOTAL		**2,796**	**765**	**1,935**	**174**	**5,303**	**4,221**	**5,386**	**3,401**
COASTWIDE		**23,701**	**37,093**	**41,608**	**54,586**	**49,052**	**56,606**	**83,723**	**49,481**

a estimates for 1996 are preliminary and are adjusted for the presence of hatchery fish
b population estimate based on spawner counts related back to independent population estimates
c mark-recapture population estimate based on seining at Huntley Park in the lower Rogue River
d poor estimate

TABLE A-4. Derivation of spawner rebuilding criteria for Oregon coastal coho salmon.

Group and Basin	Spawners needed to fully seed the best habitat	Spawner Rebuilding Criteria Level 1	Spawner Rebuilding Criteria 150% Level 1
NORTH			
Nehalem	17,500	8,800	13,200
Tillamook	2,000	1,000	1,500
Nestucca	1,800	900	1,400
Direct Ocean Tribs.	400	200	300
TOTAL	**21,700**	**10,900**	**16,400**
NORTH-CENTRAL			
Siletz	4,300	2,200	3,300
Yaquina	7,100	3,600	5,400
Alsea	15,100	7,600	11,400
Siuslaw	22,800	11,400	17,100
Direct Ocean Tribs.	5,700	2,900	4,400
TOTAL	**55,000**	**27,500**	**41,300**
SOUTH-CENTRAL			
Umpqua	29,400	14,700	22,100
Coos	7,200	3,600	5,400
Coquille	5,400	2,700	4,100
Coastal Lakes	8,000	4,000	6,000
TOTAL	**50,000**	**25,000**	**37,500**
SOUTH			
Rogue	5,400	2,700	4,100
TOTAL	**5,400**	**2,700**	**4,100**
COASTWIDE	**132,100**	**66,100**	**99,200**

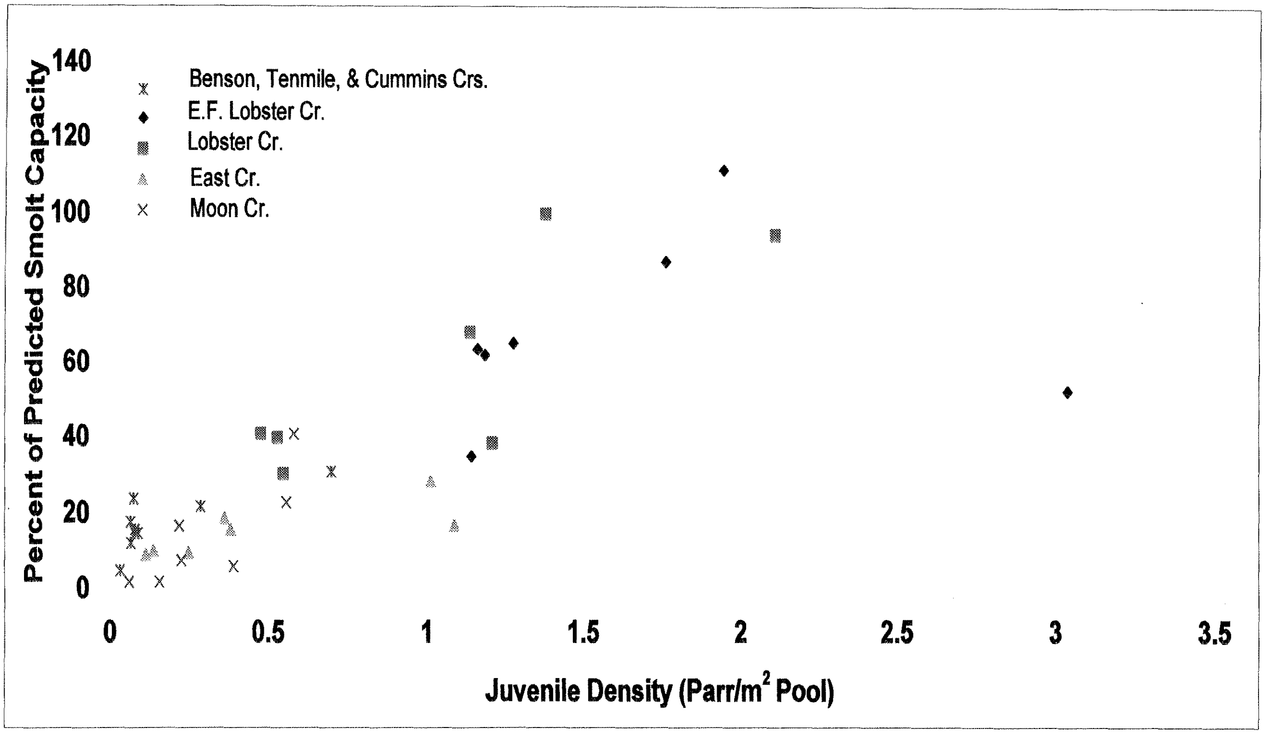

Figure 1. Performance of the coho salmon habitat limiting factors model (HLFM Version 5.0) in 7 study streams in terms of observed smolts as a percent of smolt capacity predicted by HLFM, versus the density of juveniles present the previous summer.

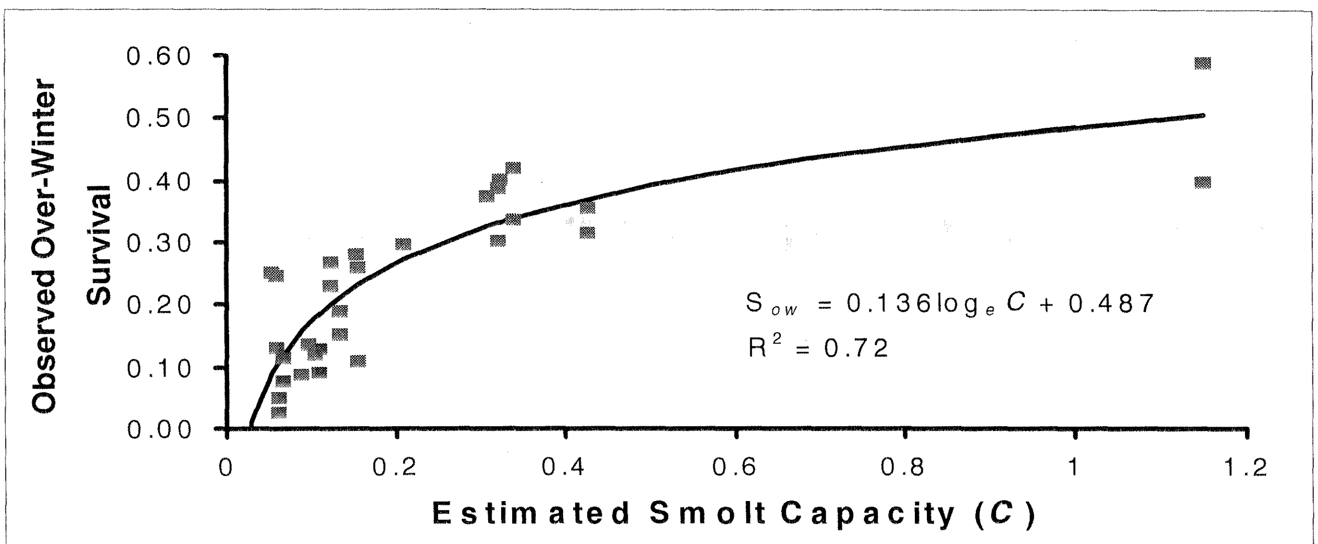

Figure 2. Relationship between observed over-winter survival of coho salmon and smolt capacity as estimated by the HLFM for 5 study streams.

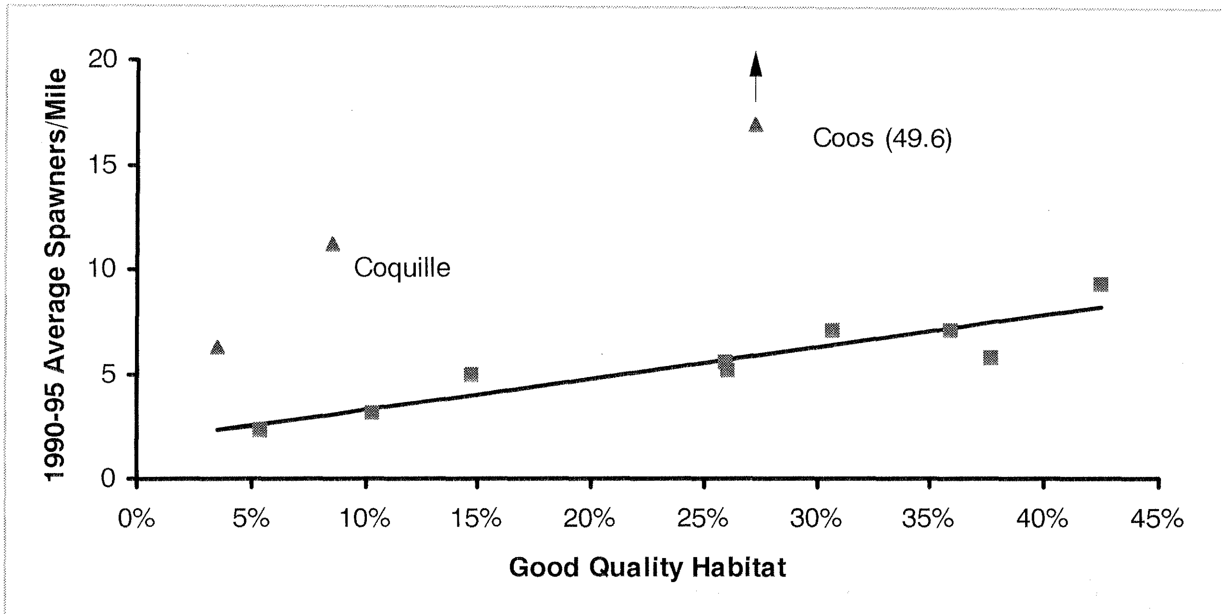

Figure 3. Relationship between 1990-95 mean coho spawners per mile in 11 coastal Oregon basins and percent of good quality habitat.

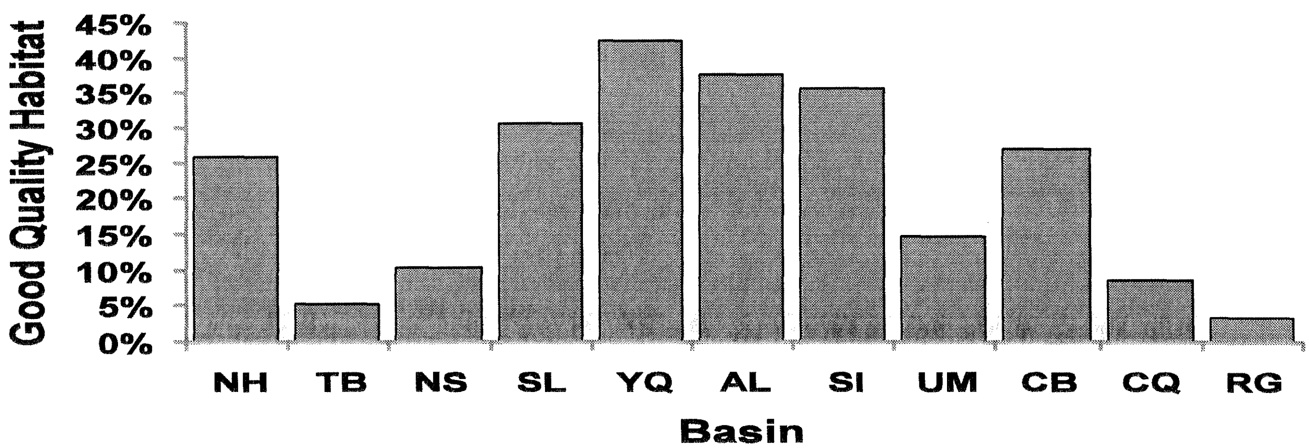

Figure 4. The proportion coho salmon habitat in Oregon coastal basins where populations will at least replace themselves if marine survival were 3%. NH = Nehalem; TB = Tillamook Bay; NS = Nestucca; SL = Siletz; YQ = Yaquina; AL = Alsea; SI = Siuslaw; UM = Umpqua; CB = Coos Bay; CQ = Coquille; RG = Rogue.

APPENDIX B

TABLE B-1. Oregon Production Index (OPI)[a] coho abundance (ocean harvest impacts and ocean escapement) by index and SRS accounting in thousands of fish, 1970-1996.

			Ocean Escapement						
			Oregon and California Coastal						
	Ocean Fisheries			OCN Spawners[e]				Abundance	
Year	Troll[b]	Sport[c]	Hatchery Returns and Freshwater Harvest[d]	Index	SRS	Private Hatchery Returns	Columbia River	Index	SRS
1970	1,463.7	499.0	80.3	249.2	-	-	895.3	3,187.5	-
1971	2,543.5	715.8	53.8	322.4	-	-	544.5	4,180.0	-
1972	1,275.6	560.3	29.9	126.9	-	-	277.8	2,270.5	-
1973	1,320.3	443.2	42.2	161.1	-	-	291.3	2,258.1	-
1974	2,095.1	668.6	49.5	132.8	-	-	460.8	3,406.8	-
1975	1,079.2	463.7	19.2	158.6	-	-	292.5	2,013.2	-
1976	2,936.1	977.7	62.6	158.3	-	-	337.0	4,471.7	-
1977	664.4	412.1	21.4	66.8	-	4.2	93.8	1,262.8	-
1978	1,104.2	524.6	12.6	73.8	-	12.3	307.5	2,035.0	-
1979	1,056.6	334.4	27.4	173.6	-	49.2	276.5	1,917.7	-
1980	506.9	526.4	32.1	108.9	-	38.7	301.6	1,514.6	-
1981	830.9	339.9	34.1	73.0	-	117.8	170.2	1,565.9	-
1982	740.9	300.4	37.1	132.6	-	184.7	453.1	1,848.8	-
1983	429.6	275.0	18.2	58.8	-	133.9	109.0	1,024.5	-
1984	95.8	174.2	51.2	208.7	-	115.4	424.1	1,069.4	-
1985	166.4	280.4	45.4	190.9	-	332.0	367.2	1,382.3	-
1986	643.5	320.6	81.8	190.8	-	453.7	1,549.1	3,239.5	-
1987	469.1	296.2	45.3	82.5	-	119.3	310.3	1,322.7	-
1988	844.7	297.2	62.4	160.8	-	116.1	667.9	2,149.1	-
1989	646.9	425.5	62.3	144.5	-	46.9	713.9	2,040.0	-
1990	277.6	357.1	30.6	104.0	(20.9)	35.6	196.7	1,001.6	(918.5)
1991	450.6	469.9	84.0	135.5	(36.4)	35.1	954.3	2,129.3	(2,030.2)
1992	67.5	256.5	52.6	138.6	(39.3)	-	215.3	730.5	(631.6)
1993	13.2	140.8	41.5	168.0	(54.5)	-	114.2	477.7	(364.1)
1994	2.7	3.0	31.8	130.5	(43.7)	-	170.6	338.6	(250.9)
1995	5.4	43.5	39.3	131.3	(52.4)	-	74.9	294.3	(214.6)
1996[f]	7.0	31.8	49.6	212.1	(88.1)	-	111.4	411.9	(286.6)

a/ The OPI includes coho harvest impacts and ocean escapement occurring south of Leadbetter Point, Washington.
b/ Includes estimated troll fishery hook-and-release mortality for the years 1982-1996 and estimated drop-off mortality for all years.
c/ Includes estimated sport fishery hook-and release for the years 1994-1996 and estimated drop-off mortality for all years.
d/ Includes returns from STEP smolt releases.
e/ Spawner escapements to rivers have historically been estimated by a nonrandom standard index. A spawner escapement methodology study based on stratified random sampling (SRS) has been in effect since 1990. The SRS methodology indicates that actual escapements are probably less than those projected by the standard index.
f/ Preliminary.

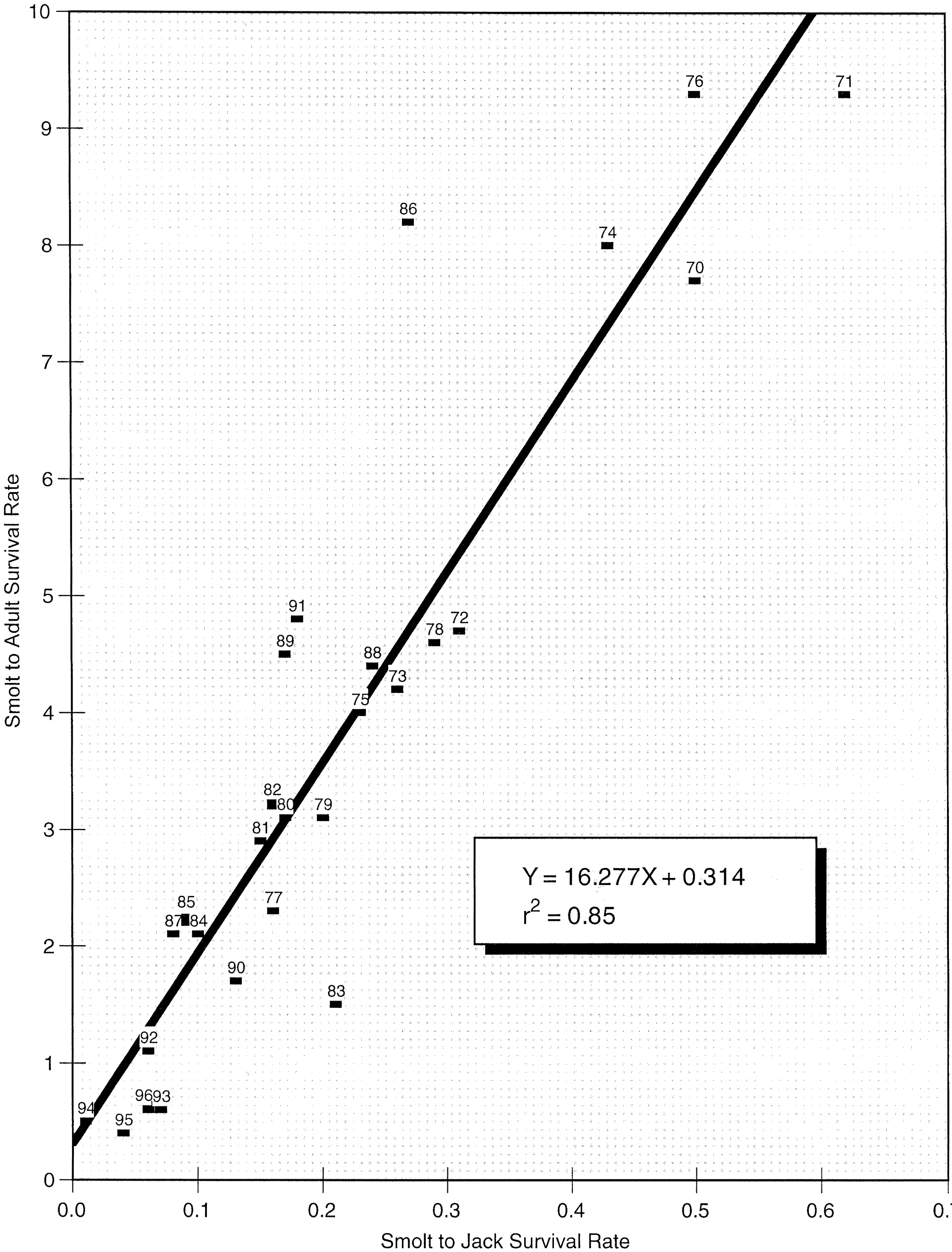

FIGURE B-1. Linear regression of smolt to adult survival on smolt to jack survival for Columbia River and Oregon Coastal hatchery coho, 1970-1996.

TABLE B-2. Estimation of total allowable harvest exploitation rates for OCN coho under Status Quo. It is not possible to predict the specific exploitation rates without a great deal of uncertainty and some subjectivity. The expected rates generally include the maximum possible rate based on the current FMP and possible increases in OCN abundance.

Adult Return Year and Marine Survival	Expected Allowable Exploitation Rate	Rationale for Rates
1998: Low	≤10-13%	The FMP allows up to a 20% exploitation rate, but the rate must not jeopardize the stock. If marine survival is again low (as in the previous 5 years), the Council would likely select a rate of no more than 13% given the poor ocean conditions for 1997 and 1998 smolts, developing El Niño, NMFS 1997 guidance for OCN coho (≤13%), and listing of the southern Oregon/northern California coho ESU.
Medium	≤20%	If marine survival and abundance is up, but less than 250,000 index adults, the Council could increase the harvest rate over the recent levels up to a maximum of 20%, if it does not jeopardize the stock. If the stock size increased above 250,000 adults, the harvest rate could exceed 20%.
High	-	High marine survival does not appear possible for the 1995 brood.
1999: Low	≤20%	More uncertainty than in predicting 1998, but likely to be the same as 1998 given present and expected ocean conditions for 1998 smolts. If both 1998 and 1999 have low marine survival, the rate would likely be in the 10-13% range.
Medium	≤35%	If OCN abundance increases to 150% of 1992-1996 average (311,000 index adults), FMP allows 36%; however, consideration of relationship to SRS numbers and protection of listed ESUs would likely reduce the rate.
High	≤50%	If OCN abundance increases to 200% of recent average (415,000 idex adults), FMP allows 52%; however, consideration of relationship to SRS numbers and protection of listed ESUs would likely reduce the rate.
2000: Low	≤20%	Much the same as for 1998 or potentially a lower rate if depression continues.
Medium	≤35%	Similar to 1999 rationale.
High	≤50%	Even with great abundance increases in general, protection of listed ESUs would likely preclude rates as high as 50%.

TABLE B-3. Estimation of total allowable harvest exploitation rates for OCN coho under Alternative 1.

	Spawner Numbers		Spawner Rebuilding Status			Total Allowable Exploitation Rate for the Estimated Marine Survival Level		
Stock Component	Parent	Grandparent	Low	Medium	High	Low	Medium	High
1998 Adult Return:								
Northern	4,000	2,400	X			≤10-13%	≤10-13%	-
North-Central	13,600	15,400	X			≤15%	≤15%	-
South-Central	34,800	21,900		X		≤15%	≤20%	-
Southern	4,200	1,900		X		≤15%	≤20%	-
Aggregate	56,600	41,600						
1999 Adult Return:								
Northern	3,400	4,500	X			≤10-13%	≤15%	≤15%
North-Central	18,800	7,800	X			≤15%	≤15%	≤15%
South-Central	56,200	42,100			X	≤15%	≤30%	≤35%
Southern	5,400	200		X		≤15%	≤20%	≤25%
Aggregate	83,700	54,600						
2000 Adult Return (assumes less than Level #1 parent spawners):								
Northern	NA	4,100	X			≤10-15%	≤15%	≤15%
North-Central	NA	9,700	X			≤10-15%	≤15%	≤15%
South-Central	NA	29,900	X			≤15%	≤15%	≤15%
Southern	NA	5,300	X			≤15%	≤15%	≤15%
Aggregate	NA	49,100						
2000 Adult Return (assumes Level #1 parent spawners):								
Northern	NA	4,100		X		≤15%	≤20%	≤25%
North-Central	NA	9,700		X		≤15%	≤20%	≤25%
South-Central	NA	29,900		X		≤15%	≤20%	≤25%
Southern	NA	5,300		X		≤15%	≤20%	≤25%
Aggregate	NA	49,100						
2000 Adult Return (assumes Level #2 or greater parent spawners):								
Northern	NA	4,100		X		≤15%	≤20%	≤25%
North-Central	NA	9,700		X		≤15%	≤20%	≤25%
South-Central	NA	29,900			X	≤15%	≤30%	≤35%
Southern	NA	5,300			X	≤15%	≤30%	≤35%
Aggregate	NA	49,100						

TABLE B-4. Estimation of total allowable harvest exploitation rates for OCN coho under Alternative 2.

	Spawner Numbers		Spawner Rebuilding Status			Total Allowable Exploitation Rate for the Estimated Marine Survival Level		
Stock Component	Parent	Grandparent	Low	Medium	High	Low	Medium	High
1998 Adult Return:								
Northern	4,000	2,400	X			≤10-13%	≤10-13%	-
North-Central	13,600	15,400	X			≤10-13%	≤10-13%	-
South-Central	34,800	21,900	X			≤15%	≤15%	-
Southern	4,200	1,900	X			≤15%	≤15%	-
Aggregate	56,600	41,600						
1999 Adult Return:								
Northern	3,400	4,500	X			≤10-13%	≤15%	≤15%
North-Central	18,800	7,800	X			≤10-13%	≤15%	≤15%
South-Central	56,200	42,100		X		≤15%	≤20%	≤25%
Southern	5,400	200		X		≤15%	≤20%	≤25%
Aggregate	83,700	54,600						
2000 Adult Return (assumes less than full parent seeding)								
Northern	NA	4,100	X			≤10-13%	≤15%	≤15%
North-Central	NA	9,700	X			≤10-13%	≤15%	≤15%
South-Central	NA	29,900	X			≤15%	≤15%	≤15%
Southern	NA	5,300	X			≤15%	≤15%	≤15%
Aggregate	NA	49,100						
2000 Adult Return (assumes full seeding or greater parent spawners):								
Northern	NA	4,100		X		≤15%	≤20%	≤25%
North-Central	NA	9,700		X		≤15%	≤20%	≤25%
South-Central	NA	29,900		X		≤15%	≤20%	≤25%
Southern	NA	5,300		X		≤15%	≤20%	≤25%
Aggregate	NA	49,100						

APPENDIX C

Final Assessment of Risk Associated with the Harvest Management Regime of the Thirteenth Amendment to the Pacific Coast Salmon Plan

Oregon Department of Fish and Wildlife
National Marine Fisheries Service

October 1998

Introduction

The thirteenth amendment to the Pacific Fishery Management Council's (Council) ocean salmon fishery management plan (FMP) was approved for public review at the September 9-12, 1997 Council meeting. A public review draft of the amendment was released in October and public hearings were held in Oregon and California. At the November 3-7, 1997 meeting, the Council recommended the National Marine Fisheries Service (NMFS) implement the amendment. As part of the recommendation, the Council requested minor language changes and a risk assessment of the amendment's fishery management regime.

This document was prepared by the Oregon Department of Fish and Wildlife (ODFW) and the NMFS and is an amended version of the final report on the risk assessment requested during the adoption of Amendment Thirteen (A-13).

Background

Description of Status Quo (Amendment 11)

Oregon Coastal Natural (OCN) coho fishery management has been regulated under the eleventh amendment of the FMP adopted by the Council in 1993. Amendment 11 (A-11) manages OCN coho based on a maximum sustainable yield (MSY) spawner escapement level of 42 adults per mile in standard index areas or 200,000 adult spawners (PFMC 1993). The escapement goal is based on the stock-recruitment relationship for Oregon coastal coho and represents a coast-wide aggregate (ODFW 1982). Fisheries are not managed by exploitation rate under A-11 unless stock projections are below 240,000 adult ocean abundance in which case fisheries are managed for a "20% incidental harvest rate to prosecute other fisheries which under no circumstances will cause irreparable harm to the OCN stock" (PFMC 1993).

Description of Amendment 13

The State of Oregon, under the *Oregon Coastal Salmon Restoration Initiative* or *The Oregon Plan*, developed A-13 as one of many measures to help restore OCN coho and prevent the need for listing under the federal Endangered Species Act. This amendment deviates from the status quo OCN coho fishery management regime by separating the OCN coho population into four sub-aggregate stock components and by using total exploitation rate as the management goal. This approach addresses unique conservation concerns of distinct OCN coho populations and ties harvest management to observed parent spawner abundance and juvenile survival as opposed to projected spawner abundance. For a detailed description, refer to *Draft Amendment 13 to the Pacific Coast Salmon Plan* (PFMC 1997).

Description of the Council's Request

The risk assessment request stated the need for three major evaluations. First, a projection of spawner abundance under low, medium, and high marine survival conditions over four generations (twelve years). Secondly, an estimate of the probability of achieving the projected spawner abundance which includes statistical variability of key parameters (marine survival, spawner abundance, fishery impacts, and habitat capacity). Finally, a direct comparison of the A-13 fishery management regime to the status quo A-11 fishery management regime was requested.

This amended version of the final report also includes an analysis of long term (100 years) spawning escapement and local extinction probabilities for OCN coho. Long term risk analysis was not part of the Council's initial request but is included to address requests made by members of the Salmon Technical Team and the Scientific and Statistical Committee.

Description of the Assessment Approach

A habitat-based life-cycle model that incorporates environmental, demographic, and genetic population stochasticity was chosen as the tool that could provide the most complete analysis relative to the specific requests. A detailed description of the model is attached as Appendix A (Nickelson and Lawson, in press). Monte Carlo trials of 1,000 runs were conducted for each sub-aggregate under both the A-11 and A-13 harvest management regimes for four generations at low, medium, and high marine survival. Production from the lake systems was not included in this modeling exercise because the habitat-based life-cycle model was not designed to simulate lake systems. Escapements to the Rogue River were included although this system is not part of the historical OCN accounting. Output from model runs includes a median population size for three broods over four generations, cumulative probability of attaining ending population sizes, and the probability of achieving ending population sizes that meet the escapement thresholds identified in A-13.

Habitat-Based Life-Cycle Model

The habitat-based life-cycle model (Nickelson and Lawson, 1996 and in press) was modified to specifically address the Council's request for a risk assessment. Detailed simulations of the A-13 and A-11 harvest management decision criteria were developed and incorporated into the model.

Stream-reach-specific spawner escapements for 1995-97 and habitat quality data for each stream reach within each sub-aggregate were compiled and used as input to the model. The model included 3,500 individual stream reaches encompassing all four OCN sub-aggregates of A-13. The model did not include Oregon coastal lake systems that represent some of the most stable OCN production. Variability surrounding key parameters not already described in the model were incorporated into the analysis. These modifications to the model are described in Appendix B.

Monte Carlo trials of 1,000 iterations were run at low (1.8%), medium (5.4%), and high (8.6%) smolt to adult survival under each of the management regimes.

Ocean fishery impacts were modeled at the highest allowable level for A-13 model runs. Additional freshwater fisheries that would be allowed under A-13 when individual basins reach full seeding of high-quality habitat were not modeled. Fishery impacts were modeled to approximate recent Council management for A-11 model runs during years with low abundance and at the highest allowable level for A-11 model runs under higher abundances. Abundance levels triggering lower exploitation rates in A-11 were the same as those in A-13 (see Appendix B).

Model projections of median population size under each marine survival category were plotted for the sub-aggregate and aggregate populations for each harvest management regime (Figures 1 &2). Probability of achieving ending population sizes described in A-13 as stock component rebuilding criteria (level 1, level 2, and full seeding of high quality habitat) were calculated for each management regime and each starting population size (Figures 3 & 4). The OCN lake component was removed from the A-13 escapement benchmarks for this analysis as lakes were not included in the modeling exercise. Additionally, probabilities of achieving ending population sizes capable of theoretical full seeding during periods of improved marine survival are estimated. These full seeding levels are based on the premise that increasing marine survival rates require higher spawning escapements to take full advantage of the productive capacity of the entire system and were derived through previous runs of the habitat-limiting factors model (Tom Nickelson, personal communication).

Results and Discussion

Projection of Spawner Abundance at Low, Medium, and High Marine Survival over Four Generations

Projected median population sizes for OCN coho sub-aggregates show that rebuilding is most likely to occur under medium and high marine survival conditions (Figure 1). During prolonged low marine survival, the OCN sub-aggregate populations tend to remain stable at current levels of abundance, with little or no rebuilding (Figure 1). The four subaggregates show similar trends in population size within each marine survival category.

Probability of Achieving Projected Spawner Abundance

Probabilities of achieving escapement benchmarks are higher under the A-13 management regime than the A-11 regime, particularly at medium and high marine survival (Figures 3 & 4). Model runs at low marine survival indicate the probability of rebuilding in four generations is small and very similar between management regimes (Figures 3 & 4).

However, four generations is a relatively short time period to rebuild, especially for the very small 1997 brood. It can be expected that rebuilding of a small brood (1997) would take longer and, over the short term, have lower probabilities of achieving rebuilding targets compared to a brood that was twice as large (1996).

Probabilities associated with achieving full seeding of high quality habitat are higher under the A-13 management regime than under the A-11 regime at the medium and high marine survivals (Figures 3 & 4). Probabilities of achieving full seeding of the 1996 brood in four generations with 5.4% marine survival are 84% with A-13 and 64% with A-11.

Figure 5 displays the cumulative probabliity of attaining median OCN population sizes for three brood cycles modeled at low, medium, and high marine survival for A-11 and A-13 management.

Direct Comparison of the A-13 Management Regime to the A-11 Management Regime

Both harvest management regimes, when modeled at low marine survival, result in population sizes in the range of recent observations (1990-97). Model runs at low marine survival, indicate that projected escapements are very similar under both management regimes (Figure 2), however A-11 management at low marine survival was modeled using 13% or 15% exploitation rates rather than the full 20% as allowed. The A-11 model runs under low escapements represent historical Council practices under this management regime and could have actual impacts up to 20%; higher than those that were modeled. Projected spawner escapements at low marine survival would be somewhat lower under A-11 if the fishery exploitation rate was allowed to approach the maximum allowable level. For comparative purposes, projected median population size for the OCN aggregate was also modeled with zero harvest and is included in Figure 2.

Projected median population size for the OCN aggregate under A-13 and A-11 indicates that at medium and high marine survival A-13 has the capability of allowing higher escapements (Figure 2). Additionally, management under A-13 provides for higher probabilities of achieving escapement thresholds (Figures 3-5).

Long-term Simulation Modeling

Thirty-three generation model runs were completed for the 1997 brood under zero, A-11, and A-13 harvest levels. Marine survival for the long-term modeling ranged from 1.5% to 6%, on a template of the Aleutian Low Pressure Index (ALPI). The ALPI has a long-term periodicity of about 50 Years. Figure 6 displays a 33 generation time series of spawning escapements with zero harvest and A-11 and A-13 harvest strategies. Under A-13 median escapements of 200,000 or greater occur approximately 20% of the time and the upper quartiles of the median exceed 200,000 fish approximately 70% of the time. Escapements under A-11 are lower than under A-13 and the median escapement is never greater than 175,000 fish. While escapements under a zero harvest scenario always exceed those under A13 and A11 management, escapements with no harvest still fail to exceed 200,000 fish in more than 30% of the 33 generations

Figure 7 displays local extinction probabilities with zero harvest and A-11 and A-13 harvest strategies. Extinction probabilities are lowest with zero harvest and lower under A-13 than under A-11.

Conclusion

A-13's low allowable exploitation rates will permit recovery and full seeding of high-quality habitat within several generations if marine survival improves. Modeling indicates that the probability of achieving full seeding of available habitat is higher under A-13 than A-11, particularly with medium and high marine survival. The overall risk associated with A-13 is lower than the risk associated with A-11, although both management regimes show low risk at medium to high marine survivals. On average, A-11 management effectively capped escapements at levels near the 200,000 goal. In contrast, the A-13 harvest rate based management regime permits escapements to increase above escapement goals defined under A-11. This feature of A-13 gives managers the adaptive flexibility to tap the full potential of less productive freshwater spawning and rearing habitat when marine survivals are high.

It is clear, however, if poor marine survival persists for many generations, no harvest management regime alone will restore OCN coho.

Acknowledgements

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Appendix A

Description of the Population Viability Model of Nickelson and Lawson (1998)

Coho Salmon Life-Cycle

We based our model on the life cycle of coho salmon in Oregon. Coho salmon in coastal streams typically spawn from early November through mid-January. Juveniles emerge from the gravel in spring and typically spend a summer and winter in freshwater (primarily in second to fifth order streams) before migrating to the ocean as smolts in their second spring. A very small percentage of juveniles (<5%) spend an additional winter in freshwater, migrating to the ocean in their third spring (Moring and Lantz 1975). Precocious males, called jacks, return to freshwater at the end of one summer in the ocean as age-2 spawners. They comprise about 20% of each run (Moring and Lantz 1975). Adult coho return to freshwater after their second summer in the ocean as age-3 spawners. Because of the predominance of age-3 adults in Oregon coho salmon populations, they are considered to have 3 brood cycles.

The Model

The general approach taken here was to use reach-specific production parameters derived from Nickelson's (1998) habitat limiting factors model (HLFM) to model coho salmon production in a river basin. Each reach represented a population, modeled separately through processes of egg production, egg-to-parr survival, parr-to-smolt survival, marine survival, harvest, and spawner escapement. Populations in a basin were linked through straying of spawners among reaches. Successive generations were simulated by using spawners from one generation to seed the next. Stochastic variation was included at several stages of the life-cycle model. Monte Carlo simulations were used to produce a set of likely outcomes from a set of input parameters. Details of the modeling at each life stage are described below.

Spawners

Spawners were the starting point for the simulations and the ending point for each generation. For the purpose of the model, spawners included only age-3 adults, thus a 3-year generation time. For simplification, jacks were not included in the calculations. Similarly, because age-4 adults are very rare, they were also excluded from the model. The absence of these two age-classes from the modeled populations could possibly result in an underestimation of the productive potential of the modeled populations (Botsford and Brittnacher 1998) because of the lost contribution to the reproductive capacity of successive broods.

Wild coho salmon in coastal Oregon streams tend to spawn over a period of 2-3 months (Cooney and Jacobs 1995), preventing fish spawning early from interacting with fish spawning later. This usually is not a problem when populations are large; spawners should have little difficulty finding mates. However, when spawner populations are very small and some fish are present in a stream early and others late, finding a mate could become a matter of chance. A spawner not finding a mate is a depensatory effect of small spawner numbers. To simulate the effects of this depensation, time of spawning was split into three periods: early, mid, and late. Spawners in each reach were assigned randomly to the three periods. The number of female spawners in each time period was drawn from a binomial distribution having p = 0.5 and n = the number of spawners in the time period. There is no reliable data for sex-ratio of wild coho salmon in Oregon, and the data for hatchery coho salmon is conflicting. With 20% of males returning as jacks it is likely that more than half of the returning age-3 adults are females. However, given the lack of consistent data, we modeled a 50:50 sex ratio.

Eggs

Egg deposition (D) was calculated as 2,500 eggs per female (Moring and Lantz 1975, ODFW unpublished data for 1990-95). When marine survival was less than 0.8% a fecundity reduction of 24% was applied to simulate the effects of El Niño (Johnson 1988); low marine survival, associated with increased ocean temperature, tends to be accompanied by small body size and reduced fecundity in coho salmon. When all spawners in a time period were females, egg deposition for that time period was zero. No adjustment was made for the infrequent high female:male sex ratios. Mathisen (1962) found no difference in egg mortality that could be attributed to sex ratios as high as 15 females per male in sockeye salmon (*O. nerka*), much higher than would typically be drawn from a binomial distribution.

Moring and Lantz (1975) estimated no fry emerge from about 15% of coho salmon redds, likely the result of gravel scouring (Koski 1966). We reduced egg deposition to account for this mortality by assuming one redd per female and drawing the number of successful redds in each reach from a binomial distribution having $p = 0.85$, and n = number of females. Egg deposition from the three time periods was summed to arrive at a total number of eggs in each reach.

Summer parr

The number of summer parr in each reach was calculated by multiplying egg deposition by an egg-to-parr survival rate (S_{parr}), which was estimated from a density dependent function based on the relative level of seeding (P), where:

[1] $P = D / D_m$

and D_m is egg deposition needed to produce maximum smolts from the reach as estimated using the habitat model of Nickelson (1998).

Relative seeding level was used as an independent variable to estimate egg-to-parr survival rate because each reach had a different productive capacity. Thus, a given number of eggs would represent a different level of seeding in each reach and therefore a different point on a density dependent curve. The relationship between relative seeding level and egg-to-parr survival rate, based on data from Moring and Lantz (1975) and Hall et al. (1987), yielded the following equation ($p < 0.001$; r = 0.762):

[2] $S_{parr} = 0.079P^{-0.699}\, e^{E}$.

The annual E value represents variability due to basin-wide environmental factors, such as extreme flows, that could affect survival uniformly across reaches. Survival rates differed among reaches because of differences in juvenile density. In the model, E was calculated each year by multiplying the standard deviation of the residuals from the fit of Equation 2 by a value chosen randomly from a standard normal distribution. The fitted curve resulted in survival rates >100% when seeding level was <3.7%, so egg-to-parr survival rate was capped at 44%, the highest observed in the data set. The log-normal form of the deviation term also had a tendency to produce unrealistically high survival rates all along the curve. To constrain modeled variability the maximum random value chosen from the standard normal distribution was set at 0.946. This resulted in limiting the upper extreme of variability to a value consistent with the maximum positive residual actually observed in the data set.

Genetic effects

At this point in the life history, we applied a factor to account for genetic effects of small spawner population size. When effective population size (N_e) is small, generally on the order of 100 individuals or less, genetic fitness is reduced because deleterious mutations accumulate due to random genetic drift (Lynch 1998). When N_e is relatively large ($\geq$1 000 individuals), genetic reduction in fitness is generally not a problem. This reduction in fitness is in the range of 1.5% per generation at very low N_e and is cumulative (Lynch 1998). A conservative estimate of N_e is approximately 20% of the actual number of spawners (Lynch 1998). Because there is genetic interaction among successive broods of coho salmon, through mixing of age-2 jacks, age-3 adults, and age-4 adults, N_e can be approximated by:

[3] $N_e = 0.2 * 3\ N_i$

where N_i is the number of spawners in a basin in year i as determined by summing spawner populations across reaches. We modeled reduction in fitness (f) as a reduction in survival rate, and describe the portion attributable to any given generation by assuming: 1) $f = 0$ when $N_e \geq 1\ 000$; 2) $f = 0.001$ when $N_e = 100$; 3) $f = 0.015$ when $N_e = 5$, and; 4) the change in f is linear between $N_e = 5$ and $N_e = 100$ and between $N_e = 100$ and $N_e = 1\ 000$ (M. Lynch, University of Oregon, Eugene, personal communication).

The cumulative effect through time of deleterious mutations (g) can be expressed as:

[4] $g_i = (1 - f_1)\ (1 - f_2)\ (1 - f_3)\ \ldots\ (1 - f_i).$

In the model, g_i was multiplied by the egg-to-parr survival rate to effect a reduction in survival.

This model of genetic effects was intended to capture, in a very general way, one aspect of genetics that could be important at low population sizes. We have not accounted for genetic diversity among populations in any way. The process of natural selection would be expected to reduce effects of inbreeding depression over time. We chose not to model natural selection because it is thought to operate on a longer time frame than inbreeding depression, we have little information to model the effect, and we wanted the model predictions to err on the side of low population numbers. Other efforts are underway to model genetic risks to salmon populations (M. Lynch, University of Oregon, Eugene, personal communication).

Smolts

The number of smolts in a reach was calculated by multiplying summer parr by a reach-specific over-winter survival rate as described by Nickelson (1998). The over-winter survival function was:

[5] $S_{ow} = 0.1361 / \log_e C + 0.487 + E,$

where S_{ow} is over-winter survival rate and C is estimated smolt capacity in smolts/m^2 ($r = 0.806$, $p < 0.001$). As with egg-to-parr survival, annual deviation from the regression (Equation 5) was modeled as variation due to environmental patterns, such as rainfall, that affect the basin uniformly. The deviation term for a given year was calculated as the standard deviation of the observed residuals from Equation 5 multiplied by a value chosen randomly from a standard normal distribution. The value for the over-winter survival rate for a reach in a given year was derived by adding the annual deviation term to the value of S_{ow}. This deviation term, like the egg-to-parr deviation term, has a tendency to produce unrealistically high survival rates. To curb this tendency, the maximum random value chosen from the normal distribution was 2.260. This confined the variability in maximum survival rates to a range consistent with the maximum positive residual observed in the data. Smolt number for a given reach was capped at *M*. When calculated survival values were <0, they were set to 2.5%, the lowest actual value observed.

Adults

The number of adults from each reach was determined using a binomial distribution with n = the number of smolts and p = a marine survival rate incorporating environmental variability. For the purpose of this model, marine survival was defined as the period encompassing downstream smolt migration from the natal stream and ocean residence until their second summer. Harvest of adults was modeled from a binomial distribution with n = the number of adults and p = 1 minus the fishery exploitation rate. Adults remaining after harvest returned as spawners, as additional natural mortality on adults was assumed to be negligible.

Spawners

As spawners entered a basin they returned to their natal reaches with a 5% within-basin straying rate. The straying rate was applied in the form of two components: 1) fish left a reach randomly with a binomial probability distribution having $p = 0.05$ and n = the number of spawners returning to that reach, and; 2) fish that have left a reach select a new reach at random with equal probability for all reaches. The effect was to redistribute 5% of the spawners each generation, permitting repopulation of reaches where spawners had gone locally extinct. Labelle (1992) found that straying of wild adult coho salmon among Vancouver Island tributaries to the Strait of Georgia ranged from 0 to 7.8%, averaged 4.2% one year, 0% a second year, and 2.1% overall. The value we used for within basin straying was roughly double Labelle's among basin rate because we judged that straying within a basin was apt to be greater that straying between basins.

Appendix B

Habitat Based Life Cycle Model Modifications and Assumptions

Marine Survival Rate

Marine survival was variable within a level and was predicted with error.

Low	For model runs under the low category a 0.018 (CV = 35%) marine survival rate was applied. This represents two times the average observed OPI hatchery marine survival. There is evidence to suggest that naturally produced coho salmon survive at twice the rate as hatchery coho during years with low marine survival (Tom Nickelson, personal communication).
Medium	For model runs under the medium category a 0.054 (CV = 45%) marine survival rate was applied. This represents 1.5 times the average observed OPI hatchery marine survival under the medium category. A linear relationship between OPI hatchery and OCN marine survival was assumed.
High	For model runs under the high category a 0.086 (CV = 10%) marine survival rate was applied. This represents the average observed OPI hatchery marine survival under the high category. Naturally produced coho salmon survive at the same rate as hatchery coho during years with high marine survival (Tom Nickelson, personal communication).

Marine Survival Predictor

Predicted marine survival of Columbia River hatchery coho is one of the control variables for Amendment 13 management. Marine survival is predicted using the relationship between jacks per smolt and adults per smolt in the Columbia River. Log-transformed jacks per smolt and log-transformed adults per smolt for the years 1970-1996 were regressed. The fitted regression was:

$$\ln(\text{adults/smolt}) = 2.2725 + 0.9093 * \ln(\text{jacks/smolt}).$$

with $r2 = 0.80$ and a standard error of 0.4045. Predicted marine survival was estimated, with error, from the actual modeled marine survival:

$$\text{predicted\_marine\_survival} = \exp(\ln(\text{marine\_survival}) + 0.4045*\text{std\_norm}))$$

where std_norm is a random draw from a standard normal distribution.

Post-season Exploitation Rate

Exploitation rate targets set pre-season are implemented with error. This error was modeled using a logit regression (Mary Buckman, personal communication). The logit of the post-season exploitation rate (post_er) is ln(post_er/(1-post_er)). The relationship between pre-season and logit post-season exploitation rates on OCN coho from 1983 to 1987 is:

logit(post_er) = -2.664 + 5.474*pre_er,

where pre_er is the preseason exploitation rate. Regression statistics include r^2 = 0.7079, mean (xbar) = 0.3474, sum of squared errors of x (ssqx) = 0.5475, mean squared error (mse) = 0.5209, and number of observations (n) = 15. The new exploitation rate, including error, is calculated in several steps. First, the variance of the pre-season rate is calculated (in a logit regression variance is not uniform over all x):

var = mse * (1+1/n + (((pre_er-xbar)2)/ssqx).

The standard deviation (sd) is the square root of the variance. The logit estimate (yhat) from the regression is:

yhat = -2.664 + 5.474*pre_er.

A normally-distributed error term is added:

new_yhat = yhat + std_norm*sd.

Finally, the logit estimate is back-transformed:

post_er = exp(new_yhat/(1+new_yhat)).

In practice, the fit of this regression was biased low, especially in the range of 20% to 40% exploitation rates Thus this method could produce post-season exploitation rates (in relation to pre-season targets) that were lower, on average, than the management system is actually achieving. The confidence limits are quite wide, however.

Spawning Ground Escapement Estimates

The variability in the Stratified Random Sampling (SRS) survey spawning population estimates was incorporated into the 1995-97 population estimates and applied to each subsequent year's escapement estimates (bootstrap). Current sampling plans produce sub-aggregate population estimates with precision of $\pm$ 30% for the 95% confidence interval.

Administration of the harvest regime specified in Amendment 13 requires estimates of spawners in 13 coastal basins. These estimates will be generated from SRS surveys in each basin. The SRS survey methodology was simulated by specifying a number of sampled reaches in each basin (Steve Jacobs, personal communication), selecting that number of reaches at random from each basin, and expanding the number of spawners in the sampled reaches by the sampling fraction. This captures only the sampling errors, and does not include variability in numbers of spawners observed and in the AUC expansion that is applied to the survey data. As a result, spawners estimates in the model are more accurate and, potentially, less biased than in practice.

OCN Predictor

The current OCN predictor is a multiple regression of spring upwelling and winter sea surface temperature on the natural log of OCN recruits. A rigorous simulation of this predictor would involve simulating two environmental time series and reimplementing a nonlinear fitting algorithm. As a simpler alternative a gamma distribution with a mean of the known recruitment (from the model) and a coefficient of variation similar to that of the predictor was sampled. A gamma distribution was used because it will always return a positive integer, and the right-hand tail is not as extreme as a standard normal distribution. Parameters for the gamma distribution were estimated from reconstructed OCN recruitments using Stratified Random Survey (SRS) expansions applied to the years 1970-1997. The methodology for this reconstruction has not yet been finalized, so a method similar to what will likely be adopted was chosen. The mean of SRS ocean recruits from this reconstruction was 176,000 with a coefficient of variation of 0.84. The gamma distribution was given a beta of 2, corresponding to a coefficient of variation of 0.7071. This is a fairly pessimistic view of the power of prediction. However, the error is applied to the actual recruitment rather than the mean, and gamma distributions with high coefficients of variation are skewed to the right, with the median values lower than the mean. This results in a predictor that is more often low than high. Over the past ten years OCN predictors have more often been high than low, so this method may represent lower risk to the stocks that the actual management regime.

Management Models

Management models were implemented as target exploitation rates based on a set of rules and the current state of the fishery, known to managers with error. Two sets of rules were modeled, one simulating Amendment 11 (status quo), and the other simulating Amendment 13. With one exception only the prescribed regimes were modeled. For Amendment 11 a reduced exploitation rate was modeled for low spawner escapements, similar to the Council's recent management decisions.

Amendment 11 -- status quo

Amendment 11, as modeled, defines a spawner escapement goal of 200,000 fish for the Oregon coast. For simplicity in this application, the goal included Rogue River, but not the coastal lakes. Although Amendment 11 specifies only a minimum 20% exploitation rate, in practice the Council has reduced OCN exploitation rates in response to conservation concerns. In the simulation, two conservation levels were defined based on criteria established for Amendment 13. Level 1 was 66,000 fish, the level defined as 50% of full seeding of the best habitat in Amendment 13. Level 0 was defined as 38% of Level 1, or 25,080 fish.

Amendment 11 management starts with a known number of ocean recruits. The OCN predictor is applied to produce an estimate of recruits. The estimated number of recruits is compared to the three escapement criteria. If estimated recruits are less that the Level 0 criterion then the pre-season exploitation rate (pre_er) is 0.13. If estimated recruits are greater than Level 0 but less than the Level 1 criterion the pre_er is 0.15. If estimated recruits are less than the goal plus 20%, or 240,000, the pre_er is 0.20. If estimated recruits are greater than 240,000, the pre_er is set to achieve an escapement of 200,000. The post-season exploitation rate (post_er) is then selected using pre_er as input, as described above. The post_er is then applied to the ocean recruits. From the returning spawners the life-cycle model is then used to estimate the next generation of ocean recruits.

Amendment 13

Amendment 13 is fundamentally different from Amendment 11 in that it specifies an exploitation rate based on parental and grand-parental escapements, and predicted marine survival. Implementing Amendment 13 requires considerably more information than Amendment 11. Only the ocean portion of the Amendment was implemented. There are in-river harvest opportunities that have not been modeled here. This leaves the potential for exploitation rates on some stocks to be higher than those modeled.

Amendment 13 defines five escapement levels for management triggers. These are:

1) Full seeding of high quality habitat
   * Inriver harvest is not to reduce run below this level based on predicted run size.
   * Predictors do not currently exist.
2) 75% seeding of high quality habitat.
   * Subaggregate parental escapement at this level triggers exploitation rate of 0.35 if predicted marine survival is also high and grandparental escapement is at level 3.
   * Subaggregate parental escapement at this level triggers exploitation rate of 0.30 if predicted marine survival is medium and grandparental escapement is at level 3.
3) 50% seeding of high quality habitat
   * Subaggregate parental escapement at this level triggers exploitation rate of 0.25 if marine survival is high and grandparental escapement was at this level.
   * Subaggregate parental escapement at this level triggers exploitation rate of 0.20 if marine survival is medium and grandparental escapement was at this level.
4) 38% seeding of high quality habitat
   * Subaggregate parental escapement above this level but below 50% seeding triggers exploitation rate of 0.15.
   * Subaggregate parental escapement below this level and low marine survival triggers exploitation rate of 0.13.
   * Subaggregate parental escapement below this level and medium or high marine survival triggers exploitation rate of 0.15.
5) 10% seeding of high quality habitat
   * Any basin escapement below this level reduces parental spawner status for the subaggregate by one level.

Marine Survival is divided into three levels based on the predicted marine survival. These are high (ms > .05), medium (0.021< ms < 0.05), and low (ms <= 0.21).

To model Amendment 13 management, spawner estimates are produced for each basin and subaggregate. Marine survival is predicted and classified as high/medium/low. Based on these estimates an allowable exploitation rate for each subaggregate is chosen. The subaggregate with the lowest exploitation rate drives the exploitation rate for the aggregate. Based on this exploitation rate a post-season exploitation rate is selected and applied to the fishery.

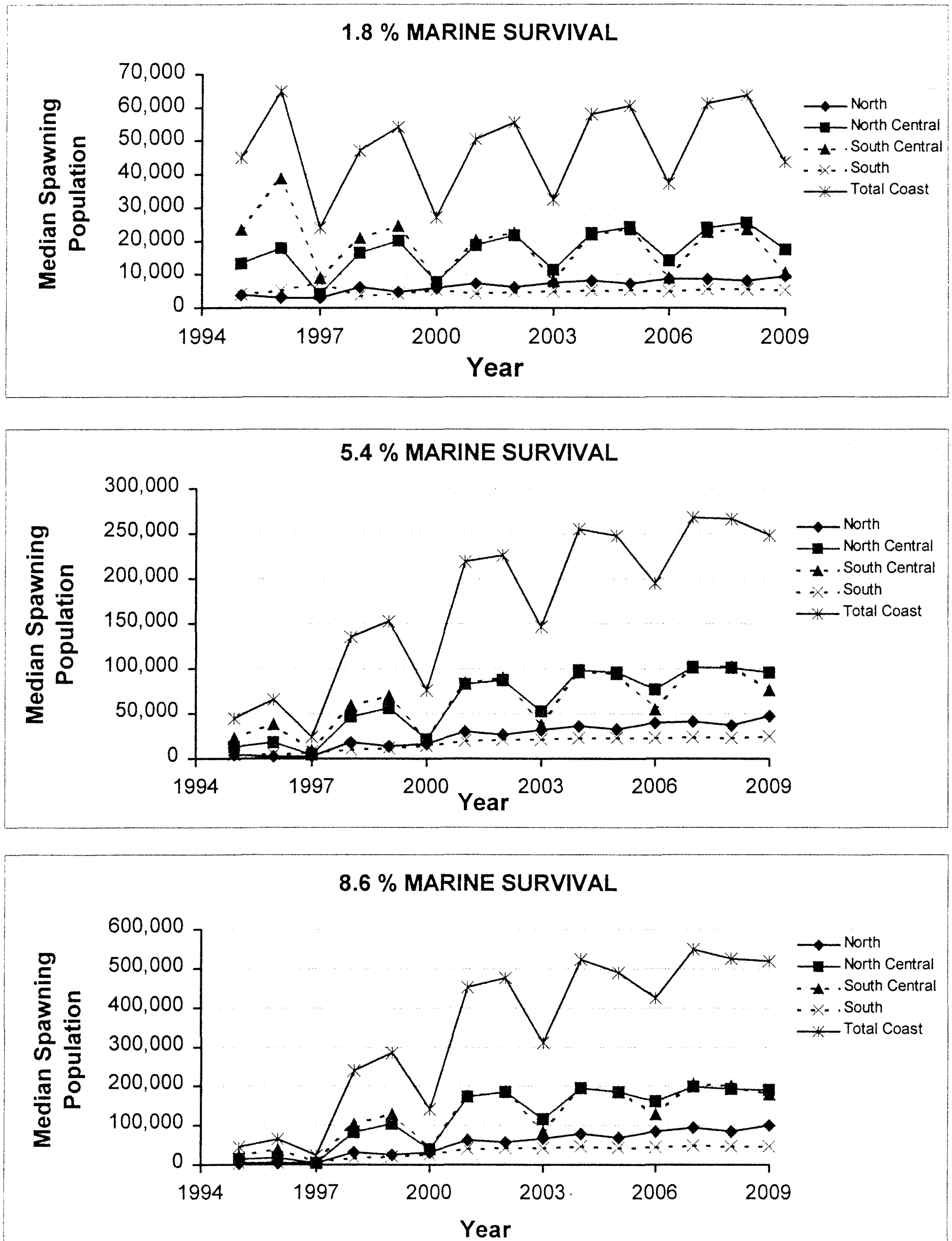


Figure 1. Projected median spawning populations over four generations under A-13 management and low, medium and high marine survivals.

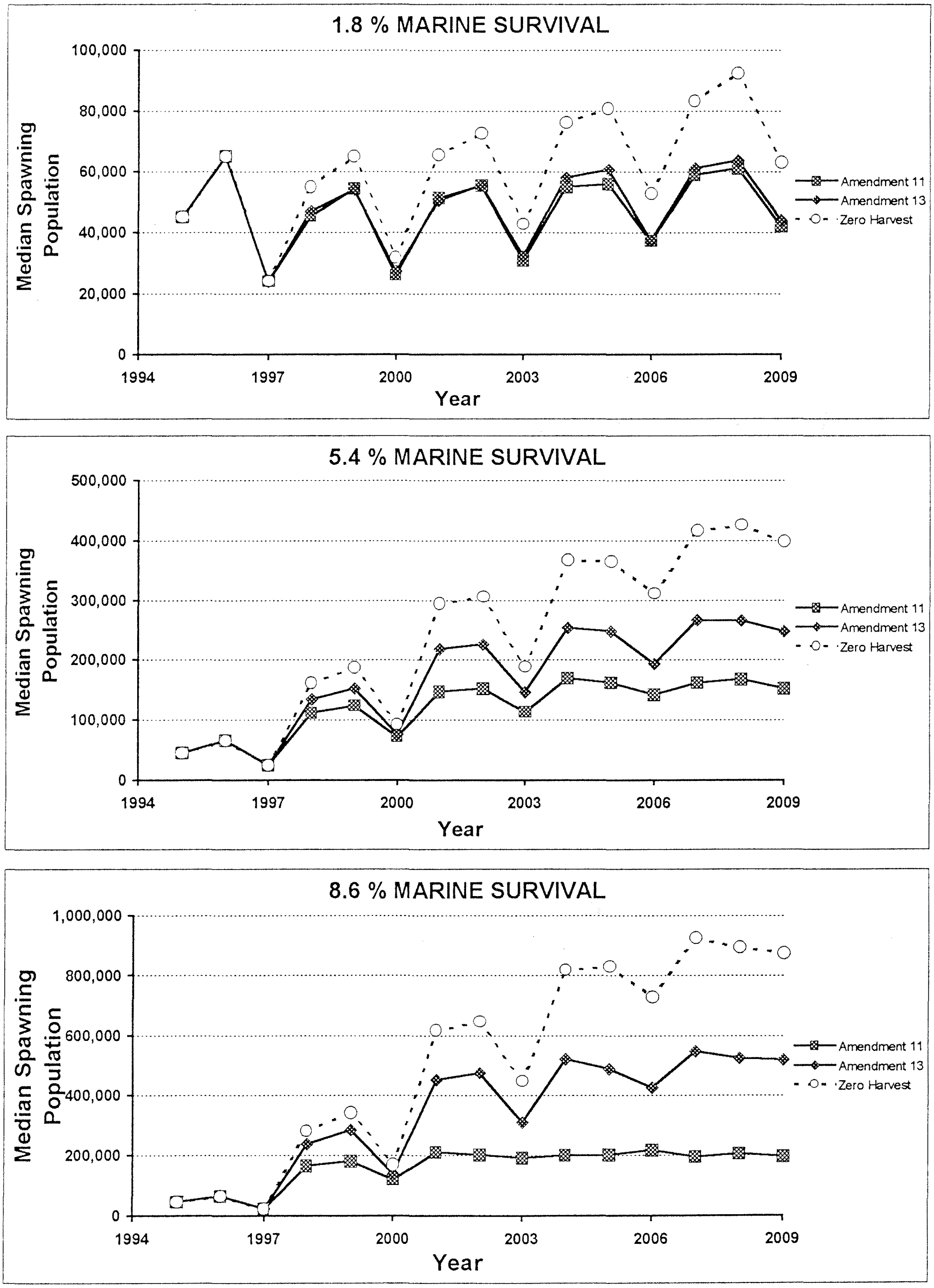


Figure 2. Comparison of projected aggregate OCN spawning populations when modeled for A-11 and A13 management regimes and for no harvest at low, medium, and high marine survivals.

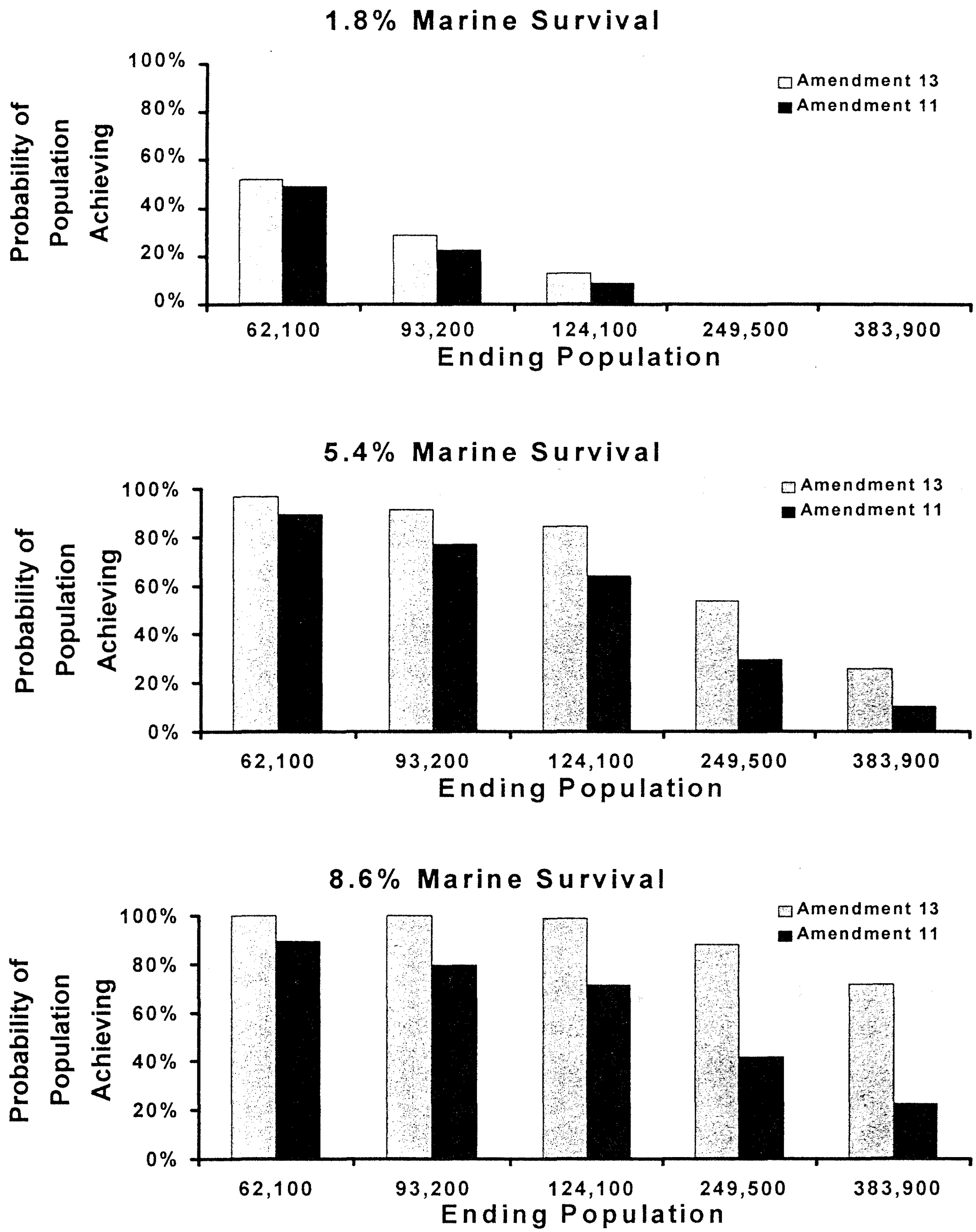


Figure 3. Probabilities of 1996 brood OCN coho achieving specific spawning populations after four generations under conditions of low, medium, and high marine survivals. The two smallest spawning populations (62,100, and 93,200 fish) represent 50% and 75% of full seeding at low marine survivals. The next three highest spawning populations (124,100; 249,500; and 383,900 fish respectively) represent full seeding at low, medium, and high marine survivals.

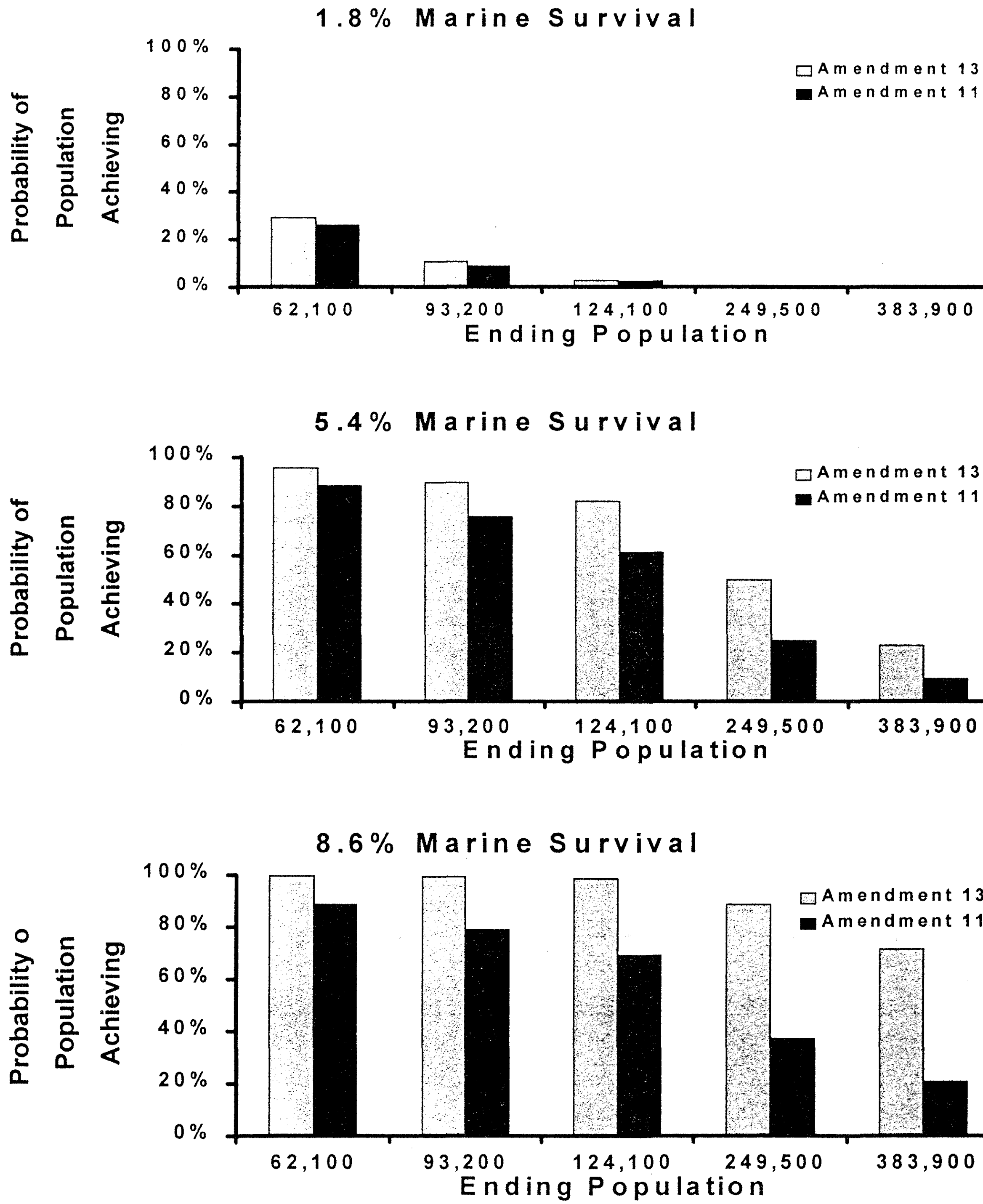
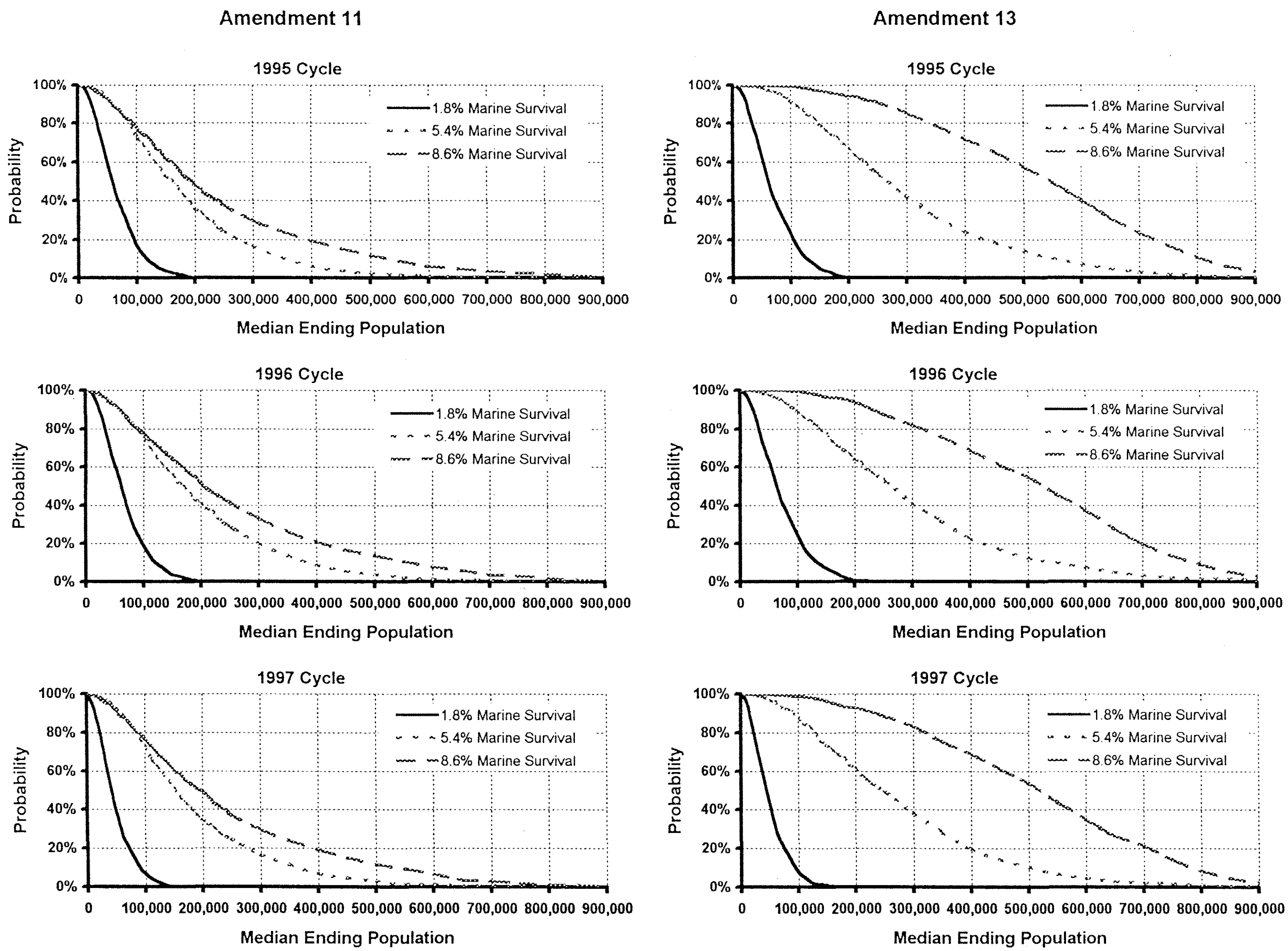


Figure 4. Probabilities of 1997 brood OCN coho achieving specific spawning populations after four generations under conditions of low, medium, and high marine survivals. The two smallest spawning populations (62,100, and 93,200 fish) represent 50% and 75% of full seeding at low marine survivals. The next three highest spawning populations (124,100; 249,500; and 383,900 fish respectively) represent full seeding at low, medium, and high marine survivals.

Figure 5. Probabilities of attaining median ending OCN populations for three brood cycles modeled at low, medium, and high marine survival for A-11 and A-13 management.



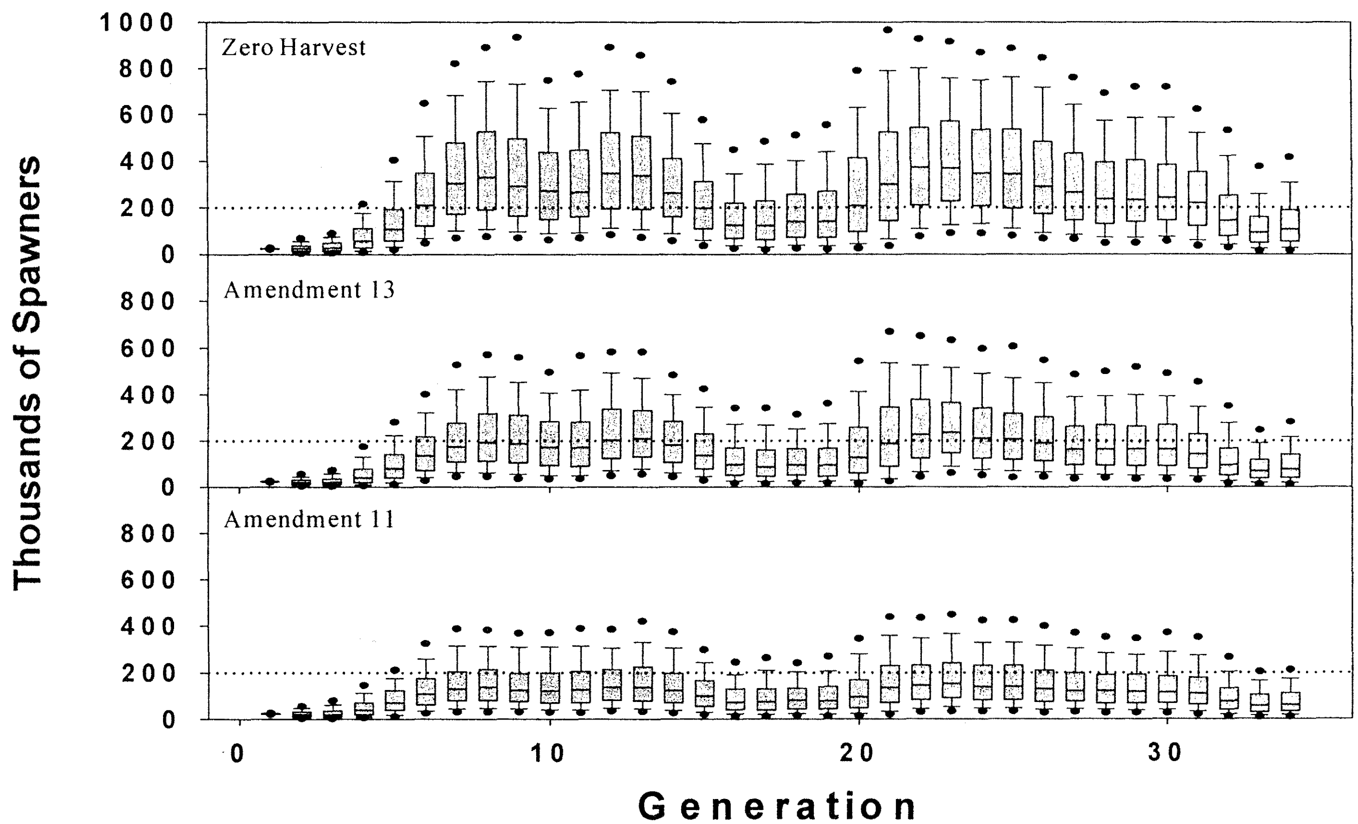


Figure 6. A time series of 33 generations of spawning escapements with zero harvest, and A-11 and A-13 harvest strategies. Marine survival ranged from 1.5% to 6% on a template of the Aleutian Low Pressure Index with a periodicity of approximately 50 years. The boxes depict the median and upper/lower quartiles, whiskers are 10/90 percentiles, and dots are 5/95 percentiles.

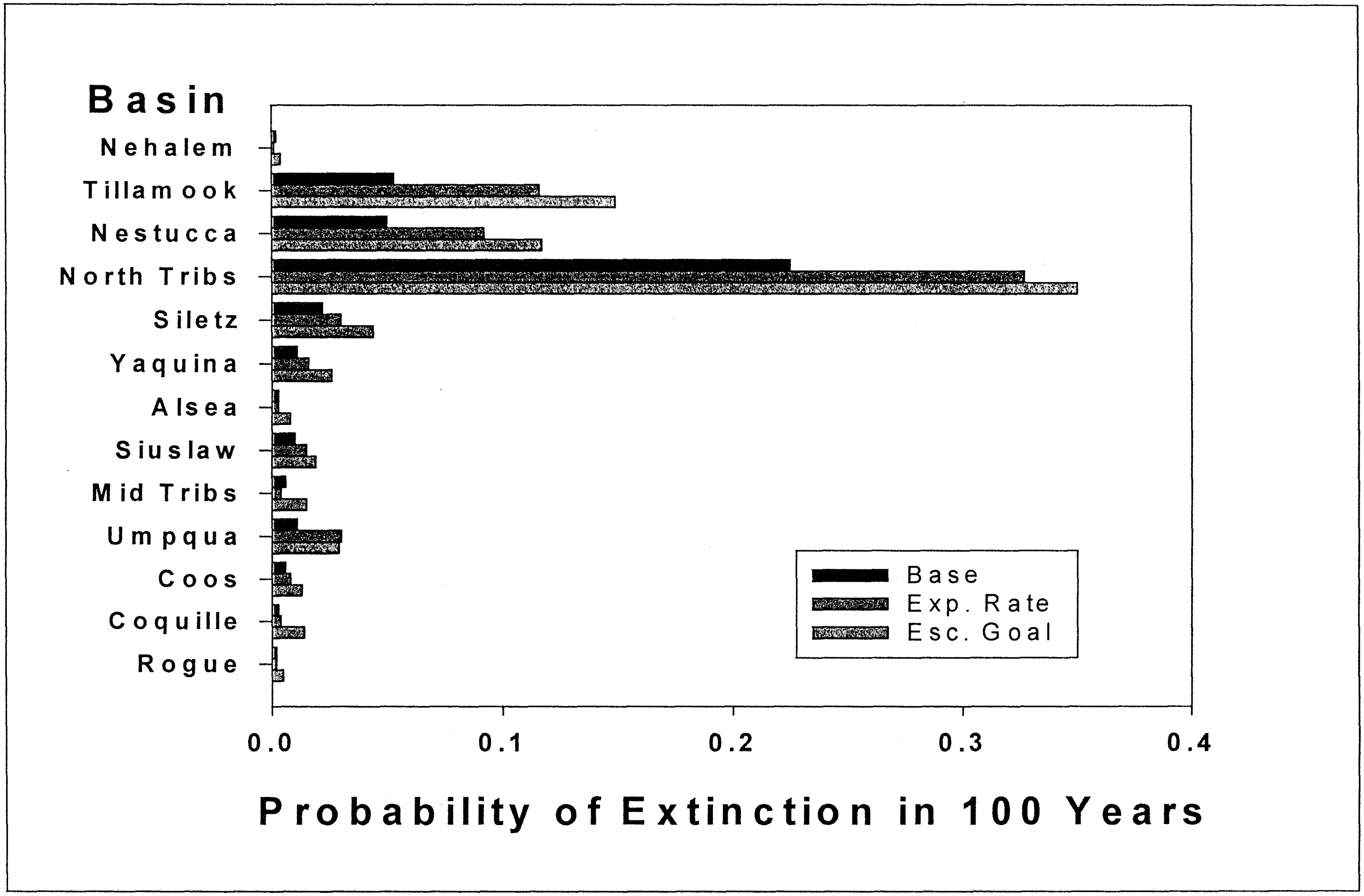


Figure 7. Local extinction probabilities with zero harvest and A-11 and A-13 harvest strategies.