ALASKA LEGISLATURE COMMITTEE FILES 1997-1998 8672

9668 SENATE RESOURCES

SB

40

Alaska State Legislature

Senate

Official Business

RICK
HALFORD
State Capitol
Juneau, Alaska
99801-1182
Phone (907) 465-4958

P.O. Box 670190
Chugiak, Alaska 99567
Phone (907) 694-4958

600 E. Railroad Avenue
Wasilla, Alaska 99654
Phone (907) 376-4958

CSSB 40(RES)
Sponsor Statement

"An Act relating to the assessment of discrete salmon stocks"

Although fishery management in Alaska has been very successful in providing abundance of harvestable salmon on a statewide basis, record catches alone do not ensure that we are fulfilling our constitutional mandate for sustained yield. It is incumbent upon us all to pass along a healthy and diverse resource to future generations of Alaskans. I introduced SB 40 to help do just that.

CSSB 40(RES) is a great deal different than the original bill. Gone are the mandates to the Board of Fisheries to adopt and implement discrete stock management in prescribed areas along specified timelines. Instead, the bill mandates discrete salmon stock assessment, leaving to the Board of Fisheries the determination of stocks for which it is appropriate, applying criteria such as the biological health of the stock and the magnitude of user conflicts.

Far too much of our fishery management is being driven by allocation battles in our most contentious fisheries, instead of by sound science and pertinent information. In reviewing proposals for particular fisheries, the Board is often asked to address allocation disputes among various user groups or to react to a sudden and unexpected conservation concern. With a great deal of impassioned testimony on all sides of the issue and no better than anecdotal information on which to base their decisions, it is nearly impossible to resolve these issues. Lack of specific scientific information brings the same issues back before the board year after year. CSSB 40(RES) will address those circumstances by providing a mechanism to gain the stock composition data and escapement information needed to equitably decide critical issues.

This bill mandates discrete salmon stock assessment that will allow the board to target research on stocks and fisheries for which they most need the information. Passage of CSSB 40(RES) will improve the management of our diverse fishery resource by assisting the board in reaching decisions in the most contentious fisheries. Decisions supported by sound science are much more likely to be accepted by the user groups. I urge your support for this measure.

0-LS0296\Q
Utermohle
2/23/98

CS FOR SENATE BILL NO. 40(RES)

IN THE LEGISLATURE OF THE STATE OF ALASKA

TWENTIETH LEGISLATURE - SECOND SESSION

BY

Offered:
Referred:

Sponsor(s): SENATORS HALFORD AND GREEN, Donley

A BILL

FOR AN ACT ENTITLED

"An Act relating to assessment of discrete salmon stocks and to discrete salmon stock assessment surcharges."

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF ALASKA:

*** Section 1.** PURPOSE AND INTENT. (a) This Act requires the Department of Fish and Game and the Board of Fisheries to prepare and prioritize a list of discrete salmon stock assessment projects that are consistent with the sustained yield of wild salmon stocks. This Act also provides a means to offset the costs incurred by the state in conducting discrete salmon stock assessment projects by increasing the fees for commercial fishing licenses. The additional revenue generated and appropriated for discrete salmon stock assessment projects is supplemental to, and not intended to replace, funds appropriated for the operation of the division of commercial fisheries management and development or the division of sport fish.

(b) It is the intent of the legislature that the cost of conducting discrete salmon stock assessment projects be funded in part from revenue derived from the sale of sport fishing licenses in an amount that annually approximates $1 for each license sold.

* **Sec. 2.** AS 16.05 is amended by adding a new section to article 5 to read:

Sec. 16.05.740. Discrete salmon stock assessment. (a) The Board of Fisheries shall, in consultation with the department, identify those stocks of salmon for which discrete salmon stock assessments are needed. The board shall rank the discrete salmon stock assessment needs in accordance with the importance of the stock to fisheries in the state, the magnitude of conflicts among users of the stock, the biological health of the stock, and the need for information to ensure the sustained yield of the stock. The department shall assist the board in the identification of needed information and the ranking of the discrete salmon stock assessment needs.

(b) The department shall

(1) annually develop, with the assistance of the board, a list of, and priority ranking for, proposed research projects to collect information necessary for the assessment of discrete salmon stocks identified by the board under (a) of this section; the projects must include research on the stock composition of salmon taken in fisheries, development of escapement objectives for discrete salmon stocks, projection of escapements for discrete salmon stocks, and other projects intended to obtain information that the board determines necessary under this section;

(2) in conjunction with the board, solicit public comment on the list of proposed projects developed under (1) of this subsection and, as appropriate, revise the projects and the priority ranking assigned to the projects based on the information and comments received during the public comment period;

(3) submit the revised list of proposed projects together with a proposed budget for each project to the governor for inclusion in the proposed budget for the department for the following fiscal year.

(c) The governor shall include a request for an appropriation to the department to fund the discrete salmon stock assessment projects identified on the revised list prepared by the department under (b) of this section as part of the budget and annual appropriation bill submitted to the legislature. The individual projects contained on the list shall be included as allocations under the appropriation for discrete salmon stock assessment projects.

* **Sec. 3.** AS 16.05.480 is amended by adding a new subsection to read:

(e) In addition to the license fee set under (a) of this section for a crewmember fishing license, a stock assessment surcharge of $10 shall be collected at the time of issuance of a crewmember fishing license. The amount of the surcharge collected under this subsection shall be deposited into the general fund. The legislature may appropriate money collected under this subsection to the Department of Fish and Game for the discrete salmon stock assessment program under AS 16.05.740.

*** Sec. 4.** AS 16.43.160 is amended by adding a new subsection to read:

(e) In addition to the amounts collected under (a) - (d) of this section, the commission shall collect, at the time of renewal of an entry permit or interim-use permit for a salmon fishery, a stock assessment surcharge that shall reasonably reflect the different rates of economic return for different fisheries. The amount of the surcharge imposed on the renewal of a permit by a person who is eligible for a reduced permit fee under (c) of this section shall be reduced in the same proportion that a renewal fee for a permit under (c) of this section bears to the renewal fee for the permit under (a) of this section. The commission shall impose an additional surcharge on the renewal of an entry permit or interim-use permit held by a nonresident to the extent permitted by law. The total amount of revenue generated by the stock assessment surcharge must approximate $500,000 annually. The amount of the surcharge collected under this subsection shall be deposited into the general fund. The legislature may appropriate money collected under this subsection to the Department of Fish and Game for the discrete salmon stock assessment program under AS 16.05.740.

*** Sec. 5.** APPLICABILITY. (a) The Department of Fish and Game, with the assistance of the Board of Fisheries, shall develop the first annual list and priority ranking of proposed projects under AS 16.05.740(b), added by sec. 2 of this Act, for submission to the governor for inclusion in the proposed budget for the department for fiscal year 2000.

(b) AS 16.05.480(e), added by sec. 3 of this Act, and AS 16.43.160(e), added by sec. 4 of this Act, are applicable to crewmember licenses, entry permits, and interim-use permits issued or renewed for 1999 or a subsequent year.

0-LS0296\L
Utermohle
4/8/97

CS FOR SENATE BILL NO. 40(RES)

IN THE LEGISLATURE OF THE STATE OF ALASKA

TWENTIETH LEGISLATURE - FIRST SESSION

BY THE SENATE RESOURCES COMMITTEE

Offered:
Referred:

Sponsor(s): SENATORS HALFORD AND GREEN, Donley

A BILL

FOR AN ACT ENTITLED

"An Act relating to assessment of discrete salmon stocks and to discrete salmon stock assessment surcharges."

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF ALASKA:

* **Section 1.** PURPOSE AND INTENT. (a) This Act requires the Department of Fish and Game and the Board of Fisheries to prepare and prioritize a list of discrete salmon stock assessment projects that are consistent with the sustained yield of wild salmon stocks. This Act also provides a means to offset the costs incurred by the state in conducting discrete salmon stock assessment projects by increasing the fees for sport and commercial fishing licenses. The additional revenue generated and appropriated for discrete salmon stock assessment projects is supplemental to, and not intended to replace, funds appropriated for the operation of the division of commercial fisheries management and development or the division of sport fish.

(b) It is the intent of the legislature that the cost of conducting discrete salmon stock assessment projects be funded in part from revenue derived from the sale of sport fishing licenses in an amount that annually approximates $1 for each license sold. The additional revenue necessary to fund the assessment projects should be generated from a $1 surcharge on sport fishing licenses or an increase in sport fishing license fees.

*** Sec. 2.** AS 16.05 is amended by adding a new section to article 5 to read:

Sec. 16.05.735. Discrete salmon stock assessment. (a) The Board of Fisheries shall, in consultation with the department, identify those stocks of salmon for which discrete salmon stock assessments are needed. The board shall rank the discrete salmon stock assessment needs in accordance with the importance of the stock to fisheries in the state, the magnitude of conflicts among users of the stock, the biological health of the stock, and the need for information to ensure the sustained yield of the stock. The department shall assist the board in the identification of needed information and the ranking of the discrete salmon stock assessment needs.

(b) The department shall

(1) annually develop, with the assistance of the board, a list of, and priority ranking for, proposed research projects to collect information necessary for the assessment of discrete salmon stocks identified by the board under (a) of this section; the projects must include research on the stock composition of salmon taken in fisheries, development of escapement objectives for discrete salmon stocks, projection of escapements for discrete salmon stocks, and other projects intended to obtain information that the board determines necessary under this section;

(2) in conjunction with the board, solicit public comment on the list of proposed projects developed under (1) of this subsection and, as appropriate, revise the projects and the priority ranking assigned to the projects based on the information and comments received during the public comment period;

(3) submit the revised list of proposed projects together with a proposed budget for each project to the governor for inclusion in the proposed budget for the department for the following fiscal year.

(c) The governor shall include a request for an appropriation to the department to fund the discrete salmon stock assessment projects identified on the revised list prepared by the department under (b) of this section as part of the budget and annual appropriation bill submitted to the legislature. The individual projects contained on the list shall be included as allocations under the appropriation for discrete salmon stock assessment projects.

* Sec. 3. AS 16.05.340 is amended by adding a new subsection to read:

(g) In addition to the license fees set under (a) of this section, a stock assessment surcharge of $1 shall be collected on each sport fishing license sold under this section. The amount of the surcharge collected under this subsection shall be deposited into the fish and game fund. The legislature may appropriate money collected under this subsection to the Department of Fish and Game for the discrete salmon stock assessment program under AS 16.05.735.

* Sec. 4. AS 16.05.480 is amended by adding a new subsection to read:

(d) In addition to the license fee set under (a) of this section for a crewmember fishing license, a stock assessment surcharge of $10 shall be collected at the time of issuance of a crewmember fishing license. The amount of the surcharge collected under this subsection shall be deposited into the general fund. The legislature may appropriate money collected under this subsection to the Department of Fish and Game for the discrete salmon stock assessment program under AS 16.05.735.

* Sec. 5. AS 16.43.160 is amended by adding a new subsection to read:

(e) In addition to the amounts collected under (a) - (d) of this section, the commission shall collect, at the time of renewal of an entry permit or interim-use permit for a salmon fishery, a stock assessment surcharge that shall reasonably reflect the different rates of economic return for different fisheries. The commission shall impose an additional surcharge on the renewal of an entry permit or interim-use permit held by a nonresident to the extent permitted by law. The total amount of revenue generated by the stock assessment surcharge must equal $500,000. The amount of the surcharge collected under this subsection shall be deposited into the general fund. The legislature may appropriate money collected under this subsection to the Department of Fish and Game for the discrete salmon stock assessment program under AS 16.05.735.

* Sec. 6. APPLICABILITY. (a) The Department of Fish and Game, with the assistance of the Board of Fisheries, shall develop the first annual list and priority ranking of proposed projects under AS 16.05.735(b), added by sec. 2 of this Act, for submission to the governor

for inclusion in the proposed budget for the department for fiscal year 1999.

(b) AS 16.05.340(g), added by sec. 3 of this Act, AS 16.05.480(d), added by sec. 4 of this Act, and AS 16.43.160(e), added by sec. 5 of this Act, are applicable to sport fishing licenses, crewmember licenses, entry permits, and interim-use permits issued for 1998 or a subsequent year.

*** Sec. 7.** AS 16.05.340(g), added by sec. 3 of this Act, is repealed January 1, 1998, if a version of SB 7 increasing certain sport fishing license fees is passed by the First Regular Session of the Twentieth Alaska State Legislature and enacted into law.

FISCAL NOTE

STATE OF ALASKA — **BILL NO.** CSSB 40
1998 LEGISLATIVE SESSION

Revision Date:	3/31/98	Dept. Affected:	Fish and Game
Title:	An Act relating to assessment of discrete salmon stocks and to discrete slamon stock assessment surcharges	BRU:	Commercial Fisheries (Limited) Entry Commission
		Component:	Limited Entry Program Administration
Sponsor:	Sen. Halford		
Requester:	Senate Resources	COMPONENT SERIAL NO.	0471

Expenditures/Revenues (Thousands of Dollars)

OPERATING EXPENDITURES	FY 99	FY 00	FY 01	FY 02	FY 03	FY 04
PERSONAL SERVICES						
TRAVEL						
CONTRACTUAL						
SUPPLIES						
EQUIPMENT						
LAND & STRUCTURES						
GRANTS, CLAIMS						
MISCELLANEOUS						
TOTAL OPERATING	0.0	0.0	0.0	0.0	0.0	0.0
CAPITAL EXPENDITURES						
CHANGE IN REVENUES ( )						

FUND SOURCE (Thousands of Dollars)

1002 Federal Receipts						
1003 GF Match						
1004 GF						
1005 GF/Program Receipts	0.0	0.0	0.0	0.0	0.0	0.0
1006 GF/MHTIA						
Other						
TOTAL	0.0	0.0	0.0	0.0	0.0	0.0

Estimate of any current year (FY98) cost: $ 0.0

POSITIONS

FULL-TIME						
PART-TIME						
TEMPORARY						

ANALYSIS: (Attach a separate page if necessary.)

No fiscal impact expected

Prepared By: Roger Kolden — Phone: 789-6160
Agency: Commercial Fisheries (Limited) Entry Commission — Date: 3/31/98

Approved by Commissioner: Bruce Twomley
Agency: Commercial Fisheries (Limited) Entry Commission — Date: 3/31/98

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FISCAL NOTE

STATE OF ALASKA
1997 LEGISLATIVE SESSION

BILL NO. CSSB 40(RES)

Revision Date:		Dept. Affected:	Fish and Game
Title:	Discrete Salmon Stock Assessment	BRU:	Sport Fish CFMD
		Component:	Sport Fish and Fisheries Management
Sponsor:	Senators Halford and Green		
Requester:	Senate Resouces Committee	COMPONENT SERIAL NO.	464 and 1941

Expenditures/Revenues (Thousands of Dollars)

OPERATING EXPENDITURES	FY 98	FY 99	FY 00	FY 01	FY 02	FY 03
PERSONAL SERVICES	338.0	1,150.0	1,150.0	1,150.0	1,150.0	1,150.0
TRAVEL	17.0	50.0	50.0	50.0	50.0	50.0
CONTRACTUAL	65.0	80.0	80.0	80.0	80.0	80.0
SUPPLIES	50.0	80.0	80.0	80.0	80.0	80.0
EQUIPMENT	50.0	40.0	40.0	40.0	40.0	40.0
LAND & STRUCTURES						
GRANTS, CLAIMS						
MISCELLANEOUS						
TOTAL OPERATING	520.0	1,400.0	1,400.0	1,400.0	1,400.0	1,400.0
CAPITAL EXPENDITURES	0	0	0	0	0	0
CHANGE IN REVENUES (1024)	520.0	1,400.0	1,400.0	1,400.0	1,400.0	1,400.0

FUND SOURCE (Thousands of Dollars)

FUND SOURCE	FY 98	FY 99	FY 00	FY 01	FY 02	FY 03
1002 Federal Receipts		300.0	300.0	300.0	300.0	300.0
1003 GF Match						
1004 GF	520.0					
1005 GF/Program Receipts		900.0	900.0	900.0	900.0	900.0
1037 GF/Mental Health						
Other (Fish and Game Fund - 1024)		200.0	200.0	200.0	200.0	200.0
TOTAL	520.0	1,400.0	1,400.0	1,400.0	1,400.0	1,400.0

Estimate of any current year (FY97) cost: $ 0

POSITIONS

POSITIONS	FY 98	FY 99	FY 00	FY 01	FY 02	FY 03
FULL-TIME	9	15	15	15	15	15
PART-TIME						
TEMPORARY		5	5	5	5	5

ANALYSIS: (Attach a separate page if necessary)

See Attachment

Note: Position requirements may change after FY99 depending upon projects selected selected for funding under the provisions of this bill.

Prepared by: Kevin Delaney and Bob Clasby
Division: Sport Fish
Phone: 465-4180 or 267-2224
Date: 4/9/97

Approved by Commissioner: Frank Rue
Agency: Fish and Game
Date: 4/9/97

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Projects funded during FY98 are:

Upper Susitna Abundance through Mark/Recapture:

Inriver abundance of migrating adult sockeye, chinook ,and coho salmon will be estimated by tagging a sample of migrating adults low in the river (most likely near Sunshine crossing) and resampling these and untagged fish upstream. Past studies, notably those associated with the Susitna Hydroelectric Assessment, have shown this to be a promising technology. Sockeye, chinook, and coho salmon will be tagged for a postseason estimate of escapement. This program is recommended for twelve years to provide assessment over two sockeye salmon life cycles.

Project cost 1st year:	$270,000
Project cost 2nd year and thereafter:	$220,000

Upper Cook Inlet Genetic Stock Identification:

Exxon Valdez Trustee Council funded development of allozyme (extensive) and DNA (limited) data sets for identification of Cook Inlet sockeye salmon in Central District fisheries. Central District and in-river fisheries were monitored during 1993-1996. This program is able to provide estimates of sockeye salmon stock composition of commercial catch within 48 hours after samples have been collected. Samples can be collected throughout the fishery with most being worked-up after the season. The project is currently in its final year and no funds are available for monitoring in 1997 or beyond. This program is recommended annually to provide data necessary to evaluate timing of stocks through the commercial fishery and to provide data inseason to fishery managers.

Annual project cost: $200,000

Genetic Stock Identification of Indicator Stocks:

Exxon Valdez Trustee Council funded development of allozyme (extensive) and DNA (limited) data sets for identification of Cook Inlet sockeye salmon in Central District fisheries. One result of that project was the discovery of several stocks that were quite unique and discernible. This project would fund monitoring a unique stock to the Kenai Peninsula (Russian River) and Northern District (most likely Susitna River population) and track their presence through their marine and riverine migration. This project in addition to the one above adds necessary additional baseline and inriver sampling. This program is recommended over one life cycle of sockeye salmon to better understand sub-population timing.

Annual project cost: $50,000

Additional projects funded in future will depend upon decisions made by the department and the Alaska Board of Fisheries based on the criteria described in this bill.

Prepared in Response to SB 40
by the Alaska Department of Fish and Game

Existing Escapement and Catch Composition Program

Project	Request	Description
Kenai River Sonar	66.8	Count and sample sockeye salmon in the Kenai R.
Kasilof River Sonar	36.7	Count and sample sockeye salmon in the Kasilof R.
Yentna River Sonar	44.5	Count and sample sockeye salmon in the Yentna R.
Crescent River Sonar	25.1	Count and sample sockeye salmon in the Crescent R.
Fish Creek Weir	13.7	Count and sample sockeye salmon in Fish Creek
Russian River Weir	78.0	Count and sample sockeye salmon in the Russian R.
UCI catch sampling	62.0	Collect age, size, and sex composition of the commercial catch
Offshore test fishing	93.8	Assess magnitude of sockeye salmon run entering UCI
Total	420.6	

Proposed Programs to be Funded with CIP Request:

Escapement Assessment

Upper Susitna Abundance through Mark/Recapture:

Inriver abundance of migrating adult sockeye salmon will be estimated by tagging a sample of migrating adults low in the river (most likely near Sunshine crossing) and resampling these and untagged fish upstream. Past studies, notably those associated with the Susitna Hydroelectric Assessment, have shown this to be a promising technology. Sockeye, chinook, and coho salmon will be tagged for a postseason estimate of escapement. This program is recommended for twelve years to provide assessment over two sockeye salmon life cycles.

Project cost 1st year: $200,000
Project cost 2nd year and thereafter: $150,000

Susitna Drainage Sub-population Abundance:

Weirs will be operated to count adult sockeye and coho salmon into selected tributaries of the Susitna River. Important sub-populations will be chosen on the Yentna River and Susitna mainstem tributaries. This program is recommended for twelve years to provide assessment over two sockeye salmon life cycles.

Project cost 1st year: $250,000
Project cost 2nd year and thereafter: $175,000

Westside Cook Inlet Abundance:

Little is known of the magnitude of sockeye salmon spawning stocks in rivers draining into the westside of Cook Inlet south of the Susitna (examples: McCarthur, Chillagan, Big River). We propose to use an appropriate combination of fixed wing, helicopter, foot surveys, and weirs to assess these populations. This program is recommended for six years to provide assessment over one sockeye salmon life cycle.

Project cost 1st year: $25,000
Project cost 2nd year and thereafter: $75,000

Knik Arm Assessment:

Weirs scheduled in 1997 to count coho salmon in Wasilla and Cottonwood Creeks will begin operation early enough to count sockeye salmon. One additional sockeye sub-population will also be chosen for assessment as will additional effort be funded to more fully document sockeye salmon presence in Knik arm. This program is recommended for twelve years to provide assessment over two sockeye salmon life cycles.

Project cost 1st year: $70,000
Project cost 2nd year and thereafter: $75,000

Escapement Goal Analysis

Kenai Peninsula Juvenile Studies:

Monitor the rearing success of juvenile sockeye salmon in the lake systems of the Kenai and Kasilof Rivers. Lake hydroacoustic surveys, limnology sampling, and smolt counts where possible will be conducted. This project was funded from 1990-1996 with Exxon Valdez oil spill settlement moneys. This program is recommended annually to provide data necessary to evaluate escapement goals, monitor productivity and forecast future returns.

Annual project cost: $150,000

Susitna River Juvenile Studies:

Monitor the rearing success of juvenile sockeye salmon in selected lake systems of the Susitna River. Lake hydroacoustic surveys, limnology sampling, and smolt weirs will be conducted. This project was funded from 1993-1995 with Exxon Valdez oil spill moneys from the state criminal settlement (CIP) This program is recommended annually to provide data necessary to evaluate escapement goals, monitor productivity, and forecast future returns.

Annual project cost: $100,000

Westside CI Juvenile Studies:

Monitor the rearing success of juvenile sockeye salmon in the Crescent River lake system. Lake hydroacoustic surveys and limnology sampling will be conducted. This project was funded in 1996 with general fund research. This program is recommended annually to provide data necessary to evaluate escapement goals, monitor productivity, and forecast future returns.

Annual project cost: $50,000

Spawning Habitat Assessment:

A better understanding of fresh water production of juvenile salmon is needed to set spawning goals which result in high sustained yields and to better identify surplus production available for harvest. In order to do this we must identify and maintain critical habitat. This project would include habitat baseline studies that would provide Federal, State and local governments with information needed to formulate and enforce effective watershed development plans. This program is recommended annually to provide data necessary to evaluate escapement goals, forecast harvestable surpluses, and monitor productivity.

Annual project cost: $125,000

Stock Composition and Run Reconstruction

Upper Cook Inlet Genetic Stock Identification:

Exxon Valdez Trustee Council funded development of allozyme (extensive) and DNA (limited) data sets for identification of Cook Inlet sockeye salmon in Central District fisheries. Central District and in-river fisheries were monitored during 1993-1996. This program is able to provide estimates of sockeye salmon stock composition of commercial catch within 48 hours after samples have been collected. Samples can be collected throughout the fishery with most being worked-up after the season. The project is currently in its final year and no funds are available for monitoring in 1997 or beyond. This program is recommended annually to provide data necessary to evaluate timing of stocks through the commercial fishery and to provide data inseason to fishery managers.

Annual project cost: $200,000

Genetic Stock Identification of Indicator Stocks:

Exxon Valdez Trustee Council funded development of allozyme (extensive) and DNA (limited) data sets for identification of Cook Inlet sockeye salmon in Central

District fisheries. One result of that project was the discovery of several stocks that were quite unique and discernible. This project would fund monitoring a unique stock to the Kenai Peninsula (Russian River) and Northern District (most likely Susitna River population) and track their presence through their marine and riverine migration. This project in addition to the one above adds necessary additional baseline and inriver sampling. This program is recommended over one life cycle of sockeye salmon to better understand sub-population timing.

Annual project cost: $50,000

UCI Marine Hydroacoustic Assessment:

The Upper Cook Inlet marine sonar survey was developed under the Exxon Valdez oil spill restoration program as a tool to estimate salmon abundance within Upper Cook Inlet marine waters. It was developed to provide information in years when sockeye salmon runs were expected to be small, which would necessitate closure of a standard regulatory Monday or Friday commercial opening. The sonar survey requires use of a chartered vessel capable of towing the sonar array, and takes 36 to 48 hours to complete, with preliminary results available at the time of completion. This program is recommended annually to provide data necessary to evaluate timing of stocks through the commercial fishery and to provide data inseason to fishery managers.

Annual project cost: $25,000

Chinook Salmon

During the late 1980's and throughout the 1990's, returns of chinook salmon to many rivers around Upper Cook Inlet have been below expected levels given parent escapements, resulting in restriction, and in some cases closures, of inriver sport and near-shore commercial and personal-use fisheries. Disappointing returns to west Cook Inlet (notably to the Lewis and Theodore rivers), northern Cook Inlet (notably the Susitna River tributaries Deshka River, Alexander Creek, and Peters Creek), and the Kenai Peninsula (notably Deep Creek) have been of particular concern. Concurrent with these reduced returns has been the growth of harvests in the northern Cook Inlet and lower Kenai Peninsula in-river recreational fisheries and in the marine sport fisheries prosecuted near Deep Creek and Homer. The harvest of chinook in the lower Cook Inlet commercial net fisheries has remained constant at about 2,000 per year. The stock composition of harvests in these marine fisheries is unknown. Without knowledge of the composition of these harvests, the department can not assess the causes behind the observed declines in production by stocks of chinook salmon returning to rivers around Upper Cook Inlet. A summary of harvest and stock composition data for these marine fisheries was first compiled by Clark et al. (1994)[1] and many of the recommendations in that report have

[1] Clark, J.H., D.N. McBride, and L. S. Timmons. 1994. Recent history of chinook salmon harvests in marine waters of south-central Alaska; compilation of harvest, size, and coded wire tag data by fishery,

been implemented by the department. Specifically, tagging has been expanded in Cook Inlet and recovery programs have been initiated in Cook Inlet and Kodiak. The first significant returns of tagged hatchery-produced chinook salmon are expected in 1997; the marine sport fishery near Deep Creek will be sampled for the first time in 1997. The marine sport fishery in Homer has been sampled in previous years with most tagged chinook having originated at hatcheries in British Columbia.

Escapements of most major stocks of chinook salmon in rivers around Upper Cook Inlet are indexed via aerial surveys. While these surveys have been adequate to implement timely regulations to conserve stocks, the quality of information from these surveys is insufficient to evaluate productivity of escapements necessary to conduct discrete-stock management. The department is developing a technology based on sonar to estimate the inriver return of chinook salmon in situations when chinook salmon are numerically the most abundant species. Although some results from this project on the Kasilof River are promising, the technology is not yet ready for export to other systems.

Existing Escapement and Catch Composition Programs

Project	Request	Description
Escapement:		
Kenai River Creel	266.9	Estimate and sample harvest inriver
Kenai River Sonar	228.1	Estimate inriver return
Lower Cook Inlet Escapement	26.8	Index escapements
Northern Cook Inlet Escapement	94.7	Index escapements
Deshka River Weir	145.2	Count and sample escapement
Total Escapement:	761.7	
Tagging:		
Kenai River Wild	155.7	Tag juveniles in Kenai River
Lower Cook Inlet Hatchery	65.6	Tag hatchery juveniles for release in LCI
Deep Creek Wild	28.3	Tag juveniles in Deep Creek
Northern Cook Inlet Hatchery	56.6	Tag hatchery juveniles for release in NCI
Deshka River Wild	207.7	Tag juveniles in Deshka River
Willow Creek Wild	199.2	Tag juveniles in Willow Creek
Cook Inlet Marine Tag Recovery	137.7	Sample marine sport fisheries for tags and estimate harvest by stock
Total Tagging:	850.8	
Grand Total:	1,612.5	

Proposed Programs to be Funded with CIP Request:

Escapement Assessment:

Kasilof Late Run Abundance through Mark/Recapture:

1980-1993 and recommendations for future assessment. ADF&G, Division of Sport Fish Fishery Management Report No. 94-9.

Inriver abundance of migrating chinook salmon will be estimated by fitting a sample with radio transmitters, then following these fish upstream where they are resampled along with fish without transmitters. This technology has been successfully applied to stocks of chinook throughout southeast Alaska. This program should continue for two years.

Annual project cost: $165.0

Upper Susitna Abundance through Mark/Recapture:

Inriver abundance of migrating adult chinook salmon will be estimated by tagging a sample of migrating adults low in the river (most likely near Sunshine crossing) and resampling these and untagged fish upstream. Past studies, notably those associated with the Susitna Hydroelectric Assessment, have shown this to be a promising technology. Estimates will include stocks migrating to the Chulitna, Talkeetna, and upper Susitna rivers above Talkeetna. This program is also presented as an increment to the sockeye program discussed in that section. As such, this program should continue fo the life of the sockeye project (10 years).

Annual project cost: $35,000

Sampling Indexed Escapements:

Age, sex, and size composition of chinook salmon spawning in several rivers will be estimated with this project. Spawning populations of chinook salmon are comprised of several age groups in any one year with older fish more likely female. Because egg production by an escapement of chinook salmon will vary according to the age and size composition of the spawning fish, quality of chinook salmon escapement is an important consideration when analyzing the productivity of stocks. This project provides funding for sampling of selected indexed spawning escapements which are not currently sampled for age, sex, and size composition. Project duration is recommended for 8 years to cover two life cycles.

Annual project cost: $25,000

<u>Stock Composition of Harvests in Marine Fisheries:</u>

Tagging Wild Juveniles in the Kasilof River:

A sample of juvenile chinook salmon in the Kasilof River will be tagged for later recovery as adults in marine fisheries. Most likely tagged smolts will be taken from the mainstem. Project should continue 3 years to cover year classes of chinook salmon.

Annual project cost: $55,000

Sampling Marine Fisheries in Lower Cook Inlet:

Tags will be recovered to estimate harvest of chinook salmon by stock in commercial and sport fisheries not currently sampled. This project provides funding for sampling both sport and commercial fisheries. Project should continue for 3 years.

Annual project cost (sport): $15,000
Annual project cost (commercial): $15,000

Completion of Genetic Baseline for Cook Inlet:

The department obtained a grant from the federal Saltonstall/Kennedy program (funds expired January 1, 1996) to begin development of a baseline data set for Southcentral and Western Alaskan chinook salmon stocks. This effort was to provide information for identification of trawl-caught chinook salmon from the Gulf of Alaska and Bering Sea. The data have been merged into a Pacific Rim interagency baseline for chinook salmon which includes extensive data from California through Western Alaska. Initial work suggests that with continued refinement of the baseline for Southcentral Alaska some broad regional identification of stocks can be precisely and accurately estimated. Potential applications include separation of Kenai Peninsula populations from Susitna River populations in Cook Inlet.

Annual project cost: $166,000

Coho Salmon

Harvests of coho salmon in and around Cook Inlet are second only to harvests of this species in Southeastern Alaska. Mixed stocks of coho salmon are harvested in the Central and Northern District commercial fisheries incidental to targeted fisheries for sockeye salmon. The state's largest sport harvests occur throughout many of the freshwaters of Upper Cook Inlet; most notably in the Kenai and Little Susitna rivers and in tributaries to the Susitna River. In recent years, hatchery-produced coho salmon have been used to develop sport fisheries in urban areas Of greatest concern is the lack of information on escapements which precludes assessment of productivity and timely response to downturns in production.

Beginning in 1992, the department implemented a comprehensive plan to estimate stock-specific harvests of hatchery-produced and some wild coho salmon[2] based on tagging juveniles and recovering tagged adults from harvests. All releases of smolts from hatcheries have carried tags and their harvest in marine fisheries estimated since 1993. Several successful recreational fisheries for coho salmon were established with these releases, even though commercial exploitation of hatchery-produced coho salmon has been substantial. A tagging program for wild juveniles in the Kenai River has shown that

[2] Meyer, S., Vincent-Lang, D., and D. McBride. 1991. Goal statement and study plan for the development of a stock assessment program for upper Cook Inlet salmon stocks. ADFG unpublished.

commercial harvests of this stock to be much smaller than anticipated, indicating that commercial harvests of coho salmon in Upper Cook Inlet are comprised mostly of stocks from northern Cook Inlet. Samples of juvenile coho salmon from the Deshka River and Willow Creek in the Susitna River watershed will be tagged next year.

Inriver returns of coho salmon are estimated with weirs across the Little Susitna and Deshka rivers; more weirs will be constructed next year across several streams around Knik Arm including Wasilla, Cottonwood, and Fish creeks. Unfortunately, no feasible technology has yet been developed to estimate inriver return of coho salmon to the Kenai River. Fortunately, annual estimates of juvenile abundance have been calculated through our tagging program on the Kenai River, estimates that can be used to develop management objectives for fisheries exploiting this stock. Even with our current program, sufficient information on escapements on the majority of stocks in Upper Cook Inlet is preventing assessment their productivity.

Existing Escapement and Catch Composition Programs

Project	Request	Description
Urban Area Fisheries	79.6	Sample sport harvests and estimate harvest by stock
Northern District Tag Recovery	31.9	Sample commercial harvests and estimate harvest by stock
Central District Tag Recovery	153.9	Sample commercial harvests for tags and estimate harvest by stock
Kenai River Tagging	126.5	Tag juveniles in Kenai River
Hatchery Tagging	42.0	Tag hatchery-produced juveniles
Little Susitna Escapement	88.1	Count and sample coho escapement
Knik Arm Escapement and Tagging	103.0	Count and sample coho escapements and tag juveniles
Susitna River Tagging	33.0	Tag juveniles in Deshka River and Willow Creek
Total:	658.0	

Proposed Programs to be Funded with CIP Request:

Escapement Assessment:

Upper Susitna Abundance through Mai

Inriver abundance of migrating adult coho salmon will be estimated by tagging a sample of migrating adults low in the river (most likely near Sunshine crossing) and resampling these and untagged fish upstream. Past studies, notably those associated with the Susitna Hydroelectric Assessment, have shown this to be a promising technology. Estimates will include stocks migrating to the Chulitna, Talkeetna, and upper Susitna rivers above Talkeetna. This program is also presented as an increment to the sockeye program discussed in that section. As such, this program should continue for the life of the sockeye project (10 years).

Annual project cost: $35,000

Yentna River Hydroacoustic:

This project will evaluate whether hydroacoustic techniques can be used to estimate inriver abundance of migrating adult coho salmon in the Yentna River. The program should be considered developmental for three years and if successful run annually for an inseason estimate of coho salmon escapement. Equipment will be purchased only if successful techniques can be developed.

Project cost year 1-3: $50,000
Purchase of equipment: $75,000
Annual project cost: $50,000

Minor Stocks:

Escapement of coho salmon into two streams on the Kenai Peninsula (Deep and Crooked creeks) will be estimated by extending the operation of weirs now used to estimate escapement of chinook salmon. Escapement of coho salmon to the Kahiltna River will be estimated with a tagging program. Work at each site is recommended to continue for four years to provide information over one life cycle (four years) with work on the Kenai Peninsula preceding work at the Kahiltna River.

Annual cost for weirs on the Kenai Peninsula: $33,000
Annual cost for tagging on the Kahiltna River: $50,000

Stock Composition of Harvests in Marine Fisheries:

Upper Susitna River Tagging:

Technology will be developed to estimate exploitation of rates of coho salmon in the marine fisheries of Upper Cook Inlet Juvenile coho salmon emigrating from Larson Lake will be tagged. Tagged adults will be recovered in current programs to sample marine harvests to estimate harvest by stock Inriver return will be estimated in another project under this CIP initiative. If juveniles in Larson Lake are representative of all juveniles in the watershed, exploitation rates estimated for adults tagged as juveniles leaving Larson Lake will be the same as rates on all adults returning to the watershed. Under these circumstances, a return of coho salmon to the entire Susitna River can be estimated. We recommend that this program continue for eight years to provide information for two life cycles.

Project cost 1st year: $35,000
Project cost 2nd year: $140,000

Project cost 3rd year and thereafter: $100,000

Development of Genetic Stock Identification Markers

Very few genetic markers, either protein or DNA, are currently available for identification of discrete populations of coho salmon. This program would identify and develop DNA markers to identify discrete stocks inhabiting Southcentral Alaska. After marker development, databases will be developed for use in stock identification studies.

Annual project cost: $97,000

Chum Salmon

Chum salmon stocks along the westside of Cook Inlet pose one of our most persisting conservation problems. Even with complete closure of terminal commercial fisheries, returns to McNeil River fail to rebuild. We need better escapement, migratory, timing, and interception information.

Proposed Programs to be Funded with CIP Request:

Escapement Assessment:

McNeil River Escapement Assessment

Currently, aerial surveys are used to estimate escapement into this system, but estimates of bear predation sometimes exceed the estimated number of chum salmon in the river. Since McNeil River flows through a wildlife sanctuary internationally famous for brown bear viewing, methods used to estimate chum salmon escapement must be unobtrusive. This project will attempt to provide more accurate escapement estimates through improvements in the aerial survey program (e.g. radio and ultrasonic tagging of adult chum salmon captured in McNeil Lagoon to determine stream life and distribution) as well as development of techniques for using unmanned video equipment.

Annual project cost: $50,000

Stock Composition of Harvests in Marine Fisheries:

Tagging Wild Juvenile Westside Cook Inlet Chum Salmon

The fate of chum salmon returning to spawn in westside Cook Inlet systems will be examined through a juvenile tagging program. Juvenile chum salmon migrating to sea from one or more westside systems (e.g. Big Kamishak, Little Kamishak, McNeil, Bruin, and Iniskin Rivers and Cottonwood Creek) will be marked with half-length coded-wire tags and returning adults will be recovered from various commercial fisheries to obtain information on run timing and migratory paths. If possible, a weir will be installed on one of the streams where juvenile tagging was conducted to obtain estimates on returning adult marked-to-unmarked ratios. This will allow estimates to be made of exploitation rates within selected commercial fisheries.

Annual project cost: $150,000

Gulf of Alaska: Chinook Salmon

During the late 1980's and throughout the 1990's, returns of chinook salmon to many rivers around Upper Cook Inlet have been below expected levels given parent escapements, resulting in restriction, and in some cases closures, of inriver sport and near-shore commercial and personal-use fisheries. Disappointing returns to west Cook Inlet (notably to the Lewis and Theodore rivers), northern Cook Inlet (notably the Susitna River tributaries Deshka River, Alexander Creek, and Peters Creek), and the Kenai Peninsula (notably Deep Creek) have been of particular concern. Concurrent with these reduced returns has been the growth of directed and incidental harvests of chinook salmon in marine sport fisheries near Kodiak, and in commercial net fisheries in the Kodiak, Chignik, and Prince William Sound management areas. There are also concerns about the bycatch of chinook salmon in the off-shore groundfish trawl fisheries.

A summary of available information on harvests and tag recoveries in these marine fisheries was first compiled by Clark et al. (1994)[3]. Fisheries in the Gulf that have or will shortly have sampling programs to recover tagged adults are: Prince William Sound commercial; Kodiak sport and commercial; and southeast Alaska commercial (troll) fisheries. Marine fisheries in the Gulf that are yet to be sampled include Chignik commercial and federally managed trawl fisheries. Many stocks of chinook salmon from Cook Inlet are now tagged; many more will tagged be under this CIP initiative. No stocks of chinook salmon from Kodiak Island are tagged. Without knowledge of the composition of now unsampled harvests in the Gulf, the department can not assess the causes behind the observed declines in production by stocks of chinook salmon returning to rivers around Upper Cook Inlet.

Existing Escapement and Catch Composition Programs

Project	Request	Description
Kodiak Rivers Escapement	33.3	Count and sample escapement in Karluk, Ayakulik, and Chignik
Kodiak Marine Tag Recovery	70.4	Sample commercial and sport harvest s recover tags and estimate harvest by stock
Total:	103.7	

[3] Clark, J.H., D.N. McBride, and L. S. Timmons. 1994. Recent history of chinook salmon harvests in marine waters of south-central Alaska; compilation of harvest, size, and coded wire tag data by fishery, 1980-1993 and recommendations for future assessment. ADFG, Division of Sport Fish Fishery Management Report No. 94-5

Proposed Programs and Analyses to be funded with CIP Initiative:

Tagging Wild Juveniles in Kodiak Island:

Samples of juvenile chinook salmon from the Ayakulik and the Karluk rivers will be tagged for later recovery as adults in marine fisheries. Projects should continue 3 years to cover year classes of chinook salmon.

Annual project costs at Ayakulik River:	$55,000
Annual project costs at Karluk River:	$55,000

Chinook Salmon Bycatch in Gulf of Alaska Trawl Fisheries:

Estimates of the incidental harvest of chinook salmon in trawl fisheries will be verified following technologies as was done for salmon bycatch in the trawl fisheries of the Bering Sea. Patterns of bycatch and CWT recoveries will be summarized by year, month, target fishery, depth, gear type and reporting area. Spatial patterns will be analyzed using geographic information system (GIS).

It is anticipated that completion of Cook Inlet GSI baseline data will provide a comprehensive coastwide baseline for chinook salmon. Analysis of this baseline will demonstrate feasibility of using this technique to identify chinook salmon bycatch. Project to identify stocks should continue for 3 years.

Trawl bycatch analysis, one time	$30,000
Annual GSI stock identification of bycatch	$50,000

Kodiak/Alaska Peninsula/Chignik

Very limited information is available on stock composition of sockeye fisheries in the outside waters of Kodiak, Chignik, Shumagin Islands, Southeast mainland areas of the Alaska Peninsula, and North Alaska Peninsula areas. Issues of interceptions of Cook Inlet sockeye in Kodiak, interception of Chignik sockeye salmon in the Cape Igvak, Shumagin Islands, and Southeast Mainland districts, and Bristol Bay sockeye in the North Alaska Peninsula fisheries are routinely addressed by the Board of Fisheries. Stock identification methods are currently not available to address these issues. Genetic stock identification methods which have been demonstrated for identifying Cook Inlet stocks in Cook Inlet catches offers promise. We propose to collect baseline samples for principal sockeye stocks in Kodiak, Chignik, South Alaska Peninsula, North Alaska Peninsula and Bristol Bay, and analyze to demonstrate feasibility to identify stocks in mixed stocks fisheries in Kodiak, and North Alaska Peninsula areas.

Kodiak Area: Sockeye and Coho Salmon.

The Kodiak management area harvests local and migratory sockeye salmon. Regulatory management plans guide inseason management of the various districts. Information on the stock specific contribution of sockeye salmon to specific districts are not available. The stock specific origin and local contribution of coho salmon harvested in the Kodiak Management area is not well known. Full escapement enumeration of local coho stocks currently does not occur.

Existing Escapement and Catch Composition Program

Project	Request	Description
Major System Weirs	199.7	Count and sample sockeye in the Karluk, Ayakulik, Frazier, Dog Salmon, Upper Station Rivers, Akalura, Saltery, Buskin, and Litnik Rivers
Minor System Weirs	29.1	Count and sample sockeye in the Paul's Bay, Malina, and Shuyak rivers
Kodiak Catch Sampling	43.7	Collect age, size, and sex composition of the commercial catch
Kodiak Test Fishery	29.2	Assess magnitude of sockeye salmon run
Total	301.7	

Proposed Programs to be Funded with CIP Request:

Escapement Assessment and Fishery Stock Identification.

Completion of Genetic Baseline for Westward Region Sockeye stocks.

Exxon Valdez Trustee Council funded development of allozyme (extensive) and DNA (limited) data sets for identification of Cook Inlet sockeye salmon in Central District fisheries. Central District and in-river fisheries were monitored during 1993-1996. Many genetic markers, both protein and DNA, are currently available for identification of discrete stocks of sockeye salmon. Extensive data (protein and DNA) are available for sockeye populations from Cook Inlet. Data from other areas are limited or nonexistent. Expand data base beyond Cook Inlet to include stocks from Kodiak, Chignik, Alaska Peninsula, and Bristol Bay Areas.

Annual Project Costs	$200,000

Kodiak Area Sockeye Salmon Fishery Stock Identification.

Stocks in Kodiak area sockeye salmon fisheries will be identified using GSI methods. Commercial fishery harvests will be sampled from June 9 until August 30. There are seven areas where sampling will occur on a weekly basis: Mainland, Igvak, Afognak, Northwest Kodiak, Southwest Kodiak, Alitak, and Eastside Districts.

Annual Project Costs	$500,000

Kodiak Area Coho Salmon Escapement Enumeration.

Increase local escapement enumeration via coho weirs and aerial surveys. Establish 6 coho salmon counting weirs and extend existing aerial surveys.

Startup Costs	$120,000
Annual Operational Costs	$240,000

Escapement Goals for Kodiak Area Sockeye Lakes.

Monitor the rearing success of juvenile sockeye salmon in selected lake systems of the Kodiak Area. Lake hydroacoustic surveys and limnology sampling will be conducted. This program is recommended annually to provide data necessary to evaluate escapement goals, monitor productivity, and forecast future returns.

Annual Costs	$82,000

Chignik Area. Sockeye and Coho Salmon.

The Chignik Lakes system is comprised of two sockeye runs that have overlapping run timing. The early run returns to Black Lake and peaks in late June and a late run peaks in late July to Chignik Lake. Scale pattern analysis is used to apportion the stocks inseason and postseason, and although this is standardized methodology, it has flaws in its application. Scale pattern analysis depends on differential growth between stocks and in some years the classification accuracy's are low for both major age classes, age 1.3 and 2.3 sockeye salmon. Another major problem is that inseason only age 2.3 sockeye salmon can be analyzed directly by scale pattern analysis, and other less reliable methods are used to assess the age 1.3 component which reduces the accuracy of inseason escapement estimates.

Stock composition of the commercial sockeye and coho salmon harvest taken outside Chignik Lagoon is unknown. The harvest of coho salmon is bimodal with peaks in late July and late August - early September. Sockeye salmon are also harvested in the Eastern, Western, Perryville and Central Districts throughout the season, however the stock composition is unknown.

Existing Escapement and Catch Composition Program

Project	Request	Description
Chignik Weir	100.1	Count and sample sockeye in the Chignik River
Chignik Catch Sampling	59.7	Collect age, size, and sex composition of the commercial catch
Chignik Test Fishery	60.0	Assess magnitude of sockeye salmon run
Total	219.8	

Proposed Programs to be Funded with CIP Request:

Escapement Assessment and Fishery Stock Identification.

Black River Sonar Enumeration.

A sonar project on the Black River (to be located above Chiaktuak creek) will complement the existing management weir which is situated on the Chignik River, below Chignik and Black Lakes. The Chignik River weir is used for establishing fishing periods and achieving overall sockeye salmon escapement goals. The Black River sonar project will be used to enhance the accuracy and reliability of apportioning catch and escapement to the appropriate run component, and assure that the escapement goals for each system are met inseason. Actual counts could be compared to scale pattern analysis estimates to check the accuracy of previous apportionment's of the Chignik Lakes' stocks post 1978. Once relationships in travel time are established scale pattern analysis could be discontinued.

Startup Costs	$83,700
Annual Project Costs	$45,000

Chignik Area Coho Salmon Escapement Enumeration.

Increase local escapement enumeration by extending operation of Chignik weir and existing aerial surveys.

Annual Operational Costs	$137,000

Alaska Peninsula Area: Sockeye and Chum Salmon

The Alaska Peninsula June fishery primarily harvests migrating sockeye and chum salmon. Pre-season quotas for these fisheries are set based on a percentage of forecasted Bristol Bay inshore sockeye catch. There is a regulatory management plan to guide inseason management. The origin of the sockeye catches are almost entirely from Bristol Bay and North Alaska Peninsula River systems. Chum salmon originate primarily from the northwestern Alaska River systems, including Bristol Bay, Kuskokwim, Lower Yukon, and Norton Sound River systems. Information on the specific river system contribution of sockeye and chum salmon to the June fishery harvest is currently not available.

The Alaska Peninsula Post June fishery is believed to harvest mainly local stocks of pink and chum salmon. In 1991 the Board of Fisheries established the Post June Salmon Management Plan for the Southern Alaska Peninsula (5 AAC 09.360) which delayed the opening of non terminal areas until July 19. This plan has reduced the incidental catch of migrating coho and chum salmon. There is potential for late run Yukon and Kotzebue Sound chum salmon occur in this fishery. The magnitude of Western Alaska chum salmon in catches as well as the stock composition of the incidental harvest of coho and sockeye salmon is unknown.

The Southeastern District Mainland Fishery (SEDM) is regulated under a management plan approved by the Alaska Board of Fisheries. In the SEDM 80 percent of the sockeye harvest from the season opening (approximately June 10) through July 25 (except in the Northwest Stepovak section) are considered Chignik River origin and 20 percent of the harvest as local Orzinski stock. The stock composition referenced in the management plan is based on a limited tagging study conducted in 1961. The stock specific contribution of sockeye salmon to the SEDM fishery.

The North Alaska Peninsula occurs in near terminal areas and harvest sockeye salmon originating in the North Alaska Peninsula river systems. Bristol Bay fishermen claim significant interception of Bristol Bay sockeye salmon occurs in the North Alaska Peninsula. Limited stock identification studies using scale pattern analysis have demonstrated that at times, substantial numbers of Bristol Bay sockeye have occurred in catches from the northern areas of the North Alaska Peninsula districts. The interception of Bristol Bay sockeye is a very controversial allocation issue. The department does not have stock specific harvest information of the commercial harvest in the North Alaska Peninsula.

Existing Escapement and Catch Composition Program

Project	Request	Description
North Alaska P. Escapement	252.9	Count and sample sockeye in Bear, Nelson, and Ilnik Rivers. Conduct aerial surveys
South Alaska P. Escapement	103.2	Count and sample sockeye in Orzinski Lake weir. Conduct aerial surveys
Sandy River Weir	37.4	Count and sample sockeye in Sandy River
P/A Catch Sampling	107.2	Collect age, size, and sex composition of the commercial catch
P/A Test Fishery	44.9	Assess magnitude of sockeye salmon run

South Unimak Test Fishery	28.0	Assess relative magnitude of sockeye and chum salmon abundance
June Fishery Stock Identification	131.5	Stock Identification June Fishery Chum Salmon Catches
Total	705.1	

Proposed Programs to be Funded with CIP Request:

Escapement Assessment and Fishery Stock Identification.

Identification of Stocks of Sockeye Salmon in North Alaska Peninsula Fishery

A GSI study is proposed to identify stocks in the North Alaska Peninsula fisheries. The study will determine the extent Bristol Bay sockeye salmon are harvested in the North Alaska Peninsula commercial salmon fisheries, as well as local stocks. Scale pattern analysis has already been tried in the North Alaska Peninsula with poor results due to the myriad of stocks potentially involved. To incorporate Bristol Bay run timing, sampling will be conducted, June 25 to July 20 from catches in the, Bear River, Three Hills, and Ilnik Sections.

Annual Project Costs $380,000

Identification of Stocks of Chum Salmon from Western Alaska

The current CIP-based program has funded the development of genetic stock identification methods for chum salmon from the June and post-June South Alaska Peninsula fisheries. One additional year of sample collection (1997) for the post-June fishery remains. When completed in FY98 or early FY99, data will be available for the 1993-1996 June fishery and the 1996-1997 post-June fishery. The current baseline discriminates among major regional groupings of chum salmon including Japanese, Russian, Northwest Alaska Summer, Fall Yukon River, Southeast Alaska/Prince William Sound, British Columbia, and Washington. However, additional DNA-level markers are needed to discriminate among Northwest Alaska summer chum complex (Bristol Bay, Kuskokwim, Lower Yukon, and Norton Sound).

Annual Project Costs $126,000

Western Alaska Salmon

KUSKOKWIM AREA

The Kuskokwim Salmon Management Area includes all waters of the Kuskokwim River, Kuskokwim Bay and waters that flow into Kuskokwim Bay. With a population of about 16,000 people, population centers include Bethel, Aniak and McGrath, plus about 35 smaller communities mostly clustered along the lower Kuskokwim River and coastal areas. Both subsistence and commercial salmon fishing are vital to the economies of local communities. Sport fishing is important in only a few discrete locations. Subsistence fishing occurs throughout the Kuskokwim Area, but commercial fishing is limited to two districts in the lower Kuskokwim River and two districts in Kuskokwim Bay. The species of greatest interest are chinook, sockeye, chum and coho salmon, with average annual harvests of 130, 190, 650, and 780 thousand fish, respectively.

Management of Kuskokwim Area salmon fisheries is difficult due to the shortfalls in fundamental stock information and basic assessment tools. Kuskokwim River fishers harvest from a mixed aggregate of species and stocks whose run timings overlap. In nearly all instances identification of discrete stocks or manageable stock aggregates is lacking, even though such aggregates likely exist. Also lacking are projects for monitoring annual spawning escapements to well distributed geographic stock aggregates. One of the Kuskokwim Bay fishing districts has no current escapement assessment other than an occasional aerial survey. Managers are also without a reliable means of assessing abundance in the Kuskokwim River in a manner timely enough for in-season information needs. Scheduled resumption of Kuskokwim River sonar by about 1999 should address this need, but the expected funding level will exclude enumeration of coho salmon. Assessment information for coho salmon is grossly inadequate in the Kuskokwim Area, yet the Kuskokwim River drainage supports the largest coho salmon harvest in the state and that harvest is increasing. During the past few years modest efforts have been made to improve on some of these shortfalls through cooperative projects with local community groups funded through federal grants, but annual funding is unstable and the modest efforts are not sufficient. These cooperative ventures need to be expanded. It is not possible to mange individual stocks or stock aggregates in the Kuskokwim Area based on current knowledge and funding.

Existing Escapement and Catch Composition Programs

Project	Request	Description
Kuskokwim Bay Fishery Monitoring	25.3	Catches sampled for age, sex, and size
Kuskokwim Bay Escapement Surveys	5.4	Aerial surveys of Kanektok and Goodnews Rivers
Goodnews River Weir	38.5	Monitor chinook, sockeye, chum, pink and coho escapement
Kuskokwim River Fishery Monitoring	58.4	Catches sampled for age, sex, and size
Kuskokwim River Run Assessment	67.4	Test fishing to determine run size and timing
Kuskokwim River Escapement Surveys	8.2	Aerial surveys of principle spawning areas
Kogrukluk River Weir	44.6	Monitor and sample escapement
Aniak River Sonar	57.2	Monitor and sample escapement
Kuskokwim River Sonar	16.5	Monitor and sample escapement
Kuskokwim Stock Biology	27.5	Sample catch and escapement for age, sex, and size
Total	349.0	

The following are projects proposed to improve discrete stock assessments for chinook, chum, and coho salmon in the Kuskokwim Area. Although SB 40 does not specifically mention chinook and coho salmon, projects for those species have been added because of their subsistence and economic importance.

Description	Start-Up Costs	Annual Costs
Stock Identification Projects:		
• Kuskokwim Bay tagging study (chinook, chum and coho) to address potential interception of Kuskokwim River stocks	100.0	150.0
• Kuskokwim River tagging in the lower river for stock run timing and distribution (chinook, chum and coho)	100.0	200.0
• Genetic stock identification baseline (sockeye and coho)	20.0	100.0
• Increase aerial survey time		20.0
Escapement Assessment Projects (many to be operated cooperatively):		
• Extension of Middle Fork Goodnews weir through coho season		20.0
• Operation of Kuskokwim River sonar through coho season		50.0
• Development of a new sonar project in the Kuskokwim River near Stony River to assess contribution of upper Kuskokwim tributaries to total run sizes(operated for all species)	200.0	200.0
Total	420.0	750.0

FISCAL NOTE

STATE OF ALASKA
1997 LEGISLATIVE SESSION

BILL NO. SB40

Revision Date:
Title: An Act relating to management of discrete slamon stocks, to salmon management assessments, and to the fishery business tax.
Sponsor: Senator Halford
Requester: Senate Resources

Dept. Affected: Fish and Game
BRU: Commercial Fisheries (Limited) Entry Commission
Component: Limited Entry Program Administration
COMPONENT SERIAL NO. 0471

Expenditures/Revenues (Thousands of Dollars)

OPERATING EXPENDITURES	FY 98	FY 99	FY 00	FY 01	FY 02	FY 03
PERSONAL SERVICES						
TRAVEL						
CONTRACTUAL						
SUPPLIES						
EQUIPMENT						
LAND & STRUCTURES						
GRANTS, CLAIMS						
MISCELLANEOUS						
TOTAL OPERATING	0.0	0.0	0.0	0.0	0.0	0.0
CAPITAL EXPENDITURES						
CHANGE IN REVENUES ( )						

FUND SOURCE (Thousands of Dollars)

1002 Federal Receipts						
1003 GF Match						
1004 GF						
1005 GF/Program Receipts	0.0	0.0	0.0	0.0	0.0	0.0
1006 GF/MHTIA						
Other						
TOTAL	0.0	0.0	0.0	0.0	0.0	0.0

Estimate of any current year (FY97) cost: $ 0.0

POSITIONS

FULL-TIME						
PART-TIME						
TEMPORARY						

ANALYSIS: (Attach a separate page if necessary.)

No fiscal impact.

Prepared By: Roger Kolden
Agency: Commercial Fisheries (Limited) Entry Commission
Phone: 789-6160
Date: 4/9/97

Approved by Commissioner: Bruce Twomley
Agency: Commercial Fisheries (Limited) Entry Commission
Date: 4/9/97

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MEMORANDUM April 10, 1997

SUBJECT: Sectional Summary of draft CSSB 40(RES) (version L; dated 4/8/97); An Act relating to assessment of discrete salmon stocks and to discrete salmon stock assessment surcharges. (CSSB 40(RES))

TO: Senator Rick Halford
Attn: Brett Huber

FROM: George Utermohle
Legislative Counsel

You have requested a sectional summary of a draft version of CSSB 40(RES)(version L; dated 4/8/97); An Act relating to assessment of discrete salmon stocks and to discrete salmon stock assessment surcharges.

As a preliminary matter, note that a sectional summary of a bill is not an authoritative interpretation of the bill. The bill itself is the best statement of its contents.

Section 1 of the bill sets out the purpose and intent of the bill.

Section 2 of the bill amends AS 16.05 by adding a new section relating to discrete salmon stock assessment projects. The Board of Fisheries, in conjunction with the Department of Fish and Game, shall identify those salmon stocks for which discrete salmon stock assessments are needed. The department shall annually develop a list and priority ranking of proposed research projects to collect information for assessment of salmon stocks identified by the board. The department shall solicit public comments on the list of proposed projects and revise the list as appropriate. The revised list of discrete salmon stock assessment projects must be submitted to the governor. The governor shall request funding for the projects included on the revised list as part of the budget and annual appropriation bill submitted to the legislature.

Section 3 of the bill adds a new subsection to AS 16.05.340 to provide for imposition of a one dollar stock assessment surcharge on resident and nonresident sport fishing licenses. The revenue collected from the surcharge may be appropriated to fund expenditures for the discrete stock assessment program.

<u>**Section 4**</u> of the bill adds a new subsection to AS 16.05.480 to provide for imposition of a $10 stock assessment surcharge on crew member fishing licenses. The revenue collected from the surcharge may be appropriated to fund expenditures for the discrete stock assessment program.

<u>**Section 5**</u> of the bill adds a new subsection to AS 16.43.160 to authorize the Alaska Commercial Fisheries Entry Commission to collect a stock assessment surcharge at the time of renewal of limited entry permits and interim-use permits for salmon fisheries. The total amount of revenue collected from the surcharge must equal $500,000. The revenue collected from the surcharge may be appropriated to fund expenditures for the discrete stock assessment program.

<u>**Section 6**</u> of the bill provides that (1) the Department of Fish and Game shall develop the first annual list and priority ranking of proposed salmon stock assessment projects for submission to the governor for inclusion in the proposed budget for the department for fiscal year 1999; and (2) the stock assessment surcharges imposed on sport fishing licenses, crew member licenses, entry permits, and interim-use permits under secs. 3 - 5 of the bill are applicable to licenses and permits issued for 1998 and subsequent years.

<u>**Section 7**</u> of the bill provides that AS 16.05.340(g), added by sec. 3 of the bill, is repealed on January 1, 1998 if a version of SB 7, increasing certain sport fishing license fees, is passed by the First Regular Session of the Twentieth Alaska State Legislature and is enacted into law.

GU:jdr
97-254.jdr

Alaska Department of Fish and Game
Commercial Fisheries Management and Development Division

EVOS-CIP Status Report

Project: Susitna River Sockeye and Coho Salmon Escapement Studies

Principal Investigators: Stan Carlson, Biometrician II, Project Leader; Patrick Shields, Fishery Biologist II, Project Biologist; Gary Todd, Fishery Biologist II, Radio Tagging

Date: 1/16/98

This project is a cooperative venture between the Commercial Fisheries Management and Development (CFMD) and Sport Fish (SF) Divisions initiated to develop and improve estimation techniques of the escapement of sockeye and coho salmon in the Susitna River drainage. Results from this project will be used by both divisions to better understand salmon production in the Susitna River and to aid fishery management planning in Upper Cook Inlet (UCI). The 1997 field season (begun FY98) consisted of a weir operated at Larson Lake (upper Susitna River) to enumerate the escapement of sockeye salmon. In addition, a study was conducted at Larson Lake to evaluate assumptions in mark-recapture estimation. The Study planned for 1998 will take place primarily on the Yentna River and will focus on evaluating the sonar counting program currently operated by UCI/CFMD Division staff. Accurate and precise estimates of sockeye and coho salmon in the Yentna River are crucial to developing escapement estimates for the entire Susitna drainage. This study will require operation of weirs at Chelatna and Judd lakes (Yentna River drainage). The Larson Lake weir will be operated again in 1998 to continue monitoring sockeye salmon escapement in the upper Susitna River.

Larson Lake Project (1997)

Primary objectives of Larson Lake study were to (1) determine the escapement of sockeye salmon into Larson Lake and compare the ratio to Yentna River escapement (sonar estimate) with ratios observed in the mid-1980s, and (2) conduct a mark-recapture (M-R) experiment to evaluate recovery sampling in spawning grounds. Inherent to the second objective were analyses of tag retention and temporal effects on recovery rates. Escapement counts and tagging operations were conducted at a weir placed just below the outlet of Larson Lake. The principal findings given below should be considered preliminary. The project report is due March 1, 1998.

Total escapement of sockeye salmon into Larson Lake was 40,282. Because of low stream velocities and the large substrate (boulder) at Larson Creek, weir integrity was not compromised and the counts were considered highly accurate. The estimated escapement of sockeye salmon in the Yentna River in 1997 was 157,797. The Larson Lake escapement was therefore 25.5% of the Yentna count. This ratio is similar to those observed 10 years earlier during the Su-Hydro studies, which are as follows: 1984 = 24.6%; 1985 = 35.4%; 1986 = 35.1%; and 1987 = 25.4%.

The M-R study primarily consisted of tagging every tenth fish passing the weir with a coded spaghetti tag. Of these, every fourth fish also received a jaw tag to estimate tag loss. All tagged fish were measured for length, identified by sex, and scale sampled for age determination. All tag recoveries were obtained from spawning grounds using a beach seine. The lake was divided into 6 distinct geographical areas and sampled on a 5-day rotation. All captured fish were observed for marks; if none were observed, the fish was measured for length, identified by sex, and marked with a fin punch prior to re-release.

A total of 9,812 sockeye salmon were captured in the recovery surveys, 8,170 (83.3%) of which were unique (first time) recoveries. Tag recovery rates declined over time and could not be accounted for by tag loss. We hypothesize that this decline was induced by tagging or handling which decreased the time available for recapture because of increased mortality or faster ripening. After accounting for tag loss, the M-R estimate of 47,855 was 19% higher than the escapement through the weir. Spawning grounds are therefore not recommended for tag recovery surveys because of the likelihood of an unknown positive bias in the estimate.

Yentna River Project (1998)

The Yentna River sonar counting program was developed by the CFMD Division to enumerate the escapement of sockeye salmon using fishwheel apportioned counts. Proposed methods to estimate sockeye and coho salmon escapements in the Susitna drainage depend on reliable sonar estimates in the Yentna River. Therefore, the 1998 project will focus on evaluating critical aspects of sonar counting. The project will be conducted cooperatively with UCI/CFMD research staff who will perform a sonar calibration study. Primary objectives of the Yentna River project are to (1) investigate migration patterns of coho salmon around the sonar counters and to their spawning areas, and (2) assess error or bias in the current sonar counting technique (for sockeye and coho salmon). The following is a preliminary overview of the proposed project. A draft operational plan is due March 31, 1998.

Objective 1 will be undertaken using radio telemetry methods. Coho salmon will be radio tagged at north and south bank fishwheels and released downstream. One component of the study will examine spatial dispersion of the fish (nearshore/offshore distribution) to determine availability to the sonar counters and fishwheels. A second component will involve aerial radio tracking of the fish upstream to determine major spawning areas. The percentage of fish that move downstream of the release site will also be estimated. The radio tagging study may also be used provide an independent M-R estimate of coho salmon escapement.

Objective 2 will involve the following components: (1) evaluation of species selectivity of the sonar site fishwheels using M-R methods; (2) a M-R recapture experiment to independently estimate sockeye salmon escapement; and (3) a comparison of estimates of otolith marked returns (from hatchery releases of sockeye salmon fry in Chelatna Lake) from apportioned sonar counts and sampling at the Chelatna Lake weir. Component 1 entails downstream releases and recoveries of marked fish in the fishwheels to evaluate recapture consistency. Component 2 involves tagging sockeye salmon at the fishwheels and recovery sampling at the Chelatna and Judd Lake weirs to compute a M-R estimate. The third component requires otolith sampling at the two sites as well as sonar and weir counts to calculate independent abundance estimates of otolith marked fish.

Budget Summary

A total of $500k was allocated to the Susitna River project, which covers FY98/99. Total expenditures for the 1997 Larson Lake project (FY98) were approximately $91k. Total projected expenditures for the 1998 field season, which includes the remainder of FY98 and partial FY99 allocations, are $329k. Approximately $80k is reserved for the remainder of FY99 as startup funds for the 1999 field season.

BUDGET

The following budget summary is for the 1998 field season, which includes the remainder of FY98 and partial FY99 allocations. Total expenditures for the 1997 Larson Lake project were approximately $91k. This budget leaves adequate startup funds ($80k) for the 1999 field season.

Line	Position	Amount ($k)
100 - personnel	Biom II, Range 19 (Stan Carlson) - 3 mo.	18
	FB II, Range 16 (Pat Shields) - 6 mo.	30
	FB II, Range 16 (Gary Todd) - 4 mo.	20
	FB II, Range 16 (John Edmundson) - 3 mo.	15
	FB I, Range 14 - 2 x 2 mo.	18
	FWT III, Range 11 - 3 x 2 mo.	24
	FWT II, Range 9 - 4 x 2 mo.	28
	FWT I, Range 7 - 4 x 1.5 mo.	20
	Subtotal	**173**
200 - travel	Field trips, meetings	4
	Subtotal	**4**
300 - contractual	Equipment repair	2
	Freight	3
	Vehicle lease	5
	Air charters	16
	Cabin rentals	3
	Subtotal	**29**
400 - commodities	Structural/institutional supplies	12
	Radio Tags - 250 x 0.18k	45
	Dart tags - 26,000 x $.38	10
	Fishwheel maintenance/repair	3
	Weir materials (Judd Lake only)	5
	Field structures (cabins, tents, platforms)	4
	Field supplies (waders, life vests, gas, etc.)	5
	Laptop computers - 2 x 2.5k	5
	Food	10
	Subtotal	**99**
500 - equipment	Radio receiver/loggers - 4 x 6.0k	24
	Subtotal	**24**
100-500	**TOTAL**	**329**

MEMORANDUM

STATE OF ALASKA
COMMERCIAL FISHERIES ENTRY COMMISSION

TO: The Honorable Rick Halford
Chairman, Senate Resources
Alaska Senate
M/S: 3100

DATE: April 1, 1998

PHONE: (907) 789-6160 VOICE
(907) 789-6170 FAX

FROM: Commercial Fisheries Entry Commission
Marlene Johnson, Commissioner
Mary McDowell, Commissioner
Bruce Twomley, Chairman

SUBJECT: Permit Surcharges Under Proposed CSSB 40 (Work Draft 0-LS0296\Q 2/23/98) on Discrete Salmon Stock Assessments.

Brett Huber, your legislative aide, requested that we provide the Senate Resources Committee with an estimate of the magnitude of the management surcharges that would need to be imposed on salmon permit and interim-use permit holders under the draft Committee Substitute for SB 40 (Work Draft 0-LS0296\Q 2/23/98). Our rough estimates are shown in the table below:

ALL SALMON INTERIM-USE AND ENTRY PERMIT HOLDERS Estimated Management Surcharge By Fee Class Required to Raise $500,000			
Fee Class	Number of 1997 Permits Issued	Estimated Management Surcharge	Revenues Raised
$15	684	$4.28	$2,927.52
$50/$150	3,045	$14.26	$43,421.70
$100/$300	1,095	$28.52	$31,229.40
$150/$450	879	$42.78	$37,603.62
$200/$600	1,799	$57.04	$102,614.96
$250/$750	3,958	$71.30	$282,205.40
Totals:	11,460		$500,002.60

CSSB 40 (Work Draft 0-LS0296\Q 2/23/98) requires that the Commercial Fisheries Entry Commission (CFEC) apply an annual stock assessment surcharge to all salmon interim-use and entry permits. The surcharges are supposed to reasonably reflect the different rates of economic return for different fisheries and are supposed to raise approximately $500,000 annually.

CFEC currently sets annual permit renewal fees to reasonably reflect the different rates of economic return for different fisheries in accordance with AS 16.43.160. CFEC annually places permits for different fisheries into one of five fee classes in accordance with the methodology described in 20 AAC 05.240. These fee classes are simple multiples of each other ranging from $50 to $250 for residents and from $150 to $750 for nonresidents as shown above. Permit holders who qualify under AS 16.43.160 (c) can pay a "poverty" renewal fee irrespective of the fee class of the permit being renewed.

The Honorable Rick Halford April 1, 1998

If CSSB 40 (Work Draft 0-LS0296\Q 2/23/98) is enacted into law, CFEC would attach the stock assessment surcharge to permits by fee class. The surcharge would vary across fee classes in the same proportion as the fee classes vary with each other. For example, the annual renewal fee in our highest fee class is five times as great as the annual renewal fee in our lowest fee class. Therefore the stock assessment surcharge for the highest fee class would be five times as great as the stock assessment surcharge for the lowest fee class.

The estimates in the table on page one of this memorandum were based upon active permits where the 1997 renewal fees have been paid. The number of permits would have been slightly higher and the stock assessment surcharges would have been slightly lower if we had included both renewed and unrenewed permits to make the estimates.

Additionally, draft CSSB 40 (Work Draft 0-LS0296\Q 2/23/98) asks CFEC to impose an additional surcharge on the renewal of an entry permit or interim-use permit held by a nonresident to the extent permitted by law. We continue to litigate the *Carlson* challenge to all nonresident fee differentials. Therefore, we do not yet have a final judgment as to what, if any, differential can be defended.

Until the state has a final judgment in Carlson, it cannot be known whether any nonresident fee differential can be defended. Any additional fee differential struck down by the court would generate even greater damage claims by the plaintiff class in *Carlson*. For these reasons, we have used the same annual stock assessment surcharges for both residents and nonresidents for the estimates provided in the table on page one of this memorandum.

CFEC stands ready to implement the bill as enacted. As soon as we have a final judgment in Carlson telling us the extent to which the law permits an additional surcharge on nonresidents, we will impose the additional surcharge.

We hope that this information is useful to the Senate Resources Committee. If you have any questions about the estimates or this memorandum, please let us know.

MEMORANDUM

STATE OF ALASKA
COMMERCIAL FISHERIES ENTRY COMMISSION

TO: The Honorable Rick Halford
Chairman, Senate Resources
Alaska Senate
M/S: 3100

FROM: COMMERCIAL FISHERIES ENTRY COMMISSION
Dale Anderson
Marlene Johnson
Bruce Twomley, Chair
M/S: 0302

DATE: April 8, 1997

FILE: memos\RHSB40.w61

PHONE: 789-6160/Voice
789-6170/FAX

SUBJECT: Permit Surcharges Under SB 40

I. Introduction:

Brett Huber, your legislative aide, requested that we provide the Senate Resources Committee with estimates of the magnitude of the management surcharges that would be imposed on Alaska interim-use and limited entry permit holders if SB40 were enacted. We were asked to make the estimates under two different assumptions about who would pay the surcharge:

1. Salmon interim-use and limited entry permit holders only.

2. All CFEC interim-use and limited entry permit holders.

This memorandum provides rough estimates and explains how CFEC would propose to establish the management surcharge on an annual basis should SB 40 be enacted.

II. Background:

SB40 (1/13/97) would require CFEC to collect an annual management surcharge on every salmon entry permit and interim-use permit at the time of renewal. The surcharge is supposed to reasonably reflect the different rates of economic return for different fisheries. CFEC is also required to set these surcharges each year to generate $500,000 in revenue.

Additionally, SB40 requires CFEC to impose a greater surcharge on the renewal of nonresident permits to the extent permitted by law. We continue to litigate the Carlson challenge to all nonresident fee differentials. Therefore we do not yet have clear direction from the Alaska Supreme Court as to what, if any, differential can be defended.

Until the Alaska Supreme Court gives us clear direction, we believe that it would be unwise to impose an additional management surcharge on nonresident permit holders. Among other things, an additional surcharge would generate even greater damage claims by the plaintiffs in Carlson. Therefore the estimates in the following sections assume that the annual management surcharge for a permit for a particular fishery will be the same for a resident and a nonresident.

CFEC currently sets annual fees to reasonably reflect the different rates of economic return for different fisheries in accordance with AS 16.43.160. CFEC annually places permits for different fisheries into one of five fee classes in accordance with the methodology described in 20 AAC 05.240. These fee classes are simple multiples of each other ranging from $50 to $250 for residents and $150 to $750 for nonresidents.

If SB40 is enacted into law, CFEC would propose attaching the management surcharge to each fee class. The management surcharge would vary across fee classes in the same proportion as the fee classes vary with each other. For example, the annual fee in our highest fee class is five times as great as the annual fee in our lowest fee class. Therefore the management surcharge for the highest fee class would be five times as great as the management surcharge for the lowest fee class. The estimates in the following sections demonstrate how this methodology might work in practice.

III. Management Surcharge On All Salmon Interim-Use Permit and Entry Permit Holders.

This section provides an estimate of the management surcharges that would be required to raise $500,000 if surcharges were imposed on all salmon permit holders irrespective of the area in which they fish. The estimate makes the following assumptions:

1. The number of salmon permits issued in each fishery will be exactly the same as the number of permits issued in 1996.

2. Persons paying poverty fees will pay exactly the same management surcharge as other permit holders in their fishery.

3. 1996 Fee Classes remain in effect.

ALL SALMON INTERIM-USE AND ENTRY PERMIT HOLDERS			
Estimated Management Surcharge By Fee Class Required To Raise $500,000			
Fee Class	*Number Of 1996 Permits Issued*	*Estimated Management Surcharge*	*Revenues Raised*
$50 / $150	5,402	$16	$86,432
$100 / $300	1,959	$32	$62,688
$150 / $450	954	$48	$45,792
$200 / $600	1,171	$64	$74,944
$250 / $750	3,257	$80	$260,560
Totals:	12,743		$530,416

As can be seen, the management surcharge required to achieve $500,000 in revenues would range from about $16 to $80 (rounded to the nearest dollar) if the number of permits issued for each salmon fishery were exactly the same as in 1996 and if the fee classes for these fisheries were exactly the same as in 1996. Under these assumptions, examples of fisheries where permit holders would pay the $16 management surcharge would be the SE Alaska hand troll fishery and the AYK salmon fisheries. Examples of fisheries where permit holders would pay the $80 management surcharge would be the Bristol Bay salmon drift gill net and the Alaska Peninsula salmon purse seine fishery.

Under SB40, the management surcharges would be altered annually when fee classes for the different fisheries were determined. So, the above estimate should be regarded as a rough "ballpark" figure only.

IV. Management Surcharge On All Interim-Use Permit and Entry Permit Holders.

This section provides an estimate of the management surcharges that would be required to raise $500,000 if surcharges were imposed on all types of permits irrespective of the species or area of the permit. The estimate makes the following assumptions:

1. The number of permits issued in each fishery will be exactly the same as the number of permits issued in 1996.

2. Persons paying reduced poverty fees will pay exactly the same management surcharge as other permit holders in their fishery.

3. 1996 Fee Classes remain in effect.

ALL INTERIM-USE AND ENTRY PERMIT HOLDERS			
Estimated Management Surcharge By Fee Class Required To Raise $500,000			
Fee Class	*Number Of 1996 Permits Issued*	*Estimated Management Surcharge*	*Revenues Raised*
$50 / $150	17,714	$9	$159,426
$100 / $300	2,304	$18	$41,472
$150 / $450	2,417	$27	$65,259
$200 / $600	1,355	$36	$48,780
$250 / $750	4,583	$45	$206.235
Totals:	28,373		$521,172

As can be seen, the management surcharge (rounded to the nearest dollar) required to achieve $500,000 in revenues would range from about $9 to $45 if the permits issued for each fishery were exactly the same as in 1996 and if the fee classes for these fisheries were exactly the same as in 1996.

Under these assumptions, examples of fisheries where permit holders would pay the $9 management surcharge would be the AYK salmon fisheries and the Norton Sound Herring gill net fishery. Examples of fisheries where permit holders would pay the $45 management surcharge would be the Bristol Bay salmon drift gill net fishery and the Southeast Alaska roe herring purse seine fishery.

Under SB40, management surcharges would be altered annually when fee classes for the different fisheries were determined. So, this particular estimate should be regarded as a rough "ballpark" figure only.

V. Additional Considerations:

The legislature may want to consider the following points when discussing proposed revisions to SB 40:

A. It Is Not Possible To Set Management Surcharges Prior To The Season To Obtain Exactly $500,000 Of Revenue.

SB40 requires that the "total amount of revenue generated by the management surcharge must equal $500,000." In order to set management surcharges prior to the season to raise exactly $500,000, CFEC would need to know exactly how many permits would be issued in each fishery prior to the season. In practice we do not know that.

Many factors can alter the number of permits that are issued in a fishery in a particular year. This is particularly true in unlimited fisheries where the number of participants can vary widely on an annual basis. CFEC can estimate each year the management surcharges needed to raise approximately $500,000, but we cannot guarantee that precisely $500,000 will be raised. Language directing us to set surcharges to raise "approximately $500,000" or "at least $500,000" would be more practicable.

B. Should Management Surcharges Be Applied To Permit Holders Qualifying For Poverty Fees?

AS 16.43.160(c) allows holders of permits who have incomes below poverty guidelines to renew permits for a reduced poverty fee irrespective of the permit's fee class for the year. Reduced fees are $15 for residents and $45 for nonresidents. Each year many permit holders take advantage of this provision. Does the legislature want a management surcharge applied to permits renewed under the poverty provision?

The numbers and types of permits that will be issued each year under the poverty provision is also difficult to predict in advance. If permit holders who qualify for the reduced fee do not have to pay the management surcharge, estimation of the appropriate surcharge will be less precise.

C. How Should Management Surcharges Be Handled If A Fishery Is Closed For The Year?

When a fishery is closed for the year before any fishing has occurred, CFEC refunds the annual permit fee or allows the fee to be applied toward the next year's renewal. CFEC also waives the annual renewal fees for persons who did not renew. Under such conditions, would the legislature want CFEC to retain or refund the management surcharge? If CFEC is to retain the surcharge, would the legislature want CFEC to collect the management surcharge from those whose annual renewal fees were waived before they renewed their permits?

Upstream

Salmon and Society in the Pacific Northwest

Committee on Protection and Management of
Pacific Northwest Anadromous Salmonids

Board on Environmental Studies and Toxicology

Commission on Life Sciences

1995

National Research Council

BACKGROUND

11

Salmon-Fishery Management Concepts

While Pacific salmon fisheries developed rapidly during their early history, our ability to manage them did not. Much of the basic biological understanding of Pacific salmon and information that could be used to manage salmon fisheries were being developed as the fisheries developed, but their application to management developed much more slowly. In his review of salmon management during the first century of Pacific salmon fisheries, Larkin (1970) suggested that almost from the beginnings of the industry two ideas were implicit in attempts at management: that salmon returned to their home stream to spawn and that catches in each river had to be limited. Those continue to be the biological bases for management, and we continue to struggle with their incorporation into a sustainable management concept.

Papers by McHugh (1970) and Larkin (1970) provided historical perspectives on the development of fishery science and management of Pacific salmon in North America. Initially, scientific investigations consisted largely of descriptive biology and examination of the "home-stream concept." The scientific basis of that concept was debated long after its acceptance in management (see, for example, Jordan 1925, Moulton 1939). But acceptance, coupled with the early recognition that salmon eggs were easily cultured, resulted in hatcheries' becoming the major management activity during the first 50 years of the industry. By the late 1930s, however, management of Pacific salmon was in transition. Larkin (1970:226) reported that "regulations for controlling harvest were inadequate, but insufficient information existed on which to construct better techniques; hatchery practices were fairly advanced but of dubious value: inroads on salmon production as a consequence of the development of other resources were beginning to cause concern." The 1930s began a period of more-quantitative assessment in fishery management (Cushing 1988, McHugh 1970). The quantitative basis of salmon management was provided by Ricker's 1954 seminal paper on stock and recruitment. Since then, management of Pacific salmon fisheries has been premised on his stock-recruitment theory.

STOCK[1] AND RECRUITMENT

Salmon-fishery management assumes that there is surplus production below some upper size of the spawning population. *Surplus* in the case of salmon means that a given number of spawners in an adult generation produces, on average, more progeny than needed to replace the parents and overcome all natural mortality sources from the time fertilized eggs are deposited in the gravel of natal streams, through juvenile and immature life phases, to adulthood. The number of surplus animals varies with the size of the population and the natural mortality rate. Smaller populations tend to have higher productivity than larger populations (i.e., number of

[1] The terminological difficulties associated with the word *stock* are discussed in Chapter 4. To permit comparison of the discussion in this chapter with much of the published literature on fisheries, we use the term *stock* here, although we use the term *population* in most of the rest of the report.

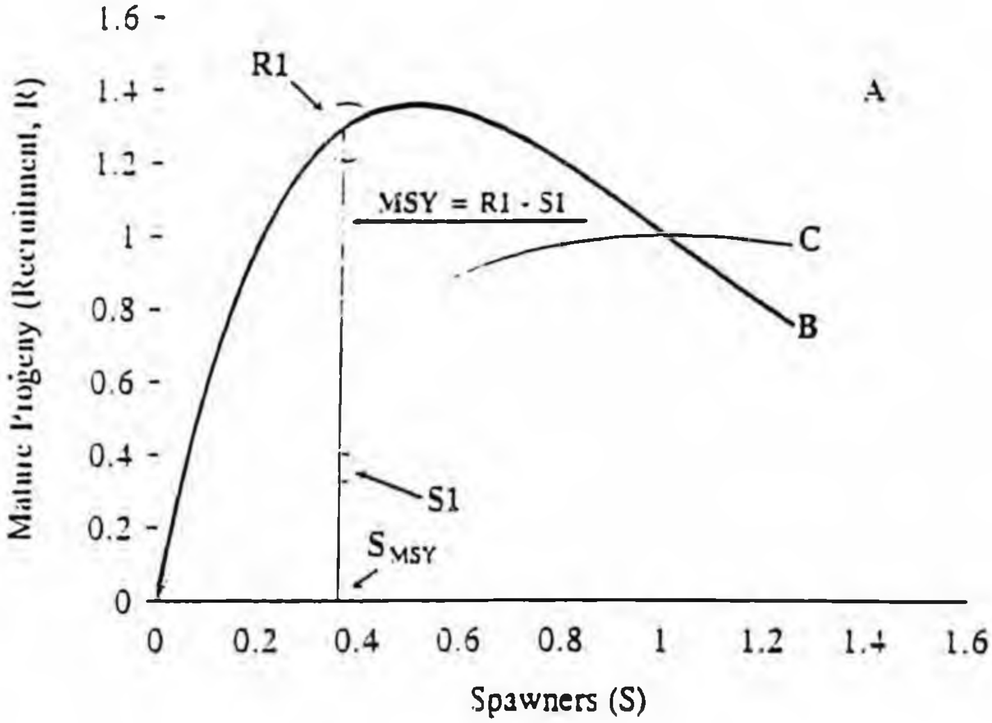

Figure 11-1 Hypothetical Ricker stock-recruitment curves relating number of animals reproducing (spawners) and production of mature progeny (recruitment). Other letters explained in text.

• The estimation of the biological production function in a highly variable natural environment.

• Differences between populations and change over time within populations.

• The necessity for accurate data on total fishing mortality by age and population over all fisheries, on number of spawners by age, and on future production.

An individual data point (i.e., the recruitment from a parental spawning stock) reflects biological processes, effects of environmental variability, and random events. Determining an appropriate production function in the presence of this variability requires a long series of data on returns over a wide range of spawning-stock sizes. The uncertainty about a recruitment function is usually high. For example, even in a sockeye population with 41 years of good assessment information, a characteristic recruitment function is not evident (Figure 11-2a). The relationship between spawners and juvenile production in freshwater is more evident (Figure 11-2b), but variability in marine survival weakens both the relationship between spawners and adult returns (Figure 11-2a) and between downstream migrants (smolts) and adult returns (Figure 11-2c). The latter relationship would already account for variation in returns attributable to variation in freshwater survival. Even in the population modeled in Figure 11-2, the estimate of S_{MSY} is uncertain; S_{MSY}= 332,000 with a 90% confidence range between 203,000 and one million spawners. This confidence range was estimated from 1,000 computer simulations of the

CORRECTION

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11

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While Pacific salmon fisheries developed rapidly during their early history, our ability to manage them did not. Much of the basic biological understanding of Pacific salmon and information that could be used to manage salmon fisheries were being developed as the fisheries developed, but their application to management developed much more slowly. In his review of salmon management during the first century of Pacific salmon fisheries, Larkin (1970) suggested that almost from the beginnings of the industry two ideas were implicit in attempts at management: that salmon returned to their home stream to spawn and that catches in each river had to be limited. Those continue to be the biological bases for management, and we continue to struggle with their incorporation into a sustainable management concept.

Papers by McHugh (1970) and Larkin (1970) provided historical perspectives on the development of fishery science and management of Pacific salmon in North America. Initially, scientific investigations consisted largely of descriptive biology and examination of the "home-stream concept." The scientific basis of that concept was debated long after its acceptance in management (see, for example, Jordan 1925, Moulton 1939). But acceptance, coupled with the early recognition that salmon eggs were easily cultured, resulted in hatcheries' becoming the major management activity during the first 50 years of the industry. By the late 1930s, however, management of Pacific salmon was in transition. Larkin (1970:226) reported that "regulations for controlling harvest were inadequate, but insufficient information existed on which to construct better techniques; hatchery practices were fairly advanced but of dubious value: inroads on salmon production as a consequence of the development of other resources were beginning to cause concern." The 1930s began a period of more-quantitative assessment in fishery management (Cushing 1988, McHugh 1970). The quantitative basis of salmon management was provided by Ricker's 1954 seminal paper on stock and recruitment. Since then, management of Pacific salmon fisheries has been premised on his stock-recruitment theory.

STOCK[1] AND RECRUITMENT

Salmon-fishery management assumes that there is surplus production below some upper size of the spawning population. *Surplus* in the case of salmon means that a given number of spawners in an adult generation produces, on average, more progeny than needed to replace the parents and overcome all natural mortality sources from the time fertilized eggs are deposited in the gravel of natal streams, through juvenile and immature life phases, to adulthood. The number of surplus animals varies with the size of the population and the natural mortality rate. Smaller populations tend to have higher productivity than larger populations (i.e., number of

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[1] The terminological difficulties associated with the word *stock* are discussed in Chapter 4. To permit comparison of the discussion in this chapter with much of the published literature on fisheries, we use the term *stock* here, although we use the term *population* in most of the rest of the report.

progeny returning per adult spawner), and their total production is limited mostly by the number of eggs deposited. In larger populations, production depends more on the interactions between spawners and habitat required for sustaining survival and growth of progeny.

Ricker (1954) noted that factors that become more effective at high densities, called "compensatory" factors by Neave (1953), control or regulate salmon populations. Compensatory mortality factors place more pressure on high-density than on low-density populations. For example, when large numbers of pink salmon reach their spawning grounds, some adults are forced to use less-suitable gravels at stream margins; in crowded conditions, late spawners might even dig out developing embryos deposited by earlier spawners. Those factors decrease the number of progeny produced per female. When chinook or steelhead spawners are less abundant, the resulting fry, fingerlings, and pre-smolts have more access to feeding positions and cover, so they may grow faster and be less vulnerable to predation.

Ricker (1954) termed the relationship between the number of spawners (stock or S) and the production of progeny (recruitment or R), the stock-recruitment function. The term *recruitment* refers to the potential availability of fish to a fishery or to form the next spawning generation. The stock often is referred to as the *escapement*, because these fish escaped capture by a fishery and return to spawn.

Fishery managers have attempted to maximize surplus production (i.e., animals available for catch) by maintaining the number of spawners at an abundance at which, according to Ricker's stock-recruitment theory, they are likely to produce the largest sustainable catch. Figure 11-1 is an example of a hypothetical Ricker stock-recruitment function. In reality, the function would be fitted statistically through a scatter of data points collected over time. The function represents the average response expected given an escapement under the environmental conditions that existed when the data were collected. If escapements merely replaced themselves in the next generation, those returns would fall along a "replacement line" where R = S (line A in Figure 11-1). However, if the function value R_1 expected for a particular S_1 exceeds the replacement value, then a surplus production ($R_1 - S_1$) could be caught and the population maintained in equilibrium at the same future S and R numbers. Salmon populations can maintain themselves at several levels of abundance, and different salmon populations have different stock-recruitment curves. In Figure 11-1, curve B describes a population with greater productivity than curve C, but one with greater density-dependence at large spawning stocks. Populations with greater productivity can sustain their production at higher exploitation rates.

The S number that, on average, maximizes the catchable number of fish generation after generation is referred to as the optimum escapement, and the associated catch is the maximum surplus reproduction or maximum sustained yield (MSY). The escapement expected to provide MSY is indicated as S_{MSY} in Figure 11-1. It occurs where the slope of the recruitment curve is 1.0, the tangent to the curve parallel to the replacement line. Once S_{MSY} is determined, the rate of exploitation that can be sustained by the population to maintain MSY can also be determined, i.e., $(R_{MSY} - S_{MSY})/R_{MSY}$. In this figure, the surplus production ($R_1 - S_1$) is equal to MSY.

Other stock-recruitment models have been proposed. The Beverton-Holt model (1957) predicts that the number of recruits increases with spawning stock ever more slowly and never exceeds a particular value (asymptote). This model does not turn downward at high S, as with Ricker's model.

Stock-recruitment functions, whether Ricker's or Beverton-Holt's, share several serious limitations for application to salmon management. The principal limitations are related to

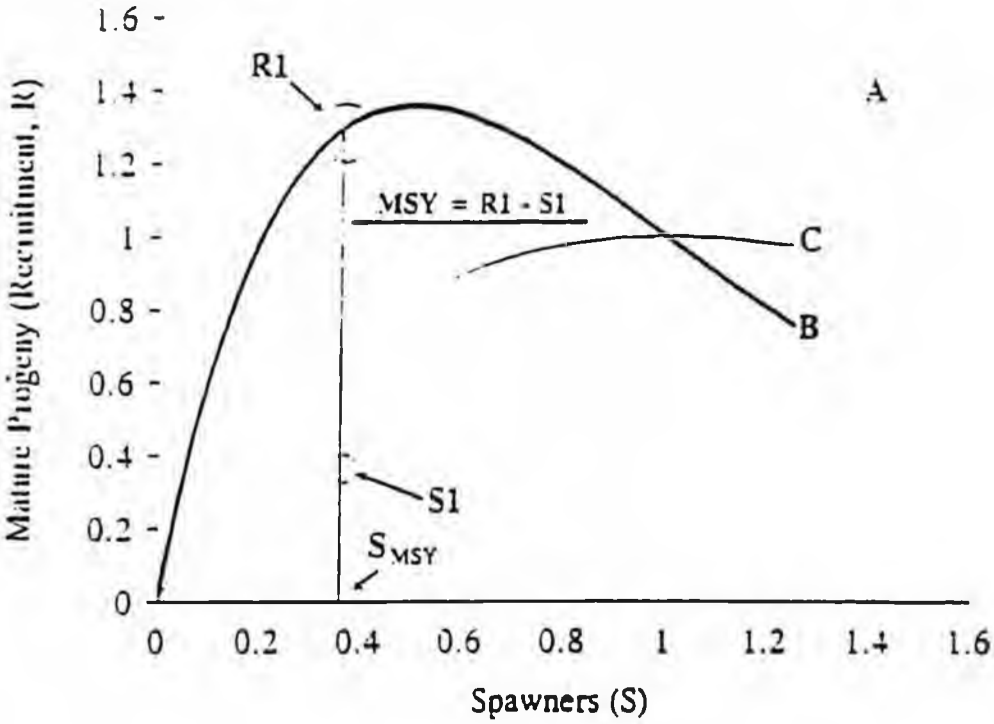


Figure 11-1 Hypothetical Ricker stock-recruitment curves relating number of animals reproducing (spawners) and production of mature progeny (recruitment). Other letters explained in text.

- The estimation of the biological production function in a highly variable natural environment.
- Differences between populations and change over time within populations.
- The necessity for accurate data on total fishing mortality by age and population over all fisheries, on number of spawners by age, and on future production.

An individual data point (i.e., the recruitment from a parental spawning stock) reflects biological processes, effects of environmental variability, and random events. Determining an appropriate production function in the presence of this variability requires a long series of data on returns over a wide range of spawning-stock sizes. The uncertainty about a recruitment function is usually high. For example, even in a sockeye population with 41 years of good assessment information, a characteristic recruitment function is not evident (Figure 11-2a). The relationship between spawners and juvenile production in freshwater is more evident (Figure 11-2b), but variability in marine survival weakens both the relationship between spawners and adult returns (Figure 11-2a) and between downstream migrants (smolts) and adult returns (Figure 11-2c). The latter relationship would already account for variation in returns attributable to variation in freshwater survival. Even in the population modeled in Figure 11-2, the estimate of S_{MSY} is uncertain; S_{MSY}= 332,000 with a 90% confidence range between 203,000 and one million spawners. This confidence range was estimated from 1,000 computer simulations of the

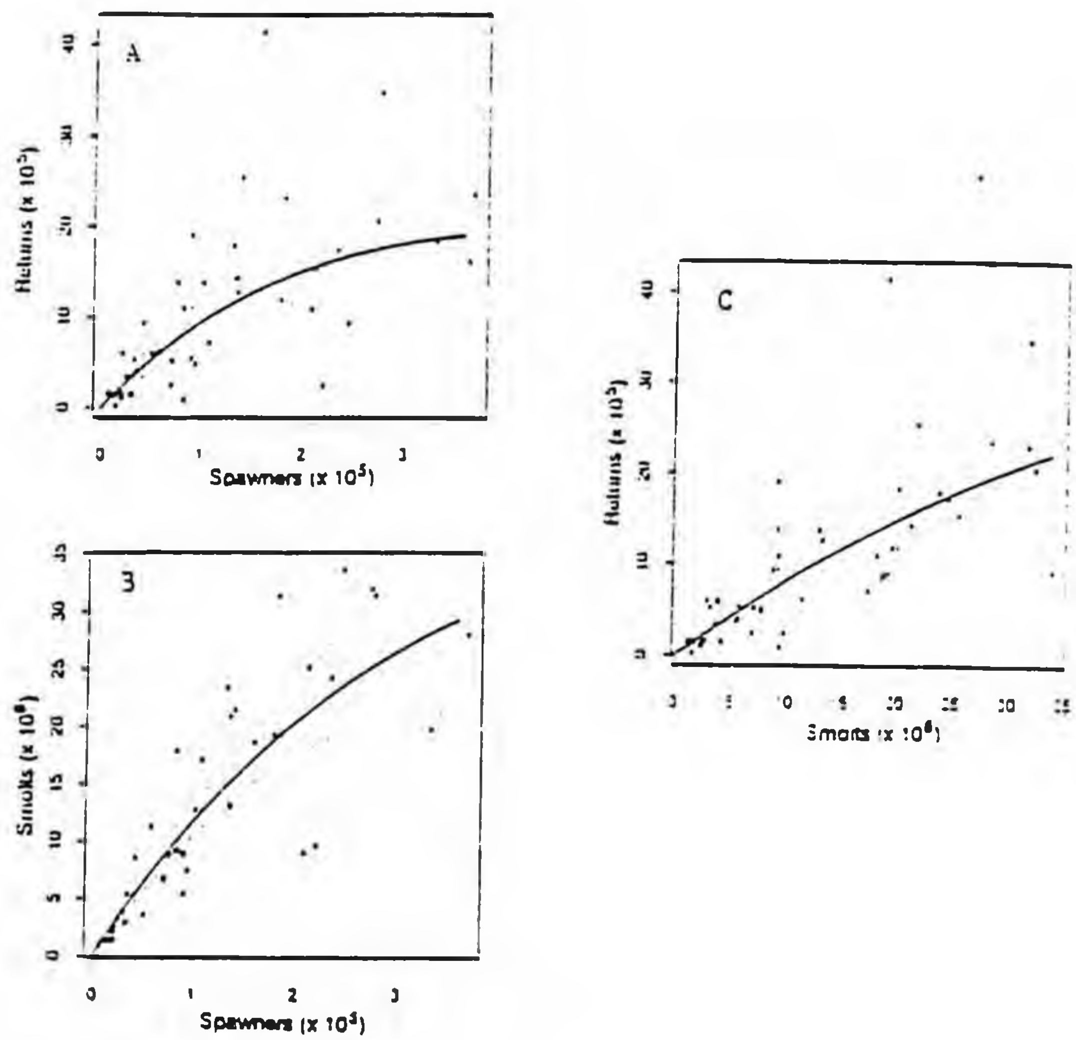


Figure 11-2 Ricker stock-recruitment data and functions for Chilko Lake sockeye salmon from Fraser River. A, adult spawners and adult recruitment; B, adult spawners and juvenile downstream migrants (age 1 – smolts); and C, migrants and adult returns.

relationship between adult spawners and adult recruitment. The distribution of the simulation results (Figure 11-3) indicates the uncertainty associated with estimates of the optimal escapement value for this population. Furthermore, the scatter plot of alpha versus beta values (S/R parameters in the Ricker function) indicates that these parameters are correlated (the oval shape of the 90% joint confidence limit indicates correlation). The wide variation in the alpha

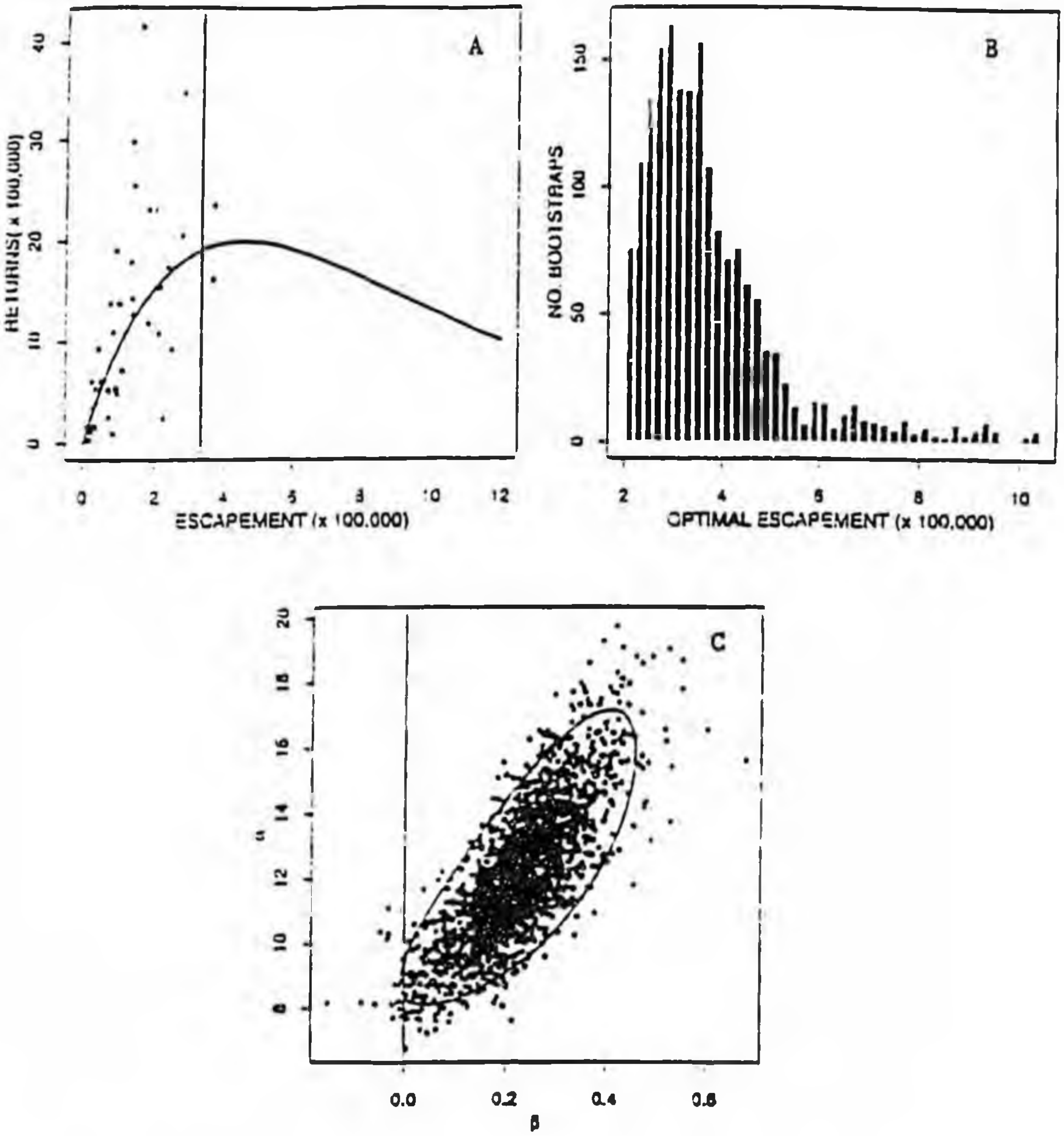


Figure 11-3 Results of 1,000 bootstrap simulations of Chilko sockeye Ricker stock-recruitment function (top left). Top-right figure is distribution of 90% confidence interval for optimal spawning-stock sizes determined by simulations. Lower figure is bivariate scatter plot of Ricker stock-recruitment parameters determined from each simulation.

value is associated with wide variation in beta; this results in a highly uncertain stock-recruitment function for this population. In salmon populations in which recruitment and spawning stock sizes have been monitored, annual variation in the ratio of returns to spawners can vary by a factor of 10. Recently the marine survival rate of chinook salmon released from Robertson Creek Hatchery (on the west coast of Vancouver Island, B.C.) has been shown to vary by a factor of more than 100 (0.1% - 13.7% survival to the second year).

Many years of data would assist in accounting for that variability, but long-term data can involve another problem. The function calculated reflects returns per spawner under past environmental conditions. If the environment changes, the stock-recruitment function changes. An obvious example is deterioration of freshwater environments, as evidenced in increased deaths associated with dams, reduction in area available for spawning or rearing because of water abstraction, or sedimentation in spawning gravels. Change in marine survival (see Beamish and Boullion 1993) also can alter the stock-recruitment function. Environmental variability makes questionable how representative any stock-recruitment function will be for current and future environmental situations. Limiting data to periods considered to be more "typical" of existing conditions might be possible, but the resulting decrease in data points would increase uncertainty substantially.

The most common concern about managing for MSY in salmon fisheries is that stock-recruitment functions vary among populations. The MSY for a population is determined by its productivity and sources and magnitudes of density-dependent mortality rates, which reflect the life history of the species and the specific habitat in which the population lives. Stock-recruitment functions are expected to vary, but the paucity of reliable data on population-specific functions makes it hard to account for the differences. An obvious example is the comparison of wild-spawned versus hatchery-reared salmon. A hatchery population can sustain its maximum catch at substantially greater exploitation rates than can a natural population because mortality associated with spawning and freshwater rearing is much lower in a hatchery than in natural systems. Assuming that after release marine mortality sources do not compensate, fewer parents are needed to reproduce the recruitment from a hatchery population (see Chapter 12). Direct comparisons of stock-recruitment functions for hatchery and wild populations (in the same geographic area and period) are rare. One good comparison involves sockeye salmon in the lower Fraser River (Figure 11-4), where an artificial spawning channel in Weaver Creek enhances the fry productivity of that population but later rearing occurs in the natural environment. Two other populations, from Birkenhead and Cultus lakes, are produced naturally and have the same adult run timing as Weaver Creek; all three populations are fished simultaneously. The catchable surplus from Weaver Creek is greater than that in the natural populations. The exploitation rates to sustain these populations at MSY are 0.76 for Weaver Creek, 0.70 for Birkenhead Lake, and 0.62 for Cultus Lake. The spawning channel has increased the productivity of the Weaver Creek sockeye, but fishing to maximize the catch from Weaver Creek would mean overfishing returns to both natural populations.

The hatchery-wild dichotomy presents an extreme example of the "mixed-stock" fishing problem. If fishing responds to apparent abundance without consideration of the stock composition (i.e., the mixture of portions of stock from source populations) or if fishing levels are based on hatchery production, the natural population will be overfished and its production will, on the average, decline. Alternatively, if the fishery is managed to sustain the natural population, substantial surplus production will return to the hatchery or could be caught in a single-population, terminal fishery.

The example of mixed-stock fishing represents a much more general problem. Differences in productivity between natural populations cause the same problem, and by-catch of other species in fisheries that are directed at a more productive species is an analogous problem. When fishing occurs on a mixture of populations with different stock-recruitment functions and fishing cannot be regulated at a rate appropriate for each component population, the stage is set

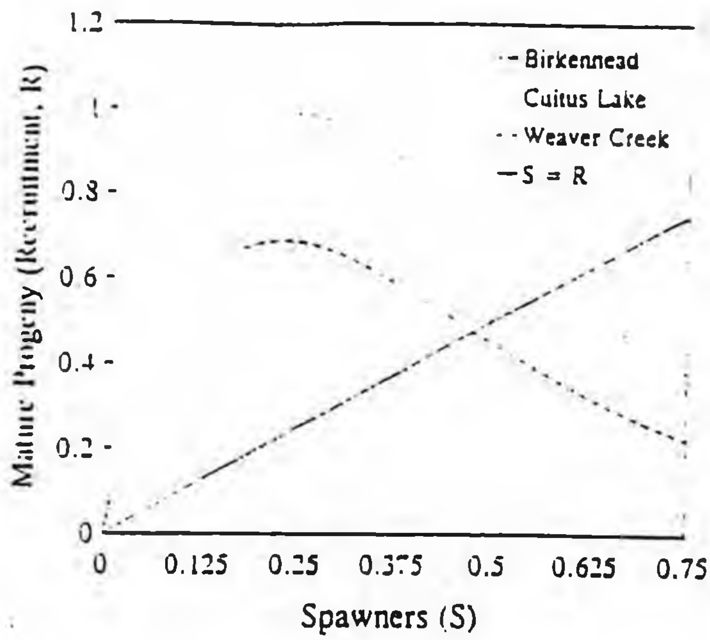


Figure 11-4 Ricker stock-recruitment curves for three Fraser River sockeye salmon populations. Weaver Creek population is enhanced but Cultus and Birkenhead populations are both naturally spawning. Source: data collected 1946-1990 by International Pacific Salmon Fisheries Commission and Canada's Department of Fisheries and Oceans.

for overfishing of the less-productive components (Ricker 1958, 1973; Hilborn 1985). For example, extinction of wild coho salmon in the lower Columbia River has occurred as fishing pressures at sea and in the lower Columbia increased to take hatchery returns; catch levels of 85-95% were directed at the returning fish (Cramer et al. 1991). The less-productive stocks are referred to as "weak stocks," but that term leads to confusion. "Weak" cannot be equated with "small", nor does it imply anything maladaptive, inferior, etc., about animals in the population. The "mixed-stock" (or mixed-population) fishery problem is related to differences in *production rates*, not the relative size of populations.

Apart from natural variability and variation among populations or over time, estimating the S_{MSY} for just one population raises a serious question. Larkin's (1977) discussion of MSY as a management concept identifies the issue of the poor quality of the data available for use in stock-recruitment analysis, and recently the joint U.S.-Canada committee on chinook salmon stated (PSC 1993b:87):

> At present, complete information necessary to determine stock productivity is not available for any individual chinook stock! For a few stocks, enough information has been available to apply stock-recruitment type analyses to estimate productivity parameters, but even these had to involve some major assumptions about age structure in catch and/or escapement and about the error structure of these data. And none include environmental factors, which are known to produce variability in annual production. . . .

To determine stock-recruitment functions is data-intensive, expensive, and statistically nontrivial. Data and cost issues are related to accurate determination of a population's mortality in each fishery and its spawning escapement by age so that production can be related to the parental generation. Salmon tend to be caught in many sequential, mixed-stock fisheries, and their escapement is not determined easily. There are few cases in which this challenge has been met to study salmon population dynamics, and the sensitivity of stock-recruitment analyses to errors in the data is poorly understood. Hilborn and Walters (1992) stated that stock-recruitment analyses can provide "terribly misleading answers" and that (p. 287)

> the types of misleading answers produced by stock and recruitment analysis are almost always the same; the answers mistakenly lead you to believe that recruitment will not decline very much with spawning stock. We think that bad stock-recruitment analyses have been a significant factor leading to over-exploitation and stock collapse for some major fisheries. . . .

Hilborn and Walters reviewed the problems associated with stock-recruitment analyses in greater detail than is appropriate here, but the committee has developed an example of the consequences of such analyses (Box 11-1). The most common outcome of simple stock-recruitment analyses is that the optimum exploitation rate is overestimated and the S_{MSY} underestimated. The consequence of this outcome could be management advice that unintentionally would lead to overfishing and contribute to declining production.

Although MSY concepts have provided the basic paradigm for salmon management since the 1950s, the paradigm has been inadequate, given the fishing pressure and economic development in the Pacific Northwest. Mixed-population fisheries, habitat change, and uncertain assessment advice have all contributed to overfishing and loss of less-productive populations. The committee reiterates Larkin's caution about the inadequacy of the MSY concept for salmon management (Larkin, 1977:9):

> The foregoing has demonstrated, I hope, that MSY is not attainable for single species and must be compromised: (1) to reduce the risk of catastrophic decline and reduction of genetic variability; and (2) to accommodate the interactions among the species of organisms that comprise aquatic communities.

Given that the limitations of stock-recruitment analyses have been known for many years, why are management strategies based on those models? Part of the answer is that technical improvements in analyses has led to unjustified confidence in abilities to compensate for deficiencies. Much of the answer, however, lies in the socioeconomics of fisheries and fishery management. In the United States and Canada, marine fish are generally viewed as "common property" resources, owned by no one—or by the public—until they are caught. Such a situation is well known to lead to excessive investments in capital and labor and to pressures to overfish resources, particularly when there is open entry (i.e., no limit on the number of people who can fish) (Gordon 1954, Scott 1955, Crutchfield and Pontecorvo 1969). However, salmon fishing in the Pacific Northwest is not now (and has not been for a long while) an open-entry fishery. The states of Washington, Oregon, and Alaska and the province of British Columbia have limited

Box 11-1 Stock-Recruitment Simulation

Stock-recruitment functions are usually nonlinear, which means that natural environment fluctuations can produce systematically skewed estimates of the long-term response of salmon populations to exploitation. The direction of this error appears to lead to overexploitation, even when statistical procedures generally accepted by fisheries biologists are properly applied. In this example, the committee develops ideas suggested by Hilborn and Walters (1992) to show how advice to management might produce serious errors.

The simulation begins with a "known" stock-recruitment relationship, the values for which are typical for chinook salmon in the Pacific Northwest: $R_t = S_{t-1} \exp(a - bS_{t-1}) \exp^{\sigma\varepsilon}$ where a = 1.6, b = 0.2, and sigma ($\sigma\varepsilon$) = 0.7.

Each brood year was fished at a 75% exploitation rate: this is common for many fall chinook populations but exceeds the 60% rate sustainable at MSY for this stock-recruitment function.

Each simulation was run for 100 years, and data from the last 30 years were collected for stock-recruitment analysis. At the end of each simulation, stock-recruitment parameters (a, b, S_{MSY}) were estimated from the 30 data points. The effects of three known error sources were examined:

> *Type 1*: Environmental variation in recruitment, normally distributed with mean zero and standard deviation σ_ε. The value of σ_ε was chosen so that production varied by a factor of 2–4.
>
> *Type 2*: Environmental variation plus observation error in spawning-escapement estimation. The error about S_t was simulated as $S_t * \exp^{\sigma_t}$, where the random normal error has mean zero and standard deviation = 0.57. This value of σ_ε was chosen to produce escapement-estimation error of ≈ 50% about the true S_t.
>
> *Type 3*: Environmental variation, observation error in spawners, and error in catch estimation. Catch error was simply generated by smoothing the catch (three-point moving average) to simulate assumed age structures or errors in catch allocation between populations.

One thousand simulations of each type were conducted, and frequency distributions for parameters a and b were compared with values of the "known" function. The solid vertical line in the figures represents the parameter values of the "known" function, and the dashed lines encompass 95% of the estimates.

Both a and b have been rescaled for clarity in presentation. The a values are expressed as the expected recruits per spawn ($\alpha = \exp^a$), and b as logarithms to spread out the distribution.

The distributions of results for Type 1 to 3 simulations are presented from top to bottom. In each distribution, the most common result of the simulations is represented by the tallest bar. In every case, the most common result is to the right of the value that we are trying to estimate (i.e., the values in the original, or "known", stock-recruitment function). Furthermore, for the productivity parameter (α), the effects of the error types are compounded as the most common value progressively deviates from the vertical line. Comparing the means of the simulations demonstrates the tendency for errors in stock-recruitment analyses to overestimate productivity and underestimate the number of spawners needed to sustain MSY.

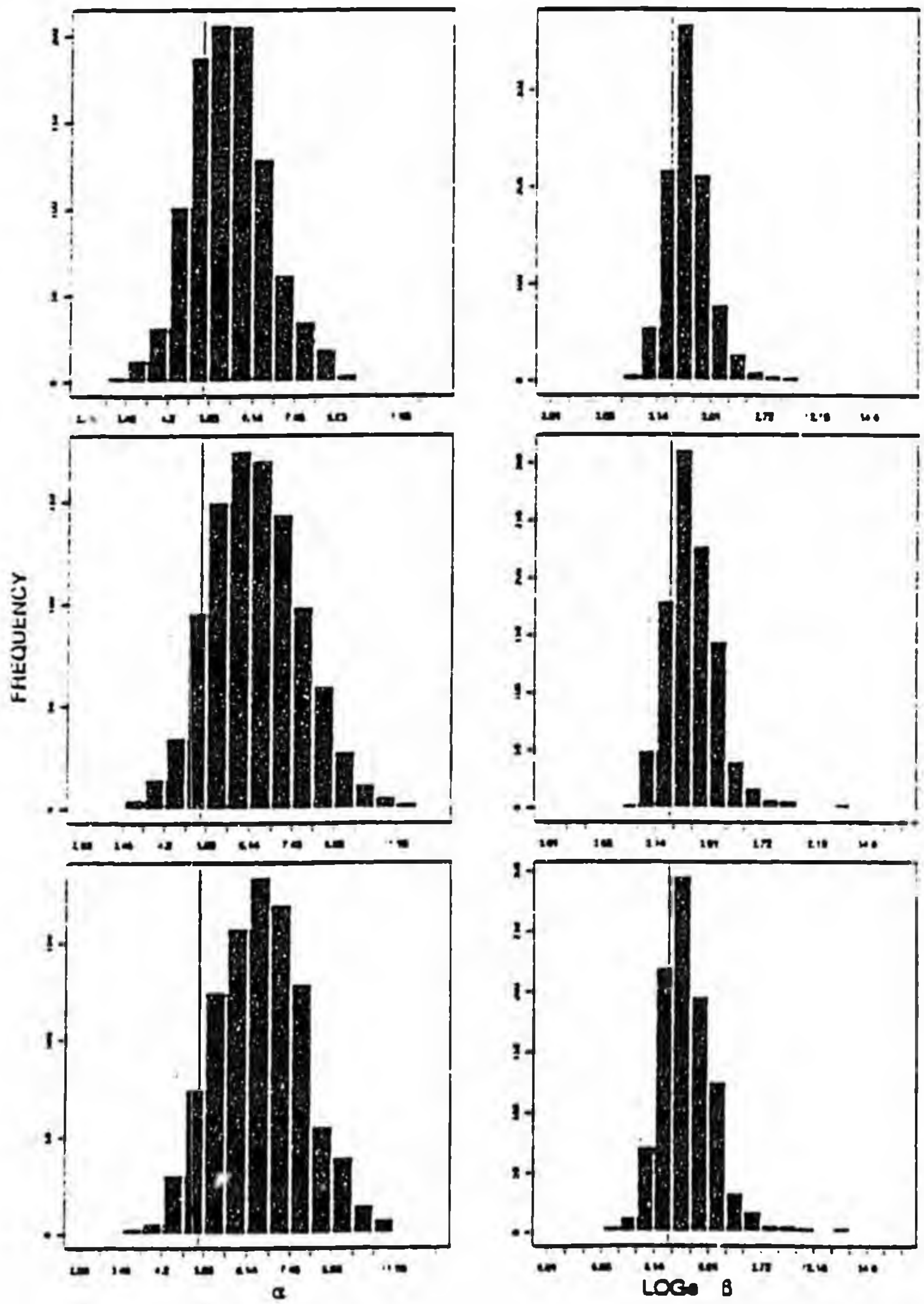
	Recruits/spawner	S_{MSY}	Sustainable exploitation rate at MSY
"Known" function	4.95	3.43	0.60
Type 1 results	5.51	1.44	0.63
Type 2 results	6.28	0.98	0.67
Type 3 results	6.49	1.11	0.675

These analyses are clearly very limited and were intended only to demonstrate, under realistic assumptions about error, the potential for misleading information (see Hilborn and Walters 1992). Advice based on these analyses would recommend a sustainable exploitation rate, at MSY, 12.5% greater than could actually be sustained by the population. While we thought we were managing correctly, the population would continue to decline.

. . . continued on next page

Box 11-1 (continued)

Simulation results for Type 1 to 3 errors described in this box. Solid vertical lines in each figure are true parameter values. Frequency histograms on left show distribution of estimated returns per spawner, and on right, natural logarithm of beta parameter (natural lags used to spread distribution). Results of 1,000 simulations for Type 1 to 3 errors are presented from top to bottom.



entry into the salmon fishery since the 1960s; this has not prevented overcapacity in boats, gear, and fishing technology, but it has raised greatly the costs of participating in the fishery and reduced overall numbers of people and boats in it. Higher costs of entry and higher investments increase the needs of fishers to pressure regulatory agencies to allow higher catches at the expense of spawning requirements.

The problem has long been recognized (e.g., Wright 1981, Ludwig et al. 1993). Wright stated (p. 38)

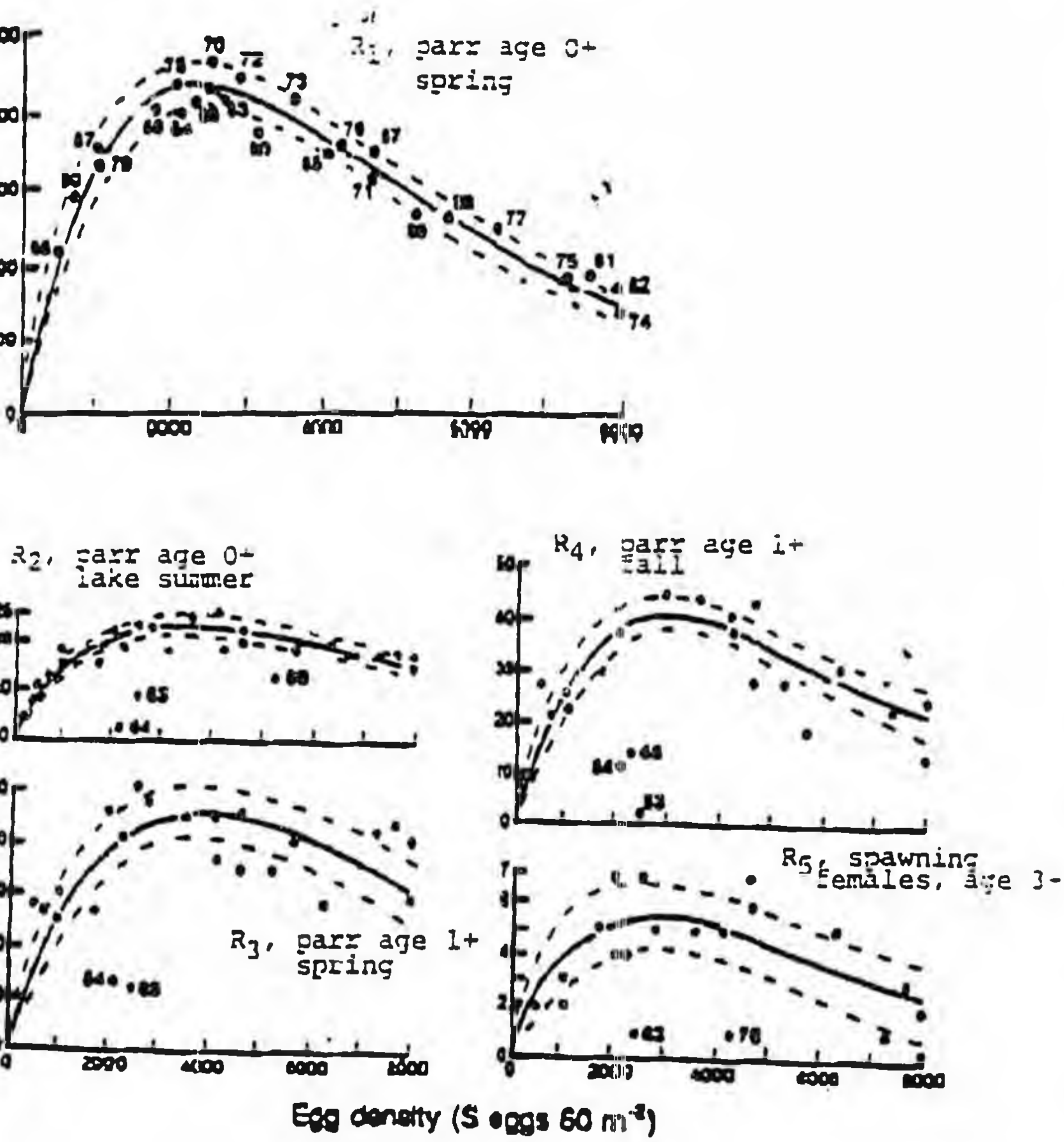
> Fishermen make poor management allies due to their perpetual optimism about strengths of the salmon runs and their understandable preoccupation with short-term economic considerations.
>
> There can be little doubt, however, that the salmon fishery lobbyists are currently winning the battle against the spawning-escapement protectors. A team of fishery scientists formed by the Pacific Fishery Management Council concluded that 40% more chinook salmon and coho salmon were needed to meet spawning-escapement requirements, under existing habitat conditions, for the combined areas of California, Oregon, and Washington (PFMC 1978:39).

Similar appraisals can be found in Fraidenburg and Lincoln (1985), Walters and Riddell (1986), and National Research Council (NRC 1994). The remedies suggested most commonly, besides complete but preferably temporary closures of the fisheries (as occurred in 1994), include restructuring managing bodies to remove apparent conflicts of interest (NRC 1994) and privatizing rights of access to salmon stocks through individual transferable quotas or similar devices, perhaps combined with buyouts or other compensations for displaced fishers. A third approach, paradoxically, is to strengthen the involvement of fishers in the management process so that they are encouraged to take more responsibility as stakeholders in either a common property or a privatized fishing situation (cf. Scott 1993). Hanna (1994) suggested that the Pacific Fishery Management Council (PFMC) has already moved a long way toward involving fishers in the management process, at least for other species of fish.

The application of stock-recruitment theory and MSY as the basis of salmon management is complex and of limited applicability. The multitude of populations and habitats, the extent of enhancement programs, and the variability and uncertainty in the data make determining an accurate optimal escapement goal elusive. However, where the necessary data are available, stock-recruitment relations can be clear (see Box 11-2). The definition of the relationship depends on the degree of environmental variability, the causes of density-dependent mortality, and data quality. Given the poor quality of the data available on almost all Pacific salmon populations, we cannot test the stock-recruitment theory rigorously. We have learned that the theory is more applicable in freshwater phases of salmon life history and that environmental variability in the marine habitat ultimately can determine the number of returning adults. Principal lessons are that salmon stock-recruitment relationships are inherently uncertain, that the determination of a specific escapement goal (S_{MSY}) is seldom justified by available data, and that the MSY concept has been inadequate for conserving population diversity or production.

Box 11-2

A most striking example of stock-recruitment relations in a salmonid is the detailed study of Elliot (1994) on anadromous brown trout (*Salmo trutta*). The figures below from Elliot's recent book show a clear curvilinear relation between spawning (measured as egg density) and recruitment to later life phases. Note that recruitment is more strongly associated with egg density at the lower ages (R_1 to R_4). The relation becomes much more variable when adult returns (R_5, age 3+ female returns) are related to egg density. The committee readily acknowledges, however, that this population inhabits a spring-fed stream not subjected to extremes of climate or high water velocities.



FISHERY MANAGEMENT IN THE FUTURE

The committee explored four general options for managing fisheries to help frame the process of developing a new management paradigm: status quo, no fishing, limited entry, and terminal fisheries.

The Status Quo

One management option is to continue to use the MSY concept while working to improve its predictive powers. The committee has concluded, however, that the MSY concept by itself is inadequate and impractical as a basis for salmon management because the model implies the existence of a continued surplus production, which is fundamentally inconsistent with historical data. In overfished populations, most stock-recruitment data will be from the lower range of escapement numbers. We can adjust for biases in data, but we cannot correct for the absence of data at larger escapements without actual observations. If we estimated S_{MSY} on the basis of historical data and managed perfectly by annually achieving this value, we would learn nothing about the productive potential or dynamics of a population: we would learn more only about natural variability in recruitment because all the return data would be scattered vertically above the S_{MSY}.

The prevailing social acrimony, particularly in connection with listings under the Endangered Species Act, argues for change in management objectives and a fuller understanding of the salmon problem. As the economic return from the salmon resource declines, debates have become increasingly polarized because action would increase economic disruption in other resource industries. The committee heard considerable testimony lamenting the inability to make the changes needed. No one is willing to accept responsibility; each interest feels that another should do more. The status quo in this social environment will perpetuate further decline and will not sustain salmon population diversity or production.

The No-Fishing Option

One solution is to stop fishing. In many situations, such as those of the Chesapeake Bay striped bass and North Sea plaice, populations have rebounded after cessation of fishing. Because of recent emergency measures taken by the PFMC, this option is in effect for most river and most ocean fisheries in Oregon, California, and Washington waters and in federal waters off those states. In other cases where fishing was stopped, such as the California anchovy fishery, depressed populations have not rebounded. One common argument is that stopping catch certainly cannot hurt and that fishing should not continue when threatened and endangered species are mixed with salmon targeted for catch.

The major problem with the no-fishing option is that the social and economic hardships caused by stopping are substantial, particularly to those who depend on salmon fishing for their livelihood. Fishing cessation usually occurs only when the overall benefits from continued fishing are so reduced that every party gets little from the population. Furthermore, people always expect the factors causing the decline to go away soon and more favorable conditions to return.

Fishers argue that commercial and recreational uses of salmon constitute an important value. They say that fishing is an excellent way of keeping the status of the populations in the public eye. Fishing is a livelihood for professional fishers. Catches are important for economic, subsistence, and ceremonial purposes for American Indians, and the expectation that catches are possible drives the recreational fishery. Eliminating fishing makes salmon less valuable economically.

Eliminating fishing is not a simple issue. Salmon are caught from southern Alaska to the central California coast by netters, trollers, anglers, and charter boats and by both Indian and non-Indian fishers. Should fishing be stopped for Alaska salmon fishers whose runs are generally in much better shape than those returning to the Columbia River? The position of Alaska salmon fishers is that salmon problems in the Pacific Northwest are due to choices made by people of the Pacific Northwest and that Alaskans should not be penalized to fix the region's problems (Pacific Salmon Commission 1993). Salmon from the Pacific Northwest are also caught in Canadian fisheries, and U.S. treaty and nontreaty fishers catch salmon from Canada. The position of Alaskan salmon fishermen has prevented the Pacific Salmon Commission (PSC) from making progress in protecting threatened and endangered salmon runs.

When elimination or control of fishing is discussed, people often think only of commercial fishing, but that is too restricted a view; all fishing kills fish. Is it legally possible to stop treaty fishing? As long as any salmon are available, treaty fishing will continue. Thus, the no-fishing option is complex: it does not imply just a simple decision to close a fishery. Closing one part of the fishery results in another group's getting a larger catch. Treaties give tribes the right to fish in their usual and accustomed places in common with non-Indians. And treaties require the United States to maintain the health of salmon stocks. In a legal sense, treaty fishing would be difficult or impossible to stop; and as long as there is fishing, other fishers will demand fishing opportunities.

If fishing cannot be eliminated legally for some peoples, such as Canadians and treaty fishers, which fishers can be restricted from fishing? Should recreational and charter fishing be stopped? Recreational and charter fishers take relatively few fish and contribute substantially to the economies of coastal communities. One variant of the no-fishing option could be for the United States to stop all ocean recreational, charter, and commercial fishing for salmon in Alaska and the Pacific Northwest. Such a ban would have favorable effects on negotiations with Canada in the PSC. However, it would be fought by all those affected. Another variant of this option would be to close all ocean fisheries in the Pacific Northwest. A complete ban of ocean fishing is close to being realized. It was proposed in 1993 for coho by the PFMC. It was proposed again in 1994 and implemented for coho, leaving only limited fishing periods for chinook. That was not the first time a no-fishing option has been proposed. In 1904, J. P. Babcock, the British Columbia fisheries commissioner, unsuccessfully proposed closing fishing on the Fraser River during 1906 as a conservation measure to build up sockeye stocks. The problem with any partial closure is that, although it might allow some increased escapement, it also redistributes catch among different fishing interests.

Canada and the United States have many points of complementary and cooperative interest that might be negotiated on a smaller, more-specific scale, rather than simple wide-scale closures. One point of complementarity is the catches of Pacific Northwest coho and chinook off the west coast of Vancouver Island and Puget Sound catches of Fraser River sockeye.

Another point of complementarity is the possibility of opening ocean fishing areas to a joint fishery of trollers from Alaska, Canada, and the Pacific Northwest.

The Limited-Entry Option

If cessation of fishing is too strong an option, limiting the number of fishers might be helpful. All West Coast commercial salmon fisheries have some form of limit on the number of gill-net and troll licenses. The underlying idea is that the number of fishers should be limited to correspond to the size of catch that can be taken. The objective of the license- limitation program is to restrict fishing capacity to a level closer to the effort that can be maintained. One problem with limited entry is that it has many of the same elements as the status quo. Limiting entry to the degree necessary to produce the needed effect is perceived as a severe step.

A second problem that limited entry does not solve is the natural tendency of fishers to become more effective. New technology, knowledge, and fishing methods make fishers more efficient with the gear that they have. Thus, a limited-entry program must continually reduce the number of fishers in accordance with both resource availability and the capacity of fishing vessels and fishers to catch salmon (Smith and Hanna 1990); a reliable way to do this has not been perfected.

A third problem is that, as with open-access fisheries, successful application of limited entry depends on the ability to calculate accurately the quantity available for fishing. People want a consistent number, but fisheries are inherently variable; no stable number can be given. A safe number would have to be conservative, and fishers would probably complain that it is too low. The MSY mode of management has continually overestimated the amount available for fishing. With management for genetic diversity, as we have been recommending throughout this report, the focus is on achieving spawning escapements. That will mean highly variable catch opportunities for a much smaller fleet of vessels.

The Terminal-Fishery Option

Catching salmon closer to the place where they spawn allows greater separation of hatchery from wild and threatened from nonthreatened populations. A way to achieve that separation is to allow only terminal fisheries. The separation can be even better achieved with live traps. With live-trap, terminal fishing, salmon needing protection can be released if they are identifiable with minimal potential for harm. Because natural mortality in the ocean, after early transitions to ocean life, reduces biomass more slowly than body growth adds biomass to the population, fishing closer to the spawning grounds would increase salmon yields.

Ocean fishers might question the quality of salmon taken in terminal fisheries; the meat of fish caught nearer to their spawning grounds will tend to be less oily and the skin more colored, and they will be less preferred by some consumers. Salmon do deteriorate in quality as they get closer to spawning, but terminal fisheries in estuaries and river mainstems would not necessarily decrease quality and the average size of the fish would be greater. Two advantages of live-trap, terminal fisheries are the potential to separate populations from one another and the ability to set catch rates for what each population can sustain. For example, salmon from threatened populations could be released. The treaty fishery in the middle Columbia would be a place to experiment with terminal fishing. Shifting to a live-trap fishery also has the potential to increase employment. Recreational fishers view set nets as wasteful of the resource and as yielding lower-quality fish. Live traps would improve the perception of Indian fishing on both conservation and quality grounds.

A major problem with the no-fishing option is at least partially solved by adopting terminal fisheries. Alaskan fishers catch salmon destined for Alaska and British Columbia streams, as well as for the Columbia River and the north coastal area. Alaskan ocean fishers question why their opportunity to fish for healthy Alaskan populations should be jeopardized by habitat and hydropower problems in the Pacific Northwest. Canadian fishers who fish mixed U.S., Canadian, and Alaskan populations do not see a reason to limit themselves when the problem is not theirs. They have not built dams on the Fraser River, and in British Columbia the habitat is less altered.

Although the current catch situation—which is unbalanced between areas—will make it politically difficult to restrict fishing to locations of origin, the committee concludes that it is worthwhile and important. Salmon management—especially population-specific management—is likely only practical if catch were allowed only near the point of origin, and in the long run, the salmon and many fishers would benefit once production increased, although which fishers benefit most would involve social factors.

Developing a New Management Paradigm

Given the complexity and scope of the salmon problem, developing a new management concept will be difficult and contentious. The committee starts by identifying several premises based on its experience:

- In Pacific salmon, the presence of many diverse, spatially distributed spawning populations is closely aligned with genetic diversity, maximal use of available habitat, and potential for increasing production from natural spawners.
- The sustainable exploitation rate is a function of a population's productivity determined over all life phases. Catch is only one of numerous mortality sources and cannot be viewed as independent or as an alternative to other sources over which we do not have control. The fishable portion of a return is determined by the brood-year survival to the time of the fishery and the desired spawning-stock size.
- Salmon are a component of ecosystems and they exist in a dynamic evolutionary process. Their production is variable and interconnected with the condition of their communities and habitats.
- Catch is a function of the fishing rate exerted by a fishery and the abundance of salmon recruited to the fishery. A low fishing rate and a high abundance can yield the same catch as higher fishing rate and a lower abundance.
- Productivity varies among populations and over time. The projected return from any

population and brood year is highly uncertain. Any management process must acknowledge and account for limitations and uncertainty in assessment information and management capabilities.

Those premises consider only biological aspects of fishery management. But the sustainability of salmon in the Pacific Northwest also is inextricably linked to economic development and social values. Society in the Northwest has exchanged natural salmon populations for economic development or argued about who was to blame as the resource declined. Figure 11-5, based on data from Matthews and Waples (1991), demonstrates the decline in Snake River spring and summer chinook salmon since the late 1950s. In spite of a progressive decline, major corrective actions were not taken until 1992, when the chinook were listed as threatened under the Endangered Species Act. The greater the decline in the resource, the greater the disruption will have to be to correct the problem. The committee believes that a stronger social commitment to the biological-resource base must be established if salmon are to be sustained. For the fishery-management process to be effective, a strong commitment to the salmon must be an integral part of the process.

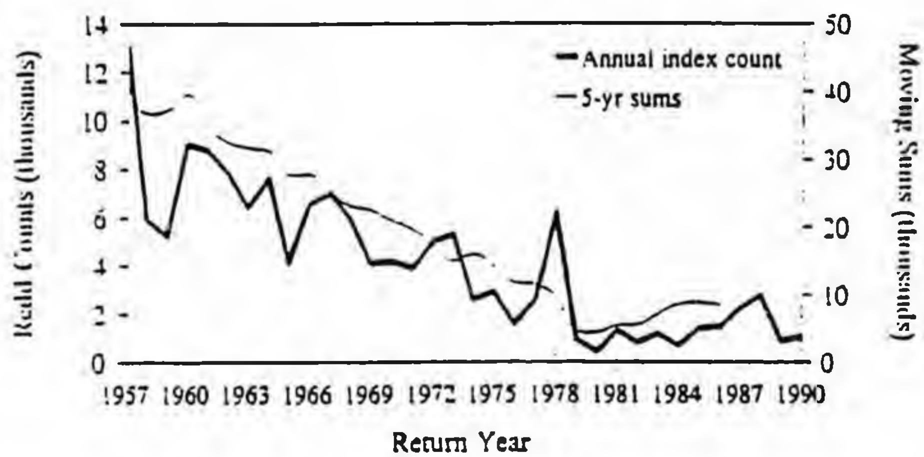


Figure 11-5 Trend in spawning-escapement index for Snake River spring and summer chinook salmon. Trend in annual redd counts and 5-year sum (for smoothing) are presented. Data from Matthews and Waples (1991) for Snake system minus Grande Ronde returns.

A management cycle for fisheries involves four activities: stock assessment to provide the biological advice, development of management plans, conducting the fisheries, and evaluation. The critical elements are sound biological advice, explicit and assessable management objectives (biological, social, economic, etc.), an institutional process for developing management plans, control of fisheries, and accountability in achieving management objectives. We consider those elements below, except for institutional processes and accountability, which are discussed in Chapter 13.

Stock Assessment and Biological Advice

Biological advice is only as sound as the information on which it is based. Advice must recognize limitations and uncertainties in knowledge and in abilities to predict recruitment. For example, the committee suggests that the concept of "optimum escapement" be replaced with a more conservative notion of a minimum sustainable escapement (MSE). An MSE concept avoids a single target escapement value and acknowledges that estimates of S_{MSY} are often biased low and rely on weak historical data. The committee emphasizes that MSE is a minimum and that actual escapements would exceed it and not be scattered about it. The committee's notion was based on protecting against the continued decline in salmon production and on concern about the use of an uninformative, possibly misleading, statistic.

The concept of MSE is analogous to minimum viable population size (Shaffer 1981, Simberloff 1988) and population viability analysis (Gilpin and Soule 1986, Shaffer 1990). It acknowledges that the longer-term sustainability of salmon populations depends on reducing the risk of extinction due to over-fishing and stochastic events (environmental and demographic variability). However, in assessing these risks, society must determine the level of security desired for salmon populations over what time period (i.e., how confident do we want to be that a population will exist in 100 or 200 years).

The MSE level could initially be determined from historical stock-recruitment data, when available. Where the data are not available, initial escapement levels may be derived from habitat assessments and/or historical escapement trends. This information may then be incorporated in demographic or life history models to determine MSE at a particular level of confidence. Uncertainty about the biological basis of this level must be allowed for when assessing the risk of extinction, but in many cases, the appropriateness of the initial MSE will be unknown. However, under the MSE concept, populations would generally be at less risk than under the earlier MSY approach, because escapements should exceed the minimum value (unless survival is so poor that the MSE is not achievable even under the absence of fishing mortality).

Estimates of MSE should ideally include information about the composition of spawning populations, the maintenance of connections between salmon demes, the role of carcasses as nutrient sources for freshwater ecosystems, intraspecific competition in reproduction, mate selection, and gene flow, but relatively little attention has been given to these factors. The need for levels of escapements that promote competition and fertilization or that maintain niches used by salmon is not well demonstrated with direct research.

In summary, the committee recommends the establishment of minimum safe levels of spawning escapements to reduce the risk of continued loss of salmon populations and production. Actual escapements should always exceed this value, with allowances for assessment error for abundances near this minimum level. Escapements would vary above the minimum depending on the population abundance and sources of mortalities. Escapements substantially above these minima will be needed to maintain salmon productivity (and therefore, sustainable exploitation rates) in many more populations than are presently available. These increased escapements are also likely to have benefits in expanding the number of spawning populations, increasing genetic diversity within populations, and enhancing natural ecological processes.

Management Objectives

The major change in objectives related to the sustainability of salmon must be to broaden the set of biological objectives. That does not imply a priority of biological objectives over socioeconomic objectives, but socioeconomic objectives should complement biological objectives. The committee concludes that the resource base necessary to sustain salmon production consists of genetic diversity (both within and between natural breeding populations) and the habitat used by all life stages of the species. Genetic diversity provides for the continuing evolutionary process and is the biological basis of future salmon production. Therefore, the committee recommends managing for the joint biological objectives of MSE and increased diversity in local breeding populations, which will result in increased production in the long run. Increasing the size and number of spawning populations will, on average, increase the abundance of salmon. The committee acknowledges that increasing diversity will require initial reductions in catch because animals must survive to reproduce. However, catch in future years should increase as salmon production increases, even though fisheries probably would be managed at lower catch rates to maintain the diversity within local breeding populations and promote the development of interpopulation diversity.

Figure 11-6 shows what is expected in accordance with MSE. Graphs A, B, and C represent what has occurred commonly in the past. Natural or wild (N) and hatchery (H) populations have been fished simultaneously, but the hatchery population has higher productivity. As total population (N + H) increases, catch often increases to a maximum (Figure 11-6b), but the catch rate (i.e., the portion of the available salmon abundance that is caught) may not be sustainable by N. Consequently, the catch of N + H begins to decrease because of the declining production from N. Eventually, management responds to conservation concerns for N and reduces the catch to conserve N. If that situation is visualized over many natural populations, loss of population diversity can be characterized by Figure 11-6c. Diversity, if measured simply by the existence of spawning populations, would be maintained for a longer period than the catch (N + H). But under increased fishing pressures, the less-productive N will begin to be lost. Diversity would probably stabilize as catch is curtailed to conserve population diversity. Under a management policy to increase interpopulation diversity and achieve minimum escapement levels, the expected outcomes would be increased habitat use by spatially and temporally more diversified salmon populations and an increased catch achieved at a lower, sustainable rate of fishing (Figure 11-6d). The potential cost of this plan is an initially decreased catch of N while diversity is increased. The magnitude of initial loss depends on the specific situation.

A useful analogy of this plan is the idea of salmon runs as a tree. Each stem, branch, and twig on the tree is a potential home for a local breeding population, an isolated reproductive group adapted to the conditions of that particular stem, branch, or twig. Some salmon climb mighty trees like the Columbia and Sacramento with complex branching. Others climb much smaller, less-complex trees like coastal streams. Cutting limbs from the dendritic structure of these salmon "trees" or placing obstructions on major limbs prevents local breeding populations from filling out the evolutionary potentials offered. That reduces the genetic diversity and viability of the salmon population as a whole and reduces habitat use and the potential production of salmon. A more holistic approach in salmon management would focus attention

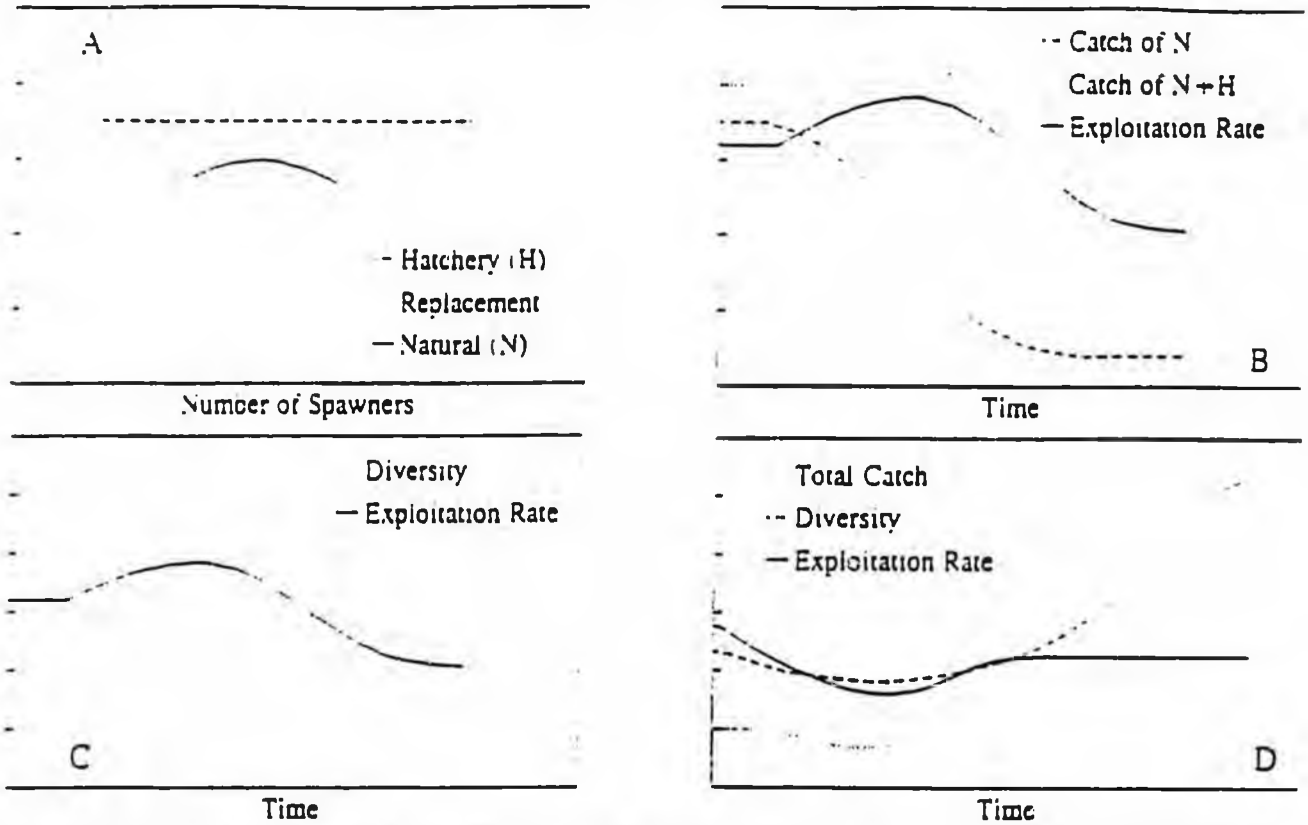


Figure 11-6 Schematic portrayal of observed historical trends in salmon populations, catch, and exploitation (plots B and C) and the expected outcome of managing for a minimum safe escapement (MSE) objective and rehabilitation of interdemic diversity (plot D). Plot A is a stock-recruitment curve showing number of recruits as a function of the number of spawners. In plots B - D, the vertical axes represent numbers of fish (for catch curves), numbers of populations (for diversity curves), and percentages (for exploitation rates). The exploitation rate is the total mortality associated with fishing activities, including the landed catch, incidental catch, discards, and hooking mortality. See text for further details.

on filling out the trees' foliage so that viable local breeding populations of salmon inhabit as many branches as possible.

How could those joint biological and socioeconomic objectives be implemented in a management plan? The committee has considered only a general process because details of implementation would involve social values and decisions. For example, how quickly diversity increases will be associated with how much social change is acceptable or with the array of economic alternatives in a specific area. A possible process would involve the following:

• Identification of natural populations with the quantitative information needed for a credible population assessment and determination of an MSE and exploitation rate that, on average, would be allowable at this level of spawning-population size. Currently there are few of these "assessment" populations, but the application of a safe escapement level will reduce the risk of misapplication to other populations and should provide reasonable starting points in the plan development. Total fishing mortality would initially be limited to the exploitation rates at the MSE.

• Predictions of available abundance to fisheries. The methods might vary between regions, species, etc., but should account for spawning-population sizes, environmental variation, and interceptions in fisheries outside the management zones. Abundance forecasting also might prove to be highly uncertain. but methods to incorporate in-season information with pre-season estimates (see Noakes 1989) could be useful in controlling fishing impacts.

• Establishment of survey designs for estimating diversity within local breeding populations. The essential need is to measure diversity and how it changes over time. Surveys would be designed to be repeatable annually and to measure quantitatively the spatial and temporal diversity of local breeding populations.

• Conduct of annual evaluations involving quantitatively assessed indicator populations. surveys of the spatial and temporal diversity of local breeding populations within geographic areas. and fishery dynamics. The indicator populations would include natural populations on which accurate stock-recruitment data can be collected and whose dynamics (e.g., freshwater and marine survival rates. productivity, etc. [see Holtby and Scrivener 1989]) can be studied. natural populations that are conducive to repeatable annual estimates of spawning escapement. and hatchery populations whose exploitation rates can be determined. Fishery dynamics are assessed to understand units of effort. relationships between catch and effort. and effort responses to abundance and ultimately to estimate catch levels for a fishery.

• Assessment of progress toward the biological objectives and incorporation of what is learned from evaluations into future management plans. Given the limitations in our knowledge and the inherent variability in the environment. the committee strongly endorses adaptive management (Walters 1986) to achieve sustainability for salmon. For example, the response of natural populations to management changes can be confounded by environmental variability. Experimental designs can be useful in controlling this interaction (see Walters et al. 1988) and in improving detection of changes in diversity over time and under different management plans or fisheries. The use of adaptive management, however, emphasizes the need for effective institutional processes for communication and participation in the development of longer-term management plans.

Control of Fisheries

Meeting the joint management objectives of achieving the MSE and increasing diversity of local breeding populations diversity will not resolve the mixed-population fishing problem or settle allocation debates. Without greater control on fishing impacts, meeting the objectives could even exacerbate these problems. Furthermore, the sequential alignment of fisheries in the Pacific Northwest, from ocean mixed-population fisheries to more terminal fisheries involving fewer populations, could result in inequitable disruption of fisheries. But sequential fisheries also present an opportunity to compensate for fishing impacts among fisheries. Given the complex of fisheries, variations in population size, and the need for social decisions in establishing a fishing plan, the committee felt that it was impractical to comment on any specific fishing options. There are only two general kinds of strategies for meeting the objectives through fishing controls:

• Reducing exploitation rates over all populations in a fishery—fishery-oriented strategies.

• Increasing the specificity (in time, area, gear, species, etc.) of a fishery to avoid or minimize impacts on particular populations—population-oriented strategies.

There are many ways to implement each kind of strategy. Fishery strategies can vary from no fishing through allowing exploitation only in specific fisheries to reducing exploitation rates in all fisheries. Population strategies can divert fishing effort to another time or area, develop a selective fishery for only marked animals (i.e., prohibit retention of unmarked fish), or develop selective fishing gear, such as live traps and fishwheels. Strategies can also be combined to limit exploitation of some populations while maintaining a fishery on others. For example, an ocean troll or recreational fishery might be managed at low exploitation rates that are sustainable by most populations. Terminal fisheries could then be managed to compensate for these ocean-fishery mortalities by either increasing or decreasing further exploitation on a population.

In developing a fishing plan, managers have to balance fishing capacity (number of vessels, effort, market prices, etc.), availability and quality of biological data (on abundance, stock composition, previous fishing impacts, etc.), and social agreements (allocation requirements, treaty vs. nontreaty, ocean recreational vs. ocean troll, etc.). Each balance has problems. In the Northwest, more people would participate in fisheries if there were more fish. The potential for additional fishing pressure is an important source of uncertainty in how a fleet will respond to a particular fishing plan. The quality of biological data varies among fisheries, but the catch rate is seldom known until after the fishing has ended for the season. Achievement of allocation agreements is uncertain because population-specific fishing mortalities often are unknown or a substantial portion of the allowable catch might be taken in fisheries outside the management region, e.g., in Canada or southeastern Alaska. The most common problem, though, is our limited ability to control in-season fishing impacts, especially on a population-specific level. In the absence of reliable pre-season predictions of population and fishery abundance, fishery managers have developed in-season estimation procedures to monitor abundance and run timing. These procedures normally compare historical test-fishery catches or catch-per-unit effort from specific fisheries, with run-size estimates to develop in-season prediction models. These models frequently also have large uncertainties due to variation in run timing, stock compositions, and environmental conditions; or simply due to measurement error in historical data. In summary, the quality of biological data varies widely between fisheries, and exploitation rates in fisheries are seldom known. This uncertainty places the objective of increasing genetic diversity at risk and argues for the continued application of conservative fishing plans, particularly in the mixed-population ocean fisheries. Fishers should recall, however, that fishing at a lower rate on an increasing population will eventually restore catch levels.

Developing fishing plans for each of the Pacific Northwest regions will necessitate consideration of specific resource problems, distribution of fisheries, and social groups. Choosing a strategy requires establishing priorities and making a number of difficult social choices. But fishing is only one mortality factor. Fishers can enhance the spawning population by forgoing catch, but salmon also require habitat for long-term sustainability. The control of fishing as a means to approach sustainability in salmon will be only as successful as our ability to address the freshwater-habitat issues. We would also expect greater support from fishers if they could see a successful return on the spawners invested. Presumably, the same would be true of Canada's participation in the Pacific Salmon Treaty

CONCLUSIONS

Since the nineteenth century, in an effort to maximize catch, salmon fisheries of the Pacific Northwest have exploited a mix of wild-spawning and hatchery-produced salmon. Fishing moved farther into the ocean to catch more and better-quality salmon earlier in their life cycle, but the stream origins of these fish were unknown. Social pressures pushed catch levels toward those which only the most-productive populations could sustain, but they were often too high for natural populations. Mixed-stock fisheries developed for human convenience, and society watched as local breeding populations of salmon went to extinction or were depressed severely. Fishing impacts and the promotion of regional economic growth combined to alter salmons' environment to their detriment. The existing technocratic model for fishery management, productivity enhancement, and environmental modification has not been able to sustain salmon catches or the diversity of salmon populations. The result has been a major reduction in economic opportunity for fishers. All fishers have without doubt suffered possibly irreparable injury from the status of salmon and the management prescriptions to deal with it. The decline in income is much greater than that in any other major resource industry in the Pacific Northwest, and catches by American Indian fishers are now smaller in numbers of fish than before the Boldt decision.

The committee concludes that fishery management objectives must explicitly recognize the need to conserve and expand the genetic diversity of the salmon resource. To accomplish this, emphasis must be given to minimum sustainable escapements and filling out the dendritic structure of salmon habitats.

A more holistic management approach must recognize the connections between the genetic resource base, habitat, and the resulting salmon production; it must also account for the uncertainty in our scientific advice and for inherent environmental variability. The committee has outlined a process intended to improve the potential sustainability of salmon in the Pacific Northwest. Furthermore, the committee does not believe that the sustainability of Pacific Northwest salmon can be achieved without limiting the interceptions of U.S. salmon in Canada and obtaining the cooperation of Alaska. An effective and cooperative Pacific Salmon Treaty is necessary. The committee does not provide specific recommendations about altering specific fisheries, because there are numerous options and interactions between fisheries. Achieving agreement on changes in fisheries will be difficult and necessitates an effective institutional process.

Executive Summary

Pacific salmon have disappeared from about 40% of their historical breeding ranges in Washington, Oregon, Idaho, and California over the last century, and many remaining populations are severely reduced. Most runs that appear plentiful today are largely composed of fish produced in hatcheries. Recreational and commercial fishing for several salmon species has been restricted or even prohibited from the coastal waters of the region to the headwaters of many streams, and tribal fishing has been much reduced. Petitions have been filed to list several populations as endangered or threatened under the Endangered Species Act; a few have been listed, and more could be soon.

Salmon have great cultural, economic, recreational, and symbolic importance in the Pacific Northwest. As a result, their declines—which have numerous interacting causes—have resulted in much concern. The often expensive efforts to reverse the declines have been controversial and unsuccessful in many cases. Faced with the possibility of dozens or perhaps even hundreds of listings of Pacific salmon under the Endangered Species Act, and faced with controversies over the effectiveness of proposed actions to slow, halt, or reverse the salmon declines, Congress requested advice from the National Research Council (NRC). In response, the NRC's Board on Environmental Studies and Toxicology assembled the expert Committee on Protection and Management of Pacific Northwest Anadromous Salmonids to review information concerning the seven species of anadromous salmonids[1] in the Pacific Northwest.

The committee was asked to "evaluate options for improving the prospects for long-term sustainability of the stocks, and [to] consider economic and social implications of such changes" (statement of task; see Preface). It was asked to perform the following tasks:

- Assess the status of the salmon stocks.
- Analyze the causes of declines.
- Analyze options for intervention.

The committee was asked to consider all stages of salmon life histories, including the ocean phase, and to consider the appropriate roles of hatcheries. Congress did not request advice on whether society *should* make the investments needed to halt and reverse salmon declines. However, the committee's analysis of options for intervention and their likely effectiveness should help to inform that policy decision.

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[1] This report deals with anadromous forms of the seven species of the genus *Oncorhynchus*. They are chinook, chum, coho, pink, and sockeye salmon and the anadromous forms of rainbow and cutthroat trout: steelhead and searun cutthroat. In this report, the general term *salmon* refers to all seven species.

STATUS OF SALMON POPULATIONS

The status of many specific salmon populations in the Pacific Northwest is uncertain, and there are exceptions to most generalizations with regard to overall status. Nevertheless, a general examination of the evidence of population declines over broad areas is helpful for understanding the current status of species with different life cycle characteristics and geographical distributions, and with some caution, the following generalizations are justified:

- *Pacific salmon have disappeared from about 40% of their historical breeding ranges in Washington, Oregon, Idaho, and California over the last century, and many remaining populations are severely depressed in areas where they were formerly abundant.* If the areas in which salmon are threatened or endangered are added to the areas where they are now extinct, the total area with losses is two-thirds of their previous range in the four states. Although the overall situation is not as serious in southwestern British Columbia, some populations there also are in a state of decline, and all populations have been completely cut off from access to the upper Columbia River in eastern British Columbia. Even if the estimate of population losses of about 40% is only a rough approximation, the status of naturally spawning salmon populations gives cause for pessimism.
- *Coastal populations tend to be somewhat better off than populations inhabiting interior drainages.* Species with populations that occurred in inland subbasins of large river systems (such as the Sacramento, Klamath, and Columbia rivers)—spring/summer chinook, summer steelhead, and sockeye—are extinct over a greater percentage of their range than species limited primarily to coastal rivers. Salmon whose populations are stable over the greatest percentages of their range (fall chinook, chum, pink, and winter steelhead) chiefly inhabit rivers and streams in coastal zones.
- *Populations near the southern boundary of species' ranges tend to be at greater risk than northern populations.* In general, proportionately fewer healthy populations exist in California and Oregon than in Washington and British Columbia. The reasons for this trend are complex and appear to be related to both ocean conditions and human activities.
- *Species with extended freshwater rearing (up to a year)—such as spring/summer chinook, coho, sockeye, sea-run cutthroat, and steelhead—are generally extinct, endangered, or threatened over a greater percentage of their ranges than species with abbreviated freshwater residence, such as fall chinook, chum, and pink salmon.*
- *In many cases, populations that are not smaller than they used to be are now composed largely or entirely of hatchery fish.* An overall estimate of the proportion of hatchery fish is not available, but several regional estimates make clear that many runs depend mainly or entirely on hatcheries.

Chapter 4 discusses some of the difficulties in evaluating the status of wild populations and how these difficulties have been addressed in recently published status reports. Regional trends are summarized, and the overall conditions of the species are presented.

THE SALMON PROBLEM

The salmon problem is the decline of wild salmon runs and the reductions in abundance of salmon even after massive investments in hatcheries. The declines—largely a result of human impacts on the environment caused by activities such as forestry, agriculture, grazing, industrial activities, urbanization, dams, hatcheries, and fishing—are widespread, although not universal. They have a variety of causes, and they are exacerbated by the unusual life cycle of Pacific anadromous salmon, which spawn in freshwater, migrate to sea to grow and mature, and return to their natal streams to reproduce. Salmon thus require high-quality environments from mountain streams, through major rivers, to the ocean. Economic development and population growth have created widespread declines in anadromous salmon abundance in the Pacific Northwest. Variations in ocean conditions—especially in water temperature and currents and the associated biological communities—also contribute to the rise and fall of salmon abundance, often thwarting the interpretation of events in freshwater and the surrounding terrestrial systems.

GENERAL CONCLUSION

To achieve long-term protection for a diversity and abundance of salmon in the Pacific Northwest, two general goals must be achieved:

- The long-term survival of salmon depends crucially on a diverse and rich store of genetic variation. Because of their homing behavior and the distribution of their populations and their riverine habitats, salmon populations are unusually susceptible to local extinctions and are dependent on diversity in their genetic make-up and population structure (Chapter 6). Therefore, management must recognize and protect the *genetic diversity* within each salmon species, and it must recognize and work with local breeding populations and their habitats. It is not enough to focus only on the abundance of salmon.
- The social structures and institutions that have been operating in the Pacific Northwest have proved incapable of ensuring a long-term future for salmon, in large part because they do not operate at the right time and space scales. As described in Chapter 13, differences among watersheds mean that different approaches are likely to be appropriate and effective in different watersheds, even where the goals are the same. This means that institutions must be able to operate at the scale of watersheds; in addition, a coordinating function is needed to make sure that larger perspectives are considered.

As a framework in which to approach its deliberations, the committee chose to focus on *rehabilitation*—a pragmatic approach that relies on natural regenerative processes in the long term and the selected use of technology and human effort in the short term—rather than on attempts to restore the landscape to some pristine former state and rather than on a primary reliance on substitution, i.e., the use of technologies and energy inputs, such as hatcheries, artificial transportation, and modification of stream channels. Rehabilitation would protect what remains in an ecosystem and encourage natural regenerative processes.

The solutions will not be easy or inexpensive to implement; even a holding action to prevent further declines will require large commitments of time and money from many people in many segments of society in the Pacific Northwest. Therefore, broad-based societal decisions are needed to successfully provide a long-term future for natural salmon populations.

ENVIRONMENTAL FACTORS

Natural and human-caused environmental changes affect all aspects of salmon life histories. Although humans can do little in the short term to control or even predict large-scale changes in environmental conditions, salmon-management programs must expect such changes and take them into account. Managers must also recognize that the natural variability in environmental conditions and people's desires for large and stable catches of salmon are often not compatible. Natural changes in environmental conditions in the ocean, in fresh water, and on land occur continually; sometimes they can lead to increased salmon productivity in an area; at other times they can lead to decreased productivity.

The emerging understanding of interdecadal changes in the ocean climate and the related mechanisms that affect salmon at sea have implications that are both exciting and disconcerting to scientists thinking about resource management. Humans are beginning to understand what happens to salmon during the majority of their lives—the portion spent at sea. Although we know little of the details, the new insights already demonstrate that variations in salmon abundance are linked to phenomena on spatial and temporal scales that humans and human institutions do not ordinarily take into account. Consider that the apparent effectiveness of hatcheries might have resulted from favorable ocean and climatic conditions in the era when the hatcheries were built; what looked like human manipulation of the total number of salmon might have been only a reapportionment among different populations. Or consider that the decline of some populations might be a direct result of introducing new hatchery populations into an ocean pasture of limited capacity.

The scale of human endeavor often has been incommensurate with the scale of salmon ecology. Some of our current policies are based on deep ignorance: it is not reasonable to assume that ocean conditions vary in ways that are generally uniform and random in their impacts on populations of salmon. Interdecadal variations and the importance of the ocean phase should be incorporated into human thought, planning, and actions in response to the effects of and attempts to repair damage that occurred during the freshwater phases of the salmon lives. The possible overriding effects of interdecadal changes in ocean conditions on salmon, the results of freshwater salmon management, and the overwhelming focus of human attention on the more-visible freshwater phases of the salmon history combine to provide the key ingredients for surprises in future.

Recently, natural environmental conditions in the Pacific Northwest appear to have been unfavorable to salmon production. As changes continue to occur, environmental conditions will probably favor salmon and lead to larger runs in some areas for a time, even without human intervention. If such changes do occur, they should be regarded as providing time to develop better strategies for rehabilitation of salmon populations. They should *not* be used as reasons for abandoning efforts to rehabilitate salmon, for they will surely be followed by other natural changes. Inappropriate short-term responses to large-scale environmental changes at sea or on land should be avoided, because there can be long lags between causes and effects.

LIMITS ON SALMON PRODUCTION

The salmon production cycle has three principal components that determine abundance:

reproductive potential of adults returning from the sea to spawn, which is affected by their growth at sea; production of offspring from natural reproduction in streams and artificial propagation in hatcheries; and sources of mortality (including natural mortality, fishing mortality, dam-caused mortality, mortality from habitat alterations and changes in environmental conditions, and so on). All three components are affected by changes in environmental conditions as well as by human activities. Variation in the three components and their interactions ultimately determine the ability to sustain salmon populations and their production. These limitations cannot be easily overcome through technology. Although it has been widely assumed that a loss of natural salmon production can be compensated by enhancement (e.g., by increasing hatchery production), chapters 6, 11, and 12 show that such an assumption is untenable by explaining the need to conserve sufficient genetic variation in natural populations to support the evolutionary and ecological processes needed for sustained salmon production. Compensating for salmon loss from any source over the long term therefore requires reducing other losses. Furthermore, an increasing appreciation of the marine environment and its effects on the above components is emerging as an essential consideration in salmon management.

VALUES

The salmon problem, like many other environmental issues, has been addressed through choices made within economic, political, and individual ethical frameworks. Values and ethical positions held by people involved in and affected by the salmon problem encompass a pluralistic, pragmatic and evolutionary approach to natural resource management. Recognizing and articulating that pluralism is important because problems in managing and protecting fish populations are due in part to the failure to articulate divergent interests, goals, and values and to address them explicitly. Chapter 5 describes how the widely varied ways that humans intervene in salmon populations are linked to socially validated values.

From a policy perspective, the salmon problem is one of long-standing and serious conflict in fact, interest, and values. People often invoke widely held values to protect particular interests, but values are genuine sources of conflict in themselves. Value conflict stems from different assessments of the desirable goals of public action. From a scientific perspective, wild salmon populations are an example of an ecosystem's natural capital. Our greatest success has been in designing ways to use human-food benefits from wild salmon. Our corresponding failure has been in protecting indirect and nonhuman benefits.

One way to present the salmon problem is to say that the value of the Pacific Northwest's salmon-capital asset has depreciated over time as its productivity has declined. A major problem is that the market does not account for the full range of costs and benefits of salmon. That is called a market distortion. When such market distortions exist, some resources are underpriced and overused, and others overpriced and underused. Many nonmarket values of salmon are underrepresented and are not easy to measure or compare. Thus management decisions often do not adequately reflect the importance of salmon to society and decisions about resource use may not achieve societal goals. To correct the discrepancy between social values and resource use, attempts can be made to design policies that reflect the full range of resource values.

Full value is a public, not a private, question. Consequently, public choices are central to the salmon problem. Public choices have to take into account many owners with multiple preferences, attributes that are not fully observable and sometimes unknown, and prices that reflect only part of the resources' full value to society. The concept of full value points to the problem of "externalities"—the problem that some costs and benefits are beyond the accounting of the decision-making unit.

Environmental variability creates economic uncertainty, which causes people to discount the future more heavily, and this leads to pressures to increase rates of immediate, direct use. Environmental variability also creates scientific uncertainty about biological processes, which can be perceived to call for a cautious approach and lead to pressures to lower rates of immediate, direct use. The resulting tension between economic and scientific responses to uncertainty adds complexity to decisions about appropriate rates of resource use. That tension is widespread in decisions concerning the salmon problem.

Problems like these emphasize the need to develop more appropriate interdisciplinary approaches. The idea of rebuilding the salmon runs of an industrialized ecosystem is heroically optimistic—a hope that might not have occurred to anyone except those who had rehabilitated the Willamette River basin in Oregon or Lake Washington near Seattle. Those environmental successes came through the disciplined execution of the planning paradigm that has been fitfully applied to the much larger Columbia basin. The extension of those experiences to the multijurisdictional, multifunctional situations of the Pacific Northwest would require coordinated action and learning on a new, larger scale—a scale on which planning and action have been tried but have not been successful. A more explicit appreciation of the values, interests, and institutions involved in this undertaking is required. Chapter 13 explores this further and urges constructive change in institutions that include cooperative management, bioregional governance, and adaptive management.

GENETICS AND CONSERVATION

Pacific salmon reproduce in freshwater streams. Their progeny migrate to the sea to grow and mature, and then return to freshwater streams to reproduce and (nearly always) die. This pattern of freshwater reproduction and growth at sea is called *anadromy*. Most of the adults actually return to the streams where they hatched. This behavior—called *homing*—is an essential part of salmon biology and makes their genetics and conservation unusual. There is a great deal of environmental variation among the various streams and lakes where salmon spawn and in the rivers through which they migrate. Because of their anadromous life cycles and homing behaviors and the variety of environments they occupy, each salmon species tends to differentiate into local breeding populations—called *demes*—that are in general reproductively isolated from other populations and adapted to each stream. To sustain productive natural populations of salmon, it is crucially important to maintain this genetic variation and local adaptation. Chapter 6 describes examples of such local adaptation.

However, more is involved than only local adaptation to various streams. Natural environmental fluctuations, including major disruptions caused by geological activity, can cause the extinction of local populations. Because homing is not perfect, fish that stray from nearby streams can replenish those populations. Strays are more likely to re-establish a population if the environment in the new stream is similar to that in the stream where they hatched. Thus, strays into tributaries in the same major river system or into nearby streams are more likely to succeed than those that stray into very different environments. This network of local populations (known as a *metapopulation*) provides a balance between local adaptation and the evolutionary flexibility that results from exchange of genetic material among local populations (Chapter 6). It likely also explains why artificial attempts to re-establish populations from a captive broodstock have often failed—too often, the gene pool of the broodstock has had reduced variation or has been derived from a population adapted to a different environment (Chapter 12). The metapopulation structure provides a balance between local adaptation and evolutionary flexibility; therefore, maintaining a metapopulation structure with good geographic distribution should be a top management priority to sustain salmon populations over the long term. Many of the committee's recommendations are based on this crucial conclusion.

There is no "correct" answer to the question of precisely how much biological diversity and population structure should be maintained or can be lost to provide a long-term future for salmon. Scientific estimates—including uncertainties associated with them—are only part of the argument. Society must decide what degree of biological security would be desirable and affordable if it could be achieved, i.e., the desired probability of survival or extinction of natural populations, over what time and what area, and at what cost. Nonetheless, biological diversity and the structure of salmon populations are being lost at a substantial rate, and this loss threatens the sustainability of naturally reproducing salmon populations in the Pacific Northwest.

HABITAT LOSS AND REHABILITATION

The main habitat requirements of salmon in freshwater include a stream or lake, the adjacent border of vegetation (riparian zone) that serves as the interface between aquatic and terrestrial ecosystems, and the quality and quantity of water (Chapter 7). The water must be clean enough and cool enough to support returning adults, for eggs to hatch, and for young to survive and grow until they migrate to sea. There must be enough water in the rivers at crucial times to make migration possible, to allow fish to escape predators, and to allow fish to find adequate food. Well-aerated streambed gravels are important for spawning. Streamside vegetation provides shade, which keeps the water cool; it provides a buffer against soil erosion, which maintains water quality; it provides living space for various animals that provide food and nutrients for streams; and it provides a source of large woody debris, which plays a key role in the formation of physical habitat and storage of sediment and organic matter and provides habitat complexity in stream channels, thus improving the stream environment for salmon. These requirements for environmental conditions in streams and adjacent riparian zones depend on the condition of the entire watershed in which they occur.

Many human activities—such as forestry; agriculture; grazing; industrial uses; commercial, residential, and recreational development; and flood control—have a variety of adverse effects on salmon habitats. For example, they can increase soil erosion, reduce the amount of woody debris in streams, raise the water temperature, add contaminants to the water, affect water flow, and reduce the amount of water available, with resultant loss or degradation of riverine and adjacent riparian and near-river habitat. Therefore, protection and rehabilitation of riverine and riparian habitats and associated watershed processes will be an integral part of rehabilitating salmon populations, although it is a major and difficult undertaking (Chapter 8). In the past few years, genuine improvements in protecting forested streams have been initiated. Nonetheless, for real progress to occur, habitat protection must be coordinated at landscape scales appropriate to salmon life histories, and they must be more consistent across different types of land use (chapters 8 and 13).

DAMS

Hundreds of dams have been built on rivers of the Pacific Northwest. They range from small irrigation dams with a hydraulic head of only a few feet to massive dams at Grand Coulee, Dworshak, and Hells Canyon on the Columbia and Snake rivers that are several hundred feet high and completely block upstream and downstream passage of anadromous fish. Dams on various rivers—some of them impassable—have greatly reduced wild runs. Even smaller dams (e.g., those associated with many hatchery operations and irrigation-diversion dams) can block salmon runs. In addition to their effects on migration, large storage dams affect the quantity and timing of water flow in the river as well as flow velocities, water chemistry, and water temperatures. Reservoirs behind dams can also inundate extensive areas of spawning and rearing habitat, although in some cases the reservoirs provide new (but different) rearing habitat. Many water diversions for irrigation lack protective fish screens of modern design; installing such screens would reduce mortality of smolts as they migrate downstream.

Even when fish ladders provide passage for adult salmon, many young salmon (smolts) migrating downriver die at dams. Although as many as 90% of young salmon might survive passage over, around, and through any single major project on the Columbia-Snake mainstem, the cumulative reduction in survival caused by passing many projects has adversely affected salmon populations. To counteract these effects, it is essential to improve the survival of smolts migrating through hydropower projects, especially in the Columbia and Snake rivers. Serious consideration needs to be given to all available alternatives for doing so; even a small improvement in survival would be helpful if it were repeated at several dams.

Controversy surrounds the effects of dams and how best to mitigate them. Alternatives include removal of dams, modification of turbines and other structural aspects of dams to improve fish survival during passage, drawdown of the water during the seaward migration of smolts to restore the river's profile to its pre-dam (river-grade) configuration to increase the flow rate and diminish the smolts' travel time, drawdown of the river to some level above river grade, augmentation of water flows during smolt migration to speed their passage downriver, transportation of smolts around dams by truck or by barge, control of predators in reservoirs and below dams, and spilling of water over dams instead of through the turbines. However, there is a dearth of good scientific information on which to base evaluations of the alternatives, some of which would be very expensive and would cause large losses of hydropower revenues.

Dam removal and drawdown of those rivers to river grade would be enormously expensive, would take many years, and probably would have long-term adverse impacts on the rivers. However, because the many dams on the Columbia River and its tributaries cumulatively have large effects on salmon survival, the addition of any new major dams in undammed reaches in the system (e.g., the Hanford Reach of the Columbia River) would make the situation worse;

existing dams should have adequate fish-passage facilities where feasible and appropriate before being relicensed. The committee is unaware of any scientific data that unequivocally support drawdown to a level above river grade as the best available dam-mitigation option for the Columbia River or the Snake River. Based on limited information, transportation appears to be the most biologically effective and cost-effective approach for moving smolts downstream. It should be continued on an adaptive basis (i.e., in such a way that additional information can be obtained about its effectiveness). Additional information is needed on effects of transportation on survival to the adult return stage, on homing, on success of natural spawning, and on genetic diversity of returning adults. Because any action that could jeopardize all of the fish in a stream must be avoided, not all the fish in any stream should be transported.

Research is needed on the effects of various options on the survival of both smolt and adult migration through dam and reservoir systems. Any management option should be applied on an adaptive (experimental) basis. The committee is not recommending that the salmon be "studied to death," a criticism often leveled at those who urge further studies. Indeed, enough is known now to take some actions. In recommending "adaptive" actions, the committee is recommending that any mitigative actions be taken in a way that allows their effects and effectiveness to be measured and assessed objectively. For example, if some fish in a stream are transported downstream, the action should be designed so its effectiveness can be assessed and compared with other alternatives. Despite the paucity of information, it is clear that no single approach would eliminate the adverse effects of dams on salmon.

HATCHERIES

Hatcheries have been used for more than 100 years in attempts to mitigate the effects of human activities on salmon and to replace declining and lost natural populations. As a result, a major proportion of salmon populations in the Pacific Northwest now consist largely of hatchery fish. These hatchery fish appear to have had substantial adverse effects on native fish populations.

For many years, people did not recognize the potential for hatchery fish to affect wild fish and did not believe that there was any limit to the ocean's capacity to provide food for growing salmon. It therefore seemed that producing more juveniles would result in more returning adults. The difficulties and shortcomings of hatchery production did not become apparent until fishing pressure and habitat-related mortality increased and marking technologies became available. As a result, hatcheries were not part of an adaptive-management program; that is, they were not considered as scientific experiments—they were not even adequately monitored—so many of their effects were not well known.

It is now clear from synthesis of experience and from consideration of well-established biological knowledge that hatcheries have had demographic, ecological, and genetic impacts on wild salmon populations and have caused problems related to the behavior, health, and physiology of hatchery fish. They have resulted (among other effects) in reduced genetic diversity within and between salmon populations, increased the effects of mixed-population fisheries on depleted natural populations, altered behavior of fish, caused ecological problems by eliminating the nutritive contributions of carcasses of spawning salmon from streams, and probably displaced the remnants of wild runs (Chapter 12). Hatchery fish have at times exceeded the capacity of streams and are increasingly being associated with reduced marine growth and survival in wild salmon populations (Chapter 12).

Many of the problems stem from purposes to which hatcheries have been put—mainly to provide substitutes for natural populations lost or displaced because of human development activities. Because of their deleterious impacts, however, hatcheries should no longer be viewed solely as factories for producing fish. Hatcheries should also be thought of as laboratories that can provide controlled environments for studying juvenile fish and for testing treatments to improve our understanding of what happens to juveniles after they leave spawning areas. Seen in that light, hatcheries can be a powerful tool for learning about salmon.

Hatchery planning, management, and operations should be changed so that their goals are to assist recovery of wild populations and to increase knowledge about salmon. As described above and in many parts of this report, especially chapters 6, 11, and 12, precautions must be taken to protect the genetic diversity and ecological productivity of naturally spawning populations of salmon. Those precautions will include an overall decrease in hatchery-fish production and—over the short term—in fishing opportunities. The basic guideline is to ensure that any hatchery production for fishing is not detrimental to natural populations. Because adaptive-management experiments should be tailored to the circumstances in different watersheds of the Pacific Northwest, decisions about use of hatcheries will differ across these watersheds. Therefore, decisions about uses of hatcheries should include a focus on the whole watershed and its linkage to the region and the ocean pasture, rather than only on the fish.

FISHING

Fishing for salmon is important in the Pacific Northwest. It includes commercial, recreational, and treaty fishing at sea and in rivers and is an important source of mortality, especially for adults returning to spawn. Salmon mortality caused by other human activities and structures such as dams, habitat loss or degradation, pollution, and water diversion and by natural factors such as predators, disease, and environmental variability together usually exceed fishing mortality. Those causes of mortality have a major effect on the production of adult fish and thus influence the rate of fishing that can be sustained. However, fishing is the easiest mortality factor to control. Control of fishing has rehabilitated marine and anadromous fish populations in various parts of the United States.

Managing salmon fisheries is more difficult than managing many other fisheries because of the geographic distribution of salmon, their metapopulation structure, and the fact that most adult fish spawn only once and then die. In the jargon of Pacific salmon fisheries, managers refer to groups of salmon populations that are identifiable for management as *stocks*. Frequently, *stock* refers to a geographic aggregate of populations that includes many local breeding populations of varied size and productivity; this is too large a unit for conservation of genetic diversity and rehabilitation of salmon production. Managing at the stock level obscures critical biological complexity. But even managing such large units is difficult because of the complex relationships, responsibilities, and obligations among a large number of institutional entities in the region, including nations, states, provinces, federal agencies, tribes, interest groups, and other organizations), the mandates of the Endangered Species Act and other laws, and the diverse array of interests and values in the region.

For rehabilitation of salmon populations, the aim for fishery management—as for other management efforts—should be to achieve long-term sustainability based on maintaining diversity of gene pools and population structures. Therefore, a successful fishery-management component for protecting natural salmon runs in the Pacific Northwest should explicitly recognize the need to maintain and rehabilitate the genetic diversity of salmon and recognize the interdependence of genetic diversity, habitat, and salmon production. It must also account for the uncertainty in scientific predictions and the inherent variability of biotic and abiotic environmental factors.

In general, the aim should be to assure adequate escapements for depleted populations. To achieve long-term sustainability, which requires sufficient genetic diversity, fishing should occur only where the identity (i.e., the originating population) of the salmon is known, when total fishing mortality is consistent with productivity of the fish, and when the catching technology ensures minimal mortality in depleted demes. This will require fishing methods that allow different degrees of fishing effort on various salmon populations and that allow identification of fish taken from depleted demes so that they can be avoided or released alive. Two methods of achieving these goals (but not the only ones) are terminal fisheries and live-catch fisheries.

In general, the serious declines of wild salmon populations show that not enough fish are being allowed to return to spawn. The number of fish returning to spawn (escapements) must be substantially increased to conserve genetic diversity within and between demes, use available habitats, rehabilitate ecological processes (including the return of nutrients to aquatic ecosystems), and increase the sustainable production of salmon. Increasing escapements will disrupt fisheries, industry, and communities, but it is necessary for restoring production. As salmon abundance increases and fisheries begin operating at lower, but sustainable, catch *rates*, actual catches will gradually increase, although probably not to the sizes of some historical catches, because those were based on excessive catch rates. Implementing this recommendation will initially require low fishing effort in many areas, especially in the ocean, and it will require cooperation from British Columbia and Alaska, because many salmon that originate in the Pacific Northwest are caught at sea in British Columbia and southeastern Alaska (chapters 10 and 11).

INSTITUTIONAL CHANGE

The long and serious decline of salmon in the Pacific Northwest has been promoted—often unwittingly—by human institutions; effective remedies, if they are to be found, will have to involve changes in those institutions. Growth in human populations and economic activity threatens the continued existence of salmon in the Pacific Northwest. Institutions developed in different times for diverse purposes have been asked to do things foreign to their original objectives and capabilities. Political changes have hindered attempts to take a long-term perspective. There has been fragmentation of effort and responsibility.

Changing institutional structures is notoriously difficult, but it is possible. Because the problems facing salmon have many aspects, a multidisciplinary approach to their solution is essential. Indeed, if the money that has been spent to date on salmon research had been spent with a more unified, regional vision, greater progress would have been made in maintaining viable salmon populations (Chapter 14). Unless agencies cooperate more effectively, salmon populations are unlikely to recover.

One problem is that current institutions and the boundaries of their jurisdictions usually do not match the spatial, temporal, or functional scales of the salmon problem. In addition, current institutional structures lack both a fine-grained aspect to respond to local concerns and variations and a coarse-grained aspect to integrate across small regions and to make sure that the interests of a few small areas do not jeopardize larger regional interests.

Because we often do not know what the effects of a management option will be, management must be undertaken with an experimental, adaptive point of view. Flexibility must be built into institutional structures to allow for changes in management practices based on experience. Institutions must allow and encourage refocusing the energies of salmon management to recognize the importance of demes in maintaining genetic processes and to maintain and expand their diversity. The goal of management should be to achieve a biologically sound escapement (instead of focusing on a "sustainable" or permissible catch) for each metapopulation and an explicit adoption of time scales for management and planning that are commensurate with the multiyear scale of salmon life cycles.

Beyond those facilitating changes, the formal institutions that manage salmon need to be restructured or refocused to reflect three important institutional principles. First, decision-making authority should be shared among all legitimate interests (cooperative management); legitimate interests that are excluded from decision-making are likely to block desirable changes. Second, the organizational structures and decision-making processes should allow for local conditions and variations and the management strategies should vary accordingly. Third, systematic learning using appropriate experimental designs (adaptive management) should be an essential goal.

As a first step, the relevant agencies in the Pacific Northwest, including the National Marine Fisheries Service, should agree on a process to permit the formulation of salmon recovery plans *in advance* of listings under the Endangered Species Act, and the Pacific Northwest states, acting individually and through the Northwest Power Planning Council, should provide technical and financial assistance to watershed-level organizations to prepare and implement these preemptive recovery plans.

A SCIENTIFIC ADVISORY BOARD TO ADDRESS SALMON PROBLEMS

A great deal is known about salmon and their difficulties, but a great deal remains unknown or controversial despite the expenditure of large amounts of money and time on research. Part of the reason for the lack of knowledge is that people have not agreed on what information is needed, have duplicated each other's work, and have been unwilling to fund needed research. An independent, multidisciplinary, standing scientific advisory board should be established to ensure that the limited money available for research is spent most productively