

ALASKA LEGISLATURE SPECIAL COMMITTEE/SUBJECT FILE 8672
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55

Agenda - Page 4

Session 7 continued

10:30-12 noon -- Interactions in Prince William Sound

Session 8 -- Interactions in Southeast Alaska

1:30-3 pm

- 1. Chinook Enhancement in Southeast Alaska. Bill Heard**
- 2. An Overview of the Pink, Chum and Coho Enhancement programs in Southeast Alaska. Don Amend**

Session 8 continued

3:30-5 pm -- Interactions - General discussion

Thursday, November 14

Session 9 -- Interactions regarding other species, especially sockeye

8:30-10 am

Session 9 continued

10:30-12 Noon

Session 10 -- The Working Party: Writing sessions divided into sub-groups

1:30-5:00 pm

Friday, November 15

Session 11 -- Approval of document

8:30-12 Noon

Afternoon

Departures

*Review papers
not discussed
until 8:30
signatures*



Juneau Center for Fisheries and Ocean Sciences

School of Fisheries and Ocean Sciences
University of Alaska Fairbanks
11120 Glacier Highway
Juneau, Alaska 99801

(907) 789-4441 Office
(907) 789-4447 FAX

WORKSHOP ON THE BIOLOGICAL INTERACTIONS OF NATURAL AND ENHANCED STOCKS OF SALMON IN ALASKA

History and Background

Hatchery operations of salmon and trout have been in progress for more than a century in Europe, North American and North Asia. For a long time little impact was felt on the natural stocks because the operations were small in scale and generally unsuccessful due to lacking biological understanding of the reproductive process and survival mechanisms in salmonid species. This has changed in Alaska, especially during the last couple of decades. Some enhancement project involving artificial propagations have produced startling results and the scope of operations are now large enough to profoundly affect natural stocks, the economic aspects of fishing and processing, and marketing.

However, no statements have been written to evaluate biological impacts which is one of the basic tasks of the proposed workshop. It is also a reflection on Alaska's present concern to preserve the natural heritage with which the State is endowed and that changes, some of an irreversible nature, must have the approval of all segments of the population.

Plans for a workshop on the biological interactions of natural and enhanced fish stocks in Alaska was initiated a year ago. It follows international meetings on this topic in Norway (1990, Institute of Nature Conservation), in Canada (1991, Department of Fisheries and Oceans), in Moscow, Idaho and Pullman Washington (1991, NATO), and in Hakodate (1991, University of Hokkaido). The impact of enhanced salmon on natural stocks was identified as one of five most important natural resources issues to the Greater Prince William Sound Area in a 1990 conference sponsored by the Science Center.

During the 1991 Alaska legislative session, the high abundance of salmon and low ex-vessel prices created concern about salmon enhancement projects throughout the State, of which the impacts of enhanced salmon on natural stocks is an important consideration. Four hatchery research project study groups were established by the Alaska State Senator Eliason, to research various questions regarding interactions between the fisheries for natural and enhanced stocks of salmon. The mission

of these groups is to prepare background material for a full scale debate by the Alaska State Legislature next spring. This workshop is independent of these legislative study groups, but complementary because it focuses in depth on the biological questions related to salmon enhancement.

Definitions and Constraints

1. Salmon enhancement is used synonymously with Ocean Ranching.
2. Pen farming of salmonid species will not be included.
3. Lake fertilization or other indirect enhancement measures such as habitat manipulation also fall outside the mandate.

Purpose

Non-profit hatchery operations and ocean ranching was legalized by the Alaska State Legislature in 1972. This occurred at a time when natural production was at a low point which also coincided with a low point of ocean temperatures. The purpose was to supplement the natural production and especially to smooth out some of the existing interannual variability. But the mandate by the Legislature to the regulatory agencies was to manage for the natural stocks and this became a Public Policy.

In the beginning this was not a problem as long as the ocean ranching took place on a limited scale. In recent years with favorable survival conditions both natural and enhanced stocks have reached unprecedented magnitudes. In some areas of successful hatchery operations natural populations have declined. Thus, the major question for the workshop is to examine:

"The Biological Basis for Maintaining Strong Coexisting Stocks of Natural and Enhanced Salmon Populations in Alaska"

In this short statement is embodied all the biological problems of the Alaskan salmon populations involving behavior and straying, cross breeding and survival rates, ocean carrying capacity and harvest rates.

Objectives

1. To examine and evaluate the relevant genetic and behavioral characteristics of natural and enhanced stocks of salmonid fishes as they relate to hatchery issues in Alaska.
2. To consider life, mortality, or survival tables for fresh water, estuarine, coastal jet, and oceanic environments, linked in space and time, for natural and enhanced stocks of salmon in Alaska.

3. To examine relevant groupings of time series case histories of interactions of natural and enhanced stocks of salmon outside Alaska.
4. To explore limits to the carrying capacity of the ocean environment in the Gulf of Alaska.

Organization

The workshop will convene a small group of experts by invitations in Cordova, Alaska under the auspices of the Prince William Sound Science Center and the School of Fisheries and Ocean Sciences at the University of Alaska, Fairbanks. The participants fall into three categories: International experts, National experts outside Alaska, and experts from inside Alaska. Many of the participants will be asked to prepare papers on topics related to the workshops objectives.

These invited papers will be circulated for peer review, edited by the workshop chairpersons, and submitted for a special issue (workshop proceedings) publication.

In recognition of the complexity of this issue and the limited amount of synoptic information to evaluate it, unanimous conclusions and recommendations are not anticipated so the underlying risk functions of different courses of action must be considered.

The workshop will be organized around 5 separate Sessions:

1. The basic genetic structures of salmon stocks.
2. Time series of hatchery data and experiments from non-Alaskan sources.
3. Interactions Issues in Alaska

This session will be organized by three species groupings (pink-chum, sockeye, chinook-coho) or by two geographic areas, Prince William Sound and Southeast Alaska. Kodiak and Cook Inlet information will be used if appropriate. This latter alternative might be advantageous due to the interaction between grouping of species.

4. Carrying Capacity of the Ocean
5. Summary of Results and Conclusions with some Recommendations for Future High Priority Directed Research.

A Discussant will be appointed for each Session with the assignment of drafting a Report to be presented in the final session.

Following the Workshop these reports will be polished off and assembled whereafter a small Review and Editorial Group will meet in Juneau or elsewhere for completion of the final Group Report. The individual session reports or final report will be treated as the invited papers: circulated for peer review, edited, and submitted with the invited papers as a special issue (workshop proceedings) publication. A scientific journal will be sought as the publisher, pending quality of the papers.

Methods

The workshop will be convened on November 10 and run continuously through the 15th. Expenses will be provided to all international guests and to those North American participants that require it.

Products

December 1991: A final report on the Workshop sessions.

June 1992: Submission of the Workshop Proceedings as an issue of a scientific journal.

Sponsorship

This workshop is sponsored by the Prince William Sound Science Center (PWSSC) and the School of Fisheries and Ocean Sciences (SFOS) University of Alaska, Fairbanks.

Co-chairpersons are Dr. A. Ole Mathisen, SFOS, and Dr. G.L. Thomas, PWSSC. The list of contributors include: Alaska Department of Fish and Game, Pacific Seafood Processors Association, Pew Charitable Trust, Prince William Sound Aquaculture Association, Sealaska Corporation, and University of Alaska Fairbanks.



P.O. Box 705
Cordova, AK 99574
(907) 424-5800 FAX: (907) 424-5820

**Workshop on the
"Biological Interactions of Natural and Enhanced
Stocks of Salmon in Alaska"**

DATES: Sunday, Nov. 10 - Friday, Nov. 15, 1991

AT: Masonic Hall and the Prince William Sound Science Center
Cordova, Alaska

ORGANIZERS: Prince William Sound Science Center and the
School of Fisheries and Ocean Sciences,
University of Alaska

OBJECTIVES:

1. To examine and evaluate the relevant genetic and behavioral characteristics of natural and enhanced stocks of salmonid fishes as they relate to hatchery issues in Alaska.
2. To consider life, mortality, or survival tables for fresh water, estuarine, coastal jet, and oceanic environments, linked in space and time, for natural and enhanced stocks of salmon in Alaska.
3. To examine relevant groups of time series case histories of interactions of natural and enhanced stocks of salmon outside Alaska.
4. To explore limits to the carrying capacity of the ocean environment in the Gulf of Alaska.

The major question for this workshop is to examine:

"The biological basis for maintaining strong coexisting stocks of natural and enhanced salmon populations in Alaska."

AGENDA

The workshop will convene a small group of experts from the international community, from elsewhere in North America and from inside Alaska. During the first two days of the workshop, which are open to the general public, papers will be presented on topics related to the workshop's objectives. A tentative list of the speakers and their topics is attached.

The latter days of the workshop will involve the experts in small group work sessions and a writing session. A summary of the

results and any conclusions reached will be approved at the final workshop session Friday morning, Nov. 15.

A final report on the workshop will be completed in December 1991. The papers presented will be circulated for peer review, edited by the workshop chairpersons and submitted for publication in June 1992.

WORKSHOP

CHAIRPERSONS: Ole Mathisen, School of Fisheries, University of Alaska, Juneau, Alaska
G.L. (Gary) Thomas, Director, Prince William Sound Science Center, Cordova, Alaska

The list of contributors includes:

The Pew Charitable Trusts
Alaska Department of Fish & Game
Pacific Seafood Processors Association
Prince William Sound Aquaculture Corporation
Sealaska Corporation
School of Fisheries and Ocean Science, University of Alaska
Prince William Sound Science Center

For further information: Nancy Bird, (907) 424-5800 or
FAX 424-5820

Gary Thomas
206-543-6475 in Seattle

Tentative list of Workshop Participants and their Topics

Conservation of genetic diversity in salmonid fishes: why, what and how.

W.W. Allendorf, Division of Biological Sciences, Missoula, Montana

An Overview of the Pink, Chum and Coho Enhancement programs in Southeast Alaska.

Don Amend, Southern Southeast Regional Aquaculture Association, Ketchikan, Alaska

The status of the Snake River chinook.

Ernest Brannon, University of Idaho, Moscow, Idaho

A theoretical evaluation of the carrying capacity of Prince William Sound, Alaska for juvenile Pacific salmon.

Ted Cooney, School of Fisheries & Ocean Sciences, University of Alaska, Fairbanks, Alaska

~~Sven Ebbesson, Institute of Marine Science, University of Alaska, Seward, Alaska - unable to attend~~

Trends in abundance of hatchery and wild stocks of pink salmon in Cook Inlet, Prince William Sound and Kodiak, Alaska.

Doug Eggers, Chief Fisheries Scientist, Alaska Dept. of Fish & Game, Juneau, Alaska

Torleif Eriksson, Swedish Univ. of Agricultural Sciences, Department of Aquaculture, Umea, Sweden

The importance of fine genetic structures in natural populations.
Tony Gharrett, School of Fisheries, University of Alaska, Juneau, Alaska

The Soviet experience in the field of salmon interactions.

Mikhail Glubokovsky, Institute of Marine Biology, Far East Branch, Vladivostok, USSR

Chinook Enhancement in Southeast Alaska.

Bill Heard, National Marine Fisheries Service, Juneau, Alaska

Interactions between wild and cultured Atlantic salmon --

A review of the experience in Norway.

Tor Heggberget, NINA, Norsk Institutt for Naturforskning, Trondheim, Norway

Density dependent changes in chum salmon, *Oncorhynchus keta*, returning to Iwate Prefecture, Japan.

Hitoshi Ida, Kitasato University School of Fisheries Sciences, Sanriku-cho, Kesen-gun, Japan

Ole Mathisen, Director, Fisheries School, University of Alaska,
Juneau, Alaska

John McMullen, President, Prince William Sound Aquaculture
Corporation, Cordova, Alaska

*Homing, straying and the interaction between wild and enhanced
stocks of salmon.*

T.P. Quinn, Fisheries Research Institute, University of
Washington, Seattle, Washington

~~Management of mixed enhanced and wild salmonids in British
Columbia.~~

~~B. E. Riddell, Dept. of Fisheries and Ocean, Biological Sciences
Branch, Nanaimo, British Columbia, Canada~~ *replacement
being
sought*

Factors affecting marine growth of Bristol Bay sockeye salmon.

Don Rogers, Fisheries Research Institute, University of
Washington, Seattle, Washington

*Gene frequencies and the management of Pacific Salmon:
Identification of wild and hatchery fish in mixed fisheries.*
Jim Seeb, Alaska Dept. of Fish & Game, Anchorage, Alaska

Population Structure of Chum Salmon

Lisa Seeb, Alaska Dept. of Fish & Game, Anchorage, Alaska

Sam Sharr, Research Biologist, Alaska Dept. of Fish & Game,
Cordova, Alaska

Bill Smoker, School of Fisheries, University of Alaska,
Juneau, Alaska

Gary Thomas, Director, Prince William Sound Science Center,
Cordova, Alaska

*The productive value of stream distances for estimating genetic
relationship in salmonid species.*

Fred M. Utter, National Oceanic and Atmospheric Administration
(NOAA), Seattle, Washington

Percy Washington, GAIA NW Inc., Seattle, Washington

Additions

Rebecca Everett, USFWS

Richard Wilmot USFWS

TENTATIVE AGENDA
Workshop on the
"Biological Interactions of Natural and Enhanced
Stocks of Salmon in Alaska"

Saturday, November 9

Participants arrive during the day.

6:00-7:30 pm Welcoming reception, at the Powder House
(transportation provided).

All the plenary meetings are held in the Masonic Hall (located at the north end of First Street). The daily schedule is as follows:

7:45 - 8:30 a.m. Continental Breakfast (at the Masonic Hall)
8:30 - 10:00 a.m. First Morning Session
10:00 - 10:30 a.m. Coffee Break
10:30 - 12:00 Second Morning Session
1:30 - 3:00 p.m. First Afternoon Session
3:00 - 3:30 p.m. Coffee Break
3:30 - 5:00 p.m. Second Afternoon Session

Sunday, November 10

First Morning Session - 8:30-10:00 a.m.

Opening remarks:

1. G.L. Thomas, Director Prince William Sound Science Center
2. Goals of the Conference - Ole Mathisen, Univ. of Alaska-Juneau
3. Prince William Sound Aquaculture Corporation - John McMullen, President
4. State Genetic Policy - Jim Seeb, Alaska Dept. of Fish & Game

Session 1 -- Ocean carrying capacity
10:30-12:00

1. *A theoretical evaluation of the carrying capacity of Prince William Sound, Alaska for juvenile Pacific salmon.*
R. Ted Cooney
2. *Density dependent changes in chum salmon, *Oncorhynchus keta*, returning to Iwate Prefecture, Japan.* Hitoshi Ida
3. *Factors affecting marine growth of Bristol Bay sockeye salmon.*
Don Rogers

4. *Interaction in natural carrying capacity limitations for natural and enhanced stocks of salmon.* Percy Washington

Session 2 -- Management of mixed stocks

1:30-3:00 p.m.

1. *Trends in abundance of hatchery and wild stocks of pink salmon in Cook Inlet, Prince William Sound and Kodiak, Alaska.* Doug Eggers
2. *Management of mixed enhanced and wild salmonids in British Columbia.* (B.E. Riddell unable to attend - replacement???)
3. *Gene frequencies and the management of Pacific Salmon: Identification of wild and hatchery fish in mixed fisheries.* Jim Seeb

Session 3 -- Summary and general discussion

3:30-4:30 p.m.

Evening

Seafood dinner at the Reluctant Fisherman
Social hour, 6:30 p.m.; Dinner, 7 p.m.

Monday, November 11

Session 4

8:30-10 am -- **Basic Genetic Structure**

1. *Conservation of genetic diversity in salmonid fishes: why, what and how.* F.W. Allendorf
2. *The productive value of stream distances for estimating genetic relationship in salmonid species.* Fred Utter
3. *Population structure of chum salmon.* Lisa Seeb
4. *The importance of fine genetic structures in natural populations.* Tony Gharrett

Session 4 continued

10:30-12:00

5. *Quantitative genetic variation of life history traits in pink salmon.* William Smoker
6. *Genetic stock identification of Yukon River chum and chinook salmon.* Richard Wilmot

7. *Genetic stock identification of Bristol Bay area salmon.* Rebecca Everett.

Session 5 -- Straying
1:30 - 2:00 pm

1. *Homing, straying and the interaction between wild and enhanced stocks of salmon.* T.P. Quinn
2. (TBA) Ewen Ebbesson (unable to attend -- paper to be distributed?)

Session 6 -- Long Term Case Histories
2:00-3:00 pm

1. *Interactions between wild and cultured Atlantic salmon -- A review of the experience in Norway.* Tor Heggberget
2. *The status of wild and hatchery propagated Swedish salmon stocks after 40 years of hatchery releases in the Baltic rivers.* Torleif Eriksson

Session 6 continued
3:30-5 pm

3. *The status of the Snake River chinook.* Ernest Brannon
4. *The Soviet experience in the field of salmon interactions.* Mikhail Glubokovsky
5. General discussion

Tuesday, November 12

Field trip to Wally Norenberg Hatchery at Esther Island (western Prince William Sound) -- Weather dependant, this may be delayed until Wednesday.

Wednesday, November 13

Session 7 -- Interactions in Prince William Sound
8:30-10 am

1. *Historical production of wild and enhanced stocks of pink salmon in Prince William Sound.* Sam Sharr

Session 7 continued

10:30-12 noon -- Interactions in Prince William Sound

Session 8 -- Interactions in Southeast Alaska

1:30-3 pm

- 1. Chinook Enhancement in Southeast Alaska. Bill Heard**
- 2. An Overview of the Pink, Chum and Coho Enhancement programs in Southeast Alaska. Don Amend**

Session 8 continued

3:30-5 pm -- Interactions - General discussion

Thursday, November 14

Session 9 -- Interactions regarding other species, especially sockeyes

8:30-10 am

Session 9 continued

10:30-12 Noon

Session 10 -- The Working Party: Writing sessions divided into sub-groups

1:30-5:00 pm

Friday, November 15

Session 11 -- Approval of document

8:30-12 Noon

Afternoon

Departures

*final recommendations
wrap-up*

**List of speakers invited to Workshop on the
Biological Interactions of Natural and Enhanced Stocks
of Salmon in Alaska
November 9 - 15, 1991 -- Cordova, Alaska**

Sponsored by the Prince William Sound Science Center and the
University of Alaska - School of Fisheries

F.W. Allendorf
Division of Biological Sciences
University of Montana
Missoula, Montana 59812-1002
Phone: (406) 243-5503
FAX: (406) 243-4184
Topic: Conservation of genetic diversity in salmonid fishes: why,
what and how.

Don Amend
Director
Southern SE Regional Aquaculture Assoc.
1621 Tongass
Ketchikan, Alaska
Phone: (907) 225-9605
FAX: (907) 225-1348
Topic: An overview of the pink, chum, coho enhancement programs in
Southeast Alaska.

Don Bailey
Salmon Enhancement Program
Department of Fisheries & Oceans

Vancouver, Canada
Phone: (604) 666-2949
FAX: (604) 666-6894
Topic: Management of mixed enhanced and wild salmonids in British
Columbia.

Ernest Brannon
University of Idaho
College of Forestry
Moscow, Idaho 83843
Phone: (208) 885-5830 or 885-7323
FAX: (208) 885-5968
Topic: The perpetual oversight of hatchery programs.

Ted Cooney
School of Fisheries & Ocean Sciences
University of Alaska
231 Irving II
Fairbanks, Alaska 99775-1080
Phone: (907) 474-7407
FAX: (907) 474-7204
Topic: A theoretical evaluation of the carrying capacity of Prince William Sound, Alaska for juvenile Pacific salmon.

Doug Eggers
Chief Fisheries Scientist
Alaska Dept. of Fish & Game
P.O. Box 25526
Juneau, Alaska 99802-5526
Phone: (907) 465-4210
FAX: 465-2604
Topic: Trends in Abundance of Hatchery and Wild Stocks of Pink Salmon in Cook Inlet, Prince William Sound and Kodiak, Alaska

Torleif Eriksson
Swedish Univ. of Agricultural Sciences
Department of Aquaculture
Box 1457
S-90124 Umea, Sweden
Phone: 46 90 19 00 10
FAX: 46 90 19 09 87
Topic: The status of wild and hatchery propagated Swedish salmon stocks after 40 years of hatchery releases in the Baltic rivers.

Rebecca Everett
Fishery Biologist
U.S. Fish & Wildlife Service
1011 East Tudor Road
Anchorage, Alaska 99503
Phone: (907) 786-3318
FAX (907) 786-3350
Topic: Genetic relationships among Pacific salmon the of the Bristol Bay area of Alaska.

Tony Gharrett
School of Fisheries
University of Alaska
11120 Glacier Highway
Juneau, Alaska 99803
Phone: (907) 789-4442
FAX: (907) 789-4447
Topic: The importance of fine genetic structures in natural populations.

Mikhail Glubokovsky
Institute of Marine Biology
Far East Branch
Academy of Sciences of the USSR
Vladivostok 690032, USSR
Phone: 296-205-202
FAX: (423) 2-242-589
Topic: The Soviet experience in the field of salmon interactions.

Bill Heard
National Marine Fisheries Service
P.O. Box 210029
Juneau, Alaska 99801
Phone: (907) 789-6003
FAX: 789 6094
Topic: Southeast Alaska Chinook; Fisheries, management, enhancement, wild stocks and treaties.

Tor Heggberget
NINA
Norsk Institutt for Naturforskning
Tungasletta 2 N.7004
Trondheim, Norway
Phone: (47 7) 58 05 00
FAX: (47 7) 91 54 33
Topic: Interactions between wild and cultured Atlantic salmon -- A review of the experience in Norway.

Hitoshi Ida
Kitasato University
School of Fisheries Sciences
Sanriku-cho, Kesen-gun
Iwate, 022-01, Japan
Phone: (81) 192-44-2121
FAX: (81) 192-44-2125
Topic: Density dependent changes in chum salmon, *Oncorhynchus Keta*, returning to Iwate Prefecture, Japan.

Ole Mathisen
Director, Fisheries School
Univ. of Alaska
11120 Glacier Highway
Juneau, Alaska 99803
Phone: (907) 789-4442 or 789-9269
FAX: (907) 789-4447
Topic: Goals of the conference

John McMullen
President
Prince William Sound Aquaculture Corporation
P.O. Box 1110
Cordova, Alaska 99574
Phone: (907) 424-7511
FAX: (907) 424-7514
Topic: Overview of the PWSAC program.

T.P. Quinn
Fisheries Research Institute
University of Washington
WH-10
Seattle, Washington 98195
Phone: (206) 543-9042
FAX: (206) 685-7471
Topic: Homing, straying and the interaction between wild and enhanced stocks of salmon.

Don Rogers
Fisheries Research Institute
University of Washington
WH-10
Seattle, Washington 98195
Phone: (206) 543-7628
FAX: (206) 685-7471
Topic: Factors affecting marine growth of Bristol Bay sockeye.

Jim Seeb
Alaska Dept. of Fish & Game
333 Raspberry Road
Anchorage, Alaska 99518-1599
Phone: (907) 267-2385
FAX: 349-5532
Topic: Gene frequencies and the management of Pacific Salmon: Identification of wild and hatchery fish in mixed fisheries.

Lisa Seeb
Alaska Dept. of Fish & Game
333 Raspberry Road
Anchorage, Alaska 99518-1599
Phone: (907) 267-2249
FAX: 344-9238
Topic: Population genetic structure of chum salmon: identification of wild and hatchery fish in mixed fisheries.

Sam Sharr
Research Biologist
Alaska Dept. of Fish & Game
P.O. Box 669

Cordova,, Alaska 99574

Phone: (907) 424-3213

FAX: (907) 4424-3235

Topic: Historical production of wild and enhanced stocks of pink salmon in Prince William Sound.

Bill Smoker
School of Fisheries
University of Alaska
11120 Glacier Highway
Juneau,, Alaska 99803
Phone: (907) 789-4442
FAX: (907) 789-4447

Topic: Quantitative genetic variation of life history traits in pink salmon.

Gary Thomas
Director
Prince William Sound Science Center
P.O. Box 6009
Lynnwood, Washington 98036
Phone: (206) 543-6475
FAX: (206) 685-7471

Topic: Overview of the PWS Science Center program.

Fred M. Utter
NOAA
2725 Montlake Blvd. E.
Seattle, Washington 98112
Phone: (206) 553-7781 or messages 553-4445
FAX: (206) 553-4313

Topic: The predictive value of stream distances for estimating genetic relationships in salmonid species.

Percy Washington
Gaia NW Inc.
10522 Lake City Way NE Suite 201
Seattle, Washington 98125
Phone: (206) 367-2864
FAX: (206) 367-2865

Topic: Interaction in natural carrying capacity limitations for natural and enhanced stocks of salmon.

Richard Wilmot
Research Fishery Biologist
U.S. Fish & Wildlife Service
1011 East Tudor Road
Anchorage, Alaska 99503
Phone: (907) 786-3312
FAX: (907) 786-3636

Topic: Genetic stock identification of Yukon River chum and chinook salmon.



Juneau Center for Fisheries and Ocean Sciences

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2 December 1991

MEMORANDUM

To: Molly McCauley
Fr: Ole A. Mathisen OAM
Re: Some personal reflections on the Cordova Workshop

1. Genetic Diversity

The message came through very loud and clear that genetic diversity must be preserved. In Norway this has largely been lost due to extensive transfer of brood stocks and escapees from pens. Sweden offers a contrast where salmon habitat has been lost due to hydroelectric dam building 30 - 40 years ago. Nevertheless the stocks and their genetic diversity have been maintained by hatchery operations without transfer between rivers or remote site planting.

2. Straying

We do not know the extent of straying or the mechanism causing imprinting. But when ocean ranching assumes the proportion seen in Prince William Sound the stage is set for straying of wild stocks in the harvest areas of enhanced stocks and also for hatchery fish to stray in the natural streams. Neither do we know how successful cross breeding will be. This clearly raises the question if a cap should be placed on enhancement activities and if so how large should this cap be?

3. Planting at Remote Locations

We know that straying increases with distance of release from donor stream or hatchery. The extensive releases at remote sites which are practiced today and much more planned for the future could potentially in time destroy genetic diversity. Furthermore if this happens, the process is irreversible and the loss is permanent. It is my opinion that we are gambling by allowing these practices without any real knowledge of the imprinting process and straying. Here lies one of the prime research areas for which the cost should largely be underwritten by the hatcheries and to some extent by the ADF&G.

4. Ocean Carrying Capacity

It was probably the general feeling of the group that we might approach an upper limit since all salmon were extremely small on both sides of the Pacific Ocean in 1991.

Opinions differed whether this happened on the outmigration or in the nearshore environment on the return migration. There probably are enough monitoring stations to follow the changing productivity of the North Pacific Ocean.

These are some points which need much more clarification and I have listed them for your own information.



Juneau Center for Fisheries and Ocean Sciences

University of Alaska Fairbanks

11120 Glacier Highway

Juneau, Alaska 99801

(907) 789-4441

11 May 1991

Carl L. Rosier, Commissioner of Fisheries
Alaska Department of Fish and Game
1255 West 8th Street
P.O. Box 3-2000
Juneau, Alaska 99802-2000

Dear Carl:

Due to a previous workshop commitment in Seattle it is very difficult for me to attend the meeting called by Senator Dick Eliason on Wednesday, May 15, at 1:30 in the Butrovich Room regarding hatcheries and hatchery programs in Alaska. The purpose of the meeting is to identify major topics and to formulate specific questions regarding hatcheries which should be researched and addressed by the Legislature.

As I see it there are specific genetic questions involved in any hatchery program. The State already has a standing committee for answering such questions and to develop guidelines for future work. Dr. Tony Gharrett from the Juneau Center for Fisheries and Ocean Sciences is a member of this group.

Then there are a number of social and economic questions with some far reaching consequences and Lee Gorsuch has expressed an interest in such problems.

My effort to convene a workshop deals with the biological aspects of the hatchery program and the interaction between wild and enhanced stocks. This question has been raised in Norway, it will be discussed in Nanaimo in June this year and later at a NATO sponsored conference at Washington State University in Pullman.

An observed decline of wild stocks of pinks in Prince William Sound with its massive ocean ranching program has prompted the question of any link and raised the following questions:

1. What is the extent of straying of enhanced stocks of pinks or any other enhanced salmon?
2. What is the reproductive success of stray cultured and wild salmon?

3. To what extent will wild fish school together with enhanced stocks and eventually be caught in a restricted harvest area.

4. What is the carrying capacity of the feeding areas in the Gulf of Alaska, not only for pink salmon but also for sockeye salmon from other districts like Bristol Bay using the same feeding grounds?

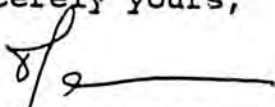
5. What is the value of an undisturbed gene pool which has developed over the last 10 -12 000 years since the ice cap receded?

Although the proposed workshop should only deal with Alaskan problems, it would be advantageous to solicit the assistance of a few experts from abroad. In Norway, Japan and the USSR enhancement programs have been practiced for a long time.

I feel confident that the workshop could conclude its work before the next session of the Legislature; but I also expect that there will remain some unanswered questions, which eventually may call for additional research. I have tentatively estimated the cost of a workshop convened at least for one week, to be \$ 50 000, half of which may come from new Science Center in Cordova.

One purpose of this letter is to convey to you Dean Alexanders interest in utilizing the talent of the School of Fisheries and Ocean Sciences and especially of the Juneau based group in assisting the State in solving some of the problems raised above.

Sincerely yours,



Ole A. Mathisen

cc: Representative Ulmer ✓
Dr. Burkett
Dean Alexander



Alaska State Legislature

SENATOR RICHARD I. ELIASON

President of the Senate

P.O. Box V
Juneau, Alaska 99811
(907) 465-3755

MEMORANDUM

TO: Pam Stoops, Director
Administrative Services Division
Legislative Affairs Agency

FROM: Sen. Dick Eliason 
Senate President

DATE: October 7, 1991

RE: Expenditure of funds for Workshop: "Biological
Interactions of Natural and Enhanced Fish Stocks
in Alaska" through School of Fisheries and Ocean Sciences

This memo authorizes the expenditure of Senate leadership funds in the amount of \$4,975 through the School of Fisheries and Ocean Sciences, University of Alaska, Fairbanks, for the workshop "Biological Interactions of Natural and Enhanced Fish Stocks in Alaska."

A copy of the projected budget for the workshop, and a summary of workshop objectives is attached. The funds provided by the Legislature are to be used to assist in paying travel and expenses for workshop participants. The workshop is scheduled for Nov. 10 - 15, and is jointly sponsored by the School of Fisheries and Ocean Sciences (U of A, Fairbanks) and the Prince William Sound Science Center. The workshop is complementary to the work being conducted by the Legislature's hatchery research project now underway in that it focuses in depth on the biological questions related to salmon enhancement, including the genetic impact of interaction between wild and hatchery stocks. Products of the

Pam Stoops
October 7, 1991
page two

workshop will include a final report on the workshop's sessions, which will be useful to the Legislative Hatchery Research Project, to the Senate Special Committee on Domestic and International Fisheries, and to individual members of the Legislature as this issue of the state's fisheries enhancement program is taken up during the next session.

It is my understanding that this funding will not be subject to the University's usual administrative overhead. If you have any questions, please contact my office.

WORKSHOP

BIOLOGICAL INTERACTIONS OF NATURAL
AND ENHANCED FISH STOCKS IN ALASKAPROJECTED BUDGET
(October 1, 1991)

Salaries and Benefits	
Science Center	
organization, secretarial, etc.	N.C.
University of Alaska	
organization, secretarial, etc.	N.C.
Services	
Publication \$65/page @ 120 pages	\$ 7,800
Room rentals	1,000
Equipment rentals	
4 IBM computers (Science Center,	
Mathisen, others)	N.C.
Speaker system	200
Flight to hatcheries	1,500
Telephone	
Science Center	500
University of Alaska	500
Supplies	
Miscellaneous conference materials	700
Zippered conference pouches	300
Travel	
Overseas airfares - 21 day advance purchase	8,000
Domestic airfares - 14 day advance purchase	9,000
Per diem	
rooms - 22 people @ \$60 for 5 nights	6,600
meals - 22 people @ \$40 for 6 days	5,280
overseas travel 3 @ \$50 for 2 days	300
2 persons (Doug Eggers & Lisa Seeb)	N.C.
Miscellaneous/contingency	500
Contingency	<u>1,295</u>
TOTAL	\$ 43,475

WORKSHOP

BIOLOGICAL INTERACTIONS OF NATURAL
AND ENHANCED FISH STOCKS IN ALASKA

CONTRIBUTORS

Prince William Sound Science Center	\$ 22,500
Sealaska Corporation	1,000
University of Alaska	5,000
Alaska Dept. of Fish & Game	5,000
Pacific Seafood Processors Association	5,000
Other contributions	4,975
TOTAL	<u>\$ 43,475</u>



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University of Alaska Fairbanks
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WORKSHOP ON THE BIOLOGICAL INTERACTIONS OF NATURAL AND ENHANCED STOCKS OF SALMON IN ALASKA

History and Background

Hatchery operations of salmon and trout have been in progress for more than a century in Europe, North American and North Asia. For a long time little impact was felt on the natural stocks because the operations were small in scale and generally unsuccessful due to lacking biological understanding of the reproductive process and survival mechanisms in salmonid species. This has changed in Alaska, especially during the last couple of decades. Some enhancement project involving artificial propagations have produced startling results and the scope of operations are now large enough to profoundly affect natural stocks, the economic aspects of fishing and processing, and marketing.

However, no statements have been written to evaluate biological impacts which is one of the basic tasks of the proposed workshop. It is also a reflection on Alaska's present concern to preserve the natural heritage with which the State is endowed and that changes, some of an irreversible nature, must have the approval of all segments of the population.

Plans for a workshop on the biological interactions of natural and enhanced fish stocks in Alaska was initiated a year ago. It follows international meetings on this topic in Norway (1990, Institute of Nature Conservation), in Canada (1991, Department of Fisheries and Oceans), in Moscow, Idaho and Pullman Washington (1991, NATO), and in Hakodate (1991, University of Hokkaido). The impact of enhanced salmon on natural stocks was identified as one of five most important natural resources issues to the Greater Prince William Sound Area in a 1990 conference sponsored by the Science Center.

During the 1991 Alaska legislative session, the high abundance of salmon and low ex-vessel prices created concern about salmon enhancement projects throughout the State, of which the impacts of enhanced salmon on natural stocks is an important consideration. Four hatchery research project study groups were established by the Alaska State Senator Eliason, to research various questions regarding interactions between the fisheries for natural and enhanced stocks of salmon. The mission

of these groups is to prepare background material for a full scale debate by the Alaska State Legislature next spring. This workshop is independent of these legislative study groups, but complementary because it focuses in depth on the biological questions related to salmon enhancement.

Definitions and Constraints

1. Salmon enhancement is used synonymously with Ocean Ranching.
2. Pen farming of salmonid species will not be included.
3. Lake fertilization or other indirect enhancement measures such as habitat manipulation also fall outside the mandate.

Purpose

Non-profit hatchery operations and ocean ranching was legalized by the Alaska State Legislature in 1972. This occurred at a time when natural production was at a low point which also coincided with a low point of ocean temperatures. The purpose was to supplement the natural production and especially to smooth out some of the existing interannual variability. But the mandate by the Legislature to the regulatory agencies was to manage for the natural stocks and this became a Public Policy.

In the beginning this was not a problem as long as the ocean ranching took place on a limited scale. In recent years with favorable survival conditions both natural and enhanced stocks have reached unprecedented magnitudes. In some areas of successful hatchery operations natural populations have declined. Thus, the major question for the workshop is to examine:

"The Biological Basis for Maintaining Strong Coexisting Stocks of Natural and Enhanced Salmon Populations in Alaska"

In this short statement is embodied all the biological problems of the Alaskan salmon populations involving behavior and straying, cross breeding and survival rates, ocean carrying capacity and harvest rates.

Objectives

1. To examine and evaluate the relevant genetic and behavioral characteristics of natural and enhanced stocks of salmonid fishes as they relate to hatchery issues in Alaska.
2. To consider life, mortality, or survival tables for fresh water, estuarine, coastal jet, and oceanic environments, linked in space and time, for natural and enhanced stocks of salmon in Alaska.

3. To examine relevant groupings of time series case histories of interactions of natural and enhanced stocks of salmon outside Alaska.

4. To explore limits to the carrying capacity of the ocean environment in the Gulf of Alaska.

Organization

The workshop will convene a small group of experts by invitations in Cordova, Alaska under the auspices of the Prince William Sound Science Center and the School of Fisheries and Ocean Sciences at the University of Alaska, Fairbanks. The participants fall into three categories: International experts, National experts outside Alaska, and experts from inside Alaska. Many of the participants will be asked to prepare papers on topics related to the workshops objectives.

These invited papers will be circulated for peer review, edited by the workshop chairpersons, and submitted for a special issue (workshop proceedings) publication.

In recognition of the complexity of this issue and the limited amount of synoptic information to evaluate it, unanimous conclusions and recommendations are not anticipated so the underlying risk functions of different courses of action must be considered.

The workshop will be organized around 5 separate Sessions:

1. The basic genetic structures of salmon stocks.
2. Time series of hatchery data and experiments from non-Alaskan sources.
3. Interactions Issues in Alaska

This session will be organized by three species groupings (pink-chum, sockeye, chinook-coho) or by two geographic areas, Prince William Sound and Southeast Alaska. Kodiak and Cook Inlet information will be used if appropriate. This latter alternative might be advantageous due to the interaction between grouping of species.

4. Carrying Capacity of the Ocean
5. Summary of Results and Conclusions with some Recommendations for Future High Priority Directed Research.

A Discussant will be appointed for each Session with the assignment of drafting a Report to be presented in the final session.

Following the Workshop these reports will be polished off and assembled whereafter a small Review and Editorial Group will meet in Juneau or elsewhere for completion of the final Group Report. The individual session reports or final report will be treated as the invited papers: circulated for peer review, edited, and submitted with the invited papers as a special issue (workshop proceedings) publication. A scientific journal will be sought as the publisher, pending quality of the papers.

Methods

The workshop will be convened on November 10 and run continuously through the 15th. Expenses will be provided to all international guests and to those North American participants that require it.

Products

December 1991: A final report on the Workshop sessions.

June 1992: Submission of the Workshop Proceedings as an issue of a scientific journal.

Sponsorship

This workshop is sponsored by the Prince William Sound Science Center (PWSSC) and the School of Fisheries and Ocean Sciences (SFOS) University of Alaska, Fairbanks.

Co-chairpersons are Dr. A. Ole Mathisen, SFOS, and Dr. G.L. Thomas, PWSSC. The list of contributors include: Alaska Department of Fish and Game, Pacific Seafood Processors Association, Pew Charitable Trust, Prince William Sound Aquaculture Association, Sealaska Corporation, and University of Alaska Fairbanks.



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20 August 1991

The Honorable Senator R.I. Eliason
P.O.Box 143
Sitka
Alaska 99835

Dear Senator Eliason:

After a conference in Norway in the Spring of 1990 on the "Interaction of Natural and Enchanced Stocks of Salmon" I realized that the same question soon would be raised in Alaska and I started to plan a workshop on the biological aspects of the problem. Since that time there have been Conferences and Symposia on the same subject matter in B.C., Washington, Idaho, Japan and in the USSR.

You realized the same need by appointing the four Legislative Committees with a very broad mandate. I have been in touch with several of the committee members and see little overlap, rather the Workshop planned by the School of Fisheries and Ocean Sciences, University of Alaska Fairbanks and the Prince William Sound Science Center will interphase well and compliment the work by your committees. We are not planning any new research. Rather our main function will be not only to summarize recent biological findings but also to evaluate them in context of the stated goal of the workshop. An important part is to identify the unknown areas, and there are many, and to suggest and prioritize future research while we also look at the risk of some decisions involving unknown factors.

I am enclosing a short Prospectus and a Budget Statement. We have collected \$ 40 000 from private sources and will hold the Workshop within the given framework. It had been my hope to have \$ 50 000 at our disposal since there still are some important people missing. So the bottom line of this long letter is a question whether you are in a position to contribute something to this workshop. If you have additional question I shall be happy to meet with you in Sitka.

Sincerely yours,

Ole A. Mathisen
Ole A. Mathisen
Professor of Fisheries

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To	Laura	From	Sen. Eliason
Co.	Sen. Eliason's Office	Co.	
Dept.		Phone #	
Fax #		Fax #	

THE FOLLOWING DOCUMENT MAY NOT FILM
LEGIBLY BECAUSE OF THE POOR QUALITY OF THE
ORIGINAL

Science Lecture Series Program
Sponsored by the Prince William Sound Science Center and
Prince William Sound Aquaculture Corporation

Friday, September 20, 1991 -- 7:30 p.m.

Old courtroom, U.S. Forest Service Building
2nd Street

Salmon Production in Prince William Sound:

*Are wild salmon fry being disadvantaged by
large scale releases of hatchery fry?*

R. Ted Cooney
School of Fisheries and Ocean Sciences
University of Alaska Fairbanks

Studies presently underway in Prince William Sound are testing the assertion that salmon production in the region is limited, in large part, by natural factors affecting the growth rates of fry during early ocean residence. Results to date implicate year-to-year variations in ocean temperature and fry food stocks as the major factors affecting run size. High levels of food and warm spring-time temperatures favor elevated fry growth rates, reducing the time that juveniles spend at small vulnerable sizes. Conversely, cold springs and poor food abundance generally translate into poorer overall future production. Cooperative Fisheries and Oceanographic Studies (CEOS) is jointly sponsored by the University of Alaska, the non-profit hatcheries and the Alaska Department of Fish and Game to describe the effects of coastal ocean temperature on salmon production in the Sound.

Dr. Cooney will discuss historical trends in salmon production in the Sound relative to oceanographic cycles in temperature and plankton in the Gulf of Alaska in addressing the question of whether or not the carrying capacity of the Sound is being approached by increasing hatchery releases. The planned operation of a new meteorological and oceanographic buoy and future plans for salmon studies in the region will also be covered in light of a predicted return to below average ocean temperatures in the Gulf.

The general public and fishing community are urged to attend this lecture and to participate in the question and answer session following Dr. Cooney's remarks. This talk is co-sponsored by the Prince William Sound Aquaculture Corporation and the Prince William Sound Science Center.

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A Theoretical Evaluation of the Carrying Capacity of Prince William Sound, Alaska for Juvenile Pacific Salmon

R. Ted Cooney
Institute of Marine Science
University of Alaska Fairbanks

Abstract

The present feeding demand on zooplankton resources by wild and ocean ranched juvenile Pacific salmon in Prince William Sound is estimated between 1.0 and 4.0 percent of the total "herbivore" production, and 4.0 to 16.0 percent of the annual macrozooplankton production in the region. When annual fry losses to early ocean mortality are taken into account, the feeding demand associated with growth rates averaging 3 to 4 percent of the body weight per day fall to 0.4 to 1.6 percent of the total herbivore production and 1.5 to 5.0 percent of the macrozooplankton production. Uncertainties associated with the numerous assumptions used in this analysis are discussed in relation to what is understood about the biology and ecology of salmon in Prince William Sound and elsewhere.

Introduction

Successes with ocean ranching of Pacific salmon in Prince William Sound, Alaska are beginning to raise management and enhancement questions about the ability of the region to support even larger releases of juveniles planned for coming years. Hatchery released salmon now comprise 50 percent or more of all adults returning to common property fisheries in the Sound. In view of a growing controversy over apparent adverse interactions between hatchery and wild salmon stocks in Washington, Oregon and British Columbia, it seems appropriate to examine the question of carrying capacity as one means to assist with the continued enhancement and management of these vital commercial and subsistence resources in the Sound. The assessment presented here follows accepted ecological theory but is based on several untested assumptions. As a result, conclusions derived from the formulation are probably valid only as general guidelines and perhaps most useful as assertions to be formally examined under field and experimental conditions.

Parsons (1987) presents generalized carbon budgets for open ocean, shelf, fjord and estuarine ecological zones in the North Pacific. Because of its depth and oceanographic characteristics, Prince William Sound is best described as a complex fjord-type ecosystem (Schmidt, 1977). In the deep fjord environment a large percentage of the organic matter produced by phytoplankton is

utilized in the water column by pelagic consumers before it can settle to the sea bed.

Annual primary production in Port Valdez/Prince William Sound probably ranges between 150 and 200 g C m⁻² y⁻¹ (Goering et al., 1973). Primary producers are light-limited during the winter months, and following a dramatic spring phytoplankton bloom that usually peaks in April and May, the production of organic matter falls to lower levels under reduced nutrient supplies for the remainder of the summer and fall. A typical subarctic spring diatom community is replaced by small flagellates in mid summer as dissolved inorganic nutrients become depleted in the photic zone (Alexander and Chapman, 1980).

Zooplankton stocks in Prince William Sound are composed of both oceanic and neritic species (Cooney and Coyle, 1988). Coastal circulation patterns and long periods of wind-driven shelf convergence seed the region with open ocean populations during the spring and fall months. The copepods Neocalanus cristatus, N. plumchrus and Eucalanus bungii are indicators of intruding oceanic communities (Cooney, 1986, 1988, Coyle et al., 1990). These populations and Pseudocalanus spp. dominate the upper-layer zooplankton populations during the spring and early summer, March-May. Occasionally, Calanus marshallae adults and early stage copepodites are common during this period as well.

As the upper-layers begin to warm and freshen in late May and June, the oceanic zooplankton community is supplanted by a neritic assemblage characterized by late stage copepodites of Calanus marshallae, the smaller copepods Acartia, Centropages, Tortanus, Pseudocalanus, and the cladocerans Podon and Evadne. For juvenile salmon entering the Sound from hatcheries or natal streams, the composition and mass of forage fields changes substantially from April through June and early July.

Studies of juvenile salmon food webs in Prince William Sound implicate the importance of calanoid copepods (Cooney et al., 1981). While many other species are found in stomachs, the bulk of the mass is generally accounted for by the copepods although pteropods, insects (particularly for juvenile chum salmon) and other taxa are occasionally important.

The local hatcheries have adopted a practice of pen rearing fry during the spring until populations of Neocalanus, Calanus and Pseudocalanus have begun to reach seasonal highs, usually during late April and early May. At this time, most hatchery stocks are released into "optimal" feeding and (presumably) growth conditions. In contrast, wild fry emerge into the near-shore environment for roughly 2 months beginning in early April and continuing through the first week or so of June. Juvenile pink salmon apparently adopt a pelagic feeding behavior immediately, taking advantage of available zooplankton populations. Juvenile chum salmon appear to require a more epibenthic food web augmented by calanoid copepods and insects (Barnard, 1981). Young salmon are believed to be resident in the Sound from April through July and early August of each year.

Carrying Capacity

The productivity of marine ecosystems reflects the amounts

and supply rates of dissolved inorganic nitrogen and silicon available to primary producers. In coastal waters, direct input of carbon from land sources may also be important. Seasonality in solar energy further modifies the magnitude and extent of the marine production cycle each year. With the exception of anoxic environments, most marine ecosystems are tightly coupled, with little carbon lost to burial in sediments.

In terrestrial ecosystems, the notion of carrying capacity refers to balances between plant production and herbivore consumption. "Over-grazing" typically leads to changes in soil stability and in the natural composition of plant stocks, followed by reductions in herbivore populations due to lowered reproductive rates and increased losses to natural mortality and predation. In the case of salmon ranching, carrying capacity denotes the ability of local receiving waters to accommodate additional consumers without adverse or other major changes in ecosystem dynamics.

It is believed that year-class strength in Pacific salmon populations is generally set during early ocean residence by predation (Parker, 1968, 1971; Healey, 1982; Hartt, 1980; Bax, 1983; Nickelson, 1986; Ricker, 1976; Foerster, 1968; Taylor, 1977; Walters et al., 1978; Holtby et al., 1990). Factors affecting the growth of juveniles at this time, such as temperature and food, are believed to mediate these important early losses to larger fishes and birds. Presumably, there are limits to the number of allochthonous consumers a natural system can absorb before competition forces measurable changes in biological structure and energy flow.

In his model of carbon flow between trophic levels in a generalized subarctic fjord ecosystem, Parsons (1987) follows accepted ecological practice in assigning values for biomass transfer efficiency between levels to estimate apex production in simple pelagic and detrital food webs. His choice of 10 percent transfer efficiency for fjords is derived from the earlier work of Cushing (1971) who demonstrated an inverse relationship between productivity and ecological transfer. While this choice is certainly subject to error, in reality it is the number of trophic exchanges leading to target apex predators that is by far the more important variable in formulations of this kind. Juvenile pink and chum salmon are almost entirely dependent on first-order consumers, meaning that only one, or at most two trophic steps are involved in the transfer of energy from phytoplankton to the young fish.

The analysis presented here uses information about the production of plankton communities in Prince William Sound to derive estimates for the production of potential salmon forage each year. A second analysis uses observations on the growth rates of surviving juveniles and their food to estimate the present demand being placed on fry forage populations each year.

Annual Herbivore Production

Adopting the fjord model of Parsons (1987) and the range in annual primary production reported by Goering et al. (1973), the total herbivore production is estimated to range between 13.8 and

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18.4 g C m⁻² y⁻¹ in Prince William Sound. In this model (a generic 300 m deep fjord), a regression equation relating vertical carbon flux to depth (Suess, 1980) predicts 8 percent of the primary production will escape the water column to feed sea bed consumers while the remainder enters a pelagic food web. Converting herbivore carbon growth to wet weight (Beers, 1966) yields values of 204 to 273 g m⁻² as the annual biomass production.

Prince William Sound has a surface area of approximately 8800 km² or 8.8×10^9 m² (Grant and Higgins, 1910). Multiplying the surface area of the Sound by the upper and lower estimates of the annual zooplankton wet weight production m⁻² results in a over-all estimate of 1.8 to 2.5×10^{12} g of forage available to all planktivores each year (Table 1). Assuming conservatively that 25 percent of this "herbivore" production is associated with macrozooplankton (Sambrotto and Lorenzen, 1987), between 4.5 and 6.0×10^{11} g are available as food for fry and other planktivores.

Salmon Fry Forage Demand

The non-profit hatcheries in Prince William Sound are presently releasing about 700 million fry and smolts annually (most are pink salmon). Alaska Department of Fish and Game believes that wild stocks contribute another 500 million fry for a total of approximately 1.2 billion juveniles. Most of these young salmon utilize a pelagic food web during their early ocean residence.

Recent studies of post-emergent recaptured fry suggest that survivors of early ocean predation increase their body weight by at least 3 percent daily (Willette; unpublished). Both hatchery and wild fry enter marine waters at body weights of about 0.25 g. The fry are thought to reside in the Sound for 4 months or about 120 days. At an increase of 3.0 percent body weight per day, a survivor leaving the Sound after the period of summer residence will theoretically weigh about 9.1 g. Assuming this exponential increase in weight results from the ingestion of pelagic forage at a 50 percent gross growth efficiency (Wissmar and Simenstad, 1988), each survivor would have to consume at least 18.2 g live weight of zooplankton before leaving the region for shelf and open ocean feeding areas. If all the entering fry/smolts survived the 4-month near-shore period, the calculated demand on local forage stocks would be 21.8×10^9 g or about 2.2×10^{10} g annually (Table 2).

The impact of fry feeding on pelagic herbivores and macrozooplankton stocks can be estimated by comparing the forage demand at several levels of growth with the available forage (Table 3). At growth rates of 3 to 4 percent of the body weight per day and using 150 g C m⁻² y⁻¹, the fry apparently take 1.2 to 4.0 percent of the annual herbivore production and 5.7 to 16.1 percent of the macrozooplankton production.

A more accurate evaluation of fry feeding demand can be achieved if account is taken of fry losses to mortality during early ocean residence. Since 1978, the marine survival of hatchery released pink salmon has averaged about 5 percent. In contrast, the marine survival of wild pink salmon is thought to

be only about 1 percent. Using an exponential model to calculate the instantaneous daily mortality rates for both populations yields losses to predators of 439 million and 390 million juveniles respectively for hatchery and wild fry populations over the 120 day period of early ocean residence. One estimate of the food consumed by non-survivors (829 million fry) can be obtained by assuming that the mortality occurs halfway through the 120 day interval when the fish are approximately 1.5 grams in size. The increase in weight of 1.25 g per fish requires the ingestion of 2.50 g of forage. Multiplying this amount by the number of fry failing to survive, predicts that those entering food webs consume approximately 9.6×10^8 g annually. The surviving 371 million fry (growing at 3 to 4 percent of their body weight daily) will ingest between 6.6×10^9 and 2.2×10^{10} g (Table 4).

Under these more reasonable conditions, the impact of the fry on local forage resources becomes 0.4 to 1.6 percent of the total herbivore production and from 1.5 to 5.0 percent of the annual macrozooplankton production.

Discussion

The simplistic formulations presented here point to rather minimal "apparent" impact by present levels of wild and ocean-ranched salmon on zooplankton forage resources in Prince William Sound. Juvenile salmon consumption (corrected for early marine mortality) ranges between 0.4 and 1.6 percent of the total "herbivore" production and only 1.5 to 5.0 percent of the macrozooplankton annual growth. However, it must be remembered that these results are based on several key assumptions supported by few or no direct observations from the region.

The trophic model of Parsons (1987) assumes that a rather small percentage of the primary production (8%) escapes the water column and that the remainder is available to pelagic consumers. Cooney and Coyle (1988), using the equations of Suess (1980) and sediment trap data, report that up to 15 percent of the production in Port Valdez (230 m deep) can sink to feed benthic consumers in that location. Interannual variability in zooplankton standing stocks, associated with fluctuations in the transport of populations into and out of Prince William Sound, very likely influence the amounts of organic matter retained in pelagic food webs each year. Losses averaging 8 to 10% of the primary production to sinking each year seem reasonable in terms of observations elsewhere.

The model of Parsons adopts a 10% ecological transfer efficiency between primary and secondary producers based on published experimental results (Cushing, 1971). This standard approach is generally accepted with the understanding that the actual transfer may vary around this value by as much as a factor of 2.0. In the case of salmon fry, what is more important is that most feeding studies implicate first-order consumers (Cooney et al., 1981) as major prey items. This means that only one trophic step (rather than more) is usually involved in transferring organic matter from phytoplankton to the young fish.

The model applied here also assumes that the primary productivity of Prince William Sound will only vary between 150

and 200 gC/m²/yr. Very few local measurements of production are available to support this contention through the years, although compared with other U.S. and Canadian fjords and Sounds, this level of production is well within reported limits (Cooney and Coyle, 1988).

Table 2 demonstrates that estimates of food consumption are very sensitive to the growth rates of the fry. The most recent studies of fry growth in Prince William Sound (Willette; unpublished) demonstrate absolute growth rates, determined from coded wire tags and otoliths, of 3-5 percent of the body weight per day. Assuming a value of 4 percent is probably representative of most conditions. However, until techniques become available (small-mesh purse seines and large surface trawls) to sample the larger more elusive fish, the degree to which growth rate determinations are biased by capture techniques will remain unknown. Given the average weight of adult pink salmon originating from central Alaska stocks reported by Rogers (1987), a daily instantaneous growth rate of 2.4 percent of the body weight applies over the 355 day ocean growth period. In actuality, this rate is expected to be higher during early ocean residence and lower in the late winter and spring of the return migration.

Since juvenile salmon are thought to be residents of the Sound for only four months, not all of the annual zooplankton production is available to them. However, because they enter the system during the peak of the annual production cycle, it is probably not unreasonable to assume that their feeding "window" encompasses at least 50 percent of the macrozooplankton production cycle, if not more.

Of even greater uncertainty is how much of the Sound the young salmon actually use for feeding purposes. Most observations indicate a variable period of shoreline/embayment dependency followed by a gradual movement into the deeper passages (Urquhart, 1979). It seems likely that something less than 100 percent of the Sound is actually used for feeding purposes. This potential limitation is further complicated by wind, tidal and density-driven upper-layer circulation patterns that may or may not replenish depleted near-shore zooplankton populations from deeper adjacent passages.

Finally, it is not known what portion of the water column can be utilized by juvenile salmon. If the young fish are restricted to the top few meters of the Sound, they will probably encounter a smaller percentage of the total zooplankton forage than if they can exploit the upper 20 or 30 m.

The degree to which these uncertainties inflate the theoretical estimates of salmon fry impact on zooplankton forage resources in Prince William Sound is presently unknown. Questions raised above generally suggest a somewhat greater rather than lesser impact but the magnitude of error is difficult to judge without information about how the juveniles actually use the Sound as a nursery area and what portion of the pelagic consumer community is selected. Present studies in the region are designed to address these and other questions about the use of Prince William Sound by juvenile salmon. It seems important that answers to questions of resource partitioning be sought in

light of evolving enhancement plans for salmon in this region.

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DRAFT

Table 1. Theoretically derived estimates of secondary production (SP) and the production of macrozooplankton (SPM) derived from simple food chain dynamics associated with four levels of primary production (PP) in Prince William Sound, Alaska

PP gC/m ² /yr	SP* gC/m ² /yr	SP** g	SPM*** g
250	23.0	3.0×10^{12}	7.5×10^{11}
200	18.4	2.4×10^{12}	6.0×10^{11}
150	13.8	1.8×10^{12}	4.5×10^{11}
100	9.2	1.2×10^{12}	3.0×10^{11}

* Herbivore production assumed to be 0.1 PP (Parsons, 1986)

** Herbivore production in live weight for Prince William Sound

*** Macrozooplankton production as 0.25 SP

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Table 2. Fry forage consumption as a function of growth rate over a 120 day period of early ocean residence in Prince William Sound, Alaska

Growth rate % body wt./day	Weight gain g	Food Consumed per fry, g	Total food* consumed
2	2.5	5.0	6.0×10^9
3	9.1	17.8	2.2×10^{10}
4	30.1	60.3	7.2×10^{10}
5	100.6	201.2	2.4×10^{11}

* assuming no mortality to fry during 120 day period

DRAFT

Table 3. Estimated impact of fry feeding on zooplankton production in Prince William Sound, Alaska derived from two levels of primary production

Fry Growth % body wt./day	Total Consumption (TC), g	TC/SP	TC/SPM
A. 150 gC/m ² /yr			
2	6.0x10 ⁹	0.003	0.013
3	2.1x10 ¹⁰	0.012	0.047
4	7.2x10 ¹⁰	0.040	0.161
5	2.4x10 ¹¹	0.134	0.537
B. 200 gC/m ² /yr PP			
2	6.0x10 ⁹	0.003	0.010
3	2.1x10 ¹⁰	0.009	0.036
4	7.2x10 ¹⁰	0.030	0.121
5	2.4x10 ¹¹	0.100	0.403

DRAFT

Table 4. Estimated impact of salmon fry feeding on zooplankton stocks in Prince William Sound accounting for losses to predation and natural mortality during the 120 day residence period

Fry	Fry Growth % body wt./day	Total Consumption, g	TC/SP	TC/SPM
371 million surviving	3	6.6×10^9	0.004	0.015
	4	2.2×10^{10}	0.016	0.050
	5	7.5×10^{10}	0.041	0.166
829 million not-surviving	2*	9.6×10^8	0.0003	0.0013

 * non-survivors assumed to grow at 2 percent or less of their body weight per day. Mortality assumed to occur half-way through the 120 day residence period

AGENDA
Workshop on the
"Biological Interactions of Natural and Enhanced
Stocks of Salmon in Alaska"

Saturday, November 9

Participants arrive during the day.

5:30-7:00 pm Welcoming reception, at the Powder House (transportation provided -- please meet in the lobby of the Reluctant Fisherman between 5:25 and 5:45 pm)

All the plenary meetings are held in the Masonic Hall (located at the north end of First Street). The daily schedule is as follows:

7:45 - 8:30 a.m.	Continental Breakfast (at the Masonic Hall)
8:30 - 10:00 a.m.	First Morning Session
10:00 - 10:30 a.m.	Coffee Break
10:30 - 12:00 noon	Second Morning Session
1:30 - 3:00 p.m.	First Afternoon Session
3:00 - 3:30 p.m.	Coffee Break
3:30 - 5:00 p.m.	Second Afternoon Session

The public is invited to all sessions on Sunday, Monday and Friday.

Sunday, November 10 *Open to the public*
First Morning Session - 8:30-10:00 a.m.

Opening remarks:

1. G.L. Thomas, Director Prince William Sound Science Center
2. Goals of the Conference - Ole Mathisen, Univ. of Alaska-Juneau
3. Prince William Sound Aquaculture Corporation - John McMullen, President
4. State Genetic Policy - Jim Seeb, Alaska Dept. of Fish & Game

Session 1 -- Ocean carrying capacity
10:30-12:00 Session Chair: (TBA)

1. *A theoretical evaluation of the carrying capacity of Prince William Sound, Alaska for juvenile Pacific salmon.* R. Ted Cooney, School of Fisheries and Ocean Sciences, University of Alaska, Fairbanks
2. *Density dependent changes in chum salmon, *Oncorhynchus keta*, returning to Iwate Prefecture, Japan.* Hitoshi Ida, Kitasato University School of Fisheries Sciences, Sanriku-cho, Kesen-gun, Japan

3. *Factors affecting marine growth of Bristol Bay sockeye salmon.* Don Rogers, Fisheries Research Institute, University of Washington, Seattle, Washington
4. *Interaction in natural carrying capacity limitations for natural and enhanced stocks of salmon.* Percy Washington, GAIA NW, Inc., Seattle, Washington
5. *The carrying capacity of the North Pacific Ocean.* W.G. Pearcy, Oregon State University, Corvallis (Summary)

Session 2 -- Management of mixed stocks

1:30-3:00 p.m. Session Chair: (TBA)

1. *Trends in abundance of hatchery and wild stocks of pink salmon in Cook Inlet, Prince William Sound and Kodiak, Alaska.* Doug Eggers, Chief Fisheries Scientist, Alaska Department of Fish & Game, Juneau, Alaska
2. *Management of mixed enhanced and wild salmonids in British Columbia.* Don Bailey, Salmon Enhancement Division, Department of Fisheries and Ocean, Vancouver, Canada
3. *Gene frequencies, risk assessment and the management of hatchery production of Pacific Salmon.* Jim Seeb, Alaska Department of Fish & Game, Anchorage, Alaska

Session 3 -- Summary and general discussion

3:30-4:30 p.m. Session Chair: (TBA)

Evening Seafood dinner at the Reluctant Fisherman
Social hour, 6:30 p.m.; Dinner, 7 p.m.

Monday, November 11 Open to the public

Session 4 -- Basic Genetic Structure

8:30-10 am Session Chair: Jim Seeb

1. *Conservation of genetic diversity in salmonid fishes: why, what and how.* F.W. Allendorf, Division of Biological Sciences, Missoula, Montana
2. *The predictive value of stream distances for estimating genetic relationship in salmonid species.* Fred Utter, National Oceanic and Atmospheric Administration (NOAA), Seattle, Washington
3. *Population genetic structure of chum salmon: identification of wild and hatchery fish in mixed fisheries.* Lisa Seeb, Alaska Department of Fish & Game, Anchorage, Alaska
4. *The importance of fine genetic structures in natural populations.* Tony Gharrett, School of Fisheries and Ocean Science, University of Alaska, Juneau, Alaska

Session 4 continued

10:30-12:00

5. *Quantitative genetic variation of life history traits in pink salmon.* ^{Bill} William Smoker, School of Fisheries and Ocean Science, University of Alaska, Juneau, Alaska
6. *Genetic stock identification of Yukon River chum and chinook salmon.* Richard Wilmot, U.S. Fish & Wildlife Service, Anchorage, Alaska
7. *Genetic relationships among Pacific salmon of the Bristol Bay area of Alaska.* Rebecca Everett, U.S. Fish & Wildlife Service, Anchorage, Alaska

Session 5 -- Straying

1:30 - 2:00 pm

Session Chair: TBA

1. *Homing, straying and the interaction between wild and enhanced stocks of salmon.* ^{T.P.} Quinn, Fisheries Research Institute, University of Washington, Seattle, Washington
2. *Do culture conditions of hatchery reared salmon affect return and straying of adults?* Sven Ebbesson (paper only)

Session 6 -- Long Term Case Histories

2:00-3:00 pm

Session Chair: TBA

1. *Interactions between wild and cultured Atlantic salmon -- A review of the experience in Norway.* Tor Heggberget, NINA, Norsk Institutt for Naturforskning, Trondheim, Norway
2. *The status of wild and hatchery propagated Swedish salmon stocks after 40 years of hatchery releases in the Baltic rivers.* Torleif Eriksson, Swedish University of Agricultural Sciences, Department of Aquaculture, Umea, Sweden

38 streams
w/feedback

Session 6 continued

3:30-5 pm

3. *The perpetual oversight of hatchery programs.* Ernest Brannon, University of Idaho, Moscow, Idaho
4. *The S... experience in the field of salmon interactions.* Mikhail Glubokovsky, Institute of Marine Biology, Far East Branch, Vladivostok, USSR
5. General discussion

Tuesday, November 12

Field trip to Wally Norenberg Hatchery at Esther Island (western Prince William Sound) --
Weather dependent, this may be delayed until Wednesday.

Departure time for field trip: 9:15 am - Please meet in hotel lobby.

Wednesday, November 13

Session 7 -- Interactions in Prince William Sound

8:30-10 am Session Chair: TBA

1. *Historical production of wild and enhanced stocks of pink salmon in Prince William Sound.* Sam Sharr, Alaska Department of Fish & Game, Cordova, Alaska
2. *(Title TBA)* Jeff Olsen, Operations Manager, Prince William Sound Aquaculture Corporation, Cordova, Alaska

Session 7 continued

10:30-12 noon -- *Interactions in Prince William Sound*

Session 8 -- Interactions in Southeast Alaska

1:30-3 pm Session Chair: Ole Mathisen

1. *Southeast Alaska Chinook; Fisheries, management, enhancement, wild stocks and treaties.* William Heard, National Marine Fisheries Service, Auke Bay Laboratory, Auke Bay, Alaska
2. *An Overview of the Pink, Chum and Coho Enhancement programs in Southeast Alaska.* Don Amend, Southern Southeast Aquaculture Association, Ketchikan, Alaska

Session 8 continued

3:30-5 pm -- *Interactions - General discussion*

Thursday, November 14

Session 9 -- Interactions regarding other species, especially sockeye

8:30-10 am Session Chair: TBA

Session 9 continued

10:30-12 Noon

Session 10 -- The Working Party: Writing sessions divided into sub-groups

1:30-5:00 pm Session Chairs in charge of each group

Friday, November 15 Open to the public

Session 11 Concluding Session

Session Chair: Gary Thomas

8:30-10 am Session leaders will present a short discussion of the findings of their working group followed by an open discussion session and approval of reports and documents.

10:30-noon Open discussion session continues.

Afternoon

Departures

REPORT TO THE BOARD OF DIRECTORS

September 20-21, 1991: PWSAC Meeting

Update of Cooperative Fisheries and Oceanographic Studies (CFOS) in Prince William Sound, Alaska

In January 1990, the Alaska Sea Grant College Program provided funding to help establish a consortium investigation of salmon production responses to oceanographic conditions affecting fry/smolts during early ocean residence. The study was joined by ADF&G, PWSAC and VFDA as co-investigators. Since that time, CFOS has established a systematic program of oceanographic monitoring and experimental studies to determine how year-to-year changes in coastal ocean climate and fry food stocks influence the production of pink and chum salmon in the Sound. This study concluded its second field season this year.

CFOS studies are guided by a growing body of scientific evidence suggesting the number of adults returning through fisheries to hatcheries and natal streams each year is determined primarily by predation during early ocean residence -- the first two to four months at sea. Conditions of food and temperature that influence the growth rates of the fry/smolts apparently mediate losses at this time. Since this critical phase is spent in the "near-shore/coastal marine environment", growth conditions can be studied in detail locally without the need for costly oceanographic expeditions to the open ocean.

The primary goal of this study is to quantitatively describe the relationships between observed levels of salmon production and variables known to affect the growth of juveniles in the coastal ocean. This information is expected to significantly enhance local forecasting procedures and provide further means to optimize the production of hatchery-released and wild stocks of salmon in the Sound. Prior studies of the oceanography of the Gulf of Alaska have established an understanding of cyclic temperature fluctuations and have also documented large year-to-year changes in upper-layer zooplankton populations. The most recent observations support a prediction of a return to cooler temperatures for the next 5-8 years. On the basis of what is presently understood about temperature influences on salmon production, this decline in temperature will quite likely be expressed in reduced wild and hatchery production. Should this be the case, hatchery stocks of pink and chum salmon may have to carry the fisheries through the upcoming inclement oceanographic period.

Experimental studies to date include descriptions of the growth ecology of large calanoid copepod populations and their energetic content, and of the potential for using satellite-sensed temperature fields to assist with forecasting and enhancement programs. The large calanoids form a substantial and important food resource for first feeding wild and hatchery fry in the region. In this regard, understanding the time-phasing and abundance of these important food organisms in relation to variable oceanographic factors is expected to help further refine release strategies designed to optimize production under different conditions of food and temperature. Additional experimental studies involve direct measurements of fry growth using coded-wire tagged fry and their otoliths. These important studies are needed to confirm the assertions that growth rate is the variable that modulates losses to predators each year.

CFOS information is also expected to be crucial in determining if, and to what extent, hatchery stocks may be interacting with wild salmon populations in Prince William Sound. Questions of resource partitioning, genetic alteration and carrying capacity are being raised by some who see hatchery production as potentially threatening to the health of wild stocks in the region. In the interest of the fishing industry, these questions must be rigorously addressed by good science immediately. While there seems to be a case for some negative interactions in Washington, Oregon and British Columbia, there is no reason to believe that these findings apply unconditionally to Alaskan mixed stocks. An upcoming workshop on this matter is scheduled for this fall in Cordova. I have been asked to participate in this workshop and I intend to present a theoretical assessment of the carrying capacity of the Sound for juvenile salmon at that time.

The present CFOS study is designed to continue through December 1994. There is a chance that it could be extended one additional year if the results warrant and the co-investigators request a continuance from the Alaska Sea Grant College Program. This coming year, CFOS expects to add a new component to study juvenile chum salmon. The chum investigation will attempt to determine why this species has failed to respond as positively to culture technique as have pink salmon. The results of the chum study are expected to help the corporation modify (if necessary) its rearing and release procedures to maximize chum production in the years to come.

I wish to thank the corporation for its generous support of CFOS studies over the past two years. Without the cooperation of hatchery managers, their staff and the front office, the study could not have been pursued. As it is, CFOS is one of the most comprehensive fisheries oceanographic investigations in the entire country. The addition of a modern satellite-linked oceanographic buoy system this fall will add the final ingredient to what may become a pilot program for future management and enhancement of salmon stocks throughout Alaska. It is my recommendation to the board that this cooperative tie to the University and Fish and Game be exploited to its maximum potential over the next four years. As a board member, I will do what I can to see that this potential is realized.

Respectfully submitted,

A handwritten signature in dark ink, appearing to read 'R. Ted Cooney', with a long, sweeping horizontal line extending to the left.

R. Ted Cooney
School of Fisheries and Ocean Sciences
University of Alaska Fairbanks

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R. Ted Cooney
School of Fisheries and Ocean Sciences
University of Alaska Fairbanks

Japan are they a good model?

use all the same fish stocks - genetic strain
go where planktivores where they feed the most
concentrating in a habitat where they
can deplete fish stocks.

Cooney, PWS-

smaller fish also present in low return years.

marine survival rates - @ the same even in higher years

PWS average	1.6 kg wt
90	1.4
91	1.1

Bristol Bay - always had smaller
fish in low return years
reduced

historical data - fish are smaller when runs are lower -
B. Bay

clearly - is shortage of food, but where does it occur?

is it local or in big ocean

related to size of schools of
fry & returning
schools.

also lower water temp in Pacific

when does growth modification occur - early? late? or

in SE - no hatching fish, still a ↓ in size, thurst growth year
also reduction in Soviet Union where no hatching fish.

zooplankton prey stocks - fluctuate greatly year to year

monitor growth conditions - esp. in near shore areas

plankton watch

temp watch

plankton watch

Genetics

Goal - maintain existing genetic diversity within & between wild populations in order to sustain productivity of both wild and enhanced stocks.

Straying - can we model

— no sign

what is significant - affects future productivity

— also disease - wipe out populations.

Disease

VHS in WA

disease in Norway -

1. request from Steve McGee
list of all fish transport permit applications
everyone's recommendation final disposition

2. chart showing
current hatchery production
— ~~for~~ what is planned and permitted
by region, and totals
by species.

3. talk to Ray Holborn, @ Canada + Washington

4. Ted Perry - salmon assessment in Canada.

wild production - temp. dependent - ocean is cooling. wild
↓ wild stocks

hatcheries - much higher return 10-20%, Chinook - 40-60%
wild, pink - 4-5% return

Carrying capacity

density dependent growth - large schools of fish - early + late
modify food supply

fish getting smaller
impaired reproductive ability
↑ predation
more difficult to market

concern - hatchery fish eating ^{food from} wild fish
not real

DRAFT
Biological Interactions of
Natural and enhanced fish
Stocks in Alaska--Workshop
14Oct1991

INTERACTIONS AND ENVIRONMENTAL CARRYING CAPACITY LIMITATIONS OF
NATURAL AND ARTIFICIAL STOCKS OF SALMONIDS

PERCY M. WASHINGTON

"Enhancement" as a technology has become synonymous with restoration, supplementation, or augmentation of depleted naturally reproducing runs of salmonids. In theory, available technology allows production, under controlled artificial conditions of almost unlimited amounts of salmonids scheduled to mitigate losses of smolts formerly produced in natural habitats that were altered or destroyed by human activities such as dams, logging, road building, mining, agriculture, rechannelization. Hatcheries were conceptually to replace spawning and the various rearing habitat requirements of salmonid and prey species. The technology evolved to reduce the high probability of mortality during freshwater life history periods of anadromous salmonids. Stocks were homogenized to produce a more easily handled, optimized single stock with advantages (to managers and hatchery operators) such as short run timing, smaller size for ease of handling, and docile behavior which improved within facility survival. Run timings (primary stock differentiation) were truncated, and growth rates of individuals within the artificial populations were increased for cost and space efficiency.

Short pulsed hatchery runs provide the basis for net fisheries that subsequently become the only efficient means of harvesting massive surplusses created by the hatchery system; 3-5% of hatchery stocks are required for population reproduction, anything less than a 95% harvest results in waste. Other harvest methods and uses that were viable historically are traps and sport harvest, natural mortality, and escapement; escapement and natural mortality were two uses of the resource which lost out due to their lack of obvious economic value. Traps were outlawed to provide increased economic opportunities; more labor intensive net fisheries. Sport fisheries represent comparatively limited levels of efficiency and effort, and are incapable of harvesting significant portions of a hatchery run in the terminal areas due to the short length of the run pulse; sport fisheries represent only a nominal portion of the total catch. Net "mop-up" fisheries are efficient and sufficient in quantity to reduce runs overnight from surplus to minimal escapement levels that support only hatchery runs; levels that have no sport fish appeal where catch per effort isn't worth the effort. Some hatchery stocks have evolved that stop feeding in terminal areas; only those that didn't hang around to feed and get caught by nets survived.

As a management tool, artificial production facilities

provide a means, at least theoretically, of producing sustainable yields of salmonids up to the carrying capacity of the ocean. As is the case in freshwater habitats, the actual oceanic yield potential is greatly increased when time, space and niche separations are observed by species and races of salmonids, as well as their propagators. In the late 1970's, the Oregon Department of Fish and Wildlife (ODFW) presented coastal upwelling and coho densities as the hypothesis for the reduction in coho production along the coast of southern Washington, Oregon, and northern California; the Oregon Production Index Area -- OPI. Empirical formulas, "Spawner/Recruit Curves" after Ricker (1972) (McGee, 1979), correlations with shrimp and crab production (McIntyre, 1978), and just about anything else were used to make the point that the ocean was too full of coho; especially during periods of low upwelling. At the time my studies of the problem as part of my dissertation project. Since everyone else was studying "ocean density" as the prime factor, I decided to break new trail and analyze existing data to determine survival at various life stanzas between the hatchery, estuary, ocean, and adult returns. I estimated survival into the ocean by use of the sex dicotomy method after Doug Chapman. To my dismay, there seemed to be something wrong with the model or the data as the survival to be an order of magnitude less than what ODFW reported (Gunzulus, 1978). I tested assumptions and looked for new methods of determining survival at the various stanzas, hitting upon size dicotomy at the estuary. Using this method, I demonstrated more than 75% mortality between the hatchery and the estuary; which was later demonstrated to be the result of poor quality hatchery releases and management practices (Washington, 1982). Subsequently, Bonneville Power Administration (BPA) Fish and Wildlife Branch noted that 75% of those fish reaching the estuary had Bacterial Kidney Disease resulting in an additional mortality (Personal Communication, Dr. Gerald Bouck) which reduced the population to less than 8% of it's original number at release.

Commercial fishermen observed and fished in massive shoals of coho of the Oregon coast. My observations during Alaska field studies in the 1960's and 70's were that wild coho did not school. Observations also suggest that hatchery coho are induced by domestication/selection processes to school. Wild coho were never encountered at sea nor in terminal areas in greater congregations than ones and twos. A high probability also exists that large numbers of the massive simultaneous hatchery releases of a single stock may migrate to the same spot in the ocean at the same time and result in production limiting densities; a problem that does not seem to exist among wild coho populations.

Genetic selection and feeding induced increases in growth rates of salmonids in hatcheries may result in decreased ultimate size potential of returning adults; this is the basis of Donaldson's work on hatchery salmon and trout production in the 1950's through 1970's, and also results from fishery gear selection. Decreased adult biomass potential results where there is an increase in precociousness. Increasing freshwater growth rates to achieve larger emigrant sizes and early release timings de-

creases the numbers of individuals reaching ultimate size potentials within the population, and reduced egg quantities and quality.

Fisheries based upon surplusses from the enhancement of resources consistently foster the over harvest of naturally reproduced stocks. On the surface, this was accomplished with no apparent damage to the artificial stocks. Indications are, however, that adults returning to hatcheries are fewer and smaller in size; only small fish can escape harvest by the size selective gears used (Becker, 1967). The historical trend of increased amounts of less efficient fishing gears, and the movement of fisheries farther from terminal areas, resulted in the selective capture of the older/larger individuals resulting from both natural and artificial production. This resulted in reduced reproductive potential in wild stocks. The reduction was a direct result of qualitative and quantitative losses of gametes associated with average individual size reductions; phenomena that also reduced spawner and progeny success. These exacerbated fishery management problems, ultimately resulting in the requisite use of artificial propagation of salmonids to maintain harvests; current best described as "put and take" salmon fisheries. In elementary fishery courses we were taught that smaller females produce smaller and fewer eggs. Followed to its logical conclusion, fewer, smaller females returning to hatcheries result in the use of all available gametes (male and female), fry and fingerlings. In combination with probable reductions in female escapement and average size in a poorly regulated fishery, gamete limited production of hatchery releases will result.

Unfortunately, most all agencies have limited management options by systematically destroying that necessary to produce large numbers of salmonids naturally; rivers were dammed, forests cut, and the seemingly endless wealth of natural resources gave rise to population centers that required agricultural products; all were at the center of habitat loss. Habitat is limiting, and limited amounts of habitat produce limited numbers of fish; limited habitat is, therefore, population limiting. Artificial production is but a tool. In its current context and use as a monoculture system, it ultimately limits production and production potential. The lessons of history should instruct us to optimize production from natural and artificially produced stocks.

A few years ago, I was present when Washington fishery managers expressed to a legislative hearing the inability to successfully manage wild and artificial stocks in the same watershed. Agency efforts at enhancing production always seems to decrease production measurably in a water ship. The natural environment is capable of producing large amounts of fish biomass in relatively sterile surroundings by simply adding nutrients from the decayed bodies of dead adult anadromous fish. The hint in this case is that the dynamics of niche, spatial and temporal separation results in a substantial increase in biomass production. If we are to have both naturally and artificially produced

salmonids, limiting competition within and among species for limited environmental resources in the freshwater environment is a must.

Artificially produced fish feed on food items in mid to surface waters (Graves 1983; Beauchamp, 1989). Wild chinook, coho, and various trout feed near bottom on bottom organisms in their various preferred habitats. In effect, artificial fish of all species produced by current methods and released as pre-smolts are only capable of competing in the freshwater "pelagic" niche for the limited amount of food available. This is particularly important in lacustrine habitats that serve as habitat for naturally reproduced sockeye stocks. Under these circumstances, artificial produced species graze down all food organisms within size ranges that efficient for capture then starve; usually well before any numbers learn to feed on bottom organisms. Species that naturally feed in the midwater/pelagic niche suffer reduced growth as a consequence (Graves, 1983; Beauchamp 198).

The issue for fishery managers of size at, and release timing continues to be an interesting one. In the 1950's and early 1960's relatively small numbers of salmonids released relatively small in size and released three to six months earlier than today's releases produced greater survival rates to adult than very large releases of very large sized salmonids released during and after the observed smolt migration periods. The question of what constitutes a smolt continues to be known only to the smolts in spite of years of research to discover the secrets of this metamorphosis. This is a very interesting academic question and basic research problem, but the fact is that it is only important for the fish to be able to determine the proper time to emigrate and that they be allowed to emigrate at will. In 1979, I coined the term "volitional release" as a means of expressing the idea of fish being able to come and go at will from artificial ponds. This concept was a solution to problems associated with discovering the appropriate release time for artificial ponds stocked with salmon of mixed stock origins and varied individual emigration timings.

The majority of "lower 48" artificial production releases continue to be into river systems; superimposing them upon wild stocks at any number of several critical life stages. Numerous observers have observed that large portions of salmonid releases have been slow to emigrate or never emigrate (Royal, 1973; Wagner 1976). Residual releases may become competitors or predators of wild fingerlings or fry salmonids. Even worse, residuals seem to attract and support predator populations; for example squaw fish and cormorants.

For reasons never satisfactorily explained, salmonids have been planted for decades in upstream areas without a full understanding of the instream ecological requirements of the released salmonids, a knowledge of what resources these released salmonids are being superimposed upon, or a concern for the ecological devastation caused by these practices. The massive releases of

non-smolt salmonids in lakes and streams probably finished, albeit unwittingly, what over fishing, dams, and other manifestations of civilization could not. While one resource agency or division of that agency carefully husbanded a wild resource, another thwarted that effort by planting a competing or predator species in that habitat, or allowed a harvest that is at cross purposes. Enormous amounts of salmonid producing habitat was lost as the result of policies and programs which may fit one need at the expense of others. For example, the effects of lake screening programs meant to discourage catchable rainbow trout plants from emigrating have negatively impacted coho, cutthroat trout, dolly varden char, sockeye salmon, white fish species, and anadromous rainbow populations in numerous lowland lakes and streams. On the other hand, the planting of non-smolt coho in Western streams have resulted in reduced production of salmonid biomass, and in cases the loss of naturally reproducing salmonid populations through biological extinction.

Numerous negative examples of the effects of monocultural techniques in artificial enhanced river systems are available. A paramount example may have been the Columbia River coho salmon experience. During the 1970's, coho of the same genetic stock were released on the same date from 19 or more sites, entered the ocean within a few weeks of each other, and tag data from those releases indicate that most utilized Pacific waters from south of Grays Harbor to Northern California. Prior to the preeminence of artificial stocks in the Columbia, mark and tag data indicated that wild stocks contributed primarily to Washington coastal fisheries and were found in the Gulf of Alaska.

It is important that we begin to practice what we preach with regard to interception fisheries. Fisheries that preclude the management of salmonids on a stock basis should be terminated before they result in the biological extinction of wild stocks and damage artificial stocks. Wild and artificial adult stocks, further, must be identifiable, and spatially and temporally separated in terminal areas; especially where harvest is by dead fish fisheries such as gillnets and seines. Returning adults of artificial origin probably mix with wild salmon adults in off shore and terminal areas. Questions of harvest rates are usually determined to the determine of wild stocks which require 10 or more times the level of escapement than do artificial stocks to remain viable.

To recapitulate, the realities are that artificial propagation based policy has served to reduced stock genetic diversity, negatively manipulated downward the size and age of returning adults, provided a convenient excuse for the worse possible resource use practices, and had profoundly negative impacts upon wild stocks. It provided a rationale because of which critical rearing habitat was not protected. Naturally reproducing stocks were inevitably over harvested in mixed stock offshore and terminal fisheries, and escapements were reduced to below sustainable yield levels or worse yet, to economic extinction. The average size of individuals in stocks were decreased resulting in

reduced reproductive potential and, ultimately, reduced production.

In conclusion, the use of artificial propagation as a mitigative tool continues to have enormous potential. The historical record dictates that the "success yardstick" of the programs which used this tool be measured in terms of personal financial gains, fish industry employment, salmon landings over a prolonged period, pounds of artificially produced salmonids released, and wild run extinctions. The negative impacts to fishery resources iterated above make this a more bitter than sweet story.

- DRAFT - UNFINISHED MANUSCRIPT -

Homing, Straying and the Interaction Between Wild and
Hatchery-Produced Salmon

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Abstract

This paper reviews studies on the patterns of straying of adult salmonids from their river or hatchery of origin, with an emphasis on Pacific salmon. The prevalence of straying varies greatly among populations. In general, introduced populations and salmon whose rearing history involves displacement or changes in water source may stray more than native stock and those reared and released on-site. Normal hatchery practices do not necessarily increase the tendency of salmon to stray, although evidence indicates that this may occur. While a generalized estimate of the proportion of salmon that stray would be useful, none seems appropriate because rivers and hatcheries vary so greatly in their tendency to produce and attract strays. There is evidence that the offspring of hatchery produced salmon may be less viable than those from local wild fish, hence straying between hatcheries and spawning grounds is cause for concern. Whether or not strays actually affect local gene pools depends not only on the prevalence of straying but on the degree of assortative mating and differential survival between populations. At present, fundamental gaps in our understanding of the genetic and environmental factors influencing straying hinder accurate prediction of the levels and consequences of straying.

Introduction

Homing to the natal site for reproduction is characteristic of salmonid fishes (Quinn 1990) but it has long been known that some individuals stray and spawn elsewhere. Straying is important for salmonids because it leads to the colonization of new habitat (Milner 1987; Milner and Bailey 1989) and avoidance of unfavorable local conditions (Lucas 1985; Leider 1989). However, research has revealed a wide variety of genetic differences among populations within species (see reviews by Ricker 1972; Saunders 1981; Taylor in press). Such differentiation presumably results from the scarcity of strays and/or their high mortality rate, relative to locally adapted salmon. The preservation of indigenous populations is one objective of salmon management (Wright 1981; McDonald 1981), in part because they are often more productive than transplanted populations (Ricker 1972; McIntyre 1984; Reisenbichler 1988).

Hatcheries differ from rivers in many respects and it is not surprising that genetic differences between hatchery and wild salmonids arise (e.g., Skaala et al. 1990; Swain and Riddell 1990; Johnsson and Abrahams 1991). To the extent that these genetic differences result in reduced fitness in the wild (Reisenbichler and McIntyre 1977; Chilcote et al. 1986), the straying of hatchery-produced salmon to interbreed with wild fish is cause for concern (Thorpe 1986; Barbat-Leterrier et al. 1989). Moreover, if the disparity in abundance between wild and hatchery-origin salmon is great, the presence of strays may frustrate efforts to correctly estimate population sizes. This paper is structured around a series of questions regarding homing to indicate the state of our understanding of this phenomenon. It concludes with recommended areas of future research to help determine the importance of straying in the interaction between wild and hatchery-produced salmon.

What is Straying?

Straying is the migration of mature individuals to spawn in a stream other than the one where they originated. The spatial scale implied by "where they originated" is vague. The management unit may be the stretch of coast, inlet or watershed. The extent to which wild salmon return to the tributary or reach within a tributary where they were spawned is not known. However, experiments have indicated that salmon released as smolts in sections of a river are more likely to return to that section than other sections (Wagner 1969; Cramer 1981).

From the standpoint of migration and orientation, a salmon strays if ascends a non-natal river and does not subsequently make its way to its natal river. However, if the fish enters a hatchery, it is seldom given the chance to retreat, so there is some question as to whether "strays" entering hatcheries would have eventually left.

When hatcheries rear salmon for a period of time and then "outplant" them (e.g., Nickelson et al. 1986), it is not clear whether "home" is the hatchery of origin or the stream of release. Similarly, when salmon are trucked around long stretches of the Columbia or Sacramento rivers (Ebel et al. 1973; Slatick et al. 1975; Sholes and Hallock 1979), is "home" the hatchery or the release site?

What proportion of naturally produced salmon stray?

Among the earliest large-scale studies of homing was Foerster's work at Cultus Lake, B.C. (summarized in Foerster 1968). All the sockeye salmon (*Oncorhynchus nerka*) smolts leaving the lake in 1931 and 1936 were fin-clipped. Marked adults comprised 99.4 and 98.5% of the returning adults of the appropriate age groups, indicating that very few sockeye from other Fraser River populations entered the lake. The vast majority of sockeye must pass Cultus Lake to return to their natal locations, so the absence of strays into the lake was noteworthy. However, there was no record of the number of marked Cultus Lake sockeye straying from the lake. Patterns of parasite prevalence and protein polymorphisms (Quinn et al. 1987) indicated that other sockeye salmon populations seldom strayed between lakes. Life history differences among populations within lake systems imply that homing to spawning areas within lakes is probably precise as well (e.g., Blair 1989).

A marking study of chum salmon, *O. keta*, on Hokkaido, Japan revealed that 97.8% of the 275 in-river recoveries were in the river of origin and the rest were found in nearby rivers (Sakano 1960, in Sano 1966). MacQuarrie and Bailey (1980) reported that 5.4 and 5.2% of the chum salmon fry produced in artificial incubation facilities on Thornton Creek strayed to Salmon Creek, B.C. in 1979 and 1980, respectively.

There is a widely held notion that pink salmon, *O. gorbuscha*, are more prone to stray than other Pacific salmon species. This was supported by the recolonization of Sashin Creek, Alaska after deliberate extermination of the even-year cycle (Merrell 1962) and the recolonization of the upper Fraser River by pink salmon after the rock slide at Hell's Gate (Vernon 1962). Parker (1967) also reported "... substantial straying within a fairly large 'home' area..." Finally, the rapid colonization of the Great Lakes by pink salmon after accidental introduction (Kwain and Lawrie 1981) and the White and Barents seas after introduction to the Kola Peninsula (Bakshtansky 1980) implies extensive straying. However, studies reviewed by Lister et al. (1981) revealed no particular tendency to stray and Gharrett (1985) reported that "no straying was observed from the genetically marked Auke Creek population into the unmarked Waydelich Creek implying accurate homing to stream of origin." I have been unable to locate a comprehensive study of straying by wild pink salmon populations, hence the conclusion that they stray more commonly than the other salmon seems premature.

There is both practical and theoretical interest in comparing straying prevalences among species (Quinn 1984). The long-term study by Shapovalov and Taft (1954) at Scott and Waddell creeks in California revealed that coho salmon, O. kisutch strayed between the creeks much more frequently than did steelhead, O. mykiss (15 and 27% vs. 2 and 3%). Unfortunately, there does not seem to have been another such study on wild populations of more than one salmon species in the same rivers and there is generally little data on straying by wild salmon. There seems to be considerable variation in straying prevalence among rivers, as several Vancouver Island coho salmon populations have much lower incidence of straying than Shapovalov and Taft (1954) reported (Labelle 1990).

In addition to studies of the distribution of adults that had been marked as juveniles, a number of experiments have assessed the fidelity of marked adults displaced from their spawning stream (presumed to be their home river). In general, the great majority of recoveries are in the river where the salmon were first captured (e.g., Hartman and Raleigh 1964). Variation in the proportion of displaced salmon returning may be related to site-specific characteristics (McCart 1970; Blair and Quinn 1991) or water flow at the time of the experiment (Helle 1966).

In general, there are so few comprehensive studies of straying by naturally produced salmon and there is so much variation in straying within species that interspecific comparisons are unwarranted. A general estimate is that 3-5% of the salmon produced in a river that survive to adulthood may spawn elsewhere but this probably overestimates straying in many cases.

Do salmon from enhancement facilities stray more commonly than naturally produced salmon?

Juvenile salmon from enhancement facilities are often marked as part of efforts to evaluate their marine survival and distribution, hence most data on homing and straying are from enhanced populations. In most cases there is no comparable tagging effort on naturally produced salmon in the same river, so it is not possible to determine if the enhancement facility influenced the proportion of salmon straying. However, two recent studies provide information on this question. Labelle (1990) tagged large numbers of coho salmon from several streams on the east side of Vancouver Island, B.C., including the Quinsam River, in which naturally produced, hatchery outplants (termed "colonization") and hatchery produced coho salmon were marked. There was no significant difference in the proportion of strays among the groups (Table 2). On the other hand, McIsaac's (1990) study of Lewis River, Washington fall chinook salmon, O. tshawytscha, indicated that even a brief period of hatchery rearing increased the proportion of strays, relative to naturally produced salmon from the same population (Table 3).

Are there spatial and temporal patterns of straying?

Given that some salmon stray, it would be useful to know whether they tend to stray to rivers below their origin (as might be expected if exhaustion influenced straying) and whether they tend to enter rivers or hatcheries with certain characteristics. Such information has been difficult to acquire owing to the difficulties of surveying non-natal rivers in an extensive and unbiased manner. Studies in which seaward migrants were fin-clipped seldom surveyed more than a few sites near the release location. However, widespread use of the coded wire tag (cwt) in hatcheries and selected rivers has presented the opportunity to study straying over large spatial scales. These tags are injected into the smolt's cranium and the presence of the tag is signalled by excision of the adipose fin. The primary purpose of such tagging studies is generally to estimate the marine distribution and survival of stocks or experimental groups. However, tags recovered from terminal fisheries, hatcheries and spawning grounds also provide information on straying.

Analysis of data on spring chinook salmon released from the Cowlitz River Salmon Hatchery indicated that most (98.6%) of the returning salmon ascended the Cowlitz River (Quinn and Fresh 1984). However, most of the strays went upstream beyond the Cowlitz River and 76.6% (446) of the estimated 582 strays were recovered in the Lewis River. This is more than four times as many as strayed to the Kalama River (108, 18.6%), even though the Kalama River is only 9 km upriver from the Cowlitz and the Lewis River is 30 km upriver of the Cowlitz.

More thorough analysis of five populations of fall chinook salmon on the Columbia River below Bonneville Dam revealed considerable variation among hatcheries in the tendency of salmon to stray, ranging from 9.9 to 27.5% (Quinn et al. 1991). More dramatic, however, was the variation in attractiveness of rivers to strays. Two hatcheries (Abernathy and Washougal) received virtually no strays whereas about 30% of the marked salmon in the Kalama and Lewis rivers were strays. It seems likely that some combination of flow, temperature and perhaps presence of conspecifics might influence the tendency of strays to enter a river. A greater understanding of the proximate factors influencing straying is needed before we can assess the possible genetic interactions among populations.

Events that affect water quality in the home river can influence straying (e.g., the eruption of Mt. St. Helens: Leider 1989). In addition to these dramatic situations, there is also some "background" year-to-year variation in straying (Quinn and Fresh 1984; Quinn et al. 1991). On a finer spatial scale, the tendency of hatchery produced salmon to enter their hatchery, as opposed to spawning in the river, can vary greatly from year to year (Table ..). Some of the factors that presumably affect general

attractiveness of rivers and hatcheries (flow, temperature, conspecifics, etc.) may also influence interannual patterns of straying.

Are there demographic patterns of straying?

It is not clear whether salmon stray

4. What factors may encourage straying? (normal hatchery culture, transplants (Bams, McIsaac and Quinn) outplants (Donaldson & Allen vs. Lister et al.), water changes...

5. Interaction between wind and hatchery-produced fish - Kalama steelhead strays into the hatchery and Elk River chinook fish that didn't enter the hatchery.

Discussion

Fundamental problem: to what extent are strays lost vs. actively comparing home to non-home sites?

Applied problems: how can straying be discouraged?

what are the survival rates of strays vs. local? reproductive isolation, etc???

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Table 1. Straying (mean of yearly %s) by coho salmon reared and released in their river of origin or the Rosewall Creek experimental hatchery. All rivers are on the east coast of Vancouver Island, B.C. (Labelle 1990).

River of Origin	Release Site	Percent Straying	
		Adults	Jacks
Trent River	Trent River	10.2	7.6
	Rosewall Creek	27.7	13.9
Black Creek	Black Creek	1.3	0.6
	Rosewall Creek	24.1	0.0
Little Qualicum River	Little Qualicum R.	7.5	0.7
	Rosewall Creek	8.3	2.3

Table 2. Mean annual percent of coho salmon straying from the Quinsam River, B.C. in relation to rearing history: spawned, reared and released from the hatchery ("hatchery"), spawned and initially reared in the hatchery but outplanted into the river ("colonization") and naturally produced ("wild"). Data from Labelle (1990).

Age group	Rearing history		
	hatchery	colonization	wild
Adults (age 3)	0.0	0.1	3.9
Jacks (age 2 males)	0.2	0.4	0.0

Table 3. Homing of Lewis River, Washington fall chinook salmon caught, tagged and released on site as fry ("wild"), caught, reared for about 10 weeks in a hatchery, tagged and released ("wild/hatchery"), and fry reared entirely in a hatchery ("hatchery"). Adult salmon were classified as having returned to the Lewis River, to adjacent rivers (one major tributary above and below the Lewis River), to other Columbia River locations or to locations outside the Columbia River system (McIsaac 1990).

Rearing history	Distribution of Returning Adults (%)			
	Lewis River	Adjacent rivers	Columbia R. system	Outside the Columbia R.
wild	96.8	<0.1	3.2	0.0
wild/hatchery	90.7	4.8	4.5	0.0
hatchery	89.7	5.7	4.6	<0.1

Table 4. Proportion of adult fall chinook salmon produced in the Elk River Hatchery, Oregon, returning to the hatchery as a percentage of the total return to the river (hatchery plus spawning grounds) (Nicholas and Downey 1983).

<u>Return year</u>	<u>Percentage entering the hatchery</u>
1972	45.2
1973	52.2
1974	15.5
1975	13.0
1976	5.9
1977	31.0
1978	10.8
1979	21.2
1980	10.8
Average	25.0

Table 5. The relationship between straying of coho and chinook salmon and steelhead trout from the release site and the distance between rearing and release sites within the same river system (from Lister et al. 1981).

	Distance from rearing to release sites (km)		
	0	4-29	47-485
Number of studies	10	5	7
Mean % straying (range)	3% (0-13)	74% (37-100)	8% (1-39)
% straying to rearing site	-	77%	55%

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Abstract

This paper reviews studies on the patterns of straying of adult salmonids from their river or hatchery of origin, with an emphasis on Pacific salmon. The prevalence of straying varies greatly among populations. In general, introduced populations and salmon whose rearing history involves displacement or changes in water source may stray more than native stock and those reared and released on-site. Normal hatchery practices do not necessarily increase the tendency of salmon to stray, although evidence indicates that this may occur. While a generalized estimate of the proportion of salmon that stray would be useful, none seems appropriate because rivers and hatcheries vary so greatly in their tendency to produce and attract strays. There is evidence that the offspring of hatchery produced salmon may be less viable than those from local wild fish, hence straying between hatcheries and spawning grounds is cause for concern. Whether or not strays actually affect local gene pools depends not only on the prevalence of straying but on the degree of assortative mating and differential survival between populations. At present, fundamental gaps in our understanding of the genetic and environmental factors influencing straying hinder accurate prediction of the levels and consequences of straying.

Abstract

Overview of Salmon Enhancement Programs in Southeast Alaska

By Donald F. Amend

All five of the pacific salmon species are being enhanced by hatcheries in Southeast Alaska. Non-hatchery enhancement is not included in this report. Hatcheries are operated by the FRED Division, regional aquaculture associations (SSRAA, NSRAA), and private non-profit corporations (PNP's). Hatcheries played a minor role in the commercial harvest prior to 1985. Since 1985, the average annual harvest of enhanced chinook was 19,590 (10.2%), coho 195,650 (8.1%), chum 695,700 (31.2%), pink 475,000 (2.1%), and sockeye 58,480 (2.4%). At full production the percent of enhanced salmon in the commercial harvest is expected to be about 32.5% chinook, 18.2% sockeye, 16.2% coho, 5.8% pinks and 66.4% chum. The annual value to the commercial fleet has averaged \$8.4 million annually and at full production is expected to average \$36.8 million annually. The annual 3% enhancement tax paid by fishermen has averaged \$2.39 million. Cost recovery is conducted only by regional aquaculture associations and PNP's. The annual revenue generated from cost recovery is estimated to be about \$2.0 million.

DO CULTURE CONDITIONS OF HATCHERY-REARED SALMON AFFECT RETURN AND STRAYING OF ADULTS?

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ABSTRACT

Available data indicate that caution should be exercised in rearing certain species of salmon using accelerated growth regimens without additional research to explore if such regimens result in straying. We do know from our experience with accelerated rearing programs in Alaska for chinooks, for example, that the result is significantly lower returns of adults and that the returns are characterized by a high percentage of jacks. The reasons for this are unknown, but a better understanding of factors affecting smolt transformation and development in general are likely to lead to augmentation of current rearing strategies which will result in better developed smolts. Recent studies have revealed the importance of thyroid hormones on olfactory imprinting and development in general.

Studies comparing saltwater survival of yearling and zero-age coho salmon have showed differential rates of survival related to the timing of release into salt water and to the timing and extent of the plasma thyroid hormone surge. In one study, about 5 times as many yearling smolts survived as compared to zero-age smolts (Dickhoff *et al.*, 1982). Those data, taken together with the information that the thyroid hormone surge (T_4) during smolt transformation in the zero-age fish were half the amplitude of the yearlings, indicate that in addition to poor survival as postsmolts, some zero-age fish may not imprint properly on the stream where they are released. The reason for that is that thyroid hormones play an essential role in olfactory imprinting. Our studies on brain chemistry and brain circuitry changes during smolt transformation revealed sequential surges of select neurotransmitters before, during and after the plasma T_4 surge. Irregularities in any of these surges

may result in inadequate imprinting or lead to inadequate brain development, which in turn could affect subsequent behavior and survival.

There is to my knowledge no direct evidence for straying of zero-age fish, but research in this area should, in my view, be carried out before accelerated rearing programs are implemented.

Density dependent changes in chum salmon, Oncorhynchus keta,
returning to Iwate prefecture, Japan

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In the last two decades, production of chum salmon in waters around Japan increased 5.8 million fish, 21.2 thousand tons (1970) to 50 million fish, 170 thousand tons (1990). Out of this production, Iwate contributes about 1/4 to 1/3 of the total.

The present study aims to clarify changes in some characteristics of the Iwate population during stock enhancement in the last two decades.

Stocks of three rivers in southern Iwate viz. Katagishi, Sakari and Kesen Rivers were investigated on their FL, BW, Age, and fecundity since 1975.

Body size in both FL and BW decreased gradually and the mode of change was almost identical with the three river stocks. Condition factor also decreased in the three stocks. Mean ages of adult increased gradually and the difference attained more than one year during the last two decades.

For the estimation of the growth during ocean resident years, scale radii and the number of circuli at each ocean resident year were analyzed. Age 4 fish, the dominant age class in recent years, were subsampled for scale analysis. Though annual variation in the length of scale radii and in the number of circuli were observed for each ocean resident year, stunted growth at first ocean year was prominent in recent years.

Highly significant negative correlations were detected between FL and number of fry released, FL and number of adult returned, and scale radii and number of fry released. A positive correlation was detected between mean age of return and the number of adult returned to Iwate prefecture.

Fecundity seemed to be decreased by increasing the size of egg in early 80s but became less obvious in late 80s.

More detailed information on their ocean resident stages is urgently needed.

Interactions between wild and cultured Atlantic salmon

A review of the experience in Norway

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ABSTRACT

About 500 streams in Norway support Atlantic salmon. Most of the Norwegian salmon populations are characterized by small numbers of fish. Physical conditions, for instance water flow and temperature regimes, vary significantly along the Norwegian coast. Analyses of age/size at maturity, timing of spawning and timing of smolt migrations clearly support the hypothesis of ecological adaptations to different physical environment. The differences in life history patterns are results of different selection pressures on salmon under varying physical conditions.

Proportions of cultured salmon have increased together with the rapid growth of the Norwegian salmon farming industry, and a maximum of 80 % cultured fish in spawning populations have been observed.

The sources of cultured salmon in Norwegian streams are fish released for general enhancements of stocks, ocean ranching and escapees from the fish farming industry. Escapees from closed pen operations in the main source of cultured fish in nature.

Possible effects of the increasing numbers of cultured fish in Norway are discussed. The most striking effect so far, have been the introductions of parasites and diseases with cultured fish. In recent years, more than 30 populations of salmon have been completely wiped out by the monogenean *Gyrodactylus*, and high mortality of adult salmon have been observed due to furunculosis in some streams. The long term effects of genetic interbreeding might result in extra mortality of wild fish due to erosion of local adaptations.

Suggestions to reduce negative effects of interactions from cultured fish are proposed.