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U. S. Atlantic Salmon Assessment Committee

Assessment 1988/01

Annual Report of the U. S. Atlantic Salmon Assessment Committee

Woods Hole, Massachusetts

12 - 16 December 1988

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Executive Summary

The U. S. Atlantic Salmon Assessment Committee and advisors to the Committee met December 12 - 16, 1988 in Woods Hole, Massachusetts to address three Terms of Reference (TR) and prepare the first Annual Assessment Report (Section 7). The report indicates that 1.4 million smolts, 4.0 million fry and nearly one million underyearling (0+) parr were released in New England rivers in 1988. Record releases in one or more categories were report for all programs. Releases of fin-clipped, Carlin and micro tagged hatchery smolts were compiled for ICES.

Reported adult returns totaled 3,604 salmon including 95 for the Connecticut, six for the Pawcatuck, 65 for the Merrimack and 2,852 for the Penobscot. The Pawcatuck, Penobscot and St. Croix rivers showed increases over 1987 while the Connecticut, Merrimack and some Maine rivers were down compared to 1987. Return rates for the Connecticut, Pawcatuck, Merrimack, Penobscot and Union were significantly below long term averages. (Section 2.1 & 2.2)

The sport harvest in Maine rivers showed slight increases for some (Penobscot, Narraguagus, and Machias) but was down in other rivers. Harvest regulations, fishing conditions and total run size interacted to produce a sport harvest of 120 salmon in the Penobscot River, 5.8% of the total run. (Section 2.3)

Population dynamics studies of juvenile salmon in the Pawcatuck River have shown mortality rates, over six month intervals, to be highly variable but affected by density. Growth rates have been independent of density. Observations of presmolt physical appearance and length suggests 100% of fish over 15.5 cm will be smolts. Concern exists over the variability of certain physiological parameters monitored for hatchery smolts and their subsequent ability to actively migrate after release. (Section 2.4)

Index site monitoring of parr growth and densities (from fry stocking) in the Merrimack River Basin has shown substantial year-to-year variation. Analysis of data from seven sites since 1984 indicates age one, two, and three smolts will be produced. Since 1982, approximately 40% of the adult returns to the Merrimack have been related to fry releases. (Section 2.4)

Recently passed legislation in Maine will help strengthen existing laws and regulations that prohibit the incidental or illegal take of salmon. Analysis of micro tag loss in adult returns to the Penobscot River suggest a maximum tag loss of less than 5% and a probable loss of less than 1%. (Section 2.4)

Smolt survival estimates and factors that affect survival were reviewed. A modelling approach was used to take estimates of harvest, adult returns and smolt releases to estimate post smolt survival (PSS) for the Penobscot River from 1968 to 1985. The model suggested that PSS averaged 3.2% over this time period, but would have to range from 9 - 15% to support a homewater return of 3 - 5% under current harvest conditions. (Section 3.1)

Hydroelectric station impacts are being investigated on the Connecticut, Merrimack and Penobscot rivers. Modeling studies and current site specific investigations suggest impacts can be severe, at least under certain low flow conditions. Adult returns from the first year of a three year smolt release study on the lower Penobscot River are not conclusive but suggested approximately equal return rates regardless of release site. Flow and passage conditions at the dams may have affected outmigrant survival. (Section 3.2)

Double-crested comorants prey on hatchery smolts released in the Penobscot River, but the effect of this predation on subsequent adult returns can not be quantified. The potential relationship between various environmental parameters, especially sea surface temperature (SST) and predator and prey abundance indices was explored. A statistically strong correlation between mean August SST, abundance of sand lance in the mid Atlantic area, and return rates of Penobscot River hatchery released smolts was shown. (Section 3.3 & 3.4)

Research proposals and investigations of the Northeast Anadromous fish Research Lab (NAFRL) and the Sunderland Office of Fishery Assistance (SOFA) were reviewed. Additionally, new terms of reference (TR), research recommendations (R), and several working groups (WG) were developed as activities of the Assessment Committee for 1989.

1 INTRODUCTION

1.1 Participants

Vaughn Anthony	National Marine Fisheries Service, Woods Hole, MA
Ed Baum	Maine Atlantic Sea-Run Salmon Commission
Henry E. Booke	U.S. Fish & Wildlife Service, Turners Falls, MA
Terry Bradley	Department of Fisheries, Animal & Veterinary Services/University of Rhode Island
Richard Buck	U.S. Commissioner to NASCO
Kenneth Cox	Vermont Fish and Wildlife
Bob Dorazio	U.S. Fish & Wildlife Service, Leetown, WV
Lewis Flagg	Maine Department of Marine Resources
Kevin Friedland	National Marine Fisheries Service, Woods Hole, MA
Steve Gephard	Connecticut Department of Environmental Protection/Marine Fisheries
Mark R. Gibson	Rhode Island Fish and Wildlife
Jon Greenwood	New Hampshire Fish and Game, Concord, NH
Jerry Marancik	U.S. Fish & Wildlife Service, E. Orland, ME
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Steve Roy	U.S. Forest Service, Vermont
Richard G. Seamans	National Marine Fisheries Service, Gloucester, MA
Bob Sousa	U.S. Fish & Wildlife Service, Turners Falls, MA
Lawrence Stolte	U.S. Fish & Wildlife Service, Concord, NH

1.2 Background

The U.S. became a charter member of the North Atlantic Salmon Conservation Organization (NASCO) in 1984. NASCO is charged with the international management of Atlantic salmon stocks on the high seas. Three Commissioners for the U.S. are appointed by the President and work under the auspices of the U.S. State Department. The Commissioners felt they needed advice and input from scientists involved in salmon research and management throughout New England and asked the New England Atlantic Salmon Committee (NEASC) to create such an advisory committee. NEASC is comprised of State and federal fishery agency chiefs who designated personnel from their staff to serve on the "NASCO Research Committee", which was formed in 1985.

The NASCO Research Committee met semi-annually to discuss the terms of reference for upcoming meetings of the International Counsel for the Exploration of the Seas (ICES) and NASCO, as well as respond to inquiries from NASCO Commissioners.

In July of 1988 Lawrence Stolte, Chairman of the Research Committee for the U.S. section to NASCO communicated with the U.S. Commissioner to NASCO, proposing a new composition, focus and name for the Research Committee. The proposed committee was to be called the U.S. Atlantic Salmon Assessment Committee, focus on annual stock assessment, proposal and evaluation of research needs and serve the U.S. section to NASCO. The U.S. Commissioners concurred with this proposal.

A key element of the proposal was development of an annual Assessment Meeting with the main goal of producing an assessment document for the U.S. Commissioners. Additionally, the report would serve as guidance, with regard to research proposals and recommendations to the State and Federal fishery agency chiefs through the New England Atlantic Salmon Committee (NEASC).

The first Assessment Meeting was held December 12-16, 1988 in Woods Hole, MA and addressed the Terms of Reference (Appendix A) proposed in July. The results of this meeting are contained in this report.

1.3 Relationship of ICES to NASCO

ICES, the official research arm of NASCO, is responsible for providing scientific advice to be used by NASCO members as a basis for formulating biologically sound management recommendations for the conservation of North Atlantic salmon stocks. ICES delegates responsibilities for the collection and analysis of scientific data on salmon to various study groups. The Working Group on Atlantic Salmon and the Anadromous and Catadromous Fish Committee, which are composed of representatives of member countries are examples.

"Terms of Reference" constitute the task assignments given to the Atlantic Salmon Working Group by ICES from recommendations received from NASCO, the EEC, member countries of ICES, the ANACAT Committee or the Working Group itself. Opportunities for development of Terms of Reference are available to the Atlantic Salmon Assessment Committee by submission of issues of interest through the U. S. Commissioners to NASCO or the appropriate channels.

2 Status of Stocks

Term of reference 1 (a, b, and c)

2.1 Stocking

Connecticut River Basin

The main stem and 11 tributaries of the Connecticut River Basin were stocked with fry, parr, or smolts during 1988 (Table 1). Over 1.3 million fry were released from the Salmon to the Ammonoosuc River. This included more than 300,000 in each of the Farmington, West, and White Rivers. Approximately 72,000 underyearling (0+) parr were released between late September (Farmington River) and early November (White River).

Smolt releases in 1988 totaled 395,000 a record for the program. Most were fin-clipped and received coded wire tags. Carlin tags were placed on 46,000 smolts (also coded wire tagged) released at Wilson, CT (Table 2). The majority of parr are fish less than 15.0 cm released simultaneously with smolt releases. Parr represented 75,200 of the 470,500 yearling fish released in 1988.

Pawcatuck River Basin

A total of 235,100 juvenile salmon was released into the basin (Table 1). Of these, 85,100 were age 0+ parr or older. A number of different strains were released. No identifiable marks were used with the exception of the Beaver River releases. These fish are being utilized in a smolt physiology study by the University of Rhode Island Zoology Department and were marked with an adipose fin clip.

The total release represents the largest since the project began. The number of wild smolt produced from pre-smolt parr or fry releases has been estimated from spring electrofishing densities at index stations. The 1988 smolt run was estimated at 7,800 fish. An additional 5,400 hatchery smolt were released. The combined total of 13,200 smolt represents the largest in the project history.

Merrimack River Basin

The main stem of the river and 10 tributaries were stocked with fry, parr and smolts in 1988 (Table 1). Over 1.7 million fry were released approaching the program goal of 1.8 million. This represents a record fry release in the Merrimack.

A total of 129,300 yearling parr was released in the main stem (Manchester, NH) and 46,800 and 43,700 age one smolts were released at Nashua, NH and Groveland, MA (head of tide) respectively. All parr were fin clipped (adipose and right ventral) and received coded wire micro tags (Table 2).

Maine Rivers

Twelve different river systems were stocked with approximately 838,000 fry, 872,000 parr, and 849,000 1-year and 87,000 2-year old smolts (Table 1). Approximately 200,000 of the salmon smolts were marked with Carlin or coded wire tags in addition, 200,000 parr and smolts received a fin clip (Table 2).

A significant number of the 1988 releases (747,400 or 98% of the 0+Parr and 151,300 or 18% of the fry) were stocked in the upper St. John River, Maine and New Brunswick, Canada by a private organization. Any adult returns from these releases will be included in the trap catch at the Mactaquac Dam in New Brunswick.

Table 1. Number of Atlantic salmon fry, 0+Parr,1Parr, 1 Smolt, and 2 Smolt stocked in New England rivers in 1988.

River	Fry	0+parr	1 parr	1smolt	2smolt
Connecticut	0	0	16,500	165,000	0
Salmon	43,300	0	14,700	64,100	0
Farmington	332,500	38,900	24,300	90,000	0
Westfield	6,000	0	0	0	0
Manhan	27,500	0	0	0	0
Deerfield	50,400	0	2,300	22,600	0
Millers	0	0	2,700	22,800	0
West	385,000	26,000	9,400	16,200	0
Saxtons	25,100	0	0	0	0
White	321,600	7,300	5,300	14,600	0
Ammonoosuc	100,000	0	0	0	0
Stevens	18,200	0	0	0	0
CT Subtotal	1,309,600	72,200	75,200	395,300	0
Pawcatuck	0	64,600	7,100	2,900	0
Beaver	0	8,000	0	2,500	0
Wood	150,000	0	0	0	0
RI Subtotal	150,000	72,600	7,100	5,400	0

Table 1 Continued. Number of Atlantic salmon fry, 0+Parr,1Parr, 1 Smolt, and 2 Smolt stocked in New England rivers in 1988.

River	Fry	0+parr	1 parr	1smolt	2smolt
Merrimack	79,900	0	129,300	90,500	0
Pemigewasset	906,500	0	0	0	0
Souhegan	110,000	0	0	0	0
Piscataquog	183,300	0	0	0	0
Contoocook	129,200	0	0	0	0
Suncook	10,500	0	0	0	0
Soucook	5,000	0	0	0	0
Baker	116,000	0	0	0	0
Smith	70,300	0	0	0	0
Mad	70,000	0	0	0	0
Beebe	37,000	0	0	0	0
MERR Subtotal	1,717,700	0	129,300	90,500	0

Table 1 Continued. Number of Atlantic salmon fry, 0+Parr,1Parr, 1 Smolt, and 2 Smolt stocked in New England rivers in 1988.

River	Fry	0+parr	1 parr	1smolt	2smolt
Penobscot	50,000	0	1,900	224,500	17,100
'Keag	125,000	0	0	224,600	0
E. BR. Penob.	106,000	0	10,500	0	0
Piscataquis	100,000	0	27,500	118,500	41,700
Pleasant	50,000	0	12,000	32,500	28,300
PENB Subtotal	431,000	0	51,900	600,100	87,100
Dennys	29,900	0	0	25,700	0
Ducktrap	10,200	0	0	0	0
E. Machias	10,000	0	7,500	20,700	0
Machias	30,200	0	31,300	30,900	0
Narraguagus	20,000	13,000	5,600	15,700	0
Pleasant	25,000	0	2,800	10,400	0
Saco	47,200	0	0	25,100	0
Sheepscot	40,000	12,000	0	10,200	0
St. Croix	0	0	0	78,700	0
Union	0	0	0	30,600	0
St. John	0	0	0	0	0
Aroostook	43,300	0	0	0	0
Upper ST. J.	151,300	747,400	0	0	0
Maine Total	838,100	772,400	99,100	848,200	87,100
1988 Totals	4,015,400	917,200	310,700	1,339,400	87,100

Table 2. Tag and mark codes of Atlantic salmon released in New England rivers in 1988.

Agency	Age	Life Stage	Stock Origin	Tag Type[1]	Fin Clip[2]	Tag Code[3]	Release Date	Release Location	Release Number
USFWS	1	Smolt	Union	M	AD	7/16/59	4/27/88	Connect.	11300
USFWS	1	Smolt	Connect.	M	AD	7/16/60	3/28/88	Connect.	18900
USFWS	1	Smolt	Connect.	M	AD+LV	7/16/61	3/18/88	Connect.	17600
USFWS	1	Smolt	Connect.	M	AD	7/16/62	3/15/88	Connect.	18300
USFWS	1	Smolt	Connect.	M	AD	7/16/63	4/26/88	Connect.	15500
USFWS	1	Smolt	Connect.	M	AD	7/17/01	4/05/88	Connect.	14600
USFWS	1	Smolt	Connect.	M	AD	7/17/02	4/27/88	Connect.	10200
USFWS	1	Smolt	Connect.	M	AD	7/17/05	4/25/88	Connect.	18000
USFWS	1	Smolt	Connect.	M	AD+RV	7/17/06	3/23/88	Connect.	19200
USFWS	1	Smolt	Connect.	M	AD	7/17/07	4/08/88	Connect.	22200
USFWS	1	Smolt	Connect.	M	AD	7/17/08	3/17/88	Connect.	22400
USFWS	1	Smolt	Connect.	M	AD	7/17/09	5/09/88	Connect.	22300
USFWS	1	Smolt	Connect.	M	AD	7/17/10	4/18/88	Connect.	22800
USFWS	1	Smolt	Connect.	M	AD	7/17/11	3/14/88	Connect.	12900
USFWS	1	Smolt	Connect.	M	AD[4]	7/17/12	4/19/88	Connect.	22700
USFWS	1	Smolt	Union	M	AD[5]	7/17/13	4/20/88	Connect.	23300
USFWS	1	Smolt	Connect.	M	AD	7/17/14	4/04/88	Connect.	16200
USFWS	1	Smolt	Union	M	AD	7/17/15	4/06/88	Connect.	22800
USFWS	1	Smolt	Union	M	AD	7/17/16	4/07/88	Connect.	22600

[1] M = Coded wire microtag; C = Carlin tag

[2] AD = Adipose; LV = Left Ventral, RV = Right Ventral; BV = Both Ventrals; N = None

[3] Micro tag code is reported as Agency Code/Data 1/Data 2; Carlin Tag ranged is given

[4] This lot was also tagged with Carlin tags between the range 550,001 - 575,000

[5] This lot was also tagged with Carlin tags between the range 575,001 - 600,000

Table 2 Continued. Tag and mark codes of Atlantic salmon released in New England rivers in 1988.

Agency	Age	Life Stage	Stock Origin	Tag Type[1]	Fin Clip[2]	Tag Code[3]	Release Date	Release Location	Release Number
USFWS	1	Parr	Union	M	AD	7/16/59	4/27/88	Connect.	1500
USFWS	1	Parr	Connect.	M	AD	7/16/60	3/28/88	Connect.	1800
USFWS	1	Parr	Connect.	M	AD+LV	7/16/61	3/18/88	Connect.	2600
USFWS	1	Parr	Connect.	M	AD	7/16/62	3/15/88	Connect.	1700
USFWS	1	Parr	Connect.	M	AD	7/16/63	4/26/88	Connect.	1000
USFWS	1	Parr	Connect.	M	AD	7/17/01	4/05/88	Connect.	5300
USFWS	1	Parr	Connect.	M	AD	7/17/02	4/27/88	Connect.	500
USFWS	1	Parr	Connect.	M	AD	7/17/05	4/25/88	Connect.	1900
USFWS	1	Parr	Connect.	M	AD+RV	7/17/06	3/23/88	Connect.	1100
USFWS	1	Parr	Connect.	M	AD	7/17/07	4/08/88	Connect.	3000
USFWS	1	Parr	Connect.	M	AD	7/17/08	3/17/88	Connect.	2900
USFWS	1	Parr	Connect.	M	AD	7/17/09	5/09/88	Connect.	2800
USFWS	1	Parr	Connect.	M	AD	7/17/10	4/18/88	Connect.	2300
USFWS	1	Parr	Connect.	M	AD	7/17/11	3/14/88	Connect.	2300
USFWS	1	Parr	Connect.	M	AD[4]	7/17/12	4/19/88	Connect.	2700
USFWS	1	Parr	Union	M	AD[5]	7/17/13	4/20/88	Connect.	2000
USFWS	1	Parr	Connect.	M	AD	7/17/14	4/04/88	Connect.	9400
USFWS	1	Parr	Union	M	AD	7/17/15	4/06/88	Connect.	2700
USFWS	1	Parr	Union	M	AD	7/17/16	4/07/88	Connect.	2300

1 M = Coded wire microtag; C = Carlin tag
2 AD = Adipose; LV = Left Ventral, RV = Right Ventral; BV = Both Ventrals; N = None
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Table 2 Continued. Tag and mark codes of Atlantic salmon released in New England rivers in 1988.

Agency	Age	Life Stage	Stock Origin	Tag Type[1]	Fin Clip[2]	Tag Code[3]	Release Date	Release Location	Release Number
USFWS	1	Smolt	Merrimack	M	AD	7/16/51 7/16/52 7/16/53 7/16/54 7/16/55 7/16/56	05/88	Merrimack	43700
USFWS	1	Smolt	Merrimack	M	AD	7/16/57 7/16/58	04/88	Merrimack	46800
USFWS	1	Parr	Merrimack	M	AD+RV	7/16/51 7/16/52 7/16/53 7/16/54 7/16/55 7/16/56 7/17/04	06/88	Merrimack	129300

[1] M = Coded wire microtag; C = Carlin tag
[2] AD = Adipose; LV = Left Ventral, RV = Right Ventral; BV = Both Ventrals; N = None
[3] Micro tag code is reported as Agency Code/Data 1/Data 2; Carlin Tag ranged is given
[4] This lot was also tagged with Carlin tags between the range 550,001 - 575,000
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Table 2 Continued. Tag and mark codes of Atlantic salmon released in New England rivers in 1988.

Agency	Age	Life Stage	Stock Origin	Tag Type[1]	Fin Clip[2]	Tag Code[3]	Release Date	Release Location	Release Number
USFWS	1	Smolt	Penobscot	C	N	600,001-625,000	5/12/88	Penob. R.	25000
USFWS	1	Smolt	Penobscot	C	N	625,001-650,000	5/12/88	Penob. R.	25000
USFWS	1	Smolt	Penobscot	C	N	650,001-675,000	5/10/88	Penob. R.	25000
USFWS	1	Smolt	Penobscot	C	N	675,001-700,000	5/11/88	Penob. R.	25000
USFWS	1	Smolt	Penobscot	M	AD	7/16/47	5/05/88	Penob. R.	25000
USFWS	1	Smolt	Penobscot	M	AD	7/16/48	5/06/88	Penob. R.	25000
USFWS	1	Smolt	Penobscot	M	AD	7/16/49	5/09/88	Penob. R.	25000
USFWS	1	Smolt	Penobscot	M	AD	7/16/50	5/10/88	Penob. R.	25000
USFWS	1	Smolt	Penobscot		LV		4/26/88	St. Croix	40000
USFWS	1	Smolt	Penobscot		RV		4/29/88	St. Croix	38700
USFWS	1	Smolt	Penobscot		RV		4/29/88	Union R.	15300
USFWS	1	Smolt	Penobscot		LV		5/05/88	Union R.	15200
USFWS	1	Smolt	Penobscot		RV		4/19/88	Saco R.	15000
USFWS	1	Smolt	Penobscot		LV		4/20/88	Saco R.	10100
USFWS	1	Smolt	Penobscot		RV		5/06/88	Penob. R.	22100
USFWS	2	Smolt	Penobscot		BV		5/09/88	Penob. R.	1600
USFWS	1	Parr	Penobscot		RV		6/21/88	Machias	24500
USFWS	1	Parr	Penobscot		RV		6/21/88	E. Machias	7500

[1] M = Coded wire microtag; C = Carlin tag
[2] AD = Adipose; LV = Left Ventral, RV = Right Ventral; BV = Both Ventrals; N = None
[3] Micro tag code is reported as Agency Code/Data 1/Data 2; Carlin Tag ranged is given
[4] This lot was also tagged with Carlin tags between the range 550,001 - 575,000
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2.2 Adult Returns

Connecticut River Basin

A total of 95 salmon (94 2SW, one 1SW) returned to three locations (Holyoke - 75, Farmington - 14, Salmon - six). Eighty seven fish were examined for data on sex, age, tags or mark status and origin. One salmon was judged to be from a fry release in the Farmington River, one from a parr release in the Salmon River and 79-84 (depending on subsequent scale analysis to determine origin) from hatchery smolts released in 1986. The single 1SW return was from a 1987 hatchery smolt release (Table 3).

The return rate of the 1986 hatchery smolts (302,200) was 0.03% or 17.7% of the weighted average return rate (0.17%) for the 1976-1985 smolt releases. The poor return in 1988 is believed to be partly attributable to two factors. First, the incidence of fatal fin condition (Frantsi et al 1972) in smolts released in the Farmington river was much higher than in previous years (Steve Gephard, CT DEP, personal communication). Secondly, no returns have been detected from smolts released in the Ammonoosuc or White rivers in 1986, based upon evaluation of coded wire tag returns to date (Table 4). Poor survival from these upriver releases may have been related to difficult passage conditions at five hydroelectric dams caused by extremely low flow in 1986 during the smolt migration (McMenemy 1986).

These factors could have affected a maximum of 34.5% of the total smolt release in 1986 and suggest a maximum "corrected" return rate (if total smolt release is reduced by 34.5%) of 0.09%, still well below the long term average. Other unknown factors also negatively impacted the 1986 smolt class.

Table 3. Adult Atlantic salmon returns to New England rivers in 1988.

River	Method of Capture	Adult Returns by Sea Age[1] 1SW	2SW	3SW + PS		Total
Connecticut	Trap	1	94		353	95
Pawcatuck	Trap		5	1	1	6
Merrimack	Trap	9	52	3	139	64
	Rod		1[2]			1
Penobscot	Trap	691	1,946	51	2343	2,688
	Rod	40	120	4	158	164
Union	Trap		45		58 5 R.K.	45
Narraguagus	Rod	3	44	1	37	48
Pleasant[3]						
Machias	Rod		8	1	4	9
E. Machias	Rod	1	12	1	14	14
Dennys	Rod		9		1	9
St. Croix	Trap	88	290	4	372	382
	Rod	6			5	6
Kennebec	Trap[4]	4	13	1		18
	Rod		2			2
Androscoggin	Trap	3	11		26	14
Sheepscot	Rod	1			15	1
Ducktrap	Rod				0	0
Saco	Trap	1	34		24	35
	Rod		3		13	3
Totals		848	2,689	67		3,604

1 1SW, 2SW, and 3SW refer to the number of sea winters prior to home water return. PS refers to previous spawners. Occasionally, 2SW, 3SW and PS fish are referred to as MSW or multi-sea winter salmon.

2 This was an illegal catch.

3 No trapping facilities in 1988; river closed to angling.

4 These fish were seined from a tributary and transported above the first hydro dam.

Table 4. Preliminary returns of tagged and marked hatchery smolts from 1986 Connecticut River releases. CWT = coded wire tag code; Carlin = Range of Carlin tag numbers used; MC = mark or clip used; S = Strain; T = Type; L = Location stocked; No. = number released; Can. = Canada (Newfoundland or Labrador); WG = West Greenland; Home = Recovered within the Connecticut River Basin.

							Adult returns			
CWT	Carlin	MC	S	T	Loc.[1]	No.	Can.	WG	Home	Total
	250-275		U	D	TF	22,800			1	1
	275-300		C	S	TF	17,500			1	1
		LV	C	K	FR3	14,800			5	5
		RV	C	K	FR2	11,800			6	6
16-01[2]		AD	C	D	WR	10,800				
16-02[2]		AD	C	D	WR	21,000				
16-03[2]		AD	C	D	TF	17,900		1	4	5
16-04[2]		AD	C	D	AM	20,000				
16-05[3]		AD	U	D	SR	18,100				
16-06[2]		AD	C	K	WR	2,500				
16-07[3]		AD	C	K	SR	9,200				
16-08[4]		AD	P	K	FR	10,500				
16-11[2]		AD	P	S	DR	12,800		1	6	7
42-26[2]		AD	P	S	MR	8,300	1		2	3
42-36[2]		AD	C	S	TF	16,100		1	2	3
						Totals	1	3	27	31

[1] Locations are: TF = Turners Falls; FR = Farmington River (2 or 3 refers to the actual stock out pond used); WR = White River; AM = Ammonoosuc River; SR = Salmon River; DR = Deerfield River; and MR = Millers River.

[2] The only cwt's reported are for males and brood stock mortalities from fish trapped at Holyoke.

[3] Two adipose clipped fish returned to the Salmon River but tags have not been retrieved to date.

[4] Three adipose clipped fish returned to the Farmington River but tags have not been retrieved to date.

Pawcatuck River Basin

A total of six salmon returned to RI in 1988. All were captured in May and June at the Potter Hill fishway trap. Scale analysis indicated that the returns were a result of 0+ and 1 parr plants in 1983, 1984, and 1986. Four age 2:2, one age 2:3, and one age 1:2 salmon comprised the run. Of the total (110) adult returns to the river since 1982; 2% were 1 SW, 97% were 2SW, and 1% were 3SW salmon. The overall return rate to the Pawcatuck has been 0.32%. Return rates have declined steadily from 0.76% for the 1980 smolt class to 0.086% for the 1986. This decline in estimated smolt survival is coincident with a switch from Penobscot River sea-run broodstock to domestic broodstock.

Merrimack River Basin

A total of 65 salmon was accounted for in 1988. Of this total, 64 salmon were recorded at the fish-lift at the lowermost main stem dam. One fish was taken illegally by rod downstream from the fish-lift.

Based on identifying marks (see the associated table) and scale analysis, it was ascertained that 34% of the run was composed of fish released as smolts in 1985, 1986, and 1987. The remainder (66%) was composed of fish released as fry in 1983, 1984, and 1985.

IDENTIFYING MARKS FOR THE SALMON RUN OF 1988

MARK	NUMBER OF FISH
CWT & ADIPOSE CLIP	14
ADIPOSE CLIP	5
RIGHT VENTRAL CLIP	2
LEFT VENTRAL CLIP	1
NONE	33

Age structure of the run was nine 1SW (14%), 53 2SW (82%), and three 3SW (4%) individuals. Fish that originated from the hatchery smolt releases had a higher 1SW component (23%) and a lower 2SW component (68%) than those originating from the fry releases of 1983, 1984, and 1985. In the latter case the 1SW component amounted to 12% and the 2SW component was 85%.

Estimated rate of return for those 2SW fish originating from the contributing smolt releases approached 0.01%. For 2SW fish originating from fry-releases the rate of return was 0.006% of the fry stocked. The rates of return for both groups were generally lower than rates previously observed. For example, return rates for 2SW fish originating from the smolt-releases of 1980 through 1984 varied from 0.02 - 0.10% (average = 0.04). The fry-releases of 1978 through 1982 resulted in rates of return of 0.005 - 0.16% (average = 0.06) of the number of fry stocked.

The lower rates of return observed in 1988 were not expected. Reasons for the decline are unknown. A number of factors, some of which may include small size of stocked smolts in 1986 and unfavorable environmental conditions within the river during the smolt outmigration are postulated as possible reasons.

Maine Rivers

Adult returns to Maine rivers in 1988 were highly variable. The St. Croix and Penobscot Rivers showed modest increases, with 10% and 15%, respectively, more salmon than 1987. Although sport catches in many of the small rivers in Washington County were slightly higher than those reported in 1987, spawning escapement was significantly below the long-term historical average. The Sheepscot River salmon run was estimated to be the lowest in 35 years.

Data are available which indicates that redd counts and other available information provide a more realistic estimate of adult returns to Maine rivers without trapping facilities than does the ICES harvest model which utilizes an angling exploitation rate of 0.25. Redd count data for the period 1985 - 1987 indicates that the exploitation rate of these rivers has declined to 5 - 10% in recent years. While low angling catches recorded in some rivers are not a good indication of run size, there are a number of problems in the methodology of redd count estimates that must be resolved before this independent estimate can be utilized.

The Penobscot River fishway trap catch was 2,688, with 547 salmon taken for broodstock and the remainder released to spawn naturally. Maximum female spawning escapement was estimated to be 34

1SW and 774 MSW salmon, and potential egg deposition is expected to be the same as 1987 (0.5 eggs/m^2). The program goal is 2.2 eggs/m^2. About 26% of the Penobscot salmon run consisted of 1 SW salmon, while 2SW salmon comprised 72% and 3SW and PS salmon comprised 2%. As in 1987, the grilse/salmon ratio was approximately double the long-term average for the Penobscot. The causes of this dramatic shift in the grilse/salmon ratio during the past two years are unknown. A detailed summary of the age and origin (wild vs. hatchery) of the 1988 Penobscot River salmon run will be available following the completion of scale readings in January of 1989. The proportion of salmon originating from natural spawning has increased to 7 - 8% of the total run in recent years, and this is expected to gradually increase with time.

Tag returns from 100,000 Carlin and 101,000 micro tagged (coded-wire) smolts released in the Penobscot River in both 1986 and 1987 were recorded in 4 rivers (Saco, Androscoggin, Kennebec and Penobscot). Although relatively equal numbers of each group were released, the return of CWTs (1SW=106, 2SW=483) was about double that of Carlin tags (1SW=41, 2SW=271). The reason for this discrepancy cannot be explained solely by tag loss, which has been previously estimated to be 27% for tagged smolts released in Maine.

The rate of return for hatchery smolts released in the Penobscot River drainage since 1969 was as follows:

Years	Rate of Return (%)	Range
1969-73	0.82	0.40 - 1.20
1974-78	0.66	0.20 - 1.30
1979-83	0.73	0.40 - 1.10
1984	0.63	
1985	0.35	
1986	0.45	

Atlantic salmon returns to Maine rivers continue to be extremely variable from year-to-year, although angling catches and redd counts for 1987-88 indicate low over-all stock abundance for 2SW salmon when compared to historic levels. The return rates for hatchery smolts released in 1985 and 1986 were the second and fourth lowest since the Penobscot River restoration program was initiated. Additionally, the grilse/salmon ratio for the adult returns in 1987 and 1988 were the highest ever recorded. This anomaly cannot be attributed to changes in hatchery management practices.

2.3 Sport Fishery

All sport fishing for Atlantic salmon in New England takes place in the state of Maine. Rod catches for 1988 were:

Harvest by Age Group

River	1SW	2SW	3SW + PS	Total	No. Caught & Released	Total Catch	(1987) Total
Penobscot	40	120	4	164[1]	125	289	(266)
Narraguagus	3	33	1	37	11	48	(40)
Machias	0	7	1	8	1	9	(8)
E. Machias	1	12	1	14	0	14	(24)
Sheepscot	1	0	0	1	0	1	(18)
Dennys	0	9	0	9	0	9	(2)
All Others	8	5	0	13	4	17	(43)
Total	53	186	7	246	141	387	(401)
	21%	76%	3%				

[1] Harvest below the Veazie trapping facility - an additional 11 salmon were taken upriver.

The Pleasant River remained closed to angling in 1988, and catches in the other Maine rivers with wild salmon runs (Dennys, E. Machias, Machias, Narraguagus, Duck Trap, Sheepscot) were about 30% of the average for the past 30 years due to low stock abundance and angling conditions. The low harvest of MSW salmon from the Penobscot River continued as a result of the small run, exceedingly high water temperatures during the angling season and because of the restrictive regulations instituted in 1985. Restrictive angling regulations instituted on the Penobscot River have been highly successful in reducing the exploitation rate of 25W salmon from 28% to 10% (Table 5). Several new management measures pertaining to sport fishing for Atlantic salmon in Maine became effective in August of 1988 (Section 2.4).

Table 5. Sport harvest of 2SW Atlantic salmon in the Penobscot River, Maine 1980 - 1988.

Year	Sport Harvest[1]	% Exploitation
1980	920	33.2
1981	789	30.0
1982	1134	27.2
1983	175	22.1
1984	399	25.4
1985[2]	396	12.6
1986	426	10.6
1987	125	7.6
1988	120	5.8
1980 to 1984 Mean	**683**	**28.3**
1985 to 1988 Mean	**267**	**9.8**

1 Adjusted for an estimated 80% reporting rate prior to 1987 (mandatory registration 1987-88).

2 Fishing regulations changed to reduce exploitation.

2.4 General Program Update

Information was provided to the committee regarding (1) activities in Rhode Island which addressed the Pawcatuck River, (2) activities addressing the Merrimack River, and (3) several aspects of the program in Maine.

Pawcatuck River

Research by the Division of Fisheries and Wildlife has centered around the population dynamics of juvenile salmon in freshwater. Studies have been undertaken on growth, mortality, and stocking densities of pre-smolt releases. Growth rates have been shown to be independent of density but positively correlated to water temperature and alkalinity. Mortality rates have been estimated for six month spring-fall and overwinter periods (Table 6). They are highly variable (CV 20-65%) and have a density dependent component. Optimum spring fry and fall parr stocking densities have been estimated at 134 and 43 fish per 100 m^2.

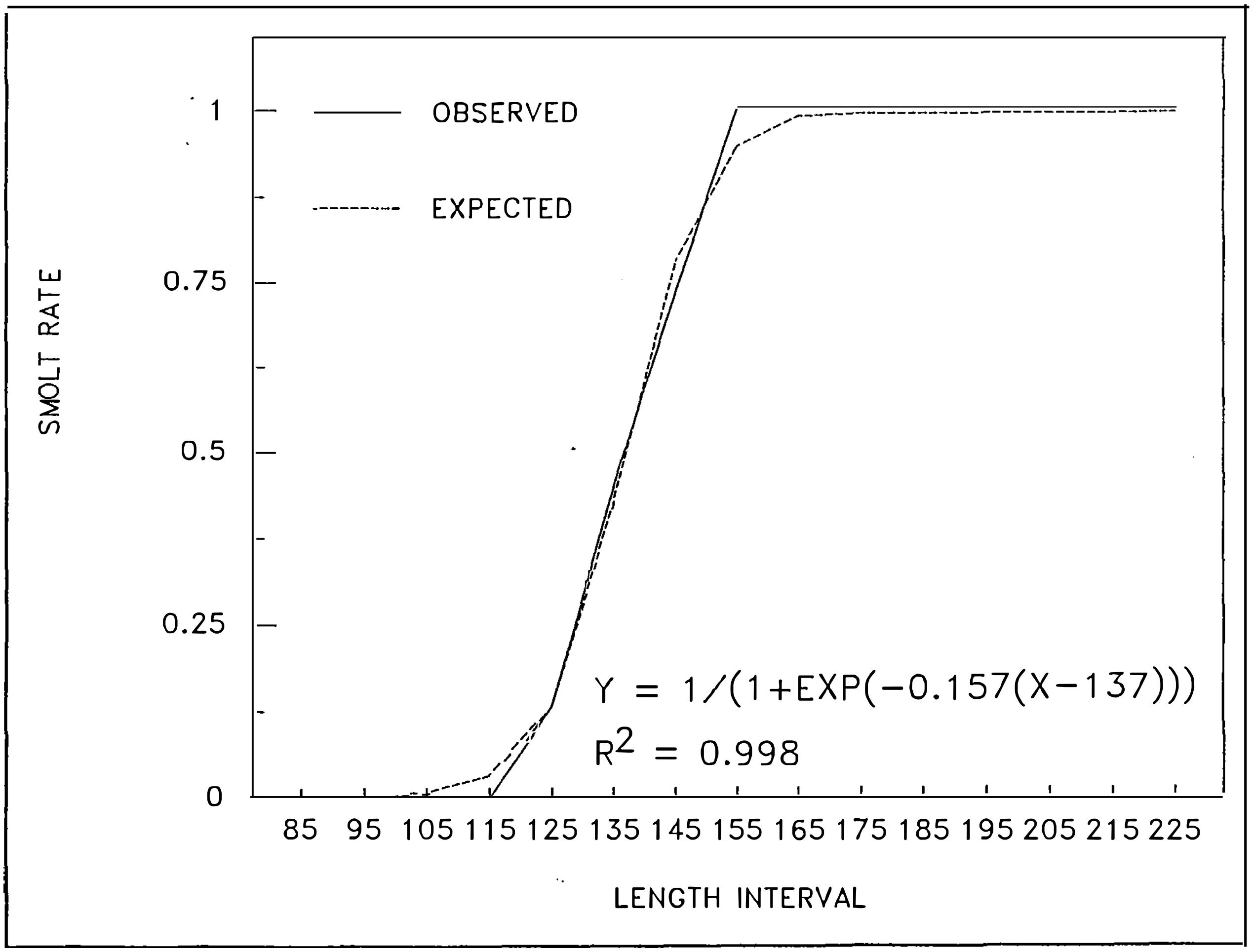
Table 6. Mortality rates by various life stages for Atlantic salmon in the Pawcatuck River.

Life Stage	Z[1]	SE	CV	S	N
Stocked Fry to 0+ Parr	.00778	.00506	.65	.241	7
0+ Parr to 1 Parr	.00419	.00251	.60	.466	5
Stocked 0+ Parr to 1 Parr	.00418	.00211	.51	.466	7
1 Parr to 1+ Parr	.00603	.00364	.60	.331	23
Stocked 1 Parr to 1+ Parr	.00423	.00248	.59	.463	9
1+ Parr to 2 Smolt	.00594	.00360	.61	.339	19
Smolt to 2SW Adult	.00838	.00168	.20	.217	7
Stocked Parr to Adult	.00560	.00270	.48	.365	6

[1] Instantaneous Z for daily period, survival compounded over six months.

Many observations have been made on the physical appearance believed to be associated with smoltification in the spring. Analysis indicates that smoltification begins in fish having a minimum length of 125 mm and approaches 100% for fish 155 mm in length. Length at 50% smoltification was estimated at 137 mm (Figure 1).

Figure 1. Estimated smolt rate by length group, Pawcatuck River 1981 -1988. Total length in mm.



Using estimates of smolt abundance, it appears that in general, larger smolt abundances will result in larger adult returns. Insufficient data exist to further quantify the relationship at this time. Overall marine survival has been 0.37% (1980 -1986 smolt runs). Analysis of the frequency distributions for back-calculated smolt lengths and observed smolt lengths in spring samples indicate that marine survival is positively correlated to smolt size.

Cooperative research by the University of Rhode Island Zoology Department has focused on the physiological aspects of smoltification, particularly the differences between hatchery and wild smolts. Laboratory results to date indicate that fish maintained in the hatchery through the smolt stage do not undergo smoltification (as evidenced by thyroxine dynamics) as uniformly as wild fish. The high variability in the biochemistry of hatchery fish may result in reduced smolt emigration. This hypothesis has been partially confirmed by trapnetting migrating smolts from known hatchery releases in two small streams where capture efficiency was high. In both instances, only about 10% of the actual release was captured in a downstream location. It may be that only a small percentage of hatchery smolts are successfully completing the smoltification stage.

Merrimack River

A great deal of effort in 1988 addressed refining the previous Atlantic salmon habitat quantification data within the basin. The currently projected 82,110 units will likely change in the future as refinements continue.

In an effort to assess the relative value of this habitat to the salmon program, the annual fry stocking program (1975 through present) has been monitored on a limited geographical basis each year in order to determine the relative abundance of each life history stage produced. In 1984 the monitoring program was expanded to address the growth and abundance of juvenile salmon in seven sampling zones (index sites). Each index site was established within a specific tributary.

Results of the sampling program (Table 7) indicate that the salmon nursery habitat is capable of producing yearlings, two-year-olds, and three-year-old smolts. Adult salmon returns also support this. From 1982 through 1988 the fry stocking program has contributed roughly 40% of the returns of which all three smolt age-classes were represented.

Table 7. Merrimack River parr densities 1984 - 1988 at index sites. A = Number stocked per unit; B = Mean TL at stocking; C = Year Class; D = Estimated 0+/Unit; E = Mean TL of 0+; F = Estimated 1+/Unit; G = Mean TL of 1+; H = Estimated 2+/Unit; and, I = Mean TL of 2+.

Index site No. 1. Baker River, 14.5 Units; Pemigewasset River/Baker River

A	B	C	D	E	F	G	H	I
30	30	1984	21.6	78	5.7	145	0.2	154
30	37	1985	11.4	75	1.9	122		227
30	25	1986	27.1	76	3.4	133	0.6	155
30	25	1987	15.4	83	6.7	126		
30	30	1988	2.5	82				

Index site No. 2. Mad River; 21.4 Units; Pemigewasset River/Mad River

A	B	C	D	E	F	G	H	I
18	30	1984	6.5	56	5.2	104	0.9	139
18	37	1985	3.0	71	1.2	107		151
18	27	1986	26.6	62	1.4	111	0.8	141
18	26	1987	12.0	67	3.2	112		
18	28	1988	0.3	84				

Index site No. 3. Pemigewassett River; 43.5 Units; Pemigewassett River/------

A	B	C	D	E	F	G	H	I
30	25	1984	8.9	88				
30	37	1985	1.6	80	0.2	162		176
30	27	1986	3.6	106	0.2	143	0.1	179
30	26	1987	7.0	100	6.0	133		
30	26	1988	0.3	84				

Index site No. 4. Smith River; 18.4 Units; Pemigewassett River/Smith River

A	B	C	D	E	F	G	H	I
30	26	1984	4.1	114	2.2	180	0.2	195
36	37	1985	2.3	79	1.2	158	0.5	174
36	25	1986	14.6	97	1.4	155	0	
36	25	1987	16.1	92	8.7	155		
36	28	1988	3.7	92				

Table 7 Continued. Merrimack River parr densities 1984 - 1988 at index sites. A = Number stocked per unit; B = Mean TL at stocking; C = Year Class; D = Estimated 0+/Unit; E = Mean TL of 0+; F = Estimated 1+/Unit; G = Mean TL of 1+; H = Estimated 2+/Unit; and, I = Mean TL of 2+.

Index site No. 5. Soucook River; 22.3 Units; Soucook River/------

A	B	C	D	E	F	G	H	I
30	30	1984	0.9	81	0.40	171		
30	37	1985						
30	25	1986	0.1	99	0.04	161	0	
30	25	1987	0.4	79	1.20	159		
30	28	1988	0.4	89				

Index site No. 6. Souhegan River; 14.2 Units; Souhegan River/------

A	B	C	D	E	F	G	H	I
30	29	1984	5.3	107	2.1	186	0.2	201
30	37	1985	13.5	108	8.6	163	0.8	172
30	25	1986	6.1	105	1.8	149	0.1	187
30	25	1987	22.3	97	13.2	154		
30	30	1988	15.6	86				

Index site No. 7. Piscataquog River; 13.9 Units; Piscataquog River/S. Br. Piscataquog

A	B	C	D	E	F	G	H	I
30	29	1984	10.8	97	8.7	157		
48	37	1985	27.1	89	6.6	151	0.7	174
48	25	1986	6.6	99	4.7	155	0.6	175
48	26	1987	14.2	62	5.8	150		
48	28	1988	22.7	88				

The cause of significant variation in the parr densities between years within an index site has not been determined but may reflect the environmental variation that occurs annually, and the differences in the quality of the fry released in any one year. Observed variation between the index sites may also be reflected in the variation of environmental conditions. In addition, the quality of the habitat is not identical between index site.

Maine Program

Management Measures

Several new Atlantic salmon management measures became effective in the State of Maine on August 4, 1988 (90 days following adjournment of the State legislature). This legislation was intended to clarify some perceived inconsistencies between statute law and Atlantic Salmon Commission regulation. While most of these measures were of a "housekeeping" nature, the cumulative impact will be to strengthen existing laws and regulations that prohibit the incidental and/or illegal take of Atlantic salmon. Below is a summary of those measures enacted, along with a brief description of the need for this action to be taken.

(1) Minimum Length in inland and coastal waters was defined at total length (Rationale: there was confusion in existing statutes whereby minimum length for some species was listed as fork length, while others were total length - this law institutes a standard of measure for Atlantic salmon).

(2) Method of Taking in coastal waters from May 1-October 15 is hook and line - salmon taken by any other means must be immediately released (Rationale: previous legislative statute seemed to allow "incidental" catch from April 1-July 15, although Atlantic Salmon Commission regulation prohibited it; now, there is no doubt regarding this issue).

(3) Closed Season in coastal waters is now from October 16-April 30 (Rationale: previous legislative statute listed closed season October 16-March 31, which was interpreted by some enforcement personnel to allow the taking of salmon during the month of April-although Atlantic Salmon Commission regulation prohibited it).

(4) Bag Limit from all waters of the state (inland and coastal) is now expressly defined as 1 per day and 5 per season). Rationale: some enforcement personnel were reluctant to enforce the 5 fish season limit in certain coastal areas. Although there were virtually no

fish taken in those areas, those enforcement personnel felt that there was a "loophole" in the existing law and this measure addresses that issue).

(5) Disposition of salmon now states that it is unlawful to sell or offer for sale any Atlantic salmon taken from inland or coastal waters except those lawfully raised by aquaculture (Rationale: there never was a prohibition against the sale of salmon lawfully taken by angling, which served as a financial incentive for salmon to be taken either legally or illegally).

(6) Recreational fishing provisions in coastal waters were refined to expressly define how and when such fish taken must be identified and registered within 24 hours (Rationale: this change requires all salmon caught to be registered and provides a mechanism for salmon caught incidentally by recreational anglers to be legally kept, tagged, and registered, and to prohibit the retention of salmon caught incidentally by commercial fishermen).

(7) Salmon imported from New Brunswick, Quebec, Nova Scotia, or Newfoundland-Labrador must be tagged with the tag used in those provinces (Rationale: the previous law was enacted shortly after New Brunswick instituted its tagging system - this measure now requires salmon imported from other Canadian provinces to also be tagged).

(8) Registration requirements were amended to include all Atlantic salmon taken by angling (Rationale: Previous registration requirements were limited to salmon >25 inches in total length [i.e., grilse were exempted] - enforcement personnel felt that since all fish had to be tagged, it was logical to require all to be registered).

Coded-Wire Tag Loss

The first CWT smolts released in Maine were stocked in the Penobscot River drainage in May of 1986. Attempts to sample adipose (AD) clipped salmon at the Veazie trap for the presence of CWTs were futile due to the difficult field conditions. However, during 1988 a total of 121 AD clipped salmon from a variety of sources were scanned for the presence of CWTs (Table 8). Only six samples resulted in a negative CWT test, and it is possible that two actually contained tags while the other four may not have originally been tagged (heads were turned in by anglers and there is no guarantee that these fish had AD clips). Tag loss after two years at sea was certainly no more than 5% and probably less than 1%, based upon the samples of broodstock held at Craig Brook National Fish Hatchery. The four negative samples from 1988 will be x-rayed at a later date to verify the absence of CWTs.

Table 8. Estimated tag loss from Penobscot River salmon in 1988.

Source of Sample	No. Tested	CWT Positive	CWT Negative
Live Broodstock	94[1]	92	2[2]
Broodstock morts	16[3]	16	0
In river morts and angler-reported	11	7	4[4]
Total	121	115	6

1 59 Females and 35 Males

2 Both males, which were more difficult to test due to the shape of the head.

3 12 Females and 4 Males

4 All from heads turned in by anglers, no verification of an original adipose clip.

3 Smolt survival estimates

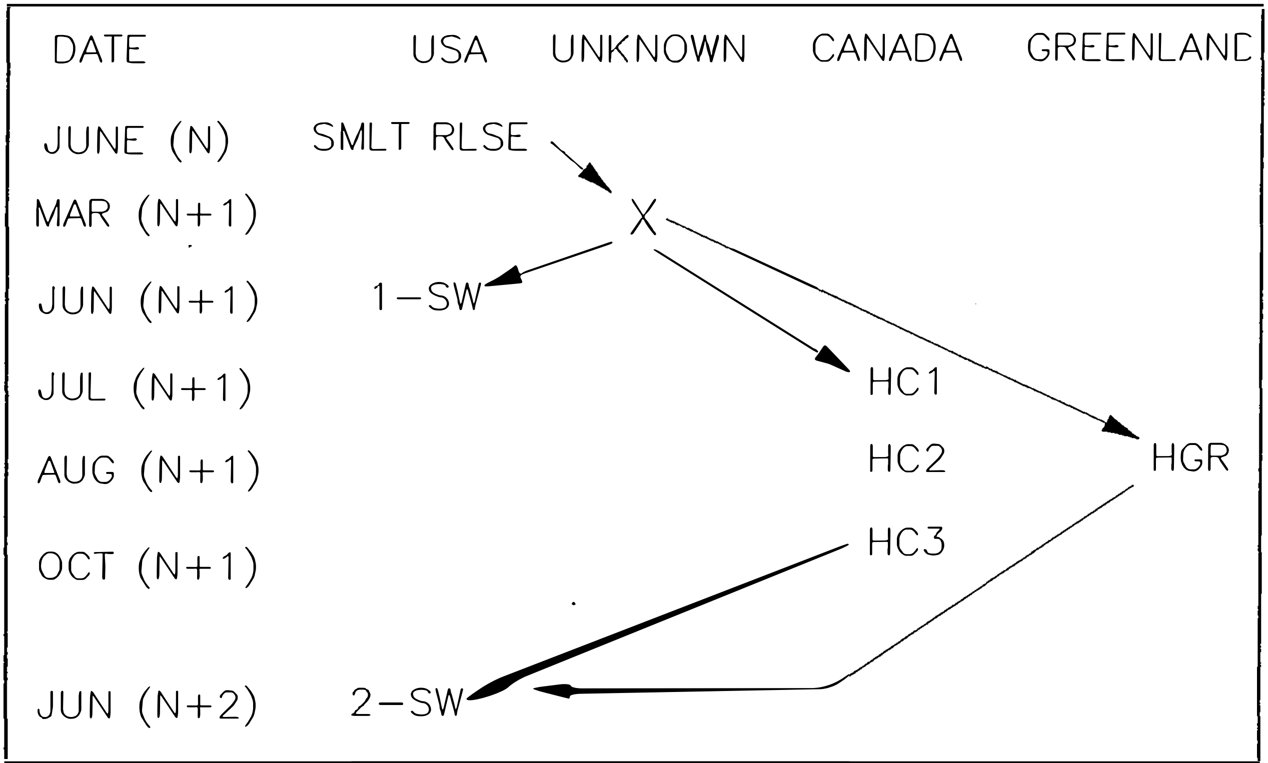
Term of Reference 3 (a, b, and c)

3.1 Review of existing program data

A preliminary summary of returns of finclipped, Carlin, and micro tagged smolts released in the Penobscot River in 1986 and 1987 was reviewed. Releases of each tag or mark type yielded varying return rates. Micro tag releases in 1986 provided the highest return rate of 0.63%, while an adjusted rate of 0.40 was calculated for Carlin tagged fish released the same year. Finclipped smolts provided the lowest return (0.21%). The return rate of paired release groups of green and blue Carlin tagged smolts (1986) were similar.

A model was developed to examine the effects of foreign fisheries on Atlantic salmon return rates and to develop estimates of mortality occurring after smolt release and before the foreign fisheries commence. For the purposes of this model, post-smolts are defined as all hatchery smolts immediately after release. They may still remain in freshwater or the estuary for a period of time before any marine migration occurs. The framework for the evaluation is a fishery model known as a "gauntlet" model (Figure 2). This approach uses information on smolt numbers, harvests, and salmon returns to estimate harvest rates and post-smolt mortality.

Figure 2. Estimation of marine mortality. Schematic diagram of post smolt salmon life history.



Estimates of post smolt mortality suggest that on the average 98.5% of the smolts die within a year of release. No temporal trends is evident in the estimates, but most survival rates above the mean occurred before 1979. All estimates since 1982 have been below the long term average.

Direct comparisons with European stocks are not reasonable because of the greater productivity of these systems. To put the post smolt survival (PSS) rates in context, it is instructive to consider what post smolt survival would be for a population having an adult return rate of 3 to 5%. Such return rates are thought to be representative of larger Canadian rivers and Maine's wild run rivers. If the derived average exploitation rates for the Canadian and Greenland fisheries are used to project the returning adults back to the pre-fishery period, PSS becomes 9 and 15% for the assumed return rates of 3 and 5%, respectively. During the period 1968 to 1985, estimated PSS exceeded 9% only in 1970 (Table 9). The projected high rate in 1970 was attributable to the estimated high exploitation in the Greenland fishery. Thus post smolt survival rates for the Penobscot River stock would have to increase by a factor of 4 to 6 in order to be consistent with an adult return rate of 3 to 5%.

The gauntlet model results suggest that low absolute levels of abundance are primarily due to processes occurring before the fisheries occur. An assessment of the relative effects of uncertainty in harvest estimates on PSS yielded the following results:

Harvest Multiplication Factor	Average PSS
0.50	0.00094
1.00	0.01350
2.00	0.02170
5.00	0.04650

Thus even with a five-fold increase in the estimated harvest numbers in foreign fisheries average PSS would be about half of that necessary for an overall return rate of 3%. The analysis of PSS should not be construed to imply that the foreign fisheries are unimportant. The gauntlet model also suggests that harvests in foreign fisheries usually exceed the total homewater returns. If PSS could be improved by management measures the US would realize only a fraction of the benefits due to high exploitation rates. Improvement of returns to US rivers must depend on both reductions in exploitation and increase in post smolt survival.

Table 9. Summary of smolt releases, harvest estimates and returns of 1 and 2-SW Atlantic salmon to the Penobscot River.

Year (i)	Smolts Released (i)	1-SW Returns (i+1)	Canadian Harvests by Std Wk (i+1) Wk41-52	Wk31-40	Wk21-30	Greenland (i+1) Wk31-40	2-SW Returns (i+2)	Post Smolt Survival	Total Return Rate[3]
1968	48698	20	98	98	98	580	126	0.0228	0.0027
1969	27821	7	64	52	315	896	91	0.0552	0.0040
1970	28497	21	153	47	120	2626	322	0.1252	0.0117
1971	68387	11	0	101	16	905	294	0.0213	0.0044
1972	73791	10	33	35	172	1318	520	0.0311	0.0075
1973	109080	31	400	36	389	2847	937	0.0466	0.0090
1974	100241	45	335	174	563	1370	591	0.0336	0.0067
1975	110556	77	175	608	1694	1684	607	0.0473	0.0059
1976	226900	45	71	110	836	959	1638	0.0180	0.0078
1977	340800	125	0	256	83	1175	695	0.0076	0.0026
1978[1]	209300	203	-	-	-	-	2670	0.0458[2]	0.0159
1979	292700	660	610	702	3658	2374	2551	0.0394	0.0118
1980	586000	901	484	351	367	2005	4050	0.0157	0.0072
1981	199600	171	210	354	1146	1374	776	0.0220	0.0048
1982	315700	187	621	434	778	525	1535	0.0144	0.0057
1983	446000	269	394	530	461	883	3114	0.0144	0.0076
1984	618000	268	1531	543	276	1515	4000	0.0149	0.0074
1985	580000	558	0	202	348	2096	1833	0.0096	0.0046
AVG	243448.4	200.5	304.6	272.5	665.9	1478.4	1463.9	0.0320	0.0071

[1] No tags were released in 1978; direct estimates of harvest for 1979 not possible.

[2] Post smolt mortality based on interpolation of exploitation rates for adjacent years.

[3] Total return rate sum of 1-SW (year i+1) and 2-SW (year i+2) returns divided by smolt releases (year i)

3.2 Impacts from hydroelectric generation and other water resource uses

Factors contributing to fish mortality have not been clearly identified or quantified for New England rivers where Atlantic salmon restoration is underway. Smolts suffer acute mortality from passage through turbines or entrainment/impingement associated with flow diversion at pump storage facilities and possibly nuclear power plants. Indirect losses such as increased predation in turbine-passed smolts or on smolts detained in head ponds behind dams may occur. Smolts unable to leave the river in a timely manner due to passage delay may revert back to parr and not contribute to the smolt run.

Hydroelectric development on the Connecticut, Merrimack and Penobscot rivers was described. Completed or ongoing assessment studies of existing bypass operations and/or facilities were also reviewed. An approach for evaluating the likelihood of smolts successfully passing downstream while having to negotiate one or more hydroelectric dams on the Penobscot River was also presented.

Connecticut River

Hydroelectric development on the Connecticut River is extensive. Smolts migrating from the upper basin must pass up to five dams, one pump storage facility, two nuclear power plants, and three fossil fuel generating plants before entering Long Island Sound. Smolt trapping studies conducted on the main stem as well as micro tag analysis from adult returns suggest that the survival of smolts migrating from upriver areas is significantly less than lower river smolt releases since they have contributed few adult returns. Smolt mortality associated with hydroelectric projects is suspected of being largely responsible for the poor survival exhibited by smolts migrating from upriver areas.

None of the hydroelectric projects are equipped with smolt exclusion devices. Bypass facilities operated to reduce mortality on smolts due to turbine passage or other entrainment have yet to be fully evaluated. Periods of spill for downstream passage have been arranged with electric utilities to provide some by-pass capability at each dam during the critical smolt out-migration period. The effectiveness of these measures is not fully understood.

Studies have been conducted to estimate turbine mortality, passage routes relative to flow pathways and volumes, potential of existing bypass routes as alternatives to turbine passage, and smolt movement in relation to heated water discharges to the river. More recently, an investigation is in progress at Bellows Falls dam to determine smolt use of several passage routes in the power canal under an assumed worse case scenario (i.e. no spill at the dam). In addition, spillage requirements at existing bypass pathways to direct smolts away from turbine intakes is being evaluated (Table 10).

Table 10. Comparison of per cent use of flow and telemetered smolts through turbines and three bypass routes at Bellows Falls Station, 1987. (Data adapted from Mudre and Saunders 1987).

Date	No. Released	Per Cent Use by Route Turbines	Sluice	Pipe	Ladder	% Flow[1]
4/27	28	64.3	14.3	14.3	7.1	1.7
5/04	24	75.0	20.8	0	4.2	3.9
5/07	23	78.3	13.0	8.7	0	1.5
5/11	21	47.6	33.3	4.8	4.8	6.9
5/13	23[2]	73.9	13.0	8.7	4.4	3.0

[1] Per cent of canal flow through all fish bypass routes (not including turbines).

[2] Two smolts did not pass through power station but remained in canal throughout the experiment.

The Northfield Mountain Pump Storage Project is capable of diverting a significant volume of river flow at low to moderate discharges and altering the flow regime of the river and is suspected of presenting a great source of mortality on smolts migrating by the plant's intake. Previous studies have indicated a near total loss of fish entrained by this facility. Further study is needed to fully assess this plant's impact on the smolt run from upriver areas.

Merrimack River

Smolts migrating from the Pemigewasset River (contains over 60% of the juvenile salmon habitat) must negotiate seven hydroelectric dams. Downstream fish passage facilities typically consisting of a sluicegate and box structure with or without a bypass conduit are in place at five of these dams. Studies have been developed and implemented to determine if radio telemetry technology will provide adequate data to evaluate the effectiveness of these downstream fish passage devices. A 1988 pilot study is the first phase of a three-year study plan. Phase two of the study involves the installation and operation of radio-tracking and data processing equipment at five main stem projects. These studies should provide additional information related to cumulative effects of hydroelectric projects on smolts.

Penobscot River

Carlin tagging study

Smolts must pass through as many as five hydroelectic stations on the main stem depending on flow. Downstream passage facilities exist at two projects and studies are underway to evaluate their effectiveness. Carlin tagged smolts have been released for three years (1986 - 1988) above each of the three lowermost dams. Returns from the 1986 release yielded similar return rates for each tag lot. Returns from a similar study (smolts released in 1984 and 1985) indicated adult returns were reduced by 50% for smolts released above five dams. Discussion of the 1986 returns emphasized that they could be affected by the type of tag and by flow conditions at the time of release. Adult returns in 1989 and 1990 need to be analyzed before any conclusions can be drawn.

"Competitive Flow" Model for Estimating Smolt Mortalities at Penobscot River Dams

An approach was developed for evaluating the likelihood of successful downstream passage for salmon smolts. The model couples historical river flow data with operational characteristics of hydroelectric dams and smolt migration rates (discussion suggested the rates used were too slow) to obtain a probability distribution of downstream mortalities. The model was applied to the main stem of the Penobscot River. This application suggested that analysis of historical flow data could be used to evaluate the magnitude of hydroelectric dam related mortality and its potential contribution to overall post smolt mortality. Selection of stocking sites and times might also be improved by analysis of flow with this model.

Discussion focused on the diel activity and movement of migrating smolts. While it is generally accepted that downstream movement principally occurs during evening hours, migration during daylight hours has been observed on the Connecticut, Merrimack and Penobscot rivers. The diel pattern of migration has important implications for dam related mortality particularly if smolts tend to concentrate directly above dams prior to increases in generation.

3.3 Freshwater predation

Stomach contents of double-crested cormorants on the lower Penobscot River between Hampden and Bucksport, Maine were sampled in 1988 to evaluate and document depredation upon hatchery-reared Atlantic salmon smolts. Smolt stocking began on April 25 and ended on May 15. Carlin-tagged smolts were released in the river at four locations: Eddington, Bradley, Milford, and Greenbush, Maine.

Double-crested cormorants were collected on six occasions. Collection of cormorants began on April 28 and continued through May 25 on more or less a weekly interval. Sampling consisted of shooting birds with No. 2 steel shot followed by necropsy to evaluate food habits.

Eighty-eight cormorants were sampled (mean number per trip = 14.7, range = 5 to 20). Sixty-five cormorants (73.9%) were females and 23 (26.1%) were males. Thirty (34.1%) of the total were immature (19 females and 11 males). The first smolt was obtained from a cormorant stomach on May 4, and the last was observed on May 25.

The majority of smolts were found in cormorants collected May 10 and May 17 (Table 11). A total of 48 fish was identified as smolts with an average of 0.55 smolts per cormorant (Table 11). For birds that fed exclusively on smolts, the mean number of smolts per cormorant was 2.2. Smolts were found in 22 (25.0%) of all cormorants collected and were the most prevalent identifiable prey of cormorants sampled (Table 12).

Table 11. Numbers of Atlantic Salmon smolts and Carlin Tags found in stomachs of Double-Crested Cormorants collected on the Penobscot River, Hampden to Bucksport, Maine, 1988.

Date	Number				Mean Number of Smolts and/or Tags/Cormorant	
	Cormorants		Smolts (Tags)			
	H-W	W-B	H-W	W-B	H-W	W-B
4/28	20	-	0	-	0.0	-
5/04	5	-	1	-	0.2	-
5/10	20	-	11	-	0.6	-
5/13	9	-	16(10)	-	1.8	-
5/17	12	6	11(16)	7(2)	1.8	1.2
5/25	13	3	2 (0)	0(0)	0.2	0.0
TOTALS	79	9	41(26)	7(2)	1.2	0.8

H-W = Hampden to Winterport docks
W-B = Winterport docks to Bucksport

Table 12. Food Habits of Double-Crested Cormorants collected on the Penobscot River, Hampden to Bucksport, Maine, 1988.

Item	Number of Stomachs		% Occurrence	
	H-W	W-B	H-W	W-B
Atlantic salmon	21	4	26.6	44.4
Unidentified	19	2	24.1	22.2
Smelts	15	1	19.0	11.1
Empty	13	1	16.5	11.1
Alewife	7	1	8.9	11.1
Eel	4	1	5.1	11.1
Shrimp	3	1	3.8	11.1
Stickleback	1	0	1.3	0.0
Sunfish	1	0	1.3	0.0
Killifish	1	0	1.3	0.0

H-W = Hampden to Winterport docks
W-B = Winterport docks to Bucksport

Twenty-eight Carlin tags were recovered from 14 cormorants (Mean = 1.3 tags/cormorant) with a high of 9 found in one bird. Estimated number of cormorants observed in the lower Penobscot River during sampling equalled 59 birds (range 25-75).

Cormorant rookeries were searched for smolt tags on June 3, 1988. A total of 352 Carlin tags was recovered from the rookeries with 177 tags originating from 1988 smolt releases (Table 3). An additional 28 1988 tags were recovered from one roosting island at Brewer on the Penobscot River.

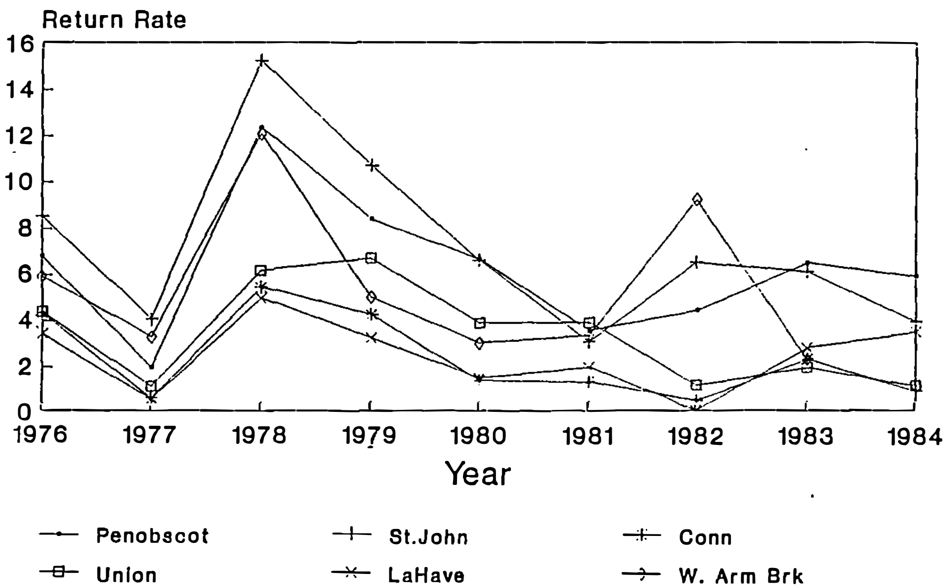
Information obtained during 1988 and for previous years indicates that smolts were one of the more important prey species of cormorants sampled from Hampden to Winterport with nearly 27% of the birds showing evidence of having preyed upon smolts. Although birds collected between Winterport and Bucksport showed high selectivity for smolts, it is believed that this represents an anomaly since only nine birds were collected on just two occasions. In 1986 and 1987, shrimp was the major food item of cormorants foraging in this river reach.

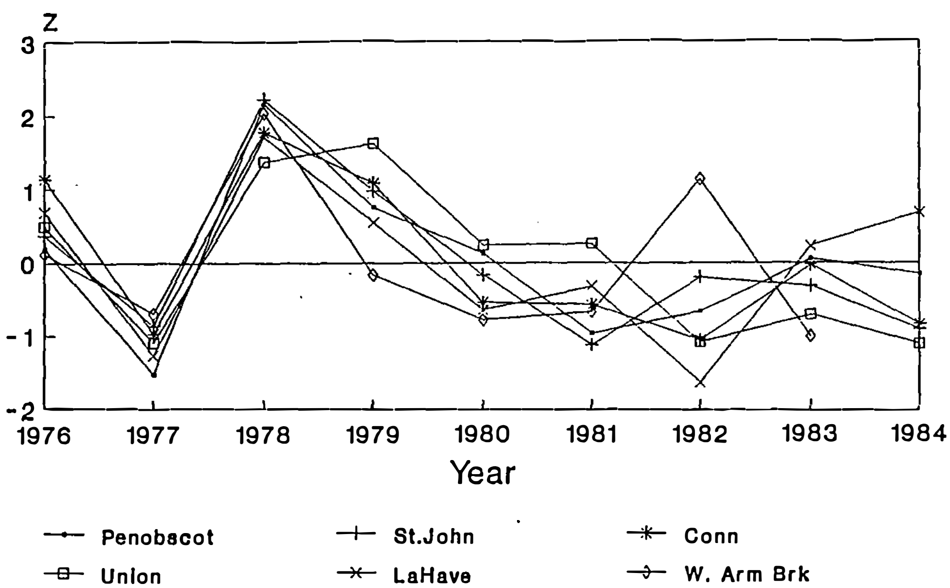
The extent of depredation upon hatchery-reared smolts in the Penobscot River is unknown as is the effect of cormorants upon the overall ocean survival rate of smolts. The crucial factor that remains unresolved is the variation in adult recapture rate of tagged lots that can be attributed to cormorant depredation.

3.4 Marine Environments

A working hypothesis that inter-annual variation in salmon smolt survival is a function of variation in physical and biological factors occurring during the early oceanic life history period was offered. The hypothesis was generated in view of the common survival trends displayed by several stocks of New England and Canadian Atlantic salmon (Figure 3). The similarities suggest that common factors across a wide geographical range are driving the inter-annual variation in the observed survival rates.

Figure 3. Return rates (number of adults per 1000 smolts released) for five hatchery smolt and one wild smolt stock. All rates are base on 2SW return except for Western Arm Brook data which are based on grilse returns. Z is the standard normal deviate for the years 1976 - 1984.





Databases of sea surface temperature (SST), predator abundance, and prey abundance were surveyed to assess the feasibility of constructing retrospective time series of data. The inventory of SST databases is not complete, but two time series of data, the Boothbay Laboratory station data (Welch 1983) and the indices of ocean temperature developed by Reddin and Shearer (1987) can be used preliminarily. The suite of likely oceanic predators, which includes sea birds, large pelagic fishes, and marine mammals, can not be easily characterized for lack of data on their distribution, abundance, and food habits. Dutil and Coutu (1988) confirmed that salmon post-smolts eat insects and crustaceans when they first enter the marine environment and gradually switch to small fish prey during the course of the first summer. They also reported that post-smolts consumed almost exclusively juvenile sand lance as their fish prey. With this in mind, time series of sand lance adult abundance for stocks on the East Coast of the United States were assembled (Nelson and Ross, unpub. man.).

An empirical modeling approach based on exploratory correlations was used. Empirical observations on smolt survival (adult return/smolts released) for six salmon populations were regressed against independent environmental and biological variables judged to have a plausible mechanism for impacting juvenile survival. Owing to the longer series of return rate data available for the Penobscot stock, this series was also examined alone. Ocean temperature was the primary physical factor entertained in view of published studies linking sea-surface temperature to the production of Canadian salmon (Reddin and Shearer 1987). Biological factors were divided along two lines of reasoning which considered predator and prey abundance as potential modifiers of post-smolt mortality.

Two important relationships emerged from the exploratory analysis. Return rate of the Penobscot stock was found to be inversely related to the location of the latitude 4 C isotherm in August. Consistent with the relationship developed by Reddin and Shearer (1987) enhanced survival appears to be related to spending their summers at low latitudes due to cold water (Figure 4). Second, trends in sand lance abundance (for the US stocks) appear correlated with adult return rates (Figure 5). It is important to remember that the hypothesized feeding relationship is between juvenile sand lance and salmon and that comparison to adult sand lance stock abundance may be misleading due to a non-linear relationship between stock and recruitment of marine pelagic spawners.

Figure 4. Penobscot River return rate, 4°C isotherm latitude in August.

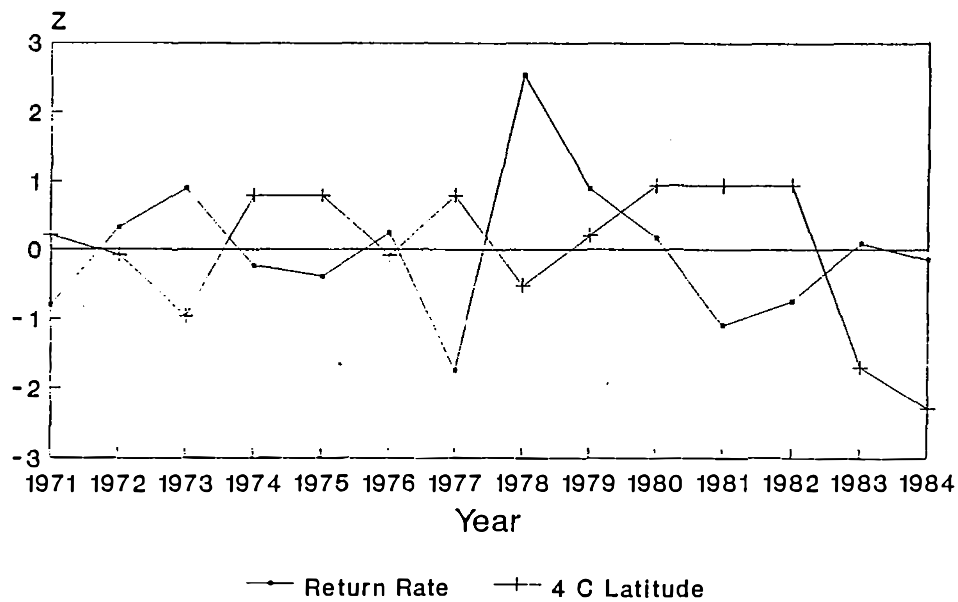
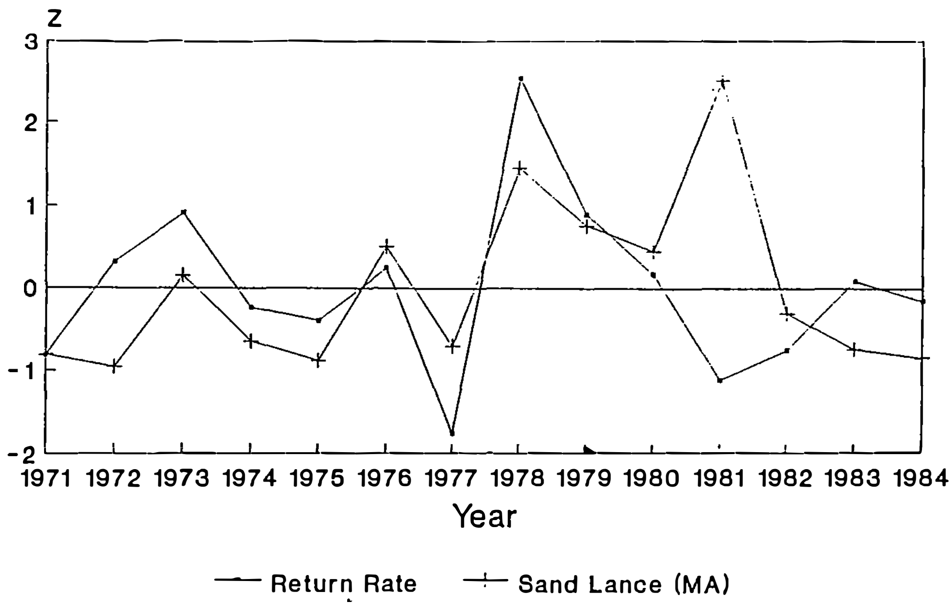


Figure 5. Penobscot River return rate, sand lance abundance mid-Atlantic region.



The implication of these correlations is that the post-smolt nursery may, at least during the first part of the summer, be located as far south as the mid Atlantic region. Dutil and Coutu (1988) demonstrated that post-smolts will remain in 15 C water through their first summer. This suggests that 15 C waters containing suitable forage, including the mid-Atlantic region, could be first summer feeding grounds for post smolts.

Exploratory correlations are risky in that they may produce spurious relationships despite the best intentions of investigators to limit them to those with plausible biological mechanisms. A better choice of dependent variable might be the adult return as opposed to the survival rate. Smolt abundance could then become the primary independent variable. The analysis could then examine the functional relationship between smolt output and adult return and the factors which produce deviations from this relationship. Interactions between smolt abundance and the biological factors are possible. Non-linear survival rates might exist.

Water temperature isotherms are compacted in the West Atlantic as opposed to the East and this represents a formidable temperature effect for New England salmon stocks. It also explains the dramatic shifts in species diversity which occur from north to south. These conditions are not encountered by European salmon stocks.

It was suggested that a bioenergetics approach could be used to estimate food consumption of post-smolts during their first summer at sea and thus predict survival. It was pointed out that examination of adult scales representing the appropriate smolt classes in concert with the estimated survival rates, might shed light on whether the mortality was predator related or due to food supply. Herring might be an appropriate prey species to examine since they are a pelagic surface layer species with overlapping spatial and temporal distribution.

4 Research recommendations (Term of Reference 2)

4.1 Research proposals of the Northeast Anadromous Fish Research Lab (NAFRL)

a. Physiological Monitoring of Hatchery Reared Smolts

The study proposes to monitor pre-smolts at the White River National Fish Hatchery (WRNFH) for various parameters that indicate the onset of smoltification. If these factors suggest development of smoltification, approximately 1000 would be transferred to a saltwater rearing site and growth rate, behavior and other parameters monitored for an additional 2 - 3 months. Discussion focused on the relevancy of the specific investigation to other salmon cultural stations, appropriateness of the salt water rearing site and concern that a true "control" was not available for the salt water rearing phase.

b. Offshore release of Hatchery Smolts from a Net Pen

This proposal involves transfer of a standard lot (25,000) of micro tagged smolts from WRNFH to a net pen in the lower Connecticut River after clear signs of smoltification have been detected in the hatchery. After transfer, the smolts would towed to a site off the mouth of the river and released. Discussion focused on the desirability of having more than one lot released in this manner, as well as having an in-river control release using the same technology. It was noted that the number of smolt available, as well as budgetary factors precluded implementing additional net pen releases in 1989.

c. Estimation of smolt survival rates

A modeling study was presented that showed the relationship between number of smolts released, sampling frequency, sampling intensity and distribution of the outmigrants as a function of time. Discussion produced suggestions that current sampling methodologies may not be able to meet the projected sample sizes estimated by the model. Further evaluation of smolt behavior and additional sampling methods may be required prior to implementation of sampling schemes based on the suggestion of the modeling study.

Results of the discussion of the various proposals will be reviewed by the NAFRL staff in developing final study proposals.

4.2 Proposals of the Sunderland Office of Fisheries Assistance (SOFA)

a. Radiotelemetry

Spatial and temporal distribution of hatchery released smolts in the lower Connecticut River (below the Holyoke Dam) would be studied under on of three possible levels, depending upon funding. Discussion involved questions of sample size and tag failure rates.

b. Population Assessment

Various smolt capture techniques would be evaluated in the lower main stem of the river. The study would utilize information from the modeling study reviewed above. Discussion revolved around known attempts to capture smolts in similar situations.

4.3 Other proposed research, data deficiencies and future terms of reference.

Items in this section were developed with reference to the previous sections and include recommendations for establishment of special working groups (WG), research needs (R), and future Terms of Reference (TR) either for the Assessment Committee or ICES as noted below.

Stocking

1. Develop a standardized report form and database to compile stocking and tagging information for all U.S. Atlantic salmon programs. Form a Working Group to work on this. (S.Rideout, L.Stolte, J.Marancik, E.Baum) **(WG)**

2. Attempt to adopt a standard definition of a hatchery smolt for all U.S. Atlantic salmon programs. The Working Group mentioned in item 1 will discuss this. **(WG)**

3. Form a "Fry & Parr Stocking Working Group" to compile all appropriate data relevant to stocking, survival, growth, and sampling of hatchery fry and parr from all U.S. programs. (K.Cox- chairman) **(WG)**

4. Review available information and pursue further research, as necessary, on the value of "training" hatchery smolts prior to release. This might include physical conditioning (e.g. high water velocity challenges) and predator avoidance conditioning. **(R)**

<u>Adult Returns</u>

5. Review in-river movement related to water temperature, flows, and water use (i.e. diversions). Compile data and determine need for future work. **(TR)**

6. Refine estimates of spawning escapement and exploitation rates using redd count techniques. **(R)**

7. Evaluate adult return rate records for Canadian hatchery programs similar to U.S. programs and compare data. **(TR - ICES)**

8. Consider development of a counting fence on a river with wild stocks. Parameters to be monitored and objectives would include: **(R)**

   a. enumerate and collect biological data on all smolts.
   b. apply CWTs to all/many departing smolts.
   c. enumerate and collect biological data on all adults.
   d. conduct comprehensive redd counts upstream of trap.
   e. calculate exploitation rates for river population.
   f. use data to better estimate run size for other rivers.
   h. use data to better evaluate hatchery stocks.

Water Resource Use Impacts

9. Review In-river movement of smolts relative to water temperature, flows, and water use (i.e. diversions). Focus on three approaches: Telemetry, Tagging, Modeling. [Note similarity to item 5, which deals with adults.] **(TR)**

10. Develop methodology to analyze snowpack and meteorological data to predict subsequent riverflow for the purpose of planning smolt releases. **(R)**

Predation

11. Analyze trends in striped bass populations relative to salmon returns trends. **(TR)**

12. Conduct a field study investigating food habits and population size (mark & recapture) of striped bass in an estuary of a salmon restoration river. **(R)**

13. Analyze trends in population size and food habits of harbor seals in New England. **(R)**

14. Monitor population sizes of riverine fish predator, e.g. smallmouth bass, northern pike. **(R)**

15. Analyze trends in population size and food habits of cormorants. **(R)**

Marine Factors

16. Sample for postsmolts on Georges Bank and other areas where postsmolts might be found. **(R)**

17. Review historical data on river-ocean water temperature differential at "salmon river" estuaries, review literature on the biological preferences of such by smolts, and analyze trends relative to adult return rates. **(TR)**

18. Analyze salmon scales for growth patterns during first year at sea to determine if food availability or predation is a major factor in postsmolt mortality. **(R)**

Habitat

19. Review the designation and evaluation of Atlantic salmon habitat throughout New England and consider potential for habitat restoration and enhancement. Consider the establishment of a Working Group. **(TR/WG)**

5 Other business

The Assessment Committee discussed the timing of the annual Assessment Meeting. The Committee concluded that the meeting would include more complete data such as result of scale reading (especially from Maine rivers) and determination of hatchery versus "wild" adult return components if held in early February. The Committee recommends that future Assessment Meetings be scheduled for the first week of February.

6 References

Dutil, J. D. and J. M. Coutu. 1988. Early marine life of Atlantic salmon, (Salmo salar), postsmolts in the northern Gulf of St. Lawrence. Fishery Bulletin 86(2): 197-212.

Frantsi, C., J. A. Ritter and A. Foda. 1972. A method to describe the quality of Atlantic salmon (Salmo salar) smolts released from hatcheries in Nova Scotia and New Brunswick. Fisheries Service. Dept. of the Environment of Canada. Halifax, NS. 15 pp.

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Mudre, J. M. and W. P. Saunders. 1987. Radio telemetric investigation of downstream passage of Atlantic salmon smolts at Bellows Falls Station. International Science and Technology, Inc. Reston, Virginia. 31 pp.

Reddin, D. G. and W. M. Shearer. 1987. Sea-surface temperature and distribution of Atlantic salmon in the Northwest Atlantic Ocean. American Fisheries Society Symposium 1: 262-275.

Welch. 1983. Maine Dept. of Marine Resources. Research Document 83/1.

7 Appendices

7.1 Terms of Reference

Terms of Reference for the Assessment Committee meeting - December 1988

1. Provide program summaries for current year to include as a minimum:

   a. current year's stocking program with breakdowns by time, location, life stage and tagging and marking status.

   b. current year's Atlantic salmon returns by sea age, tagged versus untagged, and wild versus hatchery (data on weight, sex and tag type should also be provided). Similar data for sport fishery should also be provided.

   c. general summary of program activities.

2. Evaluate a proposal to assess the fate of Atlantic salmon smolts from downstream migration to their entry into the commercial fishery as one-sea-year salmon.

3. Provide to the Committee a description of the New England data available and the source with regard to assessing the fate of Atlantic salmon smolts from downstream migration to their entry into the commercial fishery as one-sea-year salmon.

   a. Assemble information on the historical marine environmental conditions and predator distributions during smolt out-migration period and during marine migration to commercial fisheries.

   b. Evaluate completed studies related to predation on Atlantic salmon in home waters and identify additional data necessary to quantify this mortality.

   c. Identify available river flow information for the period of smolt out-migration for major New England rivers and develop a preliminary smolt passage model incorporating salmon movement data and dam related mortality. This issue is directly related to an evaluation of long-term hydroelectric impacts in relation to historical flow conditions.

7.2 Papers Submitted

PAPERS SUBMITTED

1. E.T. Baum - Preliminary Summary of 1988 Maine Atlantic Salmon Homewater Returns (Carlin Tagged and Untagged) by River and Sea Age.

2. E.T. Baum - 1988 Spawning Escapement and Estimated Egg Deposition of Atlantic Salmon in the Penobscot River, Maine.

3. E.T. Baum - 1988 Harvest of Maine Atlantic Salmon and Effectiveness of Management Measures.

4. E.T. Baum - Summary of New Atlantic Salmon Management Measures Instituted in the State of Maine.

5. E.T. Baum - Estimated 2 SW Salmon Returns to Maine Rivers in 1987-88 Utilizing the ICES WG Model and the A.O.F.C. Model.

6. E.T. Baum - Estimated Tag Loss in CWT Penobscot River Smolts Released in 1986.

7. L.W. Stolte - Atlantic Salmon Restoration Program Progress in the Merrimack River Past and Present.

8. S.G. Rideout - 1988 Salmon Returns to the Connecticut River .

9. S.G. Rideout - 1988 Salmon Stocking in the Connecticut River Basin.

10. M.R. Gibson - Atlantic Salmon Restoration in Rhode Island - 1988 Program Summary and a Brief Synopsis of Research Findings.

11. Total Atlantic Salmon Stocking in Maine 1988.

12. T. M. Bradley - Studies on Hatchery Smoltification and Seawater Survival of Atlantic Salmon (Salmo salar).

13. R. Sousa - Long Island Release of Connecticut River Atlantic Salmon Smolts.

14. Investigations of Hatchery Smolt Survival Rates in the Connecticut River.

15. P. J. Rago & R. M. Dorazio - A Statistical Framework for the Estimation of Hatchery Smolt Survival Rates in Freshwater and Estuaries.

16. E.T. Baum - Preliminary Summary of Returns of Finclipped, Carlin and CW Tagged Smolts Released in the Penobscot River, 1986-87.

17. S.G. Rideout - Passage of Atlantic Salmon Smolts at Two Connecticut River Hydro-electric Stations in Relation to Flow.

18. J.P. McKeon - Are Mortalities too Dam(n) High: Review of a Preliminary Study Conducted to Evaluate the Effectiveness of Fish Passage at Hydroelectric Facilities in the Merrimack River Basin.

19. J.R. McMenemy - Effects of Electric Generating Stations on Atlantic Salmon Smolts in the Connecticut River.

20. P.J. Rago - Estimates of Marine Mortality of Hatchery Smolts Released in the Penobscot River 1968-1985.

21. J. Greenwood and L.W. Stolte - Merrimack River - Index Sites and Expected Atlantic Salmon Production.

22. K. Friedland - Marine Survival.

23. N.R. Dube - Evaluation of Double-crested Cormorant Depredation Upon Hatchery-reared Atlantic Salmon Smolts Released in the Penobscot River, Maine. 1988 Summary.

24. P.J. Rago - Evaluating Longterm Probability of Downstream Survival: An Approach and Application.

25. V.C. Anthony - How ICES Meets the Needs of NASCO.

26. S. Rideout, S. Gephard, V. Crecco, J. McMenemy, and J. Greenwood. - Working Document on Connecticut River Atlantic Salmon Returns With Special Reference to 1986.

27. E.T. Baum - Estimated exploitation of Atlantic salmon in six Maine rivers, 1985 - 1987.