STATUS OF THE NMFS/USFWS ATLANTIC SALMON BROOD-STOCK PROGRAM (SUMMER 1984)

by

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INTRODUCTION

Captive brood-stock programs are a desirable adjunct to restoration efforts for depleted stocks of fish. These programs facilitate the continued rehabilitation of unique stocks and should produce a ratio of 1 adult spawner for each 10 eggs cultured. Thus, a larger number of eggs than produced by traditional rear/release/recapture hatchery methods can be quickly made available for enhancement purposes.

The Atlantic salmon captive brood-stock program is a cooperative effort of the National Marine Fisheries Service (NMFS) and the United States Fish and Wildlife Service (USFWS). This program has two objectives: (1) to produce eyed eggs to aid in restoration of depleted runs in Southern New England and (2) to develop and refine techniques for seawater rearing of Atlantic salmon in the temperate waters of Puget Sound. Puget Sound is an ideal environment for captive brood-stock rearing because of its sheltered waters, mild climate, and annual surface water temperatures in the range of 7°-13°C. The production of approximately 3.5 million eggs per year from disease-free brood stocks is the primary goal of the program (Table 1). These eggs will be supplied to USFWS Region 5 to provide a complement of unfed fry to be planted in Southern New England rivers.

FRESHWATER REARING

Five separate brood years of east coast Atlantic salmon stocks are being reared at NMFS facilities (Table 2). Initially, all freshwater fish were reared in dechlorinated City of Seattle water at the Northwest and Alaska Fisheries Center (NWAFC), Seattle, Washington. In January 1983, a

Table 1.--Estimated 1984 egg take - all stocks.

Stock	Estimated females available in fall 1984	Age	Egg projection
Penobscot/1979	442	5	3,500,000
Penobscot X Gaspe/1979	53	5	400,000
Gaspe/1979	75	5	500,000
Gaspe/1980	100	4	400,000
St. John/1980	70	4	210,000
TOTAL	740		5,010,000

Table 2.--Freshwater smolt production.

Stock	Brood year	Eggs received	Smolts 1 yr (%)	Smolts 2 yr (%)	Total	Survival in fresh water (%)
Penobscot	1979	15,000	919(37)	1,555(63)	2,474	16.5
St. John	1980	15,000	100(3)	3,291(97)	3,391	22.6
Connecticut	1981	15,000	2,410(29)	3,163(71)	5,573	37.2
Penobscot	1982	25,000	1,424(34)	2,735(66)	4,159	16.6*
Union	1983	15,000				97.5*

* Percent surviving to June 1984

new NMFS production facility at the University of Washington's Big Beef Creek Research Station (near Seabeck, Washington) became operational. At Big Beef Creek Station the NMFS can take advantage of high quality, pathogen-free ground water, up to 1,200 gpm at a constant 10°C. This facility now handles the freshwater production phases of the captive brood-stock program. The NMFS Big Beef Creek facility consists of a hatchery, office complex, and an outdoor rearing area (Figure 1). There are six 13-ft, six 8-ft, and thirty-two 4-ft diameter Fiberglass[1/] tanks for fry rearing and smolt production. Also, seven 16-ft diameter pools are available for adult holding during the spawning season.

The freshwater production goals are to annually produce up to 6,000 Atlantic salmon smolts. Although overall survival to seawater entry has not been up to expectations, survival has been increasing, and we are now nearing smolt production goals (Table 2). In the past, 1-year-old smolts have averaged 25-35 g, and 2-year-old smolts have averaged 80-160 g (Figure 2). However, now that production groups can be reared at 10°C year-round, we expect an increase in average smolt size.

Although furunculosis (Aeromonas salmonicida) and myxobacteria have been documented during freshwater rearing, these diseases have not been a major cause of mortality. The greatest mortality has occurred during the fry start-up phase (Figure 3) and has been attributed to the traditionally poor "first feeding response" exhibited by many cultured Atlantic salmon populations. The 1983 Union stock was started using a new commercial

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[1/]Reference to trade name does not imply endorsement by National Marine Fisheries Service, NOAA.

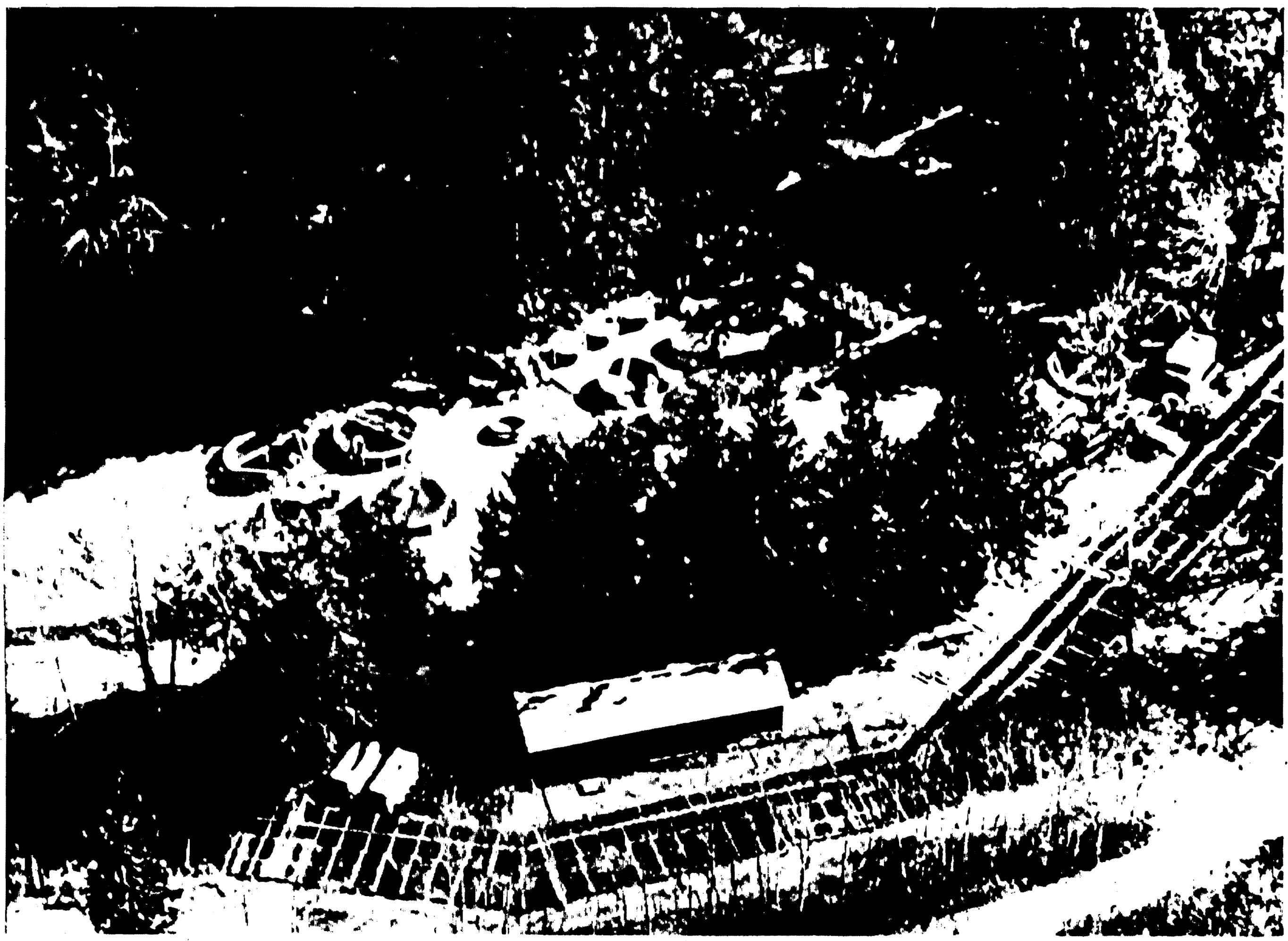

Figure 1.--Smolt production facilities at Big Beef Creek, Washington.

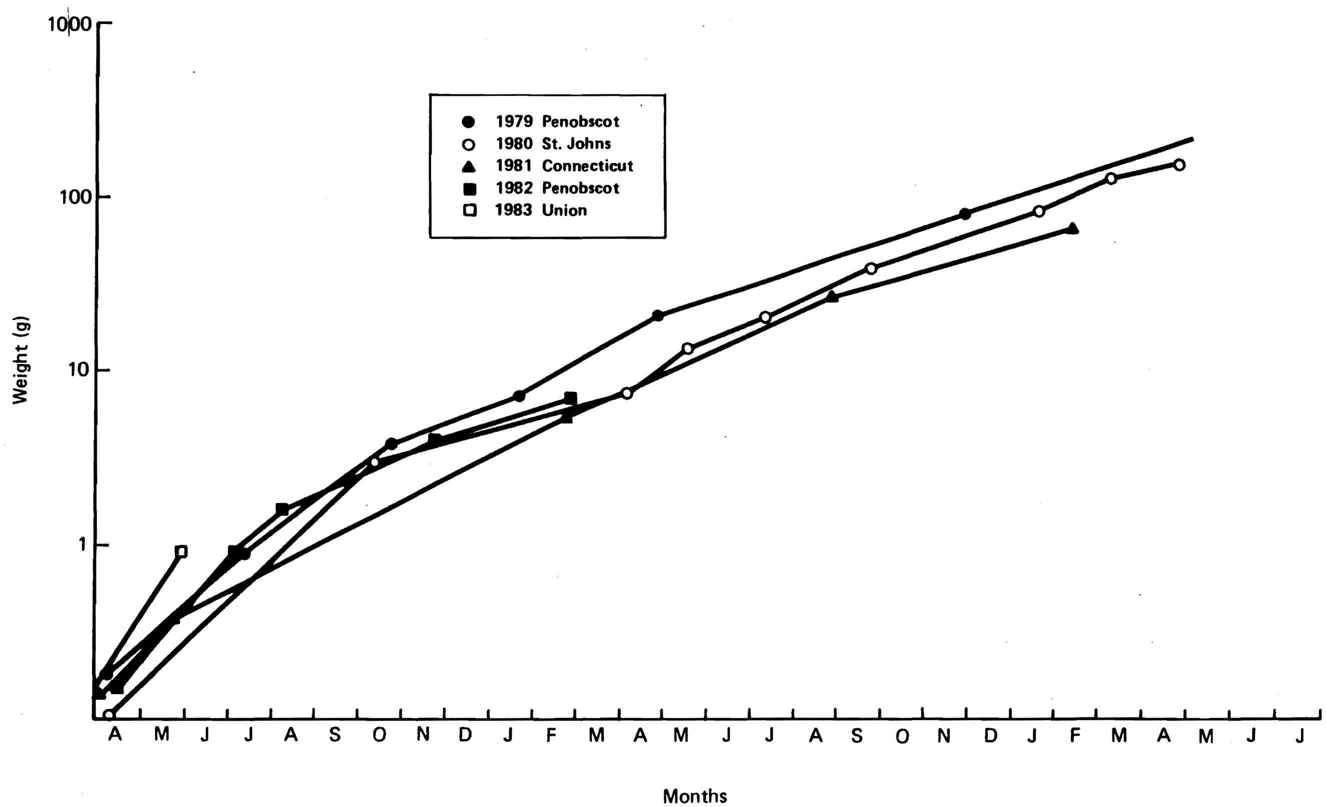

Figure 2.--Growth in fresh water.

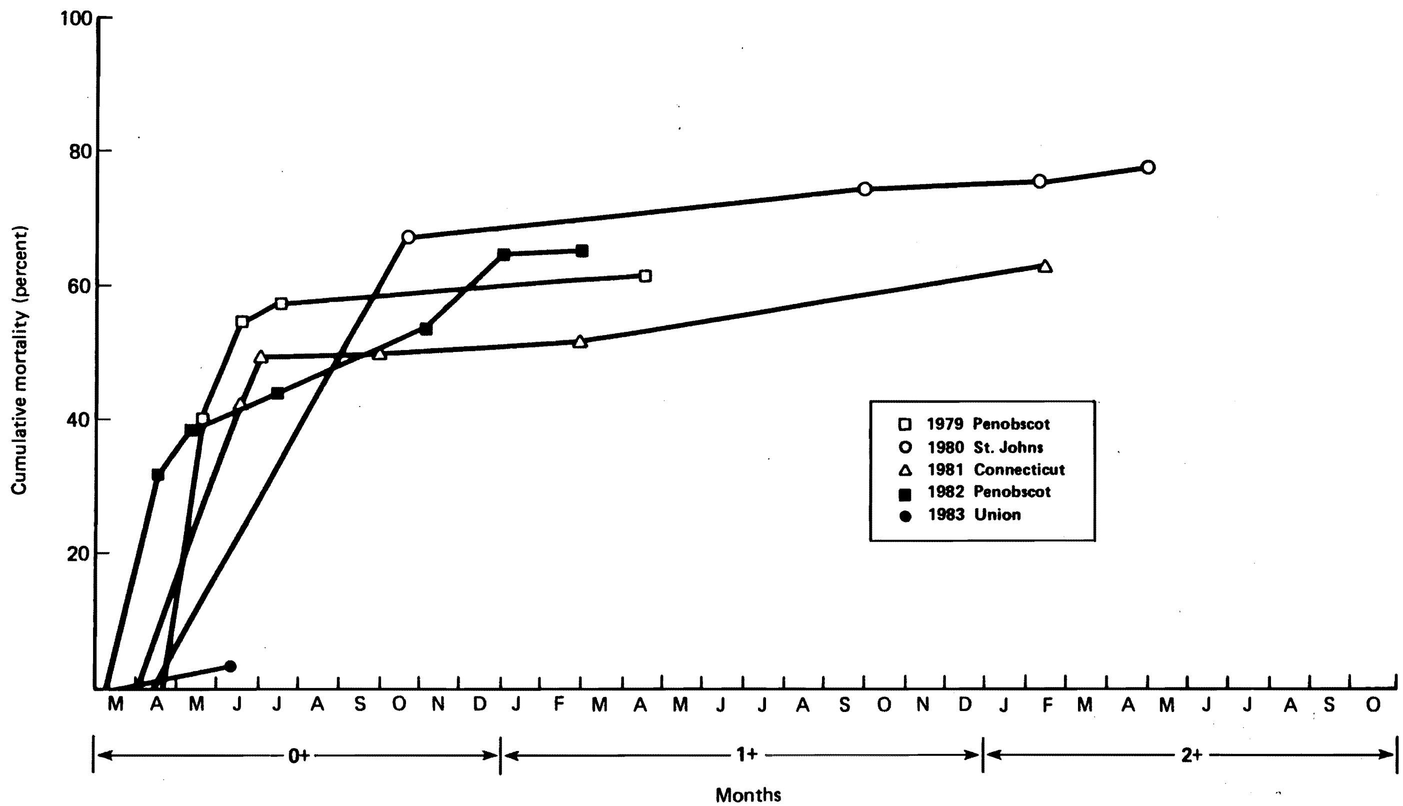

Figure 3.--Freshwater mortality.

semi-moist diet.[2/] This diet promoted a superior early feeding response, contributing to a survival of 97.5% for the first 2.5 months of rearing. Thus, we are confident that the improved diet and water supply will allow us to achieve smolt production goals.

Other substantial losses occur during smoltification. One-year-old smolts die due to the poor osmoregulatory capacity of small incompletely-smolted animals after transfer to seawater. Poor growth in the first year of marine residence may also be a reflection of inadequate smoltification at seawater entry. Losses in 2-year-old smolts have been due to fungal (*Saprolegnia* sp.) infestations that denude the pectoral girdle and compromise the ability of these fish to transfer to seawater. This year (1984), we successfully avoided fungal problems by transferring the fish to a seawater acclimation system before the peak of smoltification (January-February) instead of waiting until the fish were fully smolted (April-May) as in the past.

SEAWATER REARING

Seawater rearing is conducted at the NMFS Experimental Marine Laboratory near Manchester, Washington, in a floating net-pen complex at the end of a 900-ft pier, with office and laboratory buildings on shore (Figure 4). The floating net-pen complex has twenty-four 16- x 16-ft pens, and five 16- x 32-ft pens; both types are 12 ft deep, therefore, a 16- x 16-ft cage will hold 1,920 lb of adult salmon at a loading density of 0.75 lb/ft^3.

Higher than anticipated mortalities have occurred after direct transfer of smolts to seawater cages (Figure 5). For example, during

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[2/]Moore-Clarke Co., LaConner, Washington.

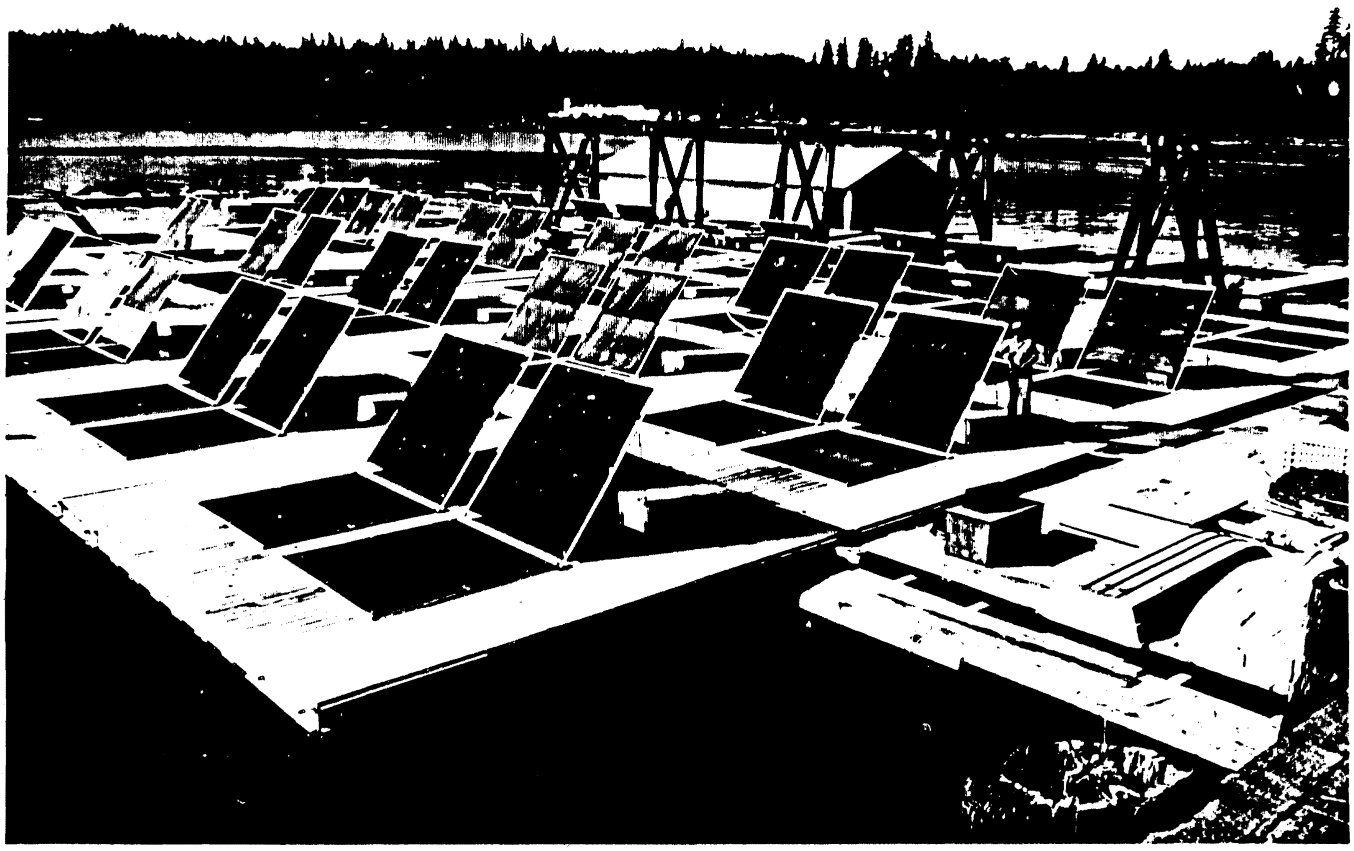

Figure 4.--Marine net-pens at Manchester, Washington.

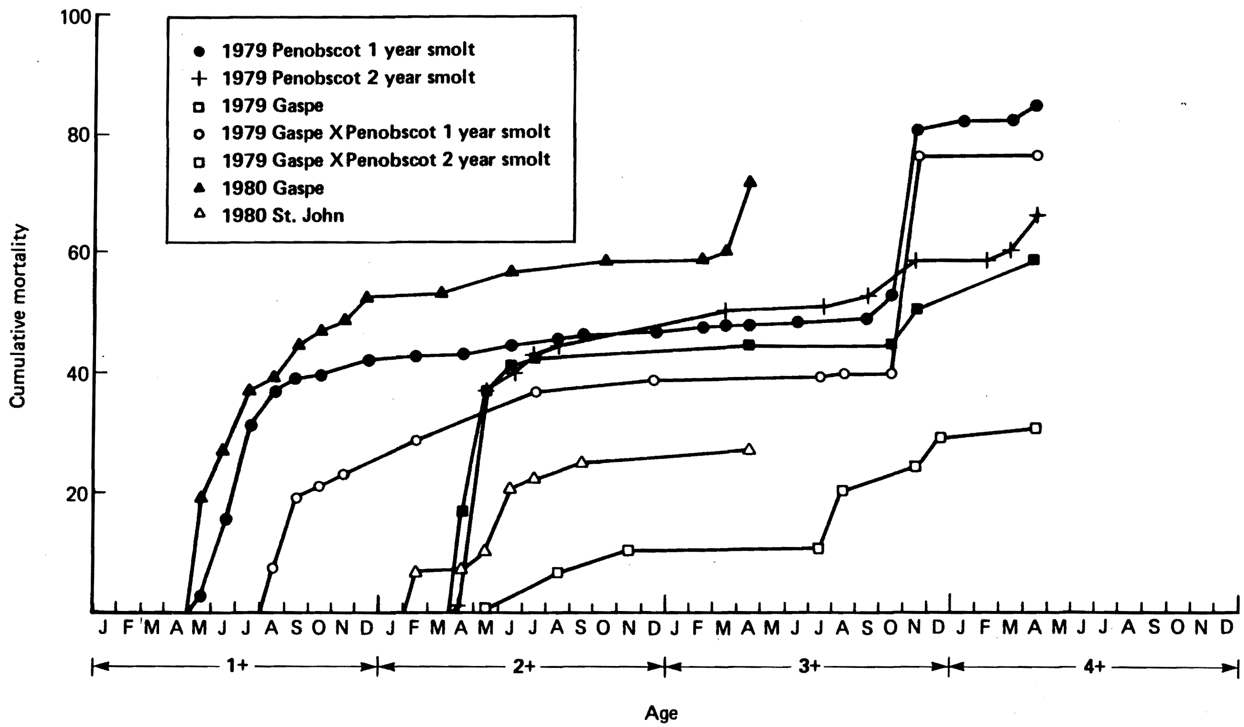

Figure 5.--Mortality in marine net-pens.

spring 1981, 1-year-old 1979-brood Penobscot smolts were moved directly to seawater (~ 28^{o}/oo salinity) after showing strong external characteristics of smoltification in late May and June. Approximately 35% mortality occurred during the first 2 months of seawater residence. Mortalities resulted from cutaneous marine myxobacterial infections and osmoregulatory difficulties.

We recently installed a pipeline carrying about 100 gpm of fresh water to the end of the pier at Manchester, allowing the construction of a seawater acclimation facility where fish, in 4-ft or 6-ft diameter circular tanks, can be exposed to any ratio of pumped fresh/salt water. Fish can now be gradually acclimated to seawater; although, they must be moved to seawater net-pens afterward. We also constructed a "freshwater lens system" which consists of a 5-ft-deep vinyl skirt around the perimeter of a 16- x 16-ft cage. Fresh water is continuously pumped into the skirted pen creating a salinity gradient of 4 to 25^{o}/oo over the full-strength seawater. Therefore, acclimating smolts can seek their preferred salinity; this avoids the problem of moving sensitive, post-acclimated fish.

In mid-February 1984, the newly constructed freshwater lens system was used to acclimate 3,094 Connecticut smolts to seawater. As of 16 March, only 150 fish had died, and the remainder appear to have successfully adapted to full-strength seawater.

After the smolts adjusted to full-strength seawater in the marine cages (2 months), survival and growth to maturity was excellent (Figures 5 and 6). (Pre-spawning mortalities in fresh water were common and are also indicated on Figure 5). Growth rates were different for the 1+ and 2+ year Penobscot smolts during seawater residence prior to maturity (Figure 7). Early growth of the 1+ smolts was depressed compared to 2+ smolts.

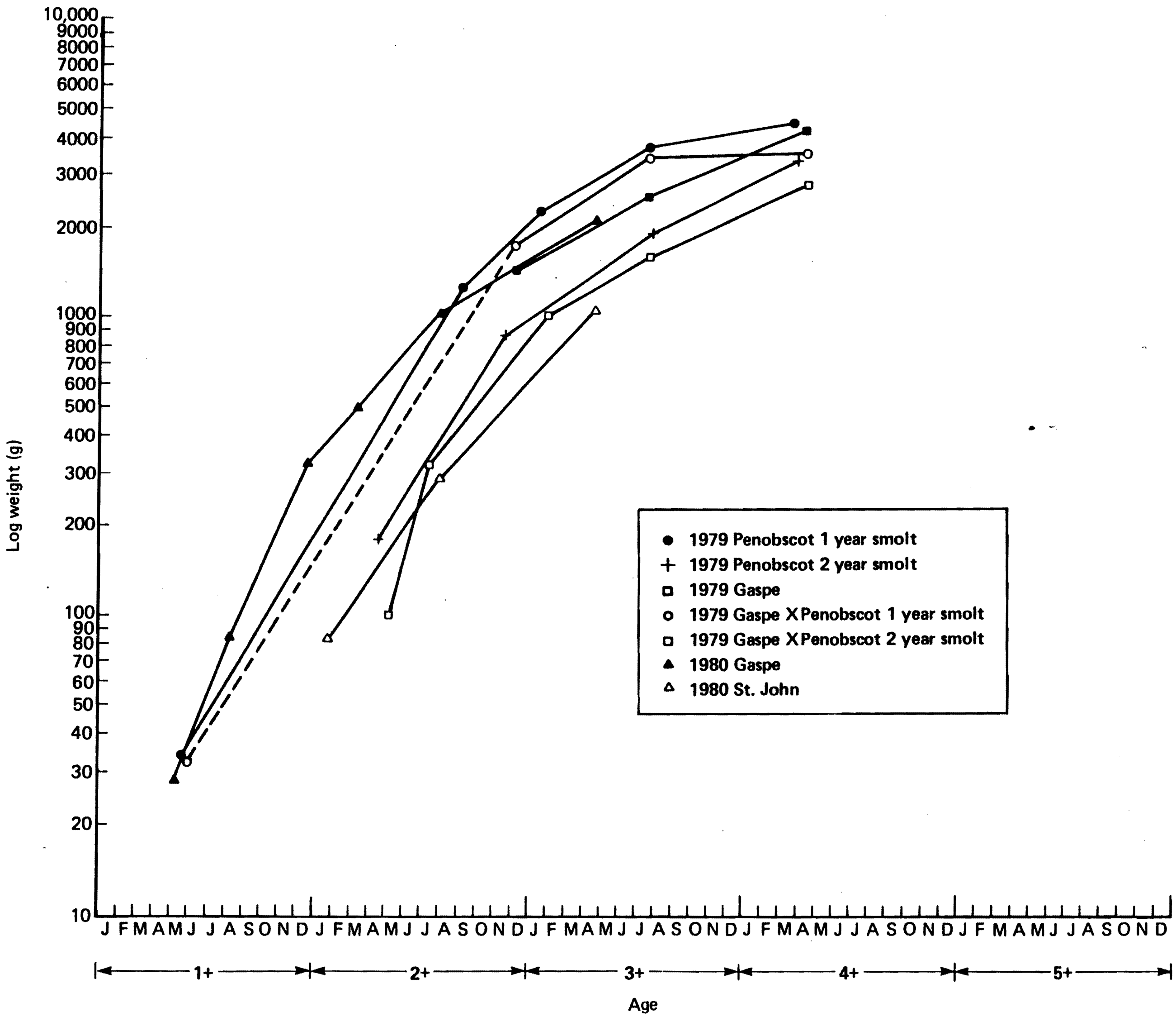

Figure 6.--Growth in marine net-pens.

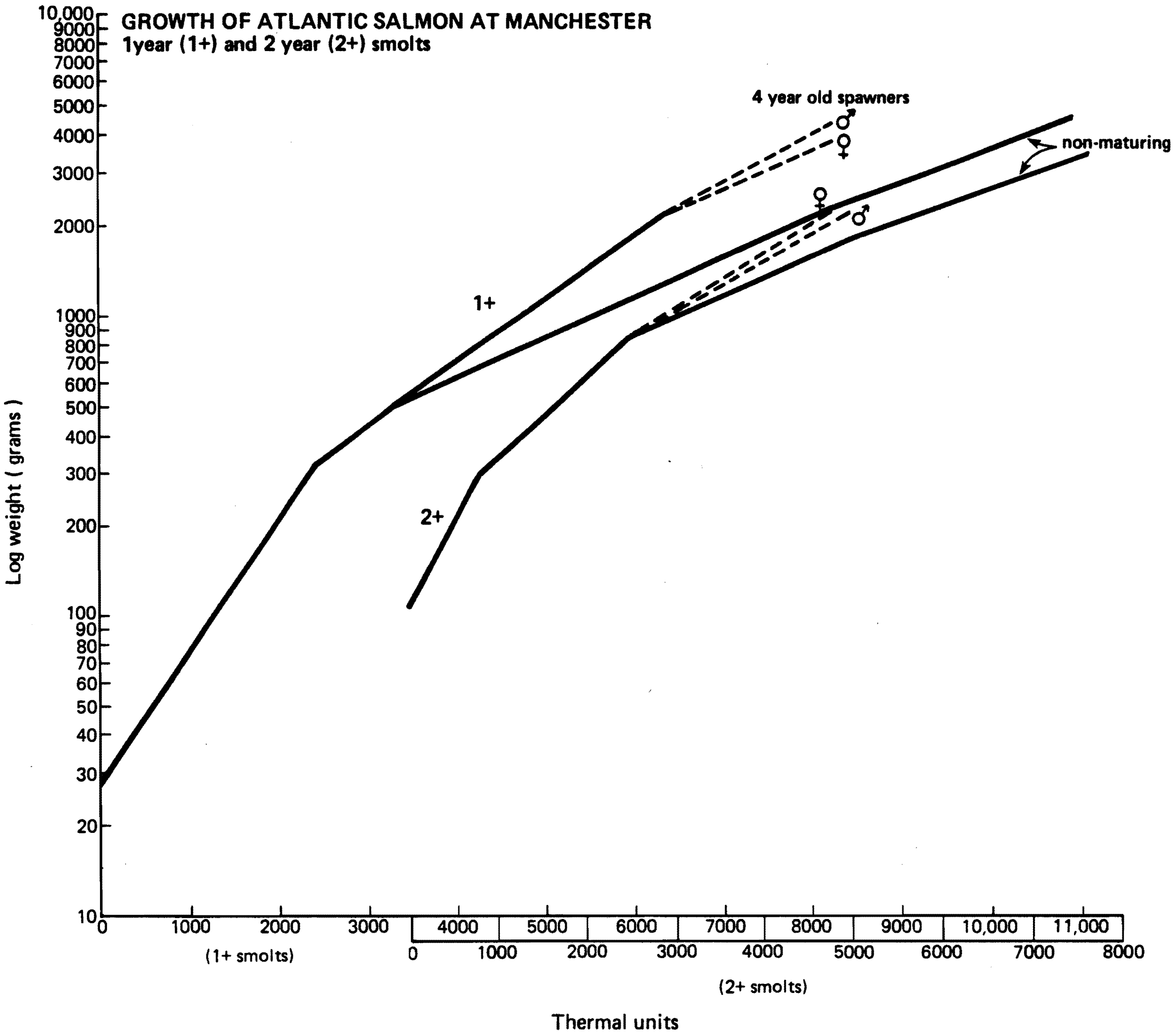

Figure 7.--Growth of 1+ and 2+ year smolts in seawater.

However, the extra year of seawater residence and growth in 1+ smolts resulted in larger average size females (3,941 g) with 67.3% of the fish maturing at 4 years of age. The possibility exists that gradual seawater acclimation of 1+ smolts combined with larger size at transfer will overcome the problems of stunted early growth, resulting in larger adults with increased fecundity. Two-year smolts produced females of 2,478 g with only 11.2% of the population reaching maturity at 4 years. Growth of other stocks and brood years appear to follow a similar pattern.

Periodic intraperitoneal injections with a vibrio bacterin/ antibacterial mixture appear to reduce vibriosis and other bacterial diseases to a "nuisance status." An atypical bacterial kidney disease (BKD) was responsible for the loss of approximately 50 2+-year-old St. John brood fish in marine net-pens this past summer (3% mortality); an unusual occurrence since we had never observed grossly detectable BKD in any other stocks of Atlantic salmon. This brood stock has been removed from the restoration program.

Another unexpected pathogen, the protozoan Kudoa thyrsitis, infected two brood years of Gaspe Atlantic salmon and the 1981 St. John stock. This marine parasite occurred approximately 5 months after seawater entry and caused less than 3% mortality.

MATURATION/SPAWNING

Last fall (1983), we undertook the first production-scale spawning for the Atlantic salmon program with the 1979-brood Penobscot stock. As adults began developing secondary sex characteristics typical of maturing fish, they were sorted in the seawater net-pens at NMFS' Manchester facility.

Potential spawners were separated and held for transport to fresh water at the Big Beef Creek Station. These fish were transferred to fresh water during September and October. Once in fresh water, some fish were given injections of luteinizing hormone-releasing hormone (LHRH) to synchronize maturation. Most fish were spawned between the end of October and middle of November.

A total of 333 maturing 4-year-old fish were transferred to fresh water for spawning (249 females, 84 males). Of the 249 females, 202 were from 1-year-old smolts (averaging 8.7 lbs at maturity) and 47 were from 2-year-old smolts (averaging 5.4 lbs at maturity). Of those fish, 194 females were successfully spawned, 15 females did not mature, and 40 females (16.1%) were lost to pre-spawning mortality due to furunculosis. At spawning, each female was killed and the eggs removed. Samples of spleen and kidney tissue and ovarian fluid were collected for disease analysis.

Approximately 920,000 eggs were obtained from the 194 females spawned during fall 1983. Average fecundity of females from 1-year-old smolts was 5,250, and from 2-year-old smolts 2,625 eggs per female. The eggs were fertilized with sperm from two males, water hardened with erythromycin phosphate (1 ppm), and subsequently incubated at 10°C.

Although the initial egg take was encouraging, only 434,000 eggs (47.2%) successfully eyed. The reason for this is not clear but possible causes include: incomplete fertilization, infertility induced by LHRH injections, high incubation temperature, and constant 10°C pre-spawning holding temperature. Subsequent tests using steelhead trout, <u>Salmo gairdneri</u>, as a model indicated that adult (pre-spawning) holding temperature exerted the strongest influence (of the afore-mentioned factors) on egg viability. Further studies, using Atlantic salmon spawners, are planned for 1984; these tests should provide a solution to future egg viability problems.

PROSPECTUS

The NMFS-USFWS brood-stock program is on schedule. The 3,500,000 egg production goal for 1984 can be met with available brood stock. The NMFS has over 20,000 fish in freshwater production and over 5,000 fish in marine net-pens. These fish should provide a stable egg base for future production cycles.

ACKNOWLEDGMENTS

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