Coho Salmon Farming in France

YVES HARACHE and ANTHONY J. NOVOTNY

ABSTRACT—The coast of Bretagne (Brittany) in France offers many suitable sites for salmon aquaculture. Seawater temperature varies from 8 to 18.5°C, but unusual climatic conditions may induce peak temperatures of 20°C. Coho salmon research was induced in France in 1971 by a CNEXO-COB (Centre National pour l'Exploration des Oceans/Centre Oceanologique de Bretagne) research team, in close relationship with NOAA-NMFS specialists. The results in freshwater-rearing were excellent, with high survival and good growth under natural conditions, leading to a large percentage of young-of-the-year (0-age) smolts. The first year of operation of an experimental saltwater, diked, tidal pond produced 7.6 metric tons of coho salmon in 1974 and 22 tons in 1975. Another pilot plant, built in June 1974, used net-pens in the Rade de Brest and produced about 4 tons.

Late spring and summer adaptation of smolts to seawater showed heavy mortality during the summer of 1974 and 1975, possibly due to high temperatures associated with high salinities. No evidence of bacterial infection was found in 1974, but Vibrio *sp. was isolated from dying fish in 1975. However, the surviving fish showed excellent growth. Part of the 0-age 26 g smolts, adapted in July 1974, reverted to parr condition with a poor growth, while the other part of the population reached an average weight of 397 g by 31 December (1.58% daily weight increase) and 735 g by 10 April 1975. Large 1-year smolts averaged 522 g by 31 December (1.25% daily weight increase) and 1,050 g by 9 April 1975. The salmon are reared in saltwater from October to May, when the sea temperature is below 13°C. The coho are marketed in France—fresh, whole, and in the size range of 0.3-0.8 kg. Market prices and acceptance are excellent. Total production should approach 100-120 tons in 1976 in three operating farms.*

RÉSUMÉ—Les côtes de Bretagne en France offrent un certain nombre de sites favorables à l'aquaculture du saumon. Les températures de l'eau de mer varient de 8 à 18,5°C mais des conditions climatiques exceptionnelles peuvent entraîner des températures proches de 20°C en été.

L'équipe d'aquaculture du Centre Océanologique de Bretagne débuta un programme de recherche sur l'élevage du saumon COHO en 1971.

Les résultats de l'élevage en eau douce furent excellents avec un fort pourcentage de survie et une bonne croissance dans les conditions naturelles, entraînant un pourcentage élevé de smolts d'âge 0.

La première année de fonctionnement d'un étang à marée expérimental permit de commercialiser 7,6 tonnes de saumon COHO en 1974 et 22 tonnes en 1975. Une autre structure pilote utilisant des cages flottantes en rade de Brest fut achevée en juin 1974 et produisit environ 4 tonnes de saumon dont 2 furent commercialisées.

Les adaptations de smolts à l'eau de mer à la fin du printemps et en été se traduisirent par de fortes mortalités estivales en 1974 et 1975, pouvant être attribuées aux températures élevées associées à une forte salinité. Aucune infection bactérienne ne fut mise en évidence en 1974 mais Vibrio *sp. fut isolé en 1975.*

Cependant les poissons survivants présentèrent une croissance excellente. Une partie des smolts d'âge 0 (26 g) adaptès en juillet 1974 régrèsserent a l'état de parr avec une faible croissance alors que le reste de la population atteignait un poids de 397 g le 31 décembre 1974 (croissance journalière: 1,58%) et 735 g le 10 avril 1975.

Le smolts de 1 an (70 g) transférés en cages flottantes en juillet 1974 atteignirent un poids de 522 g au 31 décembre 1974 (croissance journalière: 1,25%) et 1050 g le 9 avril 1975.

La production en eau de mer est actuellement programmée d'octobre à mai quand la température de l'eau est inférieure à 13°C.

Les saumons sont commercialisés en France frais, entiers dans la gamme de poids de 0,300 à 0,800 kg.

Les prix obtenus et l'acceptation sont excellents.

La production totale devarait approcher 100 à 120 tonnes en 1976 grâce à de nouvelles installations.

Harache Novotny

Yves Harache is with the Centre National pour l'Exploration des Océans, Centre Oceanologique de Bretagne, Brest, France. Anthony J. Novotny is with the Northwest Fisheries Center, National Marine Fisheries Service, NOAA, 2725 Montlake Boulevard East, Seattle, WA 98112.

This article is a contribution from the U.S./France Cooperation in Oceanology formally organized in 1972 by Yves La Prairie, Président -Directeur Général, Centre National pour L'Exploitation des Océans (CNEXO), and Robert M. White, Administrator, NOAA. James E. Hanks, Middle Atlantic Coastal Fisheries Center, National Marine Fisheries Service, Milford Laboratory (Conn.), is the NOAA Aquaculture Leader and Jacques Le Noan, Department Chief "Living Resources", Paris, is CNEXO representative for the aquaculture aspect of the Cooperation.

INTRODUCTION

Historically, the European consumer has been accustomed to Atlantic salmon, *Salmo salar*, as his first choice. However, due to the high cost of obtaining wild Atlantic salmon (which are in short supply), he has made some movement toward the more plentiful (and economical) Pacific salmon, *Oncorhynchus* spp., which is now an established consumer product.

Before the French Revolution, it is claimed, the rivers of Bretagne (Brittany) were producing over 4,500 metric tons of Atlantic salmon a year. The actual catch now is about 10 to 15 tons, and the additional high seas fisheries off Greenland of 2,500-3,000 tons is enough to endanger the species. The main causes of this disastrous diminution of Atlantic salmon are lack of management, overfishing, unadapted legislation, degradation of the environment, and an almost total absence of smolt-rearing facilities for restocking the rivers. This makes it impossible to obtain eggs from wild stocks of Atlantic salmon in France.

The French coastline, particularly that of Bretagne in the North, has geographical and climatic conditions apparently favorable to salmon farming. The Bretagne economy is partially based on exploitation of the sea, but traditional fishermen are now interested in developing aquacultural activity. Twelve rivers of Bretagne still support some small natural runs of Atlantic salmon.

Sea surface temperatures fluctuate from 8 to 18°C, with optimum range of 10 to 16°C, 9 months of the year. In 1975, the highest atmospheric temperatures recorded in Bretagne since the beginning of the century led to surface temperatures of 20-22°C in deep bays and estuaries, while the open sea surface temperatures approached 19°C.

The salinity of most of the sites deemed suitable for salmon farming range from 29-35‰. Tidal amplitudes range from 5 to 12 meters, depending on the area. This characteristic pr vides good renewal of water but limits the number of suitable sites. Storms occur frequently during the fall and winter months. Consequently, fish farms have to be protected from oceanic swell and, if possible, from the dominant southwesterly winds.

Studies of the seawater culture of coho salmon, *O. kisutch*, pioneered by the National Marine Fisheries Service (NMFS) in Puget Sound, Wash., indicated that the Pacific coho might be adaptable to the environmental conditions in the region of Bretagne. NMFS cooperative pilot farm studies proved that the coho could be grown to a marketable size in less than 18 months from fertilization of the egg, at a final production level of 250 tons per surface acre (Novotny, 1975). Thus, the Pacific coho, which are much easier to rear in fresh water than Atlantic salmon and less exigent about water quality, were chosen for the first French salmon farming tests.

The first eyed coho eggs (60,000) were purchased in December 1971 from the Washington State Department of Fisheries and were reared in fresh water in Bretagne under contract with a private fish farm. A second shipment of 200,000 eggs was received at the end of 1971, partly from the Oregon Department of Fish and Wildlife (Alsea River) and partly from the Bureau of Sport Fisheries and Wildlife (Eagle Creek National Fish Hatchery).

In 1973, CNEXO-NOAA cooperation was formally instituted for the development of coho salmon farming in France. NOAA furnished 250,000 eyed coho eggs to CNEXO, and exchanges between scientists of CNEXO's Center Oceanologique de Bretagne (COB) and NOAA's Northwest Fisheries Center of the National Marine Fisheries Service were arranged. In late 1973, a survey of possible net-pen culture sites in Bretagne was conducted by American and French scientists. In 1974, one million eyed coho eggs were obtained by French salmon rearers from U.S. hatcheries.

At the same time, two ways of rearing coho salmon to commercial size were planned: 1) Using old mill tidal ponds which are quite frequent along the sea shore and the river estuaries of Bretagne; and 2) Selecting sheltered sea areas where salmon could be reared in floating net-pens.

A pilot company, the Société pour le Développement de l'Aquaculture en Bretagne (SODAB), was organized in 1973 with CNEXO as the major owner. Two other farms using floating net-pens in open seawater were developed in 1974 and 1975 with fishermen's cooperatives.

FRESHWATER CULTURE

The first 2 years of operation (1972-73) were tests of the ability of operators to produce good survival and early growth of coho in the natural environment of the freshwater experimental hatchery. At the same time, studies were conducted at the COB laboratory concerning the size of fish and time of entry into seawater of coho smolts.

The fish were raised in the hatchery on a dry pelleted ration of French formulation and manufacture. The overall survival of the first lot of coho was only 50 percent at the end of the first year. However, the survival of the lots of the following year was 85 percent and 96 percent for one year's growth, and average weight was 50 g (Harache,[1] 1974). Eyed Atlantic salmon eggs were obtained from Scotland and cultured at the same hatchery at the same time. By contrast, the survival of Atlantic salmon at the end of the first year was only 4 percent, and the average size was less than 10 g. All fish were reared in 10-11°C reused spring water until the stream waters reached 10°C (April). In 1974, the survival was about 80 percent; in 1975, an upstream discharge of a pollutant destroyed 400,000 0-age coho in early May.

Only a small number, approximately 20 percent, of the 1971 brood progeny exhibited signs of smolting as 0-age fish in July (15-20 g) and October (35 g) of 1972. The progeny of two lots of 1972 brood eggs showed remarkable differences. Over 50 percent of the progeny of the Alsea River Hatchery parent stock smolted before the end of the first year's growth (0-age). Virtually 100 percent of the progeny from Eagle Creek Hatchery parent stock, which started feeding 3 weeks later, smolted as yearlings. However, the average size of Eagle Creek yearlings was 70 g in May 1974, which is exceptionally large. The smallest fish of the Eagle Creek stock, kept in fresh water until October 1974, weighed 150 g. In July 1974, 59 percent of the 1973 brood Eagle Creek stock were smolted as 0-age fish.

The significance of high survival and excellent growth of coho salmon in Bretagne, which had no alterations of the natural freshwater environment cannot be overlooked.

SEAWATER CULTURE

Rearing Facilities

SODAB developed a diked tidal pond (Moulin du Carpont) on the estuary of the river Jaudy for marine production (Fig. 1). The pond, which has a surface area of 6,000 m^2, is held at an average depth of 4 m, regardless of the tide. Water for the pond is produced by two 600 m^3 per hour (5.9 cubic feet per second) pumps which can work from 9 to 11 hours daily. A circulating pump in the pond moves 3,600 m^3 of water per hour (35 cubic feet per second) and induces a continuous current. At the higher tides, water can be partially renewed by gravity. The salmon are cultured in 16 Norwegian-type floating octagonal pens (Fig. 2). Pen volumes range from 193 to 230 cubic meters each. In 1975, a submersible dike was built below the upper pond, creating an additional pond with a surface area of 2,000 m, suitable for rearing. Submerged at each high tide, the dike keeps a 4-m water depth inside the lower pond which contains 12 octagonal net-pens (Harache, 1974).

Theoretical loading capacities for the upper pond were calculated by the CNEXO-NOAA team for several size ranges of coho. The studies were based on probable temperatures, oxygen saturations, oxygen consumption, and oxygen renewal. Surveys of the tidal ponds are being conducted to determine the possibilities of using this kind of pond for intensive production.

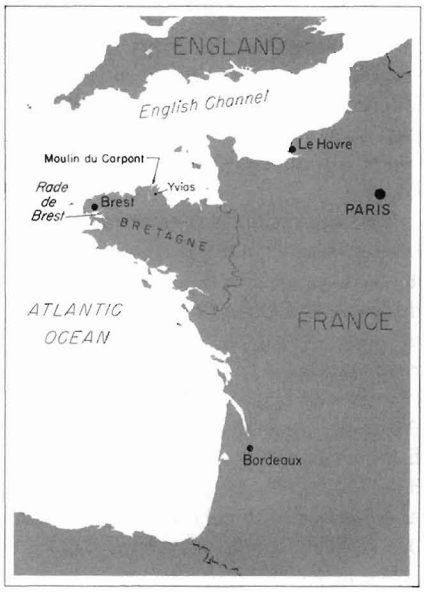

Figure 1.—Bretagne region in France, showing the locations of the diked tidal pond at Moulin du Carpont, and L'Auberlach Bay in the Rade de Brest (Brest Sound). Brest is in the same latitude as central Puget Sound, where coho salmon have been successfully cultured on a commercial scale.

Another pilot plant, much smaller, has been developed in a partially sheltered bay of Rade de Brest. A steel-pipe raft (Fig. 3), with four 60 m^3 (3 m deep) pens made of knotted nylon mesh, was installed in early June 1974

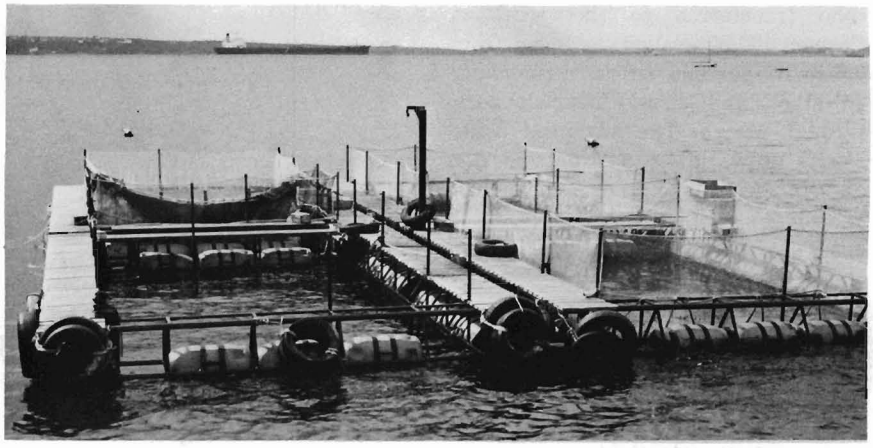

Figure 2.—Floating net-pens in the diked tidal pond at Moulin du Carpont. The Norwegian type octagonal pens are 2.5 and 3 meters deep and have volumes ranging from 193 to 230 cubic meters.

[1]Harache, Y. 1974. Premiers resultats de l'elevage experimental du saumon coho (*Oncorhynchus kisutch*). *In* L. Laubier and D. Reyss, Colloque sur l'Aquaculture, 22-24 Oct. 1973, Brest, p. 343-356. Publ. Cent. Natl. Exploit. Oceans (CNEXO), [Fr.], Ser.: Actes Colloq. 1. (Processed report.)

(Virmaux,[2] 1974 and Danioux et al., 1975). Water depth in this bay varies from 4.2 to 9 m depending on the tides. Current velocity does not exceed 0.3 m per second but wave amplitude can reach 1.5 during southwest storms in winter.

This operation is conducted in close cooperation with a fishermen's cooperative, Cooperative Maritime Aquacole du Tinduff (COMAT) that is in charge of the operation. CNEXO-COB is responsible for the technical and scientific advice and the cost of operation. After a 1-year test of the structures, five commercial size rafts with 8.5×8.5×3.5 m deep net-pens were installed and stocked with coho in early November 1975. This raft provides 2,200 m of space in which 30 to 35 tons of salmon could be produced in the future.

A third experimental station using two octagonal Norwegian-type pens is operating in the estuary of the Jaudy, close to Carpont. The current velocity of 2 knots can be considered a limiting factor in these conditions. These three projects are followed very closely by CNEXO biologists on a comparative growth and cost basis.

First Marine Production of Coho in France

The dike tidal pond at Carpont was completely equipped at the end of 1973. The first floating net-pens were installed during December 1973 and January 1974 with coho from the 1971 and 1972 parent brood stocks, ranging in size from 180 to 500 g.

The average weight increases of the coho transferred to the pond at Carpont (30-35‰salinity) ranged from 0.4 to 1.1 percent per day (depending on stock and sizes) from January through March. The advanced 0-age smolts grew slower (0.7 percent per day) in the marine environment than yearlings of the same size at time of entry (1.0 percent per day). In these stages, the fish were fed the dry pelleted ration, and mortality up to spring and early summer harvesting was almost negligible.

[2]Virmaux, J. F. 1974. Etude sur les cages flottantes pour l'aquaculture. Mem., Ec. Natl. Ing. Trav. Ruraux Tech. Sanit., Strasb., and CNEXO, Cent. Oceanol. Bretagne, Plouzane, Fr. 220 p. (Processed report.)

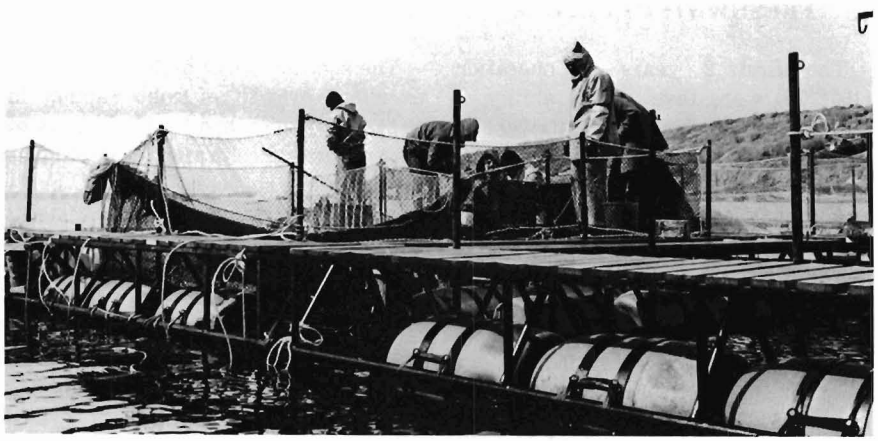

Figure 3.—Floating rigid pen-frame system and net-pens in L'Auberlach Bay, Brest Sound. Note the polyethylene kegs for flotation. Wave height can reach 1.5 meters (4.9 feet) in this bay.

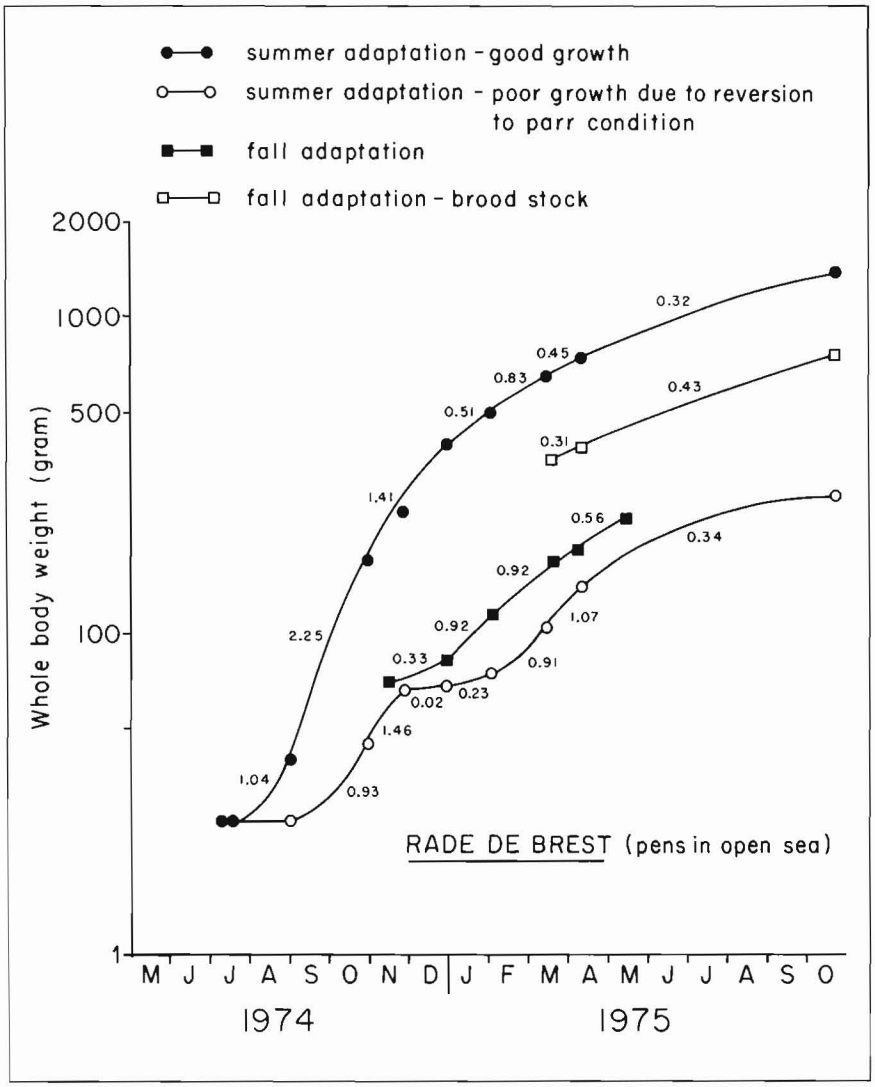

Figure 4.—Growth of zero age coho smolts in seawater. Values above the lines are the specific growth rates in percent of weight increase per day between measurement periods.

In 1974-75, we attempted to adapt 0-age and yearling smolts during June and July, when the seawater temperature was about 15°-17°C. In all the tests, mortality during the first 2-4 weeks was high with some apparent differences in each environment. The 30-day mortality of 0-age smolts (20 g) in 1974 was 100 percent in the diked tidal pond at Carpont, 95 percent at the COB laboratory, and 40 percent in the net-pens of the Rade de Brest. No evidence of disease was found in spite of alarming disease-like external symptoms. The mortality increased with time, reaching 100 percent at COB and 78 percent in the net-pens. Approximately 50 percent of the surviving fish grew well from September (1.6 percent daily increase) until late December and reached an average weight of 735 g by mid-April 1975 and 1,373 g by late October 1975 (Fig. 4). The majority of the remaining 50 percent reverted to parr condition, and growth was very poor. The fish were fed a dry pelleted ration with a food conversion rate of 1.35:1 until December 1975 and 1.7:1 in April 1975.

Yearling smolts (50 to 80 g) were transferred to 34.5‰ seawater in May and June 1974 (14° to 17°C) at the COB laboratory for experimental purposes and into a reduced segment of the Carpont tidal pond. Growth was very poor due to excessive handling and poor environment, but mortality was not excessive until July when temperatures reached 18.5°-19°C in Carpont and 17.5°C at COB. *Aeromonas salmonicida* was isolated at COB when 500 fish (averaging 72 g) in stressed condition were transferred from the COB laboratory to the net-pens in Rade de Brest at the end of July when seawater temperature was 17.2°C. (35.5‰ salinity). The mortality of these stressed fish was 72 percent in the first 3 days following transfer. However, the surviving fish grew well, reaching an average weight of 262 g by late October (1.3 percent weight increase per day) with a 1.7:1 food conversion and 522 g weight by late December (1.1 percent weight increase per day) with a 1.8:1 food conversion (Fig. 5). In April 1975, the average weight was 1,050 g with a 2.3:1 food conversion, and by late October the average was 1,590 g. At Carpont, the mortality of the same stock of fish was in excess of 90 percent, and the average weight gain was 0.7 percent per day during the first period and 0.9 percent per day during the last period. These fish were observed until early March 1975 when the average weight was 525 g (Fig. 6). The lower growth obtained in the closed pond may possibly be attributed to low levels of dissolved oxygen.

Figure 5.—Subsampling of winter coho by the CNEXO-COB biological team just prior to harvest. Floating pens in L'Auberlach Bay, Brest Sound.

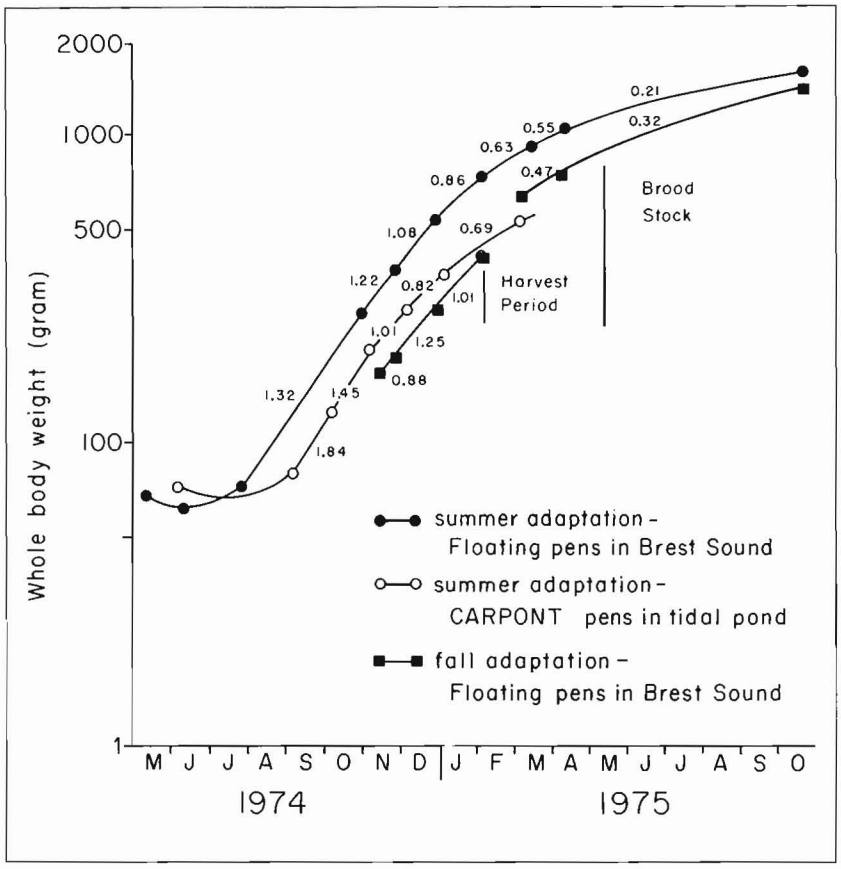

Figure 6.—Growth of yearling coho in seawater. Values above the lines are the specific growth rates in percent of weight increase per day between measurement periods.

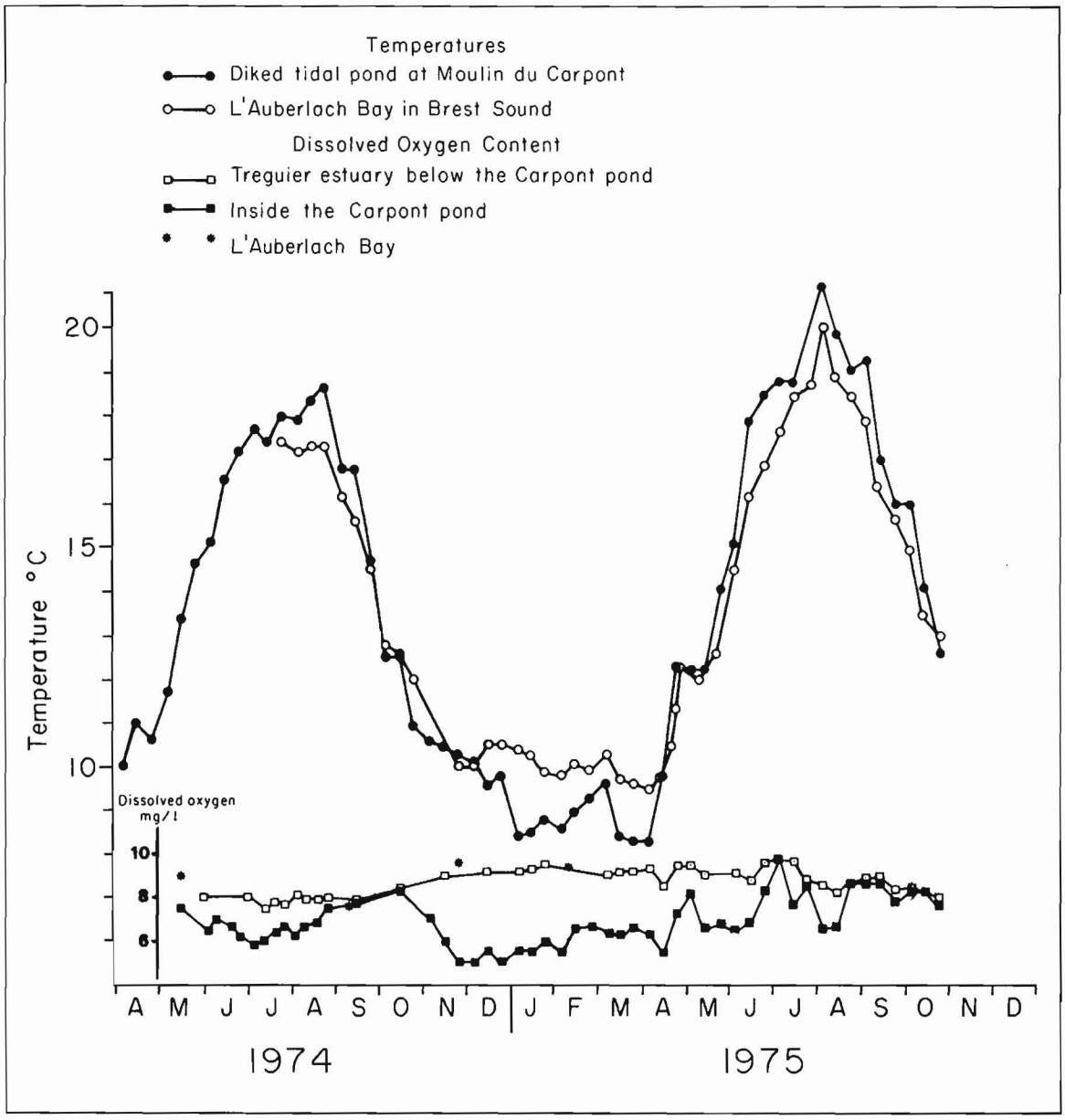

Figure 7.—Seawater temperatures and dissolved oxygen values in the diked tidal pond and in L'Auberlach Bay in Brest Sound. Dissolved oxygen values for the open estuary just outside the pond are also given. Note the differential in oxygen values when the production level reached 15 tons in late 1974.

Dissolved oxygen fell to 5-6 parts per million when the pond density approached 15 to 20 tons of fish (Fig. 7).

The results during the summer of 1975 were even worse, with a mortality in excess of 95 percent at all sites with unusually high temperatures. *Vibrio* sp. were occasionally isolated from dead or dying fish, but vibriosis could not be confirmed as the major cause of mortality.

In the fall of 1974, fish were adapted in the Rade de Brest and Carpont, either as 0-age large fall smolts (70-100 g) or as 1-18 month smolts (150-200 g). The growth of the larger fish was excellent with a 1.01 percent daily weight increase in Rade de Brest from November 1974 to February 1975. Brood stock isolated from this group reached an average weight of 1,350 g in late October.

The results with 0-age smolts were different. Coho smolts weighing 80-100 g at the time of saltwater entry had good growth and survival. Fish smaller than 70 g at saltwater entry had low growth rates but no mortality (Fig. 8).

The first coho cultured in the sea in France were harvested in April 1974 by SODAB and shipped to markets in Paris. The fish were in excellent condition—bright, silvery, good body shape, no blemishes, firm, and with good flesh color. The fish were harvested once or twice each week; they were stunned and packed whole in ice in styrofoam cartons at a total carton weight of about 10 kg. The individual weight range of marketed fish was 300-800 g, representing single portion meals or enough for two persons.

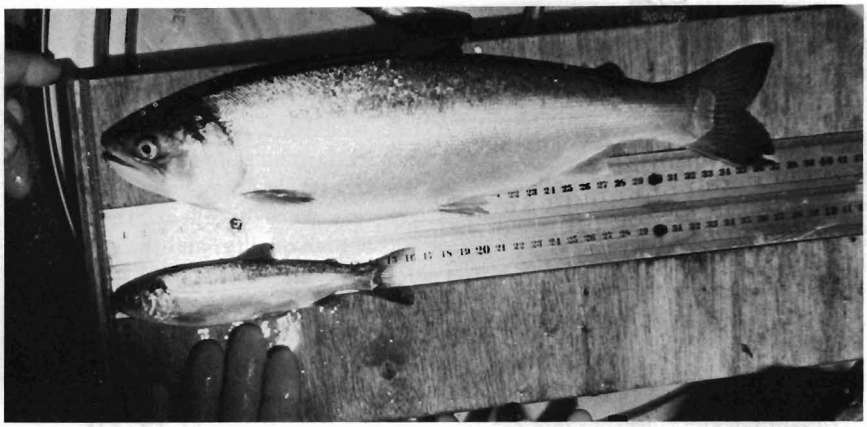

Figure 8.—Market size French coho. Coho averaging 70 grams in late July (smaller fish) reach an average of 700 grams after just 6 months growth in seawater (large fish).

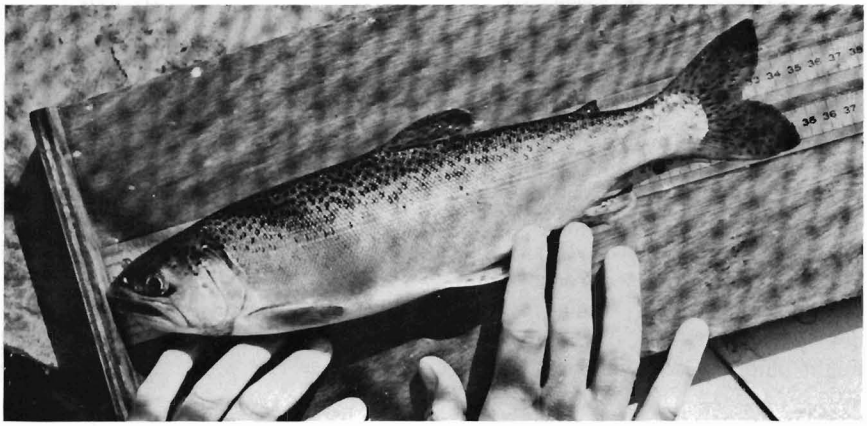

Figure 9.—Two-year-old maturing male coho in the net-pens in L'Auberlach Bay. These fish are considerably smaller than the 3-year-old mature coho from the diked tidal pont at Carpont.

Marketing continued until July, when a total of 6.2 metric tons had been shipped. New stocks of coho were introduced to Carpont from the freshwater hatchery in October 1974, and harvesting resumed in mid-December to accommodate the demand for the holiday trade. The overall production to market was 7.6 metric tons by 31 December 1974. From January to June of 1975, about 25 tons were sent to market, both by SODAB (22.5 tons) and COMAT (2.5 tons), all from fall adapted fish.

The prices paid to the salmon farmer averaged 20 Francs (F) per kg (US$2.00 per lb) for the whole fish on the Paris wholesale market, which is good. The slightly smaller coho cultured and sold in the United States are now bringing Puget Sound farmers about 14 F per kg (US$1.44 per lb) dressed. The weight loss averages 18-20 percent on dressed fish. In the French wholesale market, this new product is bringing French farmers an average 16.6 percent of the U.S. prices. In addition, the farmers of SODAB and COMAT do not have the labor expense of dressing the fish, nor the storage costs for freezing.

DEVELOPMENT OF FRENCH COHO AND BROOD STOCK

Although the CNEXO project must rely on the shipment of coho eggs from the United States for the present, the eventual goal is to develop self-sustaining French brood stocks. The excellent success that NOAA-NMFS biologists have had (at the Northwest Fisheries Center's Aquaculture Experiment Station near Manchester, Wash., in culturing 2-year-old brood parents in total confinement in floating net-pens in Puget Sound indicates that this should be possible in France. This would give French biologists the capability of genetic control to develop stocks adapted to the Bretagne environment.

In 1973, the first coho cultured entirely in the freshwater hatchery reached maturity as 2-year-old fish, weighing from 0.3 to 0.8 kg. Approximately 100,000 eggs were taken from the females, but the quality was apparently similar to the eggs of the first brood stock cultured in the sea by NOAA-NMFS at their Manchester station. The eggs were transparent, with poor yolk dispersion and extremely fragile walls. The survival through hatching was only 1-3 percent, which is identical to the results of the NMFS first year brood.

The 2-year-old fish that did not mature were transferred to the diked tidal pond at Carpont in January 1974. Only 3 percent of these fish reached maturity as 1-2.5 kg females in late 1974 as 3 year olds. Approximately 17 percent of the population matured as males in a slightly smaller size range. Although a high proportion of these maturing fish were bright and did not exhibit the usual sexual characteristics of maturing coho cultured at Manchester, eggs could be extruded from the females, and ample quantities of seminal fluid from the males (Fig. 9). Unfortunatley, the eggs were found to be in the same conditions as those of the first spawning from the freshwater hatchery. In some cases, the female gonads were atrophied.

In December 1974, at Yvias, eggs were taken in fresh water from 2-year-old fish with better results (Fig. 10). About 20 percent of the eggs survived and the resulting progeny showed good growth. These fry were 6 weeks later in the development stage than those from U.S. coho eggs fertilized in early November and reared in the same French hatchery. But, by October 1975, the French progeny had caught up with the U.S. stock, reaching an average weight of 43 g (range 10-80 g).

CONCLUSIONS

Although the growth and survival of the coho salmon in fresh water in Bretagne is better than was anticipated, there are some problems in marine rearing. When the coho are adapted to seawater in the fall or winter, there is almost no mortality in the ensuing

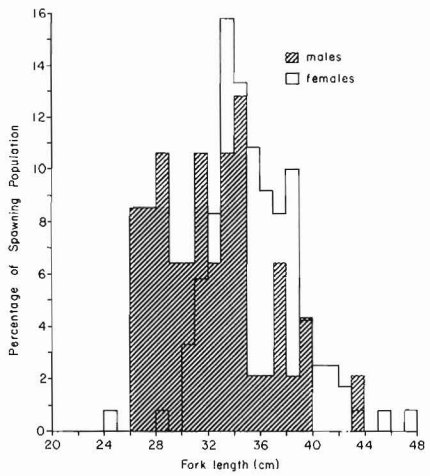

Figure 10.—Length-frequency distribution of 2-year-old coho spawning stock from the freshwater hatchery at Yvias (1972 brood). The weight range of these coho was approximately 300 to 800 grams.

months of culture, whereas normal smolts placed in seawater during the summer have high mortalities. It is possible that the combinations of high temperature and high salinity during the summer may induce an unacceptable stress, but these are factors which must be studied to determine the exact cause of these problems. Nutritional deficiency and bacterial infection cannot be overlooked as possible causes of mortality.

It is not known if the combination of high summer temperatures, high salinities and, in some cases, low dissolved oxygen levels are responsible for the poor results obtained with maturing females at Carpont in late 1974. The possible existence of nutritional deficiencies cannot, however, be excluded.

At present, a production cycle of holding coho in a freshwater hatchery until mid-fall and culturing in a sea for spring harvest appears to have the best advantages. This is a somewhat longer freshwater rearing period than in the United States, but the survival in the marine environment through marketing is high (95 percent). This slight disadvantage is almost negligible. Most recently, the CNEXO-NOAA team, working at the NMFS Manchester laboratory, found strong evidence of a possible pathogenic French vibrio. If further tests prove that this is true, the introduction of a French vibrio vaccination program similar to that developed by NMFS in Puget Sound might improve the summer rearing survival considerably[3] (Novotny, 1975 b).

Although the French production of sea-farmed coho salmon is less than 40 tons to date, it is nonetheless the first French-farmed salmon to appear on the market. Prices obtained by the SODAB growers were excellent, the product was of high quality, and the acceptance on the market was high. These favorable factors point to an established place for the coho salmon in the future of aquaculture in France.

LITERATURE CITED

Danioux, C., M. Girin, Y. Harache, and L. Laubier. 1975. L'Aquaculture Marine. (In three parts.) Grands Dossiers Alpha de la Mer 16 (176): 301-320; 17 (177):321-340; 18 (178):341-360. Grange Bateliere, Paris.

Harache, Y. 1974. L'aquaculture marine des salmonides. Penn Bed (Brest) 9(77):342-350.

Novotny, A. J. 1975a. Net-pen culture of Pacific salmon in marine waters. Mar. Fish. Rev. 37(1):36-47.

———— . 1975b. Preventative medicine: status of the legal use of vaccines. *In* T. Y. Nosho and E. L. Brannon (editors), Salmonid diseases: a workshop summary, April 17, 1974, p. 18-20. Univ. Wash. Sea Grant Prog., WSG-WO 75-2.

[3]National Marine Fisheries Service, Northwest Fisheries Center, Seattle, Wash., Monthly Report, Sept. 1974, p. 1-5.

MFR Paper 1194. From Marine Fisheries Review, *Vol. 38, No. 8, August 1976. Copies of this paper, in limited numbers, are available from D825, Technical Information Division, Environmental Science Information Center, NOAA, Washington, DC 20235. Copies of* Marine Fisheries Review *are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402 for $1.10 each.*