Striped Bass and American Eel Research

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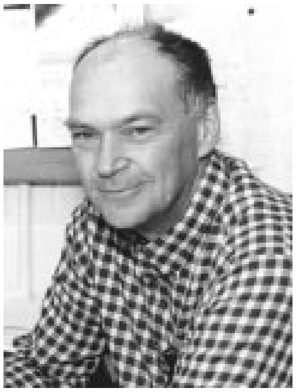

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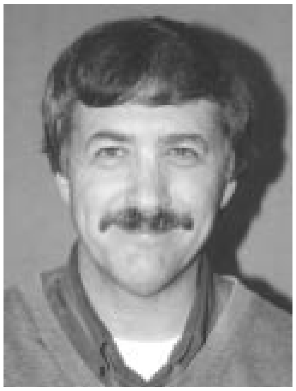

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Background

Following the early successes of salmon cage culture (now worth 100-150 million annually) in the Bay of Fundy, interest in the culture of other species with high economic value was generated. As a result, research on culture of "alternate" species began about 7 years ago. In a 1991 DFO working group, four species - halibut, haddock, striped bass, and eels - were identified as having potential for development as aquaculture species. Since then, the winter flounder has also emerged as a culture candidate.

Interest in striped bass culture arose with the collapse of the wild striped bass fishery along the east coast of the U.S. in the mid-80's, coincident with some advances by U.S. scientists in successfully inducing spawning of captive striped bass broodstock. Over the past 6 or 7 years, the production of cultured striped bass (actually the production of striped bass-white bass hybrids) has attained an annual volume of about 500 metric tons (MT). This production is split nearly evenly between pond culture and culture in closed, recirculation systems, and represents only about 0.1% of the former wild fishery production (Jessop 1991).

At present, there is only one striped bass population successfully reproducing in the Bay of Fundy - that inhabiting the Stewiacke-Shubenacadie river system in Nova Scotia. The reproductive status of former populations in the Saint John and Annapolis river systems is uncertain. The structure of Northumberland Strait populations is also uncertain. Successful recruitment occurs in the Miramichi estuary and, perhaps, in some of the smaller adjacent rivers as well.

Broodstock

The success of research on any aquaculture species requires the establishment of a successful broodstock as a source of eggs and juveniles. We acquired our first broodstock (three females, two males) (Fig. 1) from gillnets of the Stewiacke driftnet fishery in the spring of 1988. We have relied on the progeny of these five fish for almost all of our research on early development. We have spawned these fish annually since 1991. Their growth during the first 4 years of captivity (Fig. 2) averaged about 0.5 kg/year for females and about half that for males.

Figure 1: Striped bass broodstock.

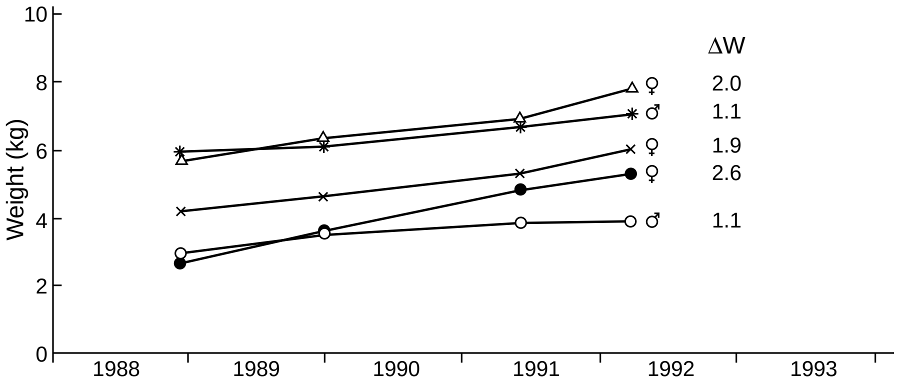

Figure 2: Weight changes in five striped bass broodstock fish for 1988-92. Each symbol represents an individual fish. Dw is the increase in weight from 1988 until 1992.

Spawning striped bass requires precise timing for injection of GnRh into the broodstock. This allows spawning to occur in the tank, and collection of eggs from the broodstock tanks. The eggs hatch in 2 days at about 16°C, and the yolk utilization requires only another 5-7 days. Larvae are first fed live brine shrimp (*artemia*) and can be weaned to artificial diets after 2-3 weeks of *artemia*.

Early Development

Our research has focused on three areas: early development, juvenile growth and performance in an aquaculture setting. Successful swimbladder inflation during yolk utilization is essential for the production of viable juveniles, and has been a recurrent problem for all who culture the species. Our inflation success has been as low as 10% in some years. We have studied optimal environmental conditions for successful early development (Peterson *et al.* 1996a). Most recently, we have found that light intensity and interior tank color influence the percentage of larvae successfully inflating their swimbladders (Table 1). Larvae reared in tanks with black interiors had 70-80% successful inflation rates, as opposed to 40-50% for larvae reared in tanks with white interiors. We believe that the white interior has an adverse effect on larval behavior. They seem to orient to the walls oddly, standing on their tails and swimming against the sides. A lower overhead light intensity seems to give a slightly better inflation rate as well. A shorter photoperiod (8 hours light, 16 hours dark) also yielded higher percentages of larvae with inflated swimbladders than did exposure to a longer photoperiod (16 hours light, 8 hours dark). In some earlier experiments, all larvae reared in continuous light failed to inflate their swimbladders. Thus, periods of darkness seem to facilitate swimbladder inflation. Larvae reared in dark tanks and under short photoperiods were larger after 12 days post-hatch. It may be that dark tanks resulted in more efficient prey capture, resulting in larger, more vigorous larvae that had more success at filling their swimbladder. Or, conversely, it may be that successful swimbladder inflation resulted in larvae that fed and grew better. Many of these uncertainties might be clarified by some appropriate observations on larval behavior as related to tank color and light intensity.

	Tank Colour			
	Dark		Light	
Intensity	Low	High	Low	High
Inflation	80-85	68-72	45-50	40-45
SL (12 dph)	8.3	8.6	7.3	7.2

	Photoperiod	
	16L:8D	8L:16D
% inflation	20-40	55-65
SL (12 dph)	7.5	8.0

Table 1: Influence of tank color and photoperiod on swimbladder inflation (%) and growth (mm) in larval striped bass. SL: standard length at 12 d post-hatch; L: light duration; D: dark duration.

Juvenile Growth

Our work on juvenile growth was performed to determine growth responses at various temperatures and salinities (Harmon and Peterson 1994), and what rations should be provided for various fish sizes and environmental conditions. The striped bass grows best at temperatures in excess of 25°C. Specific growth rates may exceed 4-5% body weight per day under such conditions for 1- to 50-g fish. At 15-17°C, growth rates of 1-2% per day are obtained. Growth rates are also greater at salinities of 12-30 o/oo than in low salinity (Fig. 3). At the higher temperatures, extremely high rations must be fed to prevent cannibalism. We feed rations of 30% body weight per day up to a size of 20 g, at which point the rations can be reduced to 10% per day. These rations compare with rations of 1.5-5% fed to salmon of similar size at temperatures of 17-20°C.

Aquaculture Strategies

Our studies on growth responses of striped bass in aquaculture operations is to determine optimal ways to culture striped bass, and to determine feasibility of commercial culture of the species in the Maritimes. Since the striped bass is adapted to warmer temperatures than the Atlantic salmon, a somewhat different strategy is required for successful commercial culture. There are three possible strategies: cage culture in areas with warmer sea surface temperatures in the summer, pond culture, and culture in recirculation systems. We have been involved with the second option

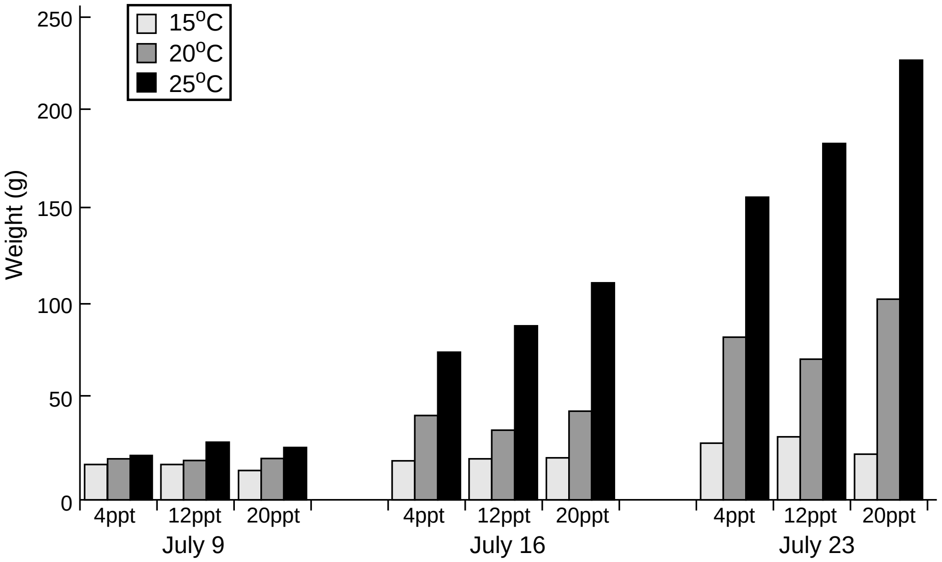

Figure 3: Growth of juvenile striped bass at nine temperature-salinity combinations. Weight gain occurred over 2 mo. Fish in all treatments started at about 1 g. Each bar represents the mean of 100 fish.

- pond culture. Rearing striped bass in coastal brackish or saltwater ponds is probably the easiest and cheapest way to culture striped bass. Freshwater ponds with water of sufficient hardness (more than 150 mg/L) is also possible, but growth is less rapid in fresh water.

Ponds of 1-2 m depth in the Maritimes will typically have temperatures exceeding 20°C for 3 months of the year (Fig. 4), during which rapid growth can be anticipated. Some growth will typically occur in May, September and October as well. Striped bass normally spawn in early June, and we consider it necessary to get the juveniles to 40-50 g by the end of the first summer in order to have a market-sized fish (ca. 600 g) by the end of the second summer. Striped bass culture will be profitable if a market-sized fish can be produced in 18 months. The current private striped bass operation produces juveniles averaging 30 g at the end of the first summer, with only the larger individuals attaining 50 g. This operation has transferred a portion of their juveniles to a recirculation system in a greenhouse for an extra 2 months growth (principally October and April). They marketed the first cultured striped bass in the Maritimes last summer (about 500 fish), a mixture of 2-summer and 3-summer fish.

One of the problems in optimizing growth in ponds is developing an optimal feeding strategy. From some casual observations, it would appear that striped bass are nocturnal feeders, so better growth may be achieved by including feedings at night. We are proposing to investigate the use of nocturnal feeding in augmenting growth in some of our experiments next year.

A striped bass culture manual is currently available (Peterson *et al.* 1996b).

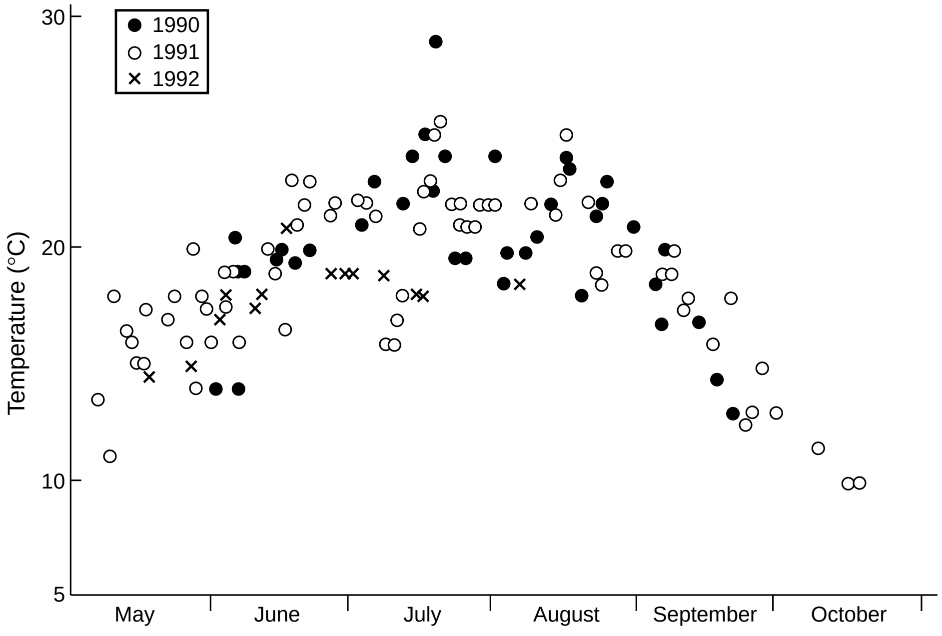

Figure 4: Temperatures recorded in experimental ponds at the St. Andrews Biological Station over three summers.

Eel Culture

Culture of eels (Fig. 5), unlike that of most aquaculture species, is totally reliant on a source of wild elvers as seedstock. This culture of eels must be integrated with management of wild eel fisheries in the Maritimes. Eels in the Maritimes are currently exploited in three ways: fished and sold as large eels to markets abroad, fished and sold as elvers - either for culture systems abroad or as a food item, and cultured to variable sizes for sale either as seedstock abroad or directly as market-sized eels. There is at present one eel farm in New Brunswick, with a second probably beginning its operation in Nova Scotia in the spring of 1996.

The research we are doing on eels, in collaboration with Dr. Tillmann Benfey at University of New Brunswick (Fredericton), addresses one basic problem in eel culture - why do 90% of cultured eels become males? This problem has market implications because males cease growing at about 150 g with the onset of sexual maturation. Females grow to 500-1000 g before beginning to mature. Some markets (the German for example) will accept only the large females.

In contrast with the situation in culture systems, most wild eels in the Maritimes become females. Our hypothesis to explain the differing sex ratios between wild and

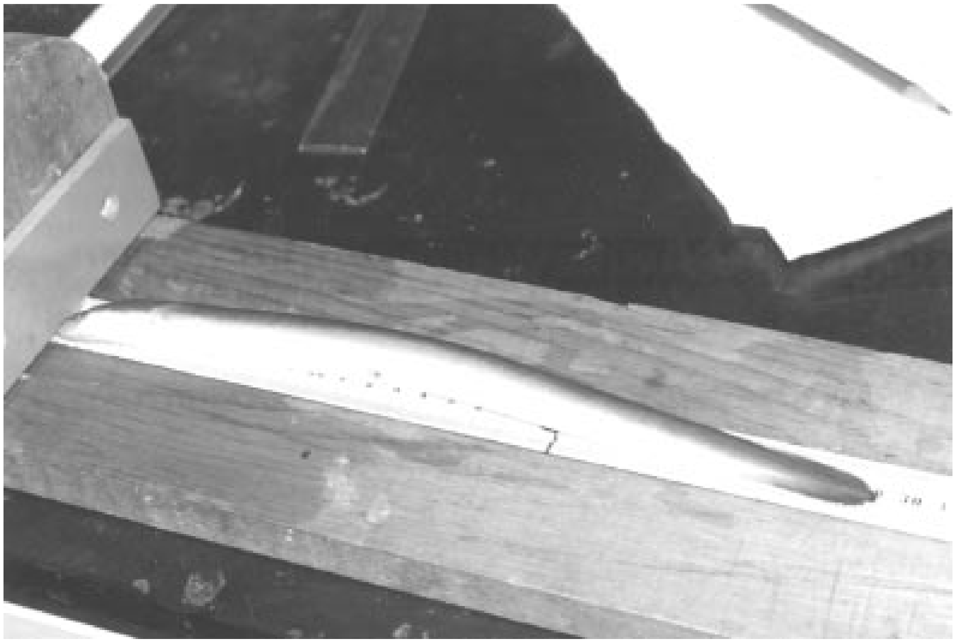

Figure 5: Eel on measuring board.

cultured eels was that wild eels experience a period of cold exposure after the first summer's growth. This period of low temperature, with cessation of feeding, may result in a high percentage of females. Temperature is known to affect sex ratios in some reptiles and fish. So, we set up two temperature treatments in the spring of 1994. In one treatment the eels were held at high (23-25°C) temperature continuously until of sufficient size to sex (ca. 30 cm). Sex must be identified by histological procedures. In the other treatment, eels were exposed to 5°C for 3 months (Dec.-Feb.), after growing at 23-25°C from June until the end of November, then re-warmed to 24°C and reared until a sexable size was attained. Growth rates in eels are highly variable.

We have sexed 38 eels: 15 from cold treatment, 23 from continuous warm temperatures (Table 2). The results indicate that we still have some way to go before we know how to produce female eels. While the only two identified females were from the cold treatments, the percentage (<10%) is not encouraging. There are several factors which could raise some questions as to the reliability of these results. As stated above, eel growth rates are highly variable. In addition, eels are cannibalistic and we had insufficient tank space to segregate small and large eels; hence, many eels were lost due to cannibalism. Several of the eels dissected for histology had smaller eels in their stomachs. The differential loss of slow growing eels may have biased our observed sex ratios.

The eel gonad is reported to become testis-like at first, then may develop oocytes later - this sequence developing from anterior to posterior. Three or four of the testes examined had some oocyte-like cells present, so there is a slight possibility that these eels might eventually have become females.

Treatment	Number of eels examined	Number of females	Number of males	Number uncertain
No Cold	15	0	14	1
Cold	23	2	18	2

Table 2: Sex determinations of eels processed histologically to date. No cold - eels maintained at 23°C throughout; cold - eels lowered to 4-5°C for 3 mo after first summer's growth. A length of about 30 cm must be attained before sex can be determined.

The future of this research is uncertain due to lack of funding. Dr. Benfey is hoping to continue by dosing eels of different sizes with estrogen to determine the size at which sex becomes fixed -i.e. cannot be altered by exposure to estrogen. Another useful approach would be to bring in wild eels of various sizes and grow them to sexable size to see at what size sex is established in wild populations.

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