ovulated spontaneously. These eggs did not develop and disappeared from the brood pouches after a few days. Thus, there appears to be no sperm storage in *I. baltica*, and females must be accompanied by a male at the time of their molts to ensure the development of their broods.

One interesting observation was that males engage in amplexus significantly more often after than before their molts. This may be explained by the observation that neurons become detached from the exoskeleton a few days before the molt (Guse 1983). Thus, if contact and/or water-borne pheromones are secreted by receptive female *I. baltica* as they are in some other peracarid females (Borowsky 1984, 1985, 1986), it is possible that the males cannot sense the stimuli produced by females shortly before their own molts, and therefore are less likely to engage in amplexus at that time.

Conclusion

The results of the present study show that *I. baltica* adults can be maintained in the laboratory, and will reproduce freely with minimal effort and at minimal cost. Females fed exclusively on *Ulva lactuca* produced many broods in succession in non-aerated, uncycled water. While further study is necessary to determine whether juveniles will develop under these conditions, and, if so, what the yield will be, the observations reported here suggest the feasibility of culturing this species for fish mariculture systems.

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OCCURRENCE OF THE FIRST FRESHWATER MIGRATION OF THE GIZZARD SHAD, *DOROSOMA CEPEDIANUM*, IN THE CONNECTICUT RIVER, MASSACHUSETTS[1]

Occurrence of a freshwater migration of the gizzard shad, *Dorosoma cepedianum* (Lesuer) (Clupeidae), is documented for the first time in a New England river system. Adult gizzard shad were observed and collected at the Connecticut River fishlift facility in Holyoke and upstream in Massachusetts during 1985 and 1986. It is believed that the Connecticut River migrants are derived from a population recently observed in Long Island Sound and already occurring in the Hudson and Connecticut River estuaries and Nantic Bay.

The gizzard shad is a widely distributed species occurring in marine and tidal freshwaters along the

[1]Contribution No. 104 of the Massachusetts Cooperative Fishery Research Unit, which is supported by the U.S. Fish and Wildlife Service, Massachusetts Division of Fisheries and Wildlife, Massachusetts Division of Marine Fisheries, and the University of Massachusetts.

middle, southern, and gulf coasts of eastern North America (Megrey 1979). Landlocked freshwater populations are known from the Mississippi River drainage (Miller 1956; Megrey 1979) and the Great Lakes (Miller 1956, 1960). On the North American Atlantic coast, the gizzard shad has been reliably reported north to northern New Jersey and New York Harbor (Breder 1938; Miller 1956) (Fig. 1).

Recent evidence indicates that the gizzard shad has ventured into the estuaries of certain major rivers draining into Long Island Sound. Dew (1974) reported that the species was first observed in the lower Hudson River estuary at Indian Point (river km 64.5) between 1969 and 1971 (Fig. 1). Subsequent surveys suggested that the lower Hudson River population is increasing and that reproduction was possibly occurring in the estuary (Dew 1974). However, George (1983) believed that the gizzard shad in the lower Hudson River are derived from fish which migrated through the Erie Canal to the Mohawk River and down the Hudson River. If George's (1983) theory is correct then the lower Hudson River population would have been founded by landlocked freshwater animals, and not by migrating "anadromous" adventives from New York Harbor.

Results and Discussion

In the Connecticut River, adult gizzard shad were first observed near the mouth (river km 2.4, Fig. 1) in 1976 by commercial fishermen using gill nets set for American shad, *Alosa sapidissima*, (Whitworth et al. 1980). In 1984 and 1985, gizzard shad

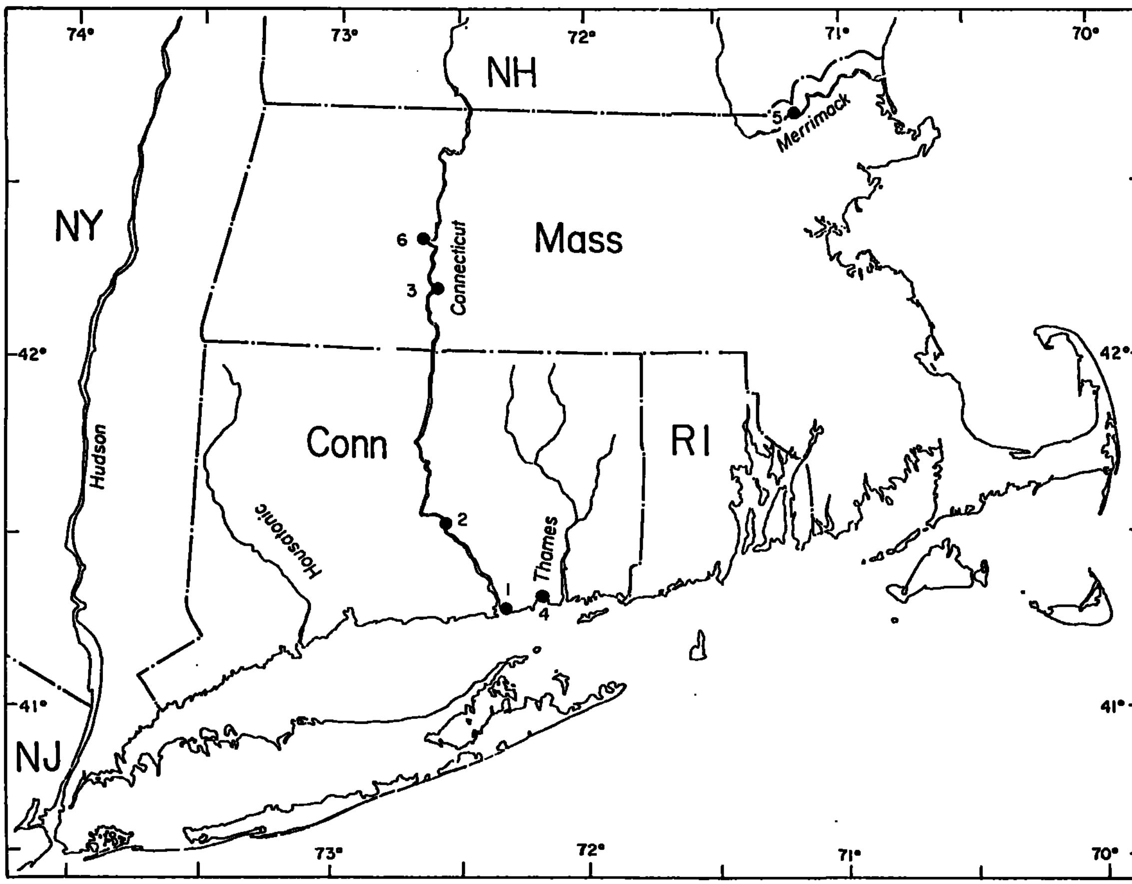

FIGURE 1.—Recent reports of the gizzard shad, *Dorosoma cepedianum*, in New England: 1. Whitworth et al. (1980), Connecticut River, river km 2.4. 2. Gephard (text fn. 2), Connecticut River, river km 26. 3. O'Leary and Smith (this paper), Connecticut River, river km 139.4. 4. Gauthier (text fn. 3), Millstone nuclear power plant. 5. S. Henry (Assistant Aquatic Biologist, Massachusetts Division of Fisheries and Wildlife, Field Headquarters, Route 135, Westboro, MA 01581), Lawrence fishway, Merrimack River. 6. O'Leary and Smith (this paper), Connecticut River, Northampton Oxbow, river km 150.

were subsequently collected by fishermen using gill nets farther up the Connecticut River estuary (river km 26; S. Gephard pers. commun.[2]; Fig. 1) and entrained at the Millstone nuclear power plant in Nantic Bay, CT (C. Gauthier pers. commun.[3]; Fig. 1). In October 1985, a single specimen was captured at the Lawrence fishway on the Merrimack River, Lawrence, MA. This specimen has been deposited into the Museum of Zoology, University of Massachusetts.

During late May and June of 1985 and 1986, over 70 subadult gizzard shad were observed at the Holyoke Dam Fishlift on the Connecticut River in Holyoke, MA (river km 139.4) approximately 69 km above the head of the tide (Fig. 1). Four live and one dead gizzard shad—two females, two males, and one unknown—were collected at the fishlift; all have been deposited into the Museum of Zoology, University of Massachusetts. Mean total length of the live fish was 418 mm (range 395-460 mm) and all were sexually mature. The mean total length of the live fish is near the maximum size reported for this species from freshwater (Miller 1960; Bodola 1965) and larger than the Mohawk River specimens discussed by George (1983). Later in July 1986, a single juvenile gizzard shad (50 mm TL) was captured in the Northampton Oxbow of the Connecticut River (river km 150, T. Savoy pers. commun.[4]; Fig. 1). The specimen is in the collections of the Connecticut Department of Environmental Protection. A follow-up survey in September by O'Leary at the same locality produced no juveniles, but two small adults (300 and 348 mm TL) were captured and these two specimens have been divided among the Museum of Zoology, University of Massachusetts and the Museum of Comparative Zoology, Harvard University. The collected juvenile specimen provides evidence that the species is breeding in the freshwater portion of the Connecticut River, and the co-occurrence of adults suggests that the Northampton Oxbow is an area where reproduction is occurring.

Cooper (1983) suggested that the gizzard shad has been extending its range northward along the east coast of North America in response to warming climate. Whether the species has moved into the Hudson River estuary (Dew 1974) while migrating northward or has entered the river from Lake Erie through the Mohawk River (Erie Canal) (George 1983) is unresolved. The species could have entered the Connecticut River only from the estuary as no inland connection between the Connecticut River and the Great Lakes or the Hudson River exists. The same argument would apply for the origin of other species encountered along the New England coast. The lack of any sightings of gizzard shad prior to 1985 at the Holyoke fishlift leads us to believe that the 1985 and 1986 migrations represent the first indisputable movement into freshwaters of gizzard shad from a marine stock occurring off the southern New England coast. These findings support Cooper's (1983) contention that the gizzard shad is extending its range northward along the eastern North American coastline.

[2]S. Gephard, Fishery Biologist, Marine Fisheries Office, State of Connecticut, Department of Environmental Protection, P.O. Box 248, Waterford, CT 06835, pers. commun. August 1985.

[3]C. Gauthier, Scientist, Northeast Utilities Environmental Laboratory, P.O. Box 128, Waterford, CT 06385, pers. commun. August 1985.

[4]T. Savoy, Fishery Biologist, Marine Fisheries Office, State of Connecticut, Department of Environmental Protection, P.O. Box 248, Waterford, CT 06385, pers. commun. August 1986.

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RELATIONSHIP OF OTOLITH LENGTH TO TOTAL LENGTH IN ROCKFISHES FROM NORTHERN AND CENTRAL CALIFORNIA

Knowing the relationship between otolith length and total length of a fish is useful for two reasons: 1) Fish size can be estimated from otolith lengths measured from otoliths encountered in predator stomachs, in core samples, archaeological sites, etc., and 2) the length of a fish can be verified when the age determined from the otolith lies outside expected values.

The otolith/total length relationship is useful in predator-prey and archeological studies if fish size can be extrapolated from otolith length. Otoliths are often the only part of a prey fish remaining in a predator's gut (Ainley et al. 1981; Treacy and Crawford 1981) or at cooking sites of archeological middens (Fitch 1972). Fish lengths could be estimated from otoliths found as remains of prey or in coastal archaeological excavations (Fitch and Brownell 1968). Existing keys (e.g., Morrow 1979) allow identification of fish species from otoliths. With these keys, personal reference collections, and the length relationships described in this paper, investigators will be able to verify species and size data collected in field sampling, and obtain more complete knowledge of prey species of marine mammals, birds, and fishes.

Large-scale surveys, such as the California cooperative survey (Sen 1984) that samples commercial rockfish landings in northern California, are prone to errors at several levels. Problems that may be encountered in collecting otoliths and measuring fish lengths include errors in recording lengths and the mixing up of otoliths. Some errors can be corrected by measuring the otolith and estimating the size of the fish it came from. Every effort should be made to eliminate erroneous data from the database before curves are constructed or cohort analysis is performed.

In this paper, I report the results of my investigation of the relationship between otolith length and total length for 30 rockfish species of the genus *Sebastes*. Linear regression statistics are presented for all fish of the species encountered.

Methods

Specimens were collected during a life history study on the rockfishes of northern and central California conducted at the Southwest Fisheries Center Tiburon Laboratory. Fish were sampled from the commercial trawl fishery, the commercial sport fishery, skiffs, and research cruises from 1977 to 1980. Specimens were identified to species, and then total lengths of frozen—then thawed—carcasses were measured on a meter board in millimeters (mm). Otoliths were measured to the nearest 0.1 mm with an ocular micrometer. The greatest length of the otolith was measured from the anterior tip to the most posterior projection (Kimura et al. 1979) (Fig. 1) as if the otolith were flat, without compensating for the curvature. Linear regressions were run on total length (y) versus otolith length (x) for 30 rockfish species. Outliers (± 3.0 standard deviations) from the line were assumed to result from measurement or recording errors and were discarded (2% of the observations).

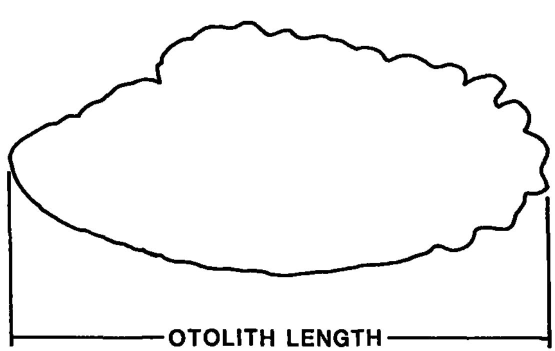

FIGURE 1.—The length of an otolith is measured from the anterior tip to the posterior projection.