

7-1982

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DOI: 10.18785/negs.0502.08

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Recommended Citation

Weinstein, M. P. 1982. Commentary: A Need for More Experimental Work in Estuarine Fisheries Ecology. *Northeast Gulf Science* 5 (2).

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COMMENTARY: A NEED FOR MORE EXPERIMENTAL WORK IN ESTUARINE FISHERIES ECOLOGY

Estuaries serve as nursery grounds for a majority of nearshore marine commercial and recreational species (McHugh 1966; Lindall and Salomon 1977). As such they have been critically examined from the standpoint of "habitat value" and distributional ecology of selected species. Yet, despite an intensive literature on the subject of estuarine nekton communities, most studies remain descriptive and little hypothesis testing involving nekton has been carried out. Although they were describing assemblies of bird communities on islands, Connor and Simberloff's (1979) statements "that such an all-encompassing theory should be built on so little (empirical) evidence invites an examination of the procedures used in its construction, and one point stands out. At no time was a parsimonious null hypothesis framed and tested," hold equally true for some of the dogma associated with the role of estuaries and the structure of estuarine nekton communities.

Past authors have cited the role of salinity (Remane 1943; Hedgpeth 1957; Gunter 1961; Keup and Bayless 1964; Khlebovich 1969; Copeland and Bechtel 1974; Gainey and Greenburg 1977; Boesch 1977; Weinstein *et al.* 1980a) temperature (Copeland and Bechtel 1974), substrate (Mills 1975; DeSylva 1975), biotic interactions, e.g., predation and competition (Neill and Cullen 1974; Nelson 1979; Heck and Orth 1980 and Weinstein and Walters 1981) and other factors in shaping nekton communities. Yet a search of the literature yields virtually no attempts at manipulative experiments designed to quantify the roles of these parameters.

Here I review some of the long standing ideas concerning the role of estuaries, then point out some basic questions that remain concerning the nursery role of estuaries and finally describe the need for marine fisheries scientists to design and execute experiments that will better define the structure of estuarine nekton communities and the interactions therein.

THE ESTUARY AS A NURSERY

The nekton utilizing estuaries generally fall into two categories. Certain taxa reside for all or most of their lifetime in the estuary; these are the estuarine endemics or permanent residents, such as killifish (Cyprinodontidae), silversides (*Menidia* spp.), and anchovies (*Anchoa* spp.). Most are forage species and play an important role in the trophodynamics of the system. The second group resides in the estuary primarily as immature individuals and only periodically reappear in the estuary as adults (mainly to feed). They are often the numerically dominant taxa and may constitute up to 70% of the nekton on a seasonal basis (Weinstein 1979, 1981).

As adults, most transient species spawn in the ocean, sometimes well offshore. Species spawned in the ocean face the additional task of reaching the mouth of the estuary and then migrating to preferred nursery zones. Once in these areas, residency may be established with several species reaching nearly adult size during this period (Herke 1971; Weinstein and Walters 1981).

PARTITIONING OF NURSERY ZONES

Three niche dimensions seem to be particularly important in separating the young of related species within estuaries: bathymetry, salinity (freshwater

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flow), and temporal components. Temperature plays an important secondary role by setting overall environmental limits and by influencing local distributions of many species. As a result three distinct ecological facies may be identified in the estuary:

1. Deep water of higher salinity in the lower reach of the estuary (McHugh 1967; Markle 1976; Chao and Musick 1977).
2. Deep water of the channels and channel slopes near the head of the estuary (Haven 1957; Markle 1976; Chao and Musick 1977; Weinstein *et al.* 1980b).
3. Shallow areas including marshes, seagrass beds and associated habitats - oyster reefs, mudflats, etc. (Reid 1954; Kilby 1955; Richards and Castagna 1970; Dahlberg 1972; Subrahmanyam and Drake 1975; Cain and Dean 1976; Hackney *et al.* 1976; Shenker and Dean 1979; Weinstein 1979).

Seasonal use of habitat in the form of sequential waves of recruitment is an added component of resource partitioning (space and food). It has been frequently observed that closely related species utilize the estuary at different times of the year; or that different age groups of the same species are spatially separated, older individuals often using a different portion of the estuary. The result of such ecological separation may be a more complete utilization of available resources, and therefore, a higher survival rate for otherwise potentially competing species. It is not clear what role biotic interactions play as a selective agent in this process, nor how they might (or might not) interact with the abiotic components listed above. These latter considerations form the basis for one of the most important areas for future estuarine research.

WHERE DO WE GO FROM HERE?

Although salt marshes, deeper es-

tuarine areas and, to a lesser extent, seagrass meadows have been the subject of intense ecological research for some time, our knowledge of how estuaries "work" is sadly lacking. Many fundamental questions remain concerning the role of estuarine habitats. For example, periods of residency for individual species are poorly known (i.e., how much population turnover is taking place?). We can not answer such simple questions as the following: how long does an individual stay in a particular area and how much exchange takes place between areas (e.g., adjacent marshes)? Similarly, the manner in which the early life stages of fishes partition resources within the nurseries has not been adequately assessed. Is food ever limiting in these seemingly rich areas? Are there indications that competition for resources (food, space, etc.) is taking place?

There are equally important questions to ask concerning other aspects of estuarine ecology and nekton communities. Are all habitats equally productive, e.g., are there differences in growth and mortality rates for nekton in individual habitats along the estuarine coenocline? What are the sources, if any, of these differences? In terms of specific habitats, do marshes serve a similar function compared to seagrass meadows (another "known" nursery area)? Or are there fundamental differences between these two habitats in their ability to produce high yields of economically important species? These differences may take the form of inequalities in the carrying capacity of the two areas or in differences in other factors which may affect growth or survival rates and the type of species utilizing the area.

The foregoing list of questions is by no means exhaustive, and doubtless anyone working in estuaries can add to this list and make it more comprehensive. What is certain, however, is that we must begin to design experiments to

sort out some of the many alternatives offered to us and derive the actual driving variables that structure estuarine communities. For example, the same sort of "caging" experiments that have been useful for marine benthos might be modified for experimental work with fishes and are being successfully employed by investigators at several institutions. Artificial oyster reefs are also being successfully manipulated to observe recruitment dynamics and behavioral interactions of the oyster reef fish community. It might also be feasible to manipulate the ichthyofauna of small tidal streams, pools or embayments by construction of weirs or some other restraining device (e.g., a culvert entering a small embayment might be manipulated to control passage of fish) with subsequent removal or addition experiments conducted in the enclosed areas. Whatever the means, it is no longer enough to argue the merits of whether estuaries are physically controlled or biologically accommodated (Sanders 1968), or both, based on descriptive (survey) data. Nor can we discuss the potential for competition, predation, disturbance or any other factors as controlling variables without experimental evidence. We must initiate the same rigorous hypothesis testing employed in terrestrial (Grant 1972; Jaeger 1972; Rosenzweig 1973; Schroeder and Rosenzweig 1975; Hairston 1980), freshwater (Zaret and Rand 1971; Dodson 1974; Kerfoot 1977; Werner and Hall 1977), benthic (Virnstein 1977) and intertidal (Connell 1961; 1974; Paine 1966, 1971, 1974; Dayton 1971; Menge 1972, 1976; Menge and Menge 1974) studies of communities which have done much to advance our state of knowledge. This is not to say that there are not problems associated with studies of this sort (Reynoldson and Bellamy 1971; Dayton 1973; Peters 1976; Wiens 1977; Wiens and Rotenberry 1979; Menge 1979) and that we are not still arguing the merits of in-

dividual experiments (e.g., the extreme difficulty in constructing proper controls for field experiments - Grant 1972) and their interpretations (Peters 1976; Connell 1975, 1978; Menge and Sutherland 1976; Wiens 1977, Hairston 1980). I fully realize the difficulties associated with manipulations of the nekton community - the fragility of the species; their mobility; the "openness" of the system. But as Hairston (1980) states: "the value of descriptive studies lies in the hypothesis which they generate. It is in the experimental testing of these hypotheses that our understanding of natural communities will advance." Further, "the fact that birds (or fish) are difficult or impossible as objects of experimental manipulation does not alter the scientific requirements involved in testing hypotheses, and it is hypotheses which we have acquired in great excess during the supposed flowering of population biology. This branch of science will make significant progress only when adequate tests are devised to allow us to separate the valid hypotheses from the array we have presented." Until these attempts are made, we will only continue to build a body of dogma with a limited basis in fact, a situation which will accomplish nothing more than allow us to continue to espouse our "pet" theories and impede our progress in understanding what is really going on.

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REFEREES

The following scientists volunteered their services as referees during 1981 for contributions submitted to Northeast Gulf Science. To them we are most grateful.

Dr. Lawrence Abele	Florida State University
Dr. William Anderson	College of Charleston
Dr. Gary April	University of Alabama, Tuscaloosa
Dr. Herbert Boschung	University of Alabama, Tuscaloosa
Dr. Scott Brande	University of Alabama at Birmingham
Dr. John Briggs	University of South Florida
Dr. Mark Chittenden	Texas A & M University
Dr. Douglas Clarke	U.S Army Corps of Engineers, Vicksburg
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