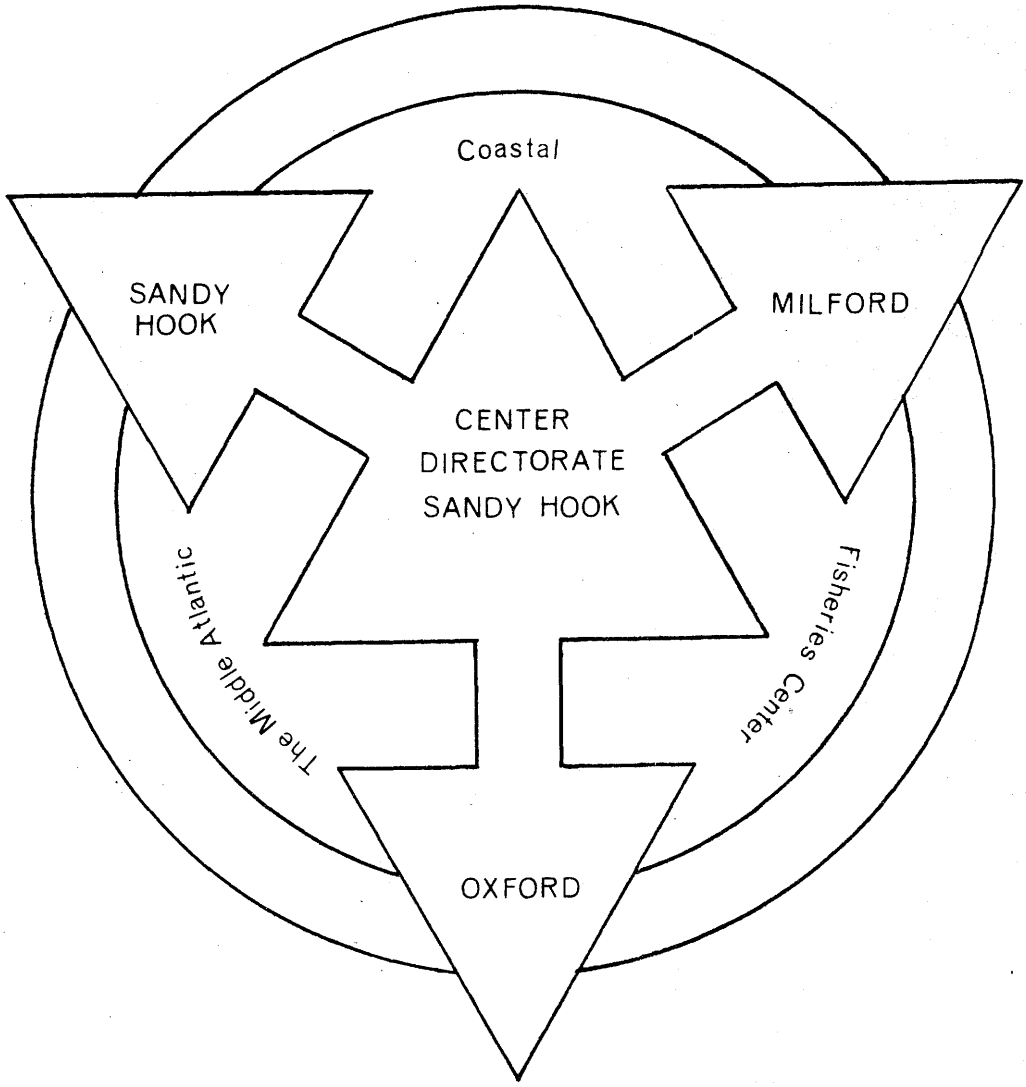
Behavioral Measures of Environmental Stress in Marine Fishes: Field and Laboratory Studies

Energy Research and Development Administration Proposal (Renewal)
Contract No. AT (49-7) 3045 (1976)

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Region

MIDDLE ATLANTIC COASTAL FISHERIES CENTER



Informal Report No. 65

June, 1975

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION PROPOSAL

(Renewal)

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U.S. Department of Commerce

National Oceanic and Atmospheric Administration

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Our research over the past several years has centered mainly on the role that temperature plays in the normal behavior and life habits of selected species of marine fish and how stress resulting from thermal extremes may modify these norms. Comparative studies dealing with the effects of temperature on adult Atlantic mackerel, Scomber scombrus, adult and juvenile bluefish, Pomatomus saltatrix, and young tautog, Tautoga onitis (Olla, Studholme, Bejda, Samet and Martin, 1975) have shown that the capability of avoiding and surviving potentially lethal thermal levels may be dependent on the behavioral repertoire of the species.

The design of our laboratory experiments and extrapolations from the laboratory to the field have been greatly enhanced by the comprehensive understanding of the normal scope of behavior as related to a species' life habits and environmental requirements provided by the results of the field program. The apparent gains we have made with this approach have encouraged us to continue and extend our studies with further emphasis on the comparison of interspecific responses as well as of those of animals at different life stages.

This past year we began laboratory studies to compare the responses of adult and young tautog to sublethal thermal stress. In previous studies (Olla and Studholme, 1975) when young tautog were subjected to high temperature stress, there was a decrease in aggression, increased association with shelter and reduction of activity. The decrease in aggression and activity culminated in individuals sharing shelter under stress. It was apparent from these results that the capability of young fish for avoiding thermal regimes that departed

from normal, was limited. Preliminary results of the first phase of a study in which adult tautog were exposed to elevated sublethal temperatures showed that interfish distance, (a measure of territoriality), was a highly sensitive indicator of stress. Recovery from stress following the return of temperature to normal levels appeared to take several weeks. Our intention for the coming year is to complete this experiment (Method as described below).

The completion of the first phase of our field studies on cunner, Tautogolabrus adspersus (Olla, Bejda and Martin, 1975) has indicated that this species, like tautog, is restricted in its home range, highly shelter dependent and territorial. It is also quiescent at night and during the winter. It would seem likely that this species would also be limited in its ability to avoid or escape potentially lethal stress conditions. This premise will be tested in the laboratory and comparison will be made on the responses to elevated temperature of these fish with tautog and the pelagic species already studied.

The field program will continue to study movements, feeding and life habits of selected inshore species in their natural environment with an emphasis on correlating these normal behaviors with various physical and biological parameters.

A. Laboratory Studies

1. The Effect of Temperature on Activity, Feeding and Social Behavior of Adult Tautog, Tautoga onitis.

The results of our studies on young tautog (Olla and Studholme, 1975) and the preliminary findings of our test on adults on their responses to elevated temperature, have shown that in both, normal patterns of behavior, including activity, feeding, aggression and territoriality are disrupted. However, there appear to be subtle differences in the response between the two age groups which may be reflective of the differences in their life habits and environmental requirements. The young fish (up to 3-4 years) which are highly restricted in their normal daily and seasonal movements, are closely associated with shelter and when subjected to high temperature stress, reduce activity and aggression, and seek shelter (Olla and Studholme, 1975). This reflects their limited ability to move from a particular home range even when potentially lethal conditions prevail. The adult fish are normally more mobile and less dependent on a home site, moving from this area to feed and migrating offshore to winter over. While social interactions (including territoriality and aggression) are a major part of the behavioral repertoire of both young and adult fish, the spatial relationships among adults are apparently an important measure of normality. During exposure to high temperature our preliminary results indicate that while activity is reduced, mobility may not be impaired to the same extent as in young fish. However, there apparently is a major breakdown in the normal spatial configurations with a corresponding reduction in aggressive interactions.

The major aim of this laboratory study will be to determine quantitatively the effects of prolonged exposure to elevated sublethal temperature on selected normal behaviors of adult fish. The experiment will be designed to replicate as closely as possible the preliminary one already completed the past year.

Procedure: Establish 3 adult tautog, approximately 40-60 cm (2♂; 1♀) in the 121- kliter aquarium under a constant 12-h photoperiod and at an acclimation temperature of 18-20°C. Preliminary results have shown that because of the normal territorial requirements of the fish and the limitations of the facility, only 2-3 fish of this size should be used in a test. Place three terra-cotta tiles, 12x24 cm approximately 2.5 m from one end of the aquarium to provide shelter. Divide the bottom of the tank into 16 areas (zones) to permit approximate measurement of interfish distances. Supply live mussels as needed to provide a natural food source and allow ad libitum feeding. Observe activity (time swimming in water column or moving about on the sand) 15 min each hour. At the same time record sequentially for each fish for 50 counts, the following: zone location, number of feeding ingestions, aggressive encounters between dominant and subordinate fish, color changes. Because these fish are normally quiescent and unresponsive at night, include only daytime observations (total 12/day). Observe in 4-day sets each week during acclimation until activity, aggression and feeding are stable. At this point (approximately 1-2 months after capture) increase temperature (about 0.04°C/h) to 29-30°C, and depending on the response, hold it at this level for 3-4 weeks. Then decrease temperature (approximately 0.04°C/h) to acclimation level. Continue observations until measurements indicate that fish have achieved stability.

2. The Effect of Temperature on the Activity, Feeding and Social Behavior of Cunner, Tautogolabrus adspersus.

As a continuation of our studies on the differential response capabilities of various marine fish species, we will investigate the effects of elevated sublethal temperature on cunner, Tautogolabrus adspersus. Our field results have indicated that this species and tautog (with which it is a co-resident in inshore temperate waters in this region) have similar life habits and environmental requirements (Olla, Bejda and Martin, 1975). Cunner, like young tautog, have a highly restricted home range, remaining close to or within shelter, especially during the quiescent night phase and during the winter when they become torpid and unresponsive. The similarities in their normal behavior would appear to indicate that their response to thermal stress would also be similar. While it had been our intention to begin tests on cunner during the past year, time limitations and the continuation of tests on young tautog necessitated that these studies be deferred to the coming year.

Procedure: Establish a pair of adult cunner, approximately 25 cm, in 1.4 or 1.5-kliter experimental testing systems (for description of systems see Olla and Studholme, 1975) under simulated natural photoperiod at an acclimation temperature of 20.0°C. Divide the bottom surface into zones to allow approximation of interfish distances. Provide 1-2 terra-cotta tiles to serve as shelter. Measure swimming activity, time in shelter, aggressive encounters, zone location and feeding for each fish to establish normal behavioral baselines. When these appear to have stabilized, raise temperature 1.3-1.5°C/h to 28-29°C and hold at this level for 5-7 days to assess effects of prolonged sublethal exposure. Drop temperature to acclimation level to measure recovery potential.

3. The Effect of Temperature on Social Attraction and Feeding Behavior of Striped Mullet, Mugil cephalus.

Having established the role of visual stimuli in schooling (intraspecific attraction) and feeding behavior of mullet at preferred temperatures (Olla and Samet, 1974), we began preliminary experiments (AEC Report, 1974) to study changes in the attraction to species mates as well as escape responses exhibited by mullet exposed to sublethal thermal stress following rapid temperature rises (0.5-1.0°C/min). This coming year we plan to continue these studies to define the escape responses more quantitatively and to initiate studies on the effect of sublethal, thermal stress on feeding behavior.

Procedure: General acclimation, holding, and testing procedures as described in AEC Report,(1974) and Olla and Samet, (1974). Following release of isolate into central tank, measure its attraction to the group for 15 min and establish normal baseline responses at acclimation level of 20°C. Rapidly raise temperature (0.5-1.0°C/min) to approximately 28-30°C. For the duration of 4 h, measure the isolate's 1) total attraction time to the group; 2) latency before escape response is exhibited, and 3) duration of escape response. Extend some tests at the sublethal temperature for 24 h to detect if and when an isolate's response to the group becomes extinguished. Begin studies to determine minimum level of elevated temperature at which visually mediated feeding responses become disrupted.

B. Field Studies

1. Normal life habits and environmental requirements of various inshore species including juvenile and adult winter flounder, Pseudopleuronectes americanus, juvenile tautog, Tautoga onitis, and juvenile cunner, Tautogolabrus adspersus.

The field program will continue to concentrate on describing and defining the life habits and environmental requirements of various inshore marine species. Emphasis will be placed on defining distribution patterns in relation to various parameters such as time of day, season, tidal and thermal changes, maturation and growth, and substrate. Food habits and forage species' abundance will be defined to indicate diversity shifts in feeding preference, changes with age and interspecific feeding relationships.

Procedure: Directly observe and collect juvenile species in situ within the study area using SCUBA and techniques as employed in previous studies, (Olla, Bejda and Martin, 1974). Determine the species, abundance, relation to cover, position in the water column, method of feeding, and types of food ingested, while also measuring various physical parameters such as temperature, current speed and duration, tidal stage, season, time of day and substrate composition. Analyze data to determine the presence and extent of a correlation between the various biological and physical parameters. Monitor movements of adult winter flounder using ultrasonic tracking techniques.

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Olla, B.L., A.J. Bejda, and A.D. Martin. (In Press). Activity, movements, and feeding behavior of the cunner, Tautogolabrus adspersus, and comparison of food habits with young tautog, Tautoga onitis off Long Island, New York. Fish. Bull., U.S. 1975.

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PROPOSED BUDGET - FY 1976

Personnel (Benefits Included)	20.3
Supplies	
Repair and maintenance of sea-water recirculation system for main experimental tank and other experimental systems; live bait fish used for feeding experimental animals; field supplies and equipment	11.6
Travel	
Scientific meetings; consultation with colleagues at other institutions; travel for field studies	4.5
Vessel Costs	
Expenses incurred for ship time to collect experimental animals - 10 days @ $375	3.8
Indirect Costs	
Support (Approximately)	9.8
	50.0