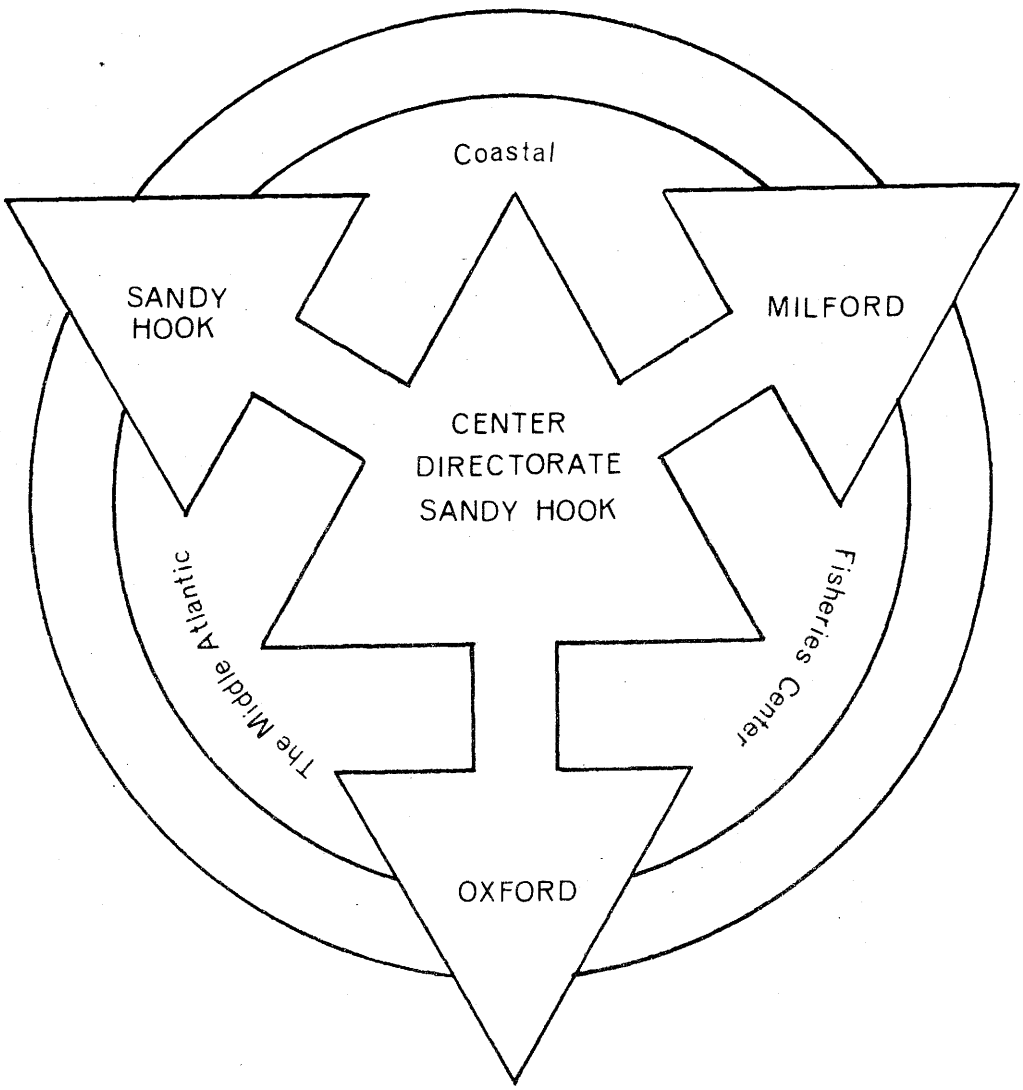
THE EFFECT OF TEMPERATURE ON THE BEHAVIOR OF MARINE INVERTEBRATES.

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

MIDDLE ATLANTIC COASTAL FISHERIES CENTER



Informal Report No. 51

March 1975

ENERGY OUTPUT STATEMENT - COOLING SYSTEMS PROGRAM

Milestones: The effects of temperature on the behavior of marine invertebrates

12/75 Acquisition of test organisms, completion of experimental systems and preliminary findings on establishment of behavioral baselines.

6/76 Report on the establishment of behavioral baselines for use in assessing sublethal thermal stress effects on selected marine invertebrate species.

12/76 Preliminary Report on the effects of sublethal temperatures on established behaviors of marine invertebrates.

SCHEDULE 189 – DUE JUNE 1

ADDITIONAL EXPLANATION FOR OPERATING COSTS
RESEARCH AND DEVELOPMENT AND PROCESS DEVELOPMENT ACTIVITIES

Field Laboratory: SANDY HOOK LABORATORY

Program (Subprogram):

1. Contractor: | Contract No.: | Task No.:

2. Project Tile: Cooling Systems Program: The effects of temperature on the behavior of marine invertebrates | 189 No.:

3. Budget Activity No.:

4. Date Prepared: 3/2/75

5. Method of Reporting: semi-annual

6. Working Location: Sandy Hook Laboratory

7. Person in Charge: Bori L. Olla

   Principal Investigator: Bori L. Olla

8. Project Terms:

   From:

   To: continuing effort

9. Man-Years	FY 19PY	FY 19CY	FY 19BY
(a) Scientific	N.A.	.2	.8
(b) Other Technical			.2
Total		.2	1.0

Approved: March 18, 1974

SCHEDULE 189 -- DUE JUNE 1 (Continued)

10. Funding	FY 19PY	FY 19CY	FY 19BY
Operating Costs:			
(a) Direct Salaries		1.5	16.3
(b) Materials, Services, Subcontracts		3.6	10.6
(c) Indirect Expenses	N.A.	.6	7.4
Total Operating Costs		5.7	34.3
Obligations for Capital Equipment Not Related to Construction			

11. Reactor Concept: N.A.

12. Materials: N.A.

13. Dates and Titles of Publications (Other Than Progress Reports).

14. Scope (to be Written by Principal Investigator). (Approximately 400 words.) See Attachment

15. Relationship to Other Projects.

16. Technical Progress in FY 19PY. See attached

17. Expected Results in FY 19CY. " "

18. Expected Results in FY 19BY. " "

19. Description and Explanation of Major Materials, Equipment and Subcontract Items.

20. Proposed Obligations for Related Construction Projects, if Any.

14. SCOPE: THE EFFECT OF TEMPERATURE ON THE BEHAVIOR OF MARINE INVERTEBRATES

Objectives:

During the past several years we have been developing and applying a variety of behavioral measures to assess the effects of thermal stress on various marine fish species. We have found that the capability of a particular species to avoid or escape a potentially lethal regime depends to a large degree on the normal behavioral repertoire and the scope of organismic responsiveness to stress. For example, pelagic species which swim continually both day and night respond to increases or decreases in temperature by increasing activity and show high potential to avoid or escape adverse thermal regimes. In contrast, demersal species which show close association with shelter appear to be very limited in their ability to move from zones of stress. The results of our studies have also shown that sublethal elevations in temperature affect: 1) feeding motivation, 2) territoriality, and 3) schooling.

In light of the stage of development that our current research program is at, we are proposing to expand our research effort to include marine invertebrates. The principal aim of the expanded research will be to investigate the effects of elevated temperature on the behavior of selected marine invertebrates. Emphasis will be on comparative aspects, studying species which possess contrasting life habits and ecological requirements. The work will begin with observations to define normal patterns of behavior in the field and laboratory. Pat-

terns which clearly transcend both the field and laboratory will serve as baseline diagnostic characters for measuring the effects of thermal stress. To extrapolate with any high degree of confidence from the laboratory to the natural situation, it is important that initial phases of defining normal include consideration of the role that these patterns play in an organism's life requirements. Departures from normal will then be interpreted within the context of the ecosystem in which the organism resides. Even before we perform the experiments which subject test organisms to stress, the definition of normal behavioral activities will provide important predictive insight of how a response may be manifested and related to survival potential.

Techniques

The bulk of the techniques which were originally developed for work on marine fish are directly applicable to many of the invertebrate species which will be studied in this investigation. Although the intention is to work with a variety of marine invertebrates with differing life habits and environmental requirements, at the outset, the studies will begin with the blue crab, Callinectes sapidus. Based on observations under natural conditions, the studies will concentrate on establishing quantitative measures of selected normal behaviors under controlled laboratory conditions. The procedures for determining normal baselines will be as follows:

Establish adult blue crabs in small groups (size and number to be determined by the territorial behavior of the animal) in aquaria at temperatures within preferred limits for this species and under a simulated natural photoperiod. Fluorescent lamps will be used for daytime lighting while incandescent bulbs will provide low-level night illumination. Water quality will be maintained by aeration and filtration through sand and gravel filters which will also provide a natural substrate for the animal. Salinity, oxygen and pH will be monitored regularly. Temperature will be continually controlled and regulated as required.

Depending upon the particular parameter to be observed, direct observations will be made, using event and tape recorders, cine and still photography and closed circuit TV.

Studies to establish normal would include observations of the following:

1) Locomotor activity including correlation with solar and/or tidal cues;
2) Feeding behavior including measures of feeding motivation, e.g. latency to feed, satiation, and the various sensory modalities employed in the detection of prey or other food;
3) Social interactions including various aspects of territoriality, aggression, dominance, reproduction and competition for food and space;

4) Predator avoidance;

5) Relation to shelter or substrate.

Although all of these observations may not be relevant for each species, they are indicative of the approach planned for the research.

Following the establishment of normal baselines, studies will focus on the effects of elevated sublethal temperature. The procedure will be as follows: Starting at acclimation, temperature will be raised (rates to be varied between sets of tests) until significant changes in baseline measures of activity, feeding, social interactions, are detected. Maintain temperature at this level to determine whether animals can adapt (either by returning to normal or stabilizing at the new level). Depending on the nature of the response, continue increase until the level is reached at which adaptation no longer occurs or return to acclimation levels to assess recovery potential. Rates of increase and temperature levels at which significant behavioral changes occur can be correlated to indicate upper behavioral limits.

Another series of experiments will include increasing temperature at rates which will permit acclimation and then holding temperature at different levels to examine the effect of chronic, sublethal exposure on established behavior norms determined under acclimation.

Much of the first year will be involved with establishing well-defined behavioral indices of normality. Subjection of the organism

to thermal stress will begin only when clear definitions of normal behavior have been accomplished.

Application

Extrapolation of these results to the natural environment will enable us to assess and predict not only the capacity for a particular species to survive certain thermal regimes, but also its capability to avoid or escape potentially lethal elevations. Many marine invertebrates, while important target organisms because of their commercial and recreational importance, also form important links in the food chain, the disruption of which may influence a variety of species depending on the particular position in the chain. An important advantage of using behavior as a measure of environmental stress is that the results often lend themselves to direct interpretation regarding environmental quality at both the population and ecosystem levels.

Effect of Temperature on Behavior of Marine Invertebrates

16. FY19PY - Not applicable

17 FY19CY - Choice of study species to be made; initial investigations as to ecological requirements and normal patterns of behavior. The degree of accomplishment at this stage is dependent on when the studies commence which is a function of funding of the proposal.

18. FY19BY Establishment of behavioral baseline measures (including activity, feeding, social interactions, etc.) of selected marine invertebrate species. Preliminary results on the effects of temperature on these established patterns.