The Space Congress® Proceedings

1973 (10th) Technology Today and Tomorrow

Apr 1st, 8:00 AM

Evaluation of an Artificial Estuarine Habitat -Initial Stage

Premsukh Poonai

Professor of Biology, Betbune-Cookman College, Daytona Beach, Florida

EVALUATION OF AN ARTIFICIAL ESTUARINE HABITAT-INITIAL STAGE

Dr. Premsukh Poonai
Professor of Biology
Bethune-Cookman College
Daytona Beach, Florida

ABSTRACT

In order to study the influence of an artificial habitat of discarded automobile tires upon the biomass in and around it, three sites were selected in the Banana River of which two will contain small groups of tires and one will not. Over a given period, the populations in and around the tires will be compared with those which existed initially or prevail on the natural site.

Preliminary observations indicate that adequate numbers may be present in the lower trophic levels but that there are perhaps inadequate populations of upper level carnivores which it appears can be increased by an artificial habitat.

INTRODUCTION

Aims

This paper summarises a part of the interim results of a research program undertaken by the Department of Biology of Bethune-Cookman College in the estuarine area of the John F. Kennedy Space Center with the financial support of the National Aeronautics and Space Administration. The aims of the study are to determine the effects of artificial havens of automobile tires upon the size of gamefish populations and to initiate undergraduate students into the methods of Biological Research in the field.

Design of the experiment

The status of the biomass at the sites of the two proposed artificial havens (see (1) (2) (3) (16) (19)) is being observed since September of 1972 for comparison with the biomass which will be observed subsequent to haven establishment and with the biomass of a third or control site which will not receive an artificial haven. The sites of the two proposed havens are respectively 75 meters South of the Bennett Causeway off Kelly's Park to be referred to as site A and about 75 meters North of a point on the Eastern Part of the NASA Causeway to be referred to as site B. The third or control site to be referred to as site C is approximately one hectare in extent and lies immediately Southeast of the Kennedy Area Recreation Park.

The artificial havens shall consist of lots of 50 tires each, suitably weighted down, connected to each other and arranged randomly to a height of about 1 meter. Measurements will be made in and around the havens and at site C for levels of plankton, grasses, algae, benthic animals, fish, shrimps and crabs. It is expected that a comparison of the biomass at various levels on the three sites and associated data, would indicate whether game fish populations may be expected to increase as a result of artificial havens and that information would be obtained for a study of the food chain in the Banana River for purposes of possibly predicting fish yields.

REVIEW OF LITERATURE

In the 1970 report of the overall Economic Development Committee of Brevard County of the State of Florida, Verlander (20) has recorded the views of the Task Forces of the Committee emphasising the need for improving the lagoonal and estuarine resources. Among the steps recommended by the Committee are, a study of the environment by Educational Institutions, increase of docking and park facilities in order encourage the influx of tourists and retired persons into the County, expansion of sport fishing and tourism, establishment of hatcheries, use of aquacultural techniques and a comprehensive environmental management study for predicting the effect of growth upon the environment.

The Committee considers that lagoonal and estuarine resources can contribute about 50 million dollars per annum to the gross income of the County instead of 2 million dollars as at the present time. However, there is no evidence of yearly growth in fish production at this time.

Lack of growth in the fish industry is a matter for some concern since a National Estuary Study (10) has indicated that the human population is increasing in the estuarine areas at a far higher rate than in the nation as a whole and that about 2/3 of the U.S. Commercial fish supply can be attributed to estuarine dependent species.

Investigations carried out by a number of workers indicate a decline in fish production in recent years. Mr. Robert M. Ingle (9) formerly Chief of

the Bureau of Marine Science and Technology has stated that the estuaries of Florida and in fact most of the coastal waters of the U.S. have lost their productivity rapidly due to littoral development and pollution. Futch (6) has recorded a decline in commercial landings of the spotted seatrout for the East Coast of Florida. Tabb (17) working for the Marine Laboratory of the University of Miami reported a decline in commercial landings for Florida as a whole during the period 1949 to 1958. Tabb (18) also observed a similar trend in the Indian River in Brevard County.

Resulting from an investigation ordered by the Florida State Board of Conservation, Hutton et al (8) reported that reduction of stands of turtle grass, Thalassia testudinum and cord grass, Spartina patens is harmful to associated animal life which utilise the site as feeding and breeding grounds. Philips (12) and Odum et al (11) have also stressed the importance of marine grasses such as Zostera marina and Thallasia testudinum and associated algae for primary productivity. Such communities are known to occur in the Indian River and St. Lucie Inlet. The importance of adequate quantities of decomposed organic matter for primary productivity has been studied extensively by Finenko and Zaika (5). They have established a close relationship between annual primary production and detritus level. It hardly needs to be mentioned that it may be expected that the productivity of the estuarine environment under study would be influenced by the phytoplankton biomass as Raymont (14) has discussed abundantly.

MATERIALS AND METHODS

During the first stage of the estuarine research, for a period of about six months the principal activities consisted of the measurement of the biomass of organisms at four combinations of trophic levels on the proposed haven sites A and B and the control site C. The four combinations of trophic levels are (a) phytoplankton, grasses and algae (b) zooplankton and benthic animals (c) small fish and shrimps (d) large fish.

The plankton sample is taken weekly from the top 3' by filtering through a plankton net and is separated into zooplankton and phytoplankton within about 2 hours. The phytoplankton contains a certain proportion of micro organic debris. Weights of plankton observed are expressed as mg/m^3 dry weight.

Grasses and algae and benthic animals are sampled by a bottom sampling dredge or by a spade if the water is shallow, to a depth of 4". The area of the soil which is collected is 2 sq. ft. on each site on each sampling date. The sample is washed through a sieve in order to remove mud, grasses and algae are weighed separately and dried, and benthic animals are weighed separately and dried. All weights are expressed as gms/m^2, dry weight. The benthic animals consist largely of annelids and bivalves.

Small fish and shrimps are sampled by drawing a seine 20' long by 4' wide in the neighborhood of sites A, B and C over a total average distance of about 50' on each site once per week. The mesh size is ¼" square. Fish and shrimps caught have varied from about ¼" to about 4" and may be considered to be the type of food which would be consumed by larger fish and crabs. The weights of small fish and shrimps are expressed in gms/m^2, dry weight.

Large fish of edible size could not be trapped in any appreciable quantities by the use of a cast-net or a 14' wide try net. Anglers have made disappointing catches over considerable periods on a large number of locations each day, so that it is not possible to use their catches to represent the yield of edible fish. A 50' seine is about to be tried for estimating the yield of edible size fish and if adequate samples are obtained with it, they will be used to represent the biomass at that trophic level.

In addition to the measurement of the biomass at four trophic level combinations, other determinations were carried out, namely, carbon fixation in gms/m^3 of water, phosphorus in parts per million of water, NaCl% and water temperature.

RESULTS AND DISCUSSION

A part of the results of the first stage of the estuarine project is summarised in Table I and consists of the data obtained from site A.

The average amount of phytoplankton which was found in the top 3' of water during the period from September, 1972 to March, 1973 was about 339 mg/m^3, dry weight. Using the energy relationships recorded by Greze (7) and assuming a daily turnover of phytoplankton, the corresponding total annual biomass of phytoplankton in terms of calories is 296,954 calories/m^3. This level of primary productivity compares somewhat unfavorably with a productivity of 2 million calories reported by Ryther (21) for coastal zones. Assuming an insolation level of 1,500,000 kilocalories of energy per m^2 per year on the surface of the water, then the proportion of energy absorbed by the phytoplankton is about 0.02% of the total incident energy.

Table I shows that the production of zooplankton is about 19 mg/m^3 per day, dry weight. At the rate of 3.5 calories per mg dry matter, the yield of zooplankton assuming a 10 day cycle is about 2427 calories/m^3/year or about 0.8% of the phytoplankton biomass.

The dry weight of benthic animals such as annelids and bivalves excluding shells is 22 g/m^2 which assuming 3 cycles per year corresponds to 198,000 calories/m^2/year. The combined biomass of zooplankton and benthic animals corresponds to about 200,427 calories/m^2/year.

The biomass of small fish and shrimps which provide food for larger fish is about 0.979 g/m^2 dry

weight, corresponding to about 16,000 calories/m^2/year, assuming 3 turnovers per year.

The energy relationships in the populations of organisms in the area of Kelly's Park, site A, can be partially represented as in Figure 1 in which the symbols have the following meanings: -

X_1, X_2, X_3, X_4 = cal./m^2/year as initial biomass

F_{01} = Kcal./m^2/year incident energy

F_{10}, F_{20}, F_{30}, F_{40}, F_{50} = cal. respired/m^2/year

F'_{10} = cal/m^2/year lost downstream

F_{40} = cal/m^2/year harvested

F_{15}, F_{25}, F_{35}, F_{45} = cal/m^2/year lost by death

t = feeding rate

r = respiration rate

m = mortality rate

h = rate of harvesting

l = rate of loss downstream

The compartment of the diagram which is denoted by x_4 could not be filled in because the methods of sampling utilised up to the present time have failed to provide any large fish. The sampling devices used were the cast-net and the try-net. It is now proposed to use a 50' seine for this purpose. Let us assume for the sake of discussion that the desired amount of large fish in the estuary were a modest 2.5 g/m^2/year dry weight which is equivalent to 14,000 calories per m^2 per year. On the basis of the present level of vegetable detritus, benthic animals and small fish and shrimps, the estuaries should be capable of producing at least 1 kilogram of edible fish per 100 m^2/year. In fact, depending upon such food, the expected production would be much greater. However, edible fish which are dependent upon smaller fish and shrimps for their main food, would experience inadequate supplies of food at present prevailing levels.

It would therefore appear that in order to ensure that adequate quantities of food shall be available for larger fish which depend upon smaller fish and shrimps, provisions must be made for multiplication and maintenance of such food stocks. Multiplication would require protection, shelter and food at lower trophic levels.

It is also possible from consideration of the preliminary data that the breeding stocks of larger fish also have been depleted. If indeed it is found that that has taken place, then protected conditions may be required for increasing the populations of breeding stock and progeny of the edible species.

There is evidence that tire havens would provide not only a protected environment but also the necessary food for maintenance of the breeding stock and progeny.

Recent measurements made on the surface of a stray sunken tire found off Kelly's Park yielded 52 g/m^2, of benthic animals and 1472 g/m^2 of plant material, both values being in terms of dry weight. These values mean that the surface of tires produce 2.5 times more benthic animals and 15 times more vegetable material than the estuarine bed.

CONCLUSION

Thus tire havens may be expected to bring about an increase in population size of the higher trophic levels particularly if utilised in conjunction with protected breeding areas.

TABLE I
SUMMARY OF PART OF DATA
SITE A. BENNET CAUSEWAY
BETHUNE-COOKMAN: NASA PROJECT

Date	Gross Primary Produc. mgC/m^3	Phytoplankton mg/m^3 Wet Wt.	Phytoplankton mg/m^3 Dry Wt.	Zooplankton mg/m^3 Wet Wt.	Zooplankton mg/m^3 Dry Wt.	Bottom Animals g/m^2 Wet Wt.	Bottom Animals g/m^2 Dry Wt.	Plants g/m^2 Wet Wt.	Plants g/m^2 Dry Wt.	Small Fish g/m^2 Wet Wt.	Small Fish g/m^2 Dry Wt.	Shrimps,Etc. g/m^2 Wet Wt.	Shrimps,Etc. g/m^2 Dry Wt.
9/23/72		1816	589	212	32	97	31	497	109				
9/30/72		817	127	217	19	49	31	112	57				
10/27/72	v. low	1798	379	135	11	20	16	608	48				
12/9/72	1875	479	184	222	10	147	32	956	323	7.6	1.7		
12/20/72		2101	520	123	15	49	29	450	124	.25	.06		
1/20/73	540	1445	388	239	25	38	21	209	120	3.8	1.8	1.23	0.5
1/27/73	v. low	1198	346	198	28	6	4	28	10	.04	.08	.01	
2/3/73	1800	1351	492	207	16	29	11	60	43	.9	.16	0.1	.01
2/24/73	1500	961	141	441	15	31		155	67	4.0	.85	0.07	.012
3/3/73	1800	1621	236			55		67	48	2.9	.87	.71	.273
Totals	7515	13587	3392	1994	171	521	174	3701	1135	16.59	5.52	1.41	.795
Means	1503	1359	339	220	19	52	22	336	103	2.76	.78	.35	.199

ACKNOWLEDGEMENTS

Bethune-Cookman College takes this opportunity to express thanks to the National Aeronautics and Space Administration for the financial grant under which the present work is being carried out. Mr. Jurgen G. Pohly, Mr. Raymond L. Norman and Mr. Royce Hall of the staff of the National Aeronautics and Space Administration have given much personal assistance during the conduct of the work. Other organizations which have given their cooperation are the Brevard County Commission, the Department of Public Works, the Florida Marine Patrol, Merritt Island Wildlife Refuge Management, the Department of Natural Resources, the Trustees of the Internal Improvement Trust Fund, the Army Corps of Engineers, the Brevard County Health Department and the Study Committee headed by Mr. Raymond Norman.

My colleagues at Bethune-Cookman College who are responsible for enabling the student participants and classes in the Biological Sciences to obtain a full share of benefit from the project are Dr. Zoila R. Avalos and Dr. James G. Marlins.

The student participants at Bethune-Cookman College who carried out the field and laboratory work are Mr. Lorenzo A. Johnson, Mr. Kevin Gibson, Mr. Anthony P. Weston, Mr. Charles G. Tanner, Miss Gayna Stevens and Mrs. Nancy Fazakas. Mr. Royce Hall has been of particular help in the field operations; also Mr. Michael Lawrence.

It is being recognized that the secretarial help provided by Mrs. Helen Wymes has been excellent.

BIBLIOGRAPHY

(1) Arve, John, "Preliminary Report on attracting fish by oyster-shell plantings in the chincateague Bay," Md. Maryland Department of Res. and Educ., Solomons, Maryland.

(2) Carlisle, J.G. (1964), "Artificial habitat in the marine environment," The Resources Agency of California, Department of Fish and Game, Fish Bulletin 124.

(3) Edmund, N.W. (1967), "Fish havens," Edmund Scientific Company, Box 500, Edscorp Building, Barrington, N.J. 08007.

(4) Elser, N.J. (1960), "A test of an artificial oyster-shell reef," Maryland Department of Res. and Educ., Inland Resources Div., Annapolis, Md.

(5) Finenko, Z.Z., and Zaika, V.E., "Relationship between and Production," Marine Food Chains, Edited by J.H. Steele, University of California Press.

(6) Futch, C.R. (1970), "The spotted sea trout," Salt Water Fisheries Leaflet 11, Marine Res. Lab., Fla. Department of Nat. Resources, St. Petersburg, Fla.

(7) Greze, V.N. (1970), "The Biomass and Production at different trophic levels," Marine Food Chains, Edited by J.H. Steele, University of California Press.

(8) Hutton, R.F., et al (1956), "The Ecology of Boca Ciega Bay *with special reference to dredging* and filling operations," Technical Series No. 17, Part I, Fla. State Board of Conservation, St. Petersburg, Fla.

(9) Ingle, R.M. (1972), "Productivity of Coastal Waters of the U.S. Personal Communication," Department of Natural Resources, Tallahassee, Florida.

(10) National Estuary Study, Vol. 5, U.S. Department of the Interior, Fish and Wildlife Service, U.S. Government Printing Office, Washington, D.C.

(11) Odum, H.T., Burkholder, P.R. and Rivers, J. (1959), "Measurement of productivity of turtle grass flats, reefs, and the Bahia Fosforescente of Southern Puerto Rico", Inst. Mar. Sci, Vol. 6, pp 154-170.

(12) Philips, R.C. (1963), "Ecology of floating algal communities", Quarterly Journal of the Fla. Acad. of Sci., 26:4.

(13) Philips, R.C. (1961), Seasonal aspect of the Marine Algal Flora of St. Lucie Inlet and adjacent Indian River, Florida, The Quarterly Journal of the Fla. Acad. of Sci., 24:2.

(14) Raymont, E.G. (1967), "Plankton and productivity in the oceans," Pergamon Press, London, New York.

(15) Springer, V.G. (1960), Icthyological surveys of the lower St. Lucie and Indian Rivers, Florida East Coast, Florida State Board of Conservation Marine Lab., St. Petersburg, Florida.

(16) Stone, R.B., and Buchanan, C.C., "Old tires makes new fishing reefs," Underwater Naturalist, 6:4.

(17) Tabb, D.C. (1961), "A contribution to the Biology of the spotted seatrout Gynoscion nebulosus of East-Central Florida," State of Florida Board of Conservation, Technical Series No. 35.

(18) Tabb, D.C. (1960), "The spotted seatrout fishery of the Indian River Area," Florida, Technical Series No. 33, State of Fla., Board of Conservation.

(19) Woodburn, K.D. (1966), "Artificial fishing reefs in Florida," Florida Board of Conservation Marine Laboratory, St. Petersburg, Florida, Salt water fisheries leaflet 8.

(20) Verlander, J.M. (1970), Overall Economic Development Program for Brevard County, Florida, Board of County Commissioners, Titusville, Fla.