CMFRI

Winter School on
Impact of Climate Change on Indian Marine Fisheries

Lecture Notes

Part 1

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EXPERIMENTAL METHODS TO ASSESS THE IMPACT OF CLIMATE CHANGE ON PLANKTON

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Introduction

The influences of solar radiation and several components of the climate in an environment on the energy budgets in marine organisms are important in evaluating the biological productivity in aquatic systems. The flow of energy within the ecosystem is chiefly regulated at the level of primary and secondary production and the success of a biologically active marine ecosystem is defined by the richness of its community of primary and secondary producers. Temperature is perhaps the most important limiting factor determining the growth and biological activity of marine flora and fauna. The general processes in the ecosystem at a natural temperature may be obtained only if the temperature dependence of organisms is known. A few vantage groups of native flora and fauna, which can possibly be indicators of climate change, are usually selected for laboratory-based studies to demonstrate the effects of climate change on the organisms and the ecosystem.

Microalgae

The following seven species of tropical eurythermal microalgae are common to the Indian coastal waters, and therefore, ideal for selection.

	Species	Class
1	*Chaetoceros calcitrans*	Bacillariophyceae
2	*Chlorella salina*	Chlorophyceae
3	*Tetraselmis chuii*	Prasinophyceae
4	*Isochrysis galbana*	Prymnesiophyceae
5	*Dicrateria inornata*	Chrysophyceae
6	*Pavlova lutheri*	Heptophyceae
7	*Nanochloropsis sp.*	Chlorophyceae

The first set of experiments can be run using laboratory-raised stock cultures, and. the next set with algae isolated from the sea and reared in the laboratory.

Phase I. Microalgal Static Monoculture

All experiments are to be run in sterile glass flasks capped with sterile cotton plugs and aluminum foil. Fluorescent lamps are used to provide ambient lighting in tandem with natural photoperiodicity prevalent in the environment. Initially two sets of experiments at upper and lower limits of normal laboratory temperature (24°C and 29°C) are to be conducted. Each species should be inoculated once and the growth and cell division patterns should be continuously observed. Nutrients are to be added only once, at the time of inoculation. Biomass, organic carbon levels, chlorophyll *a* & *b* content, nitrate, phosphate, pH and absorbance at different spectral wavelengths are to be recorded at each observation. The experiment is to be run for 20 days and repeated at different temperature levels (at steps of 0.5 °C) in closed incubator-cum-water baths with lighting and shaking facility. Observations may be made as outlined above.

Phase II. Microalgal static monoculture at different nutrient levels

The experimental setup in Phase I is to be repeated with controlled addition of nutrients ranging from zero level to the maximum level permitted in the medium used to fertilize the culture (nitrates, phosphates and silicates).

Phase III. Microalgal monoculture at continuously varying temperature

These experiments are to be done using bio-water baths with 50 rpm and 1000 lumex lighting. Monocultures will be tested in units set to varying temperatures, keeping with the natural fluctuations prevalent in the laboratory. The temperatures are to be set at +/- x ^{o}C (0.5, 1.0, 1.5, 2.0), in relation to ambient environmental temperature. Thermoelectric modules to regulate unwarranted variations from the set temperature are to be installed. The working of these modules will be based on the Peltier effect, avoiding use of refrigerants and hydro fluorocarbons. The alloy used in these modules is usually Bismuth-telluride (BiTe). Different parameters studied in Phase I are to be studied in Phase II also.

Phase IV. Multispecies static culture

The experimental setup is similar to the one in Phase I but the microalgae are introduced into the same flask, *i.e*., 6 to 7 species in one culture flask. The cell densities at every 24 hours over a period of 20 days are determined to ascertain the dominance of any particular species at a particular temperature (24^{o}C and 29^{o}C) and at different levels of nutrients, especially silicate. These experiments are repeated at varying temperatures using bio-water baths as mentioned under Phase II.

Phase V. Monospecies and mixed species static culture – high density rearing

The static culture experiments carried out under Phases I, II and IV are to be repeated in large tanks, with continuous medium addition in mono and mixed species culture to test for dominance at varying temperature by monitoring salinity and pH constantly.

Phase VI. Temperature gradient–response of mobile microalgae

The cell density, growth, motility, dispersion and nutrient profiles at varying temperatures are to be estimated along a temperature gradient prevalent in large tanks holding mass cultures of the microalgae. An immersion heater set at 30 - 32 ^{o}C placed at one point in the tank will effect temperature dispersion. On a plot of isotherms along a timescale, the cell densities and the motility of cells along the grids plotted on the tank, will indicate movements of the algae in response to temperature gradients when other parameters are kept uniform.

Phase VII. Chemostats

The cell growth performance in monospecies and multispecies cultures are to be assessed at set and varying temperatures under continuous dilution and nutrient addition for prolonged periods (>100 days). Typical modules are to be designed for the continuous dilution and monitoring , and maintaining the system sterile from contaminants .

Role of cyanobacteria

Cyanobacteria isolated from coastal waters and culture systems (high trophic and organic systems), *i.e*., growing in low or acidic pH, are to be isolated and added to the experimental set up under Phases I to V to assess the role of cyanobacteria in tandem with climate change in effecting alterations in the biological activity of phytoplankton.

Zooplankton

The experimental setups described above will be repeated using zooplankton, particularly microzooplankton and larval forms, with emphasis on growth, feeding, respiration and excretion. The different biological/behavioral parameters to be studied include

- Mobility – taxis
- Ingestion rates
- Growth

- Sex formation
- Survival
- Dominance with reference to
  - *Nutrient variability*
  - *Food/prey*
- Organic waste production

Suggested reading

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