An International Multidisciplinary e-Magazine
www.sabujeema.com
Volume 2 | Issue 11| November, 2022

SABUJEEMA

FACTORS AFFECTING PRODUCTIVITY OF AQUATIC ECOSYSTEMS

JOSHNA .M and ARUNA .S

*"Read More,
Grow More"*

Sabujeema Sabujeema
editorsabujeema@gmail.com
sabujeema-international
multidisciplinary-e-magazine

FACTORS AFFECTING PRODUCTIVITY OF AQUATIC ECOSYSTEMS

[Article ID: SIMM0202]

JOSHNA .M
Ph.D. Scholar, Department of Aquaculture, Dr. M.G.R Fisheries College and Research Institute, Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Ponneri – 601204, Tamil Nadu, India.
ARUNA .S
Assistant Professor, Department of Aquaculture, Dr. M.G.R Fisheries College and Research Institute, Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Ponneri – 601204, Tamil Nadu, India

WHAT IS AN ECOSYSTEM?

- ✓ Greek oikos, meaning "home," and systema, or "system."
- ✓ British ecologist A. G. Tansley proposed the word "ecosystem" (1935)
- ✓ American Raymond L. Lindeman gives classic definition (1942)
- ✓ Composed of a variety of abiotic and biotic components that function in an interrelated way.

INTRODUCTION

Productivity is the rate of production of living material per unit time per unit area or volume. Primary productivity – productivity due to Photosynthesis (CO_2 + $2H_2O$ ---> $(CH_2O)_n$ + H_2O + O_2). Secondary productivity - productivity due to consumption of primary producers. Unicellular algae (phytoplankton including diatoms, dinoflagellates and coccolithophores) are initially responsible for primary production, i.e. fixation of CO_2 or HCO_3^- in seas and oceans. Cellular division occurs at least once in 24 hours, so growth is rapid and is controlled chiefly by the temperature, availability of nutrients, especially nitrogen and phosphorus and light, as well as by grazing of herbivores (includes various other factors)

PRIMARY PRODUCTION

Biological process of creating high-energy organic material from inorganic material like carbon dioxide, water and other nutrients (i.e., **autotrophy**). Energy and materials generated via primary productivity get passed on "up-the-line" to other trophic levels/niches. A certain amount is kept (standing crop) and the cut portion is the primary productivity.

Factors affecting the primary production

- ✓ Light
- ✓ Depth
- ✓ Temperature
- ✓ Nutrients

All living organisms require some non-living (abiotic) factors to survive.

Light: Sunlight is essential for photosynthesis to occur. The results of calculations from researchers like Ryther (1959), Russell-Hunter (1970) and Vishniac (1971) show that, with the amount of light available, primary production in seas and oceans should be at least 5 to 10 times greater than determined by direct measurements. Evidently, factors other than light limit plankton growth, (turbidity, light quality, light intensity, refraction/reflection, etc.). Amount of light varies with latitude; it decreases from the equator towards the poles

Polar Regions: phytoplankton abundance occurs during the summer when light becomes sufficient for a net increase in primary productivity

Temperate latitudes: primary productivity is maximal in spring and autumn when the combination of available light and high nutrient concentrations allow plankton blooms to occur

Tropics: intense surface heating produces a permanent thermocline so phytoplankton are nutrient limited year round and there are only small fluctuations in primary productivity

Depth: Where sunlight reach more organisms live. Aquatic plants use sunlight to make food. As sunlight decreases amount of plants and animals decrease. Deep ocean water is too dark for photosynthesis

Upwelling: Temperature and currents will cause the recycled nutrients on the bottom of the ocean to move up and come to the surface. Provides nutrients for the phytoplankton, and thus for the entire ecosystem.

Temperature: Visible light translates into heat. Three temperature zones in ocean water. Temperature can only be a regulating factor if both light and nutrients are in excess.

Nutrients: Major inorganic nutrients that are required by phytoplankton are nitrogen and phosphorus (diatoms and dinoflagellates also required silica). Occurs in small amounts and are thus limiting factors for primary productivity; each species of phytoplankton has a particular response to different concentrations of limiting nutrients and each has a maximum growth rate.

Nutrients, especially nitrogen, are the most significant limiting factor in great parts of the oceans.

Algae can store amounts of phosphate and nitrate beyond their needs, but nitrogen and phosphorus, and to a lesser extent silicon, are the principal limiting factors for marine phytoplankton populations. In addition to these nutrients, certain trace metals can be considered as limiting factors, for example iron in the Sargasso Sea (Fogg, 1975).

Oligotrophic regions have low concentrations of essential nutrients and therefore low productivity

Eutrophic waters contain high nutrients and support high numbers of phytoplankton

Mesotrophic waters have nutrient levels between those of the two extremes

Grazing: Grazing, especially by zooplankton, stabilizes the phytoplankton population over a short period of time. Over longer periods, i.e. during a plankton bloom, there is an increase in the zooplankton population. A high grazing pressure by zooplankton stimulates phytoplankton growth, due to the nutrients liberated by the grazers (Strickland 1972).

FACTORS AFFECTING THE SECONDARY PRODUCTIVITY

- ✓ Temperature
- ✓ Food production, availability, and quality
- ✓ Oxygen concentrations
- ✓ Substrate characteristics
- ✓ Predation
- ✓ Competition
- ✓ Diversity
- ✓ Lake morphometry, lateral zonation, and allochthonous input

Temperature: Temperature has long been known to influence rates of activity from a molecular to an organismal scale. Rates of secondary production increase with temperature. P/B also is thought to rise with increased temperature, either as a linear or a curvilinear function.

Food production, availability, and quality: Positive effect of temperature on secondary production - result of the reproductive biology of zooplankton and benthos. Growth rates increase, egg development times decrease, the rate of population increase rises, and feeding rates increase with increased temperature. O'Brien *et al*. (1973) - average clutch size of *Diaptomus leptopus* decreases with temperature, and Aston (1973)-egg production by oligochaetes declines at high temperature. Temperature variation could have either a positive or negative effect on secondary production, depending upon geographic location and basin morphometry. A community of heterotrophs can fix no more energy than the amount made available to them by primary producers. Many authors have suggested that rates of production of freshwater benthos and zooplankton are positively related to food availability. Others have found that rates of zooplankton and benthos production are positively related to rates of primary production.

Oxygen concentrations: The availability of oxygen is thought to be critical, especially to the benthos – poor oxygen. Brylinsky (1980), however, has found that carnivorous zooplankton production in a wide range of lakes is also influenced by oxygen concentration in the epilimnion. Jonasson (1978) suggests that sufficient oxygen is important to benthos production because food cannot be metabolized efficiently at low oxygen levels. Aston (1973) suggests that egg production in freshwater oligochaetes is constant with decreasing oxygen concentration until some critical low level is reached. Pond benthos seem to require >l mg/L of dissolved oxygen in order to maintain positive production. At least for some benthos, secondary production and oxygen concentration are inversely related

Substrate characteristics: Important to lake and stream benthos is the character and composition of the substrate. Hamill *et al.* (1979), working in a large river, found that the production of benthic snails was highest at intermediate substrate particle size. For lacustrine benthos, secondary production seems to rely more heavily on organic matter content than particle composition

Predation: Current thought regarding the effect of predation upon secondary production is contradictory. Hall *et al.* (1970), Zytkowicz (1976), Waters (1977), and Banse & Mosher (1980) suggest that predation leads to increased production, presumably because the slow growing organisms are removed from the population. Zndanova & Tseyev (1970), Miller et al. (1971), Prikhod'ko (1975), and Momot (1978) suggest that predation decreases production perhaps due to a decline in growing biomass.

Competition: Thoughts on competition are less contradictory but less well developed. The basic belief is that competition decreases the production of a population (see George 1975; Benke 1976; Lavandier 1981). Production ecologists have not considered the possible positive effects of competition on community production (cf. economic theory).

Diversity: The effect of diversity upon secondary production has only been considered (to my knowledge) by Paterson & Walker (1974). Their data suggest that the low benthos diversity in a saline lake allowed very high rates of secondary production.

Lake morphometry, lateral zonation, and allochthonous input: The morphological characteristics of the ecosystem or placement within it also seems to affect secondary production. Shallower lakes support higher rates of secondary production (Johnson 1974; Zytkowicz 1976; Matuszek 1978; Brylinsky 1980). Johnson (1974) also suggests that the surface area of a lake may be important, since in larger lakes the profundal zone is less enriched by the littoral zone or allochthonous sources. Other authors have suggested the importance of allochthonous materials to secondary production in both lakes and streams (Edmondson 1974; Marchant & Williams 1977; Martien & Benke 1977; Waters 1977; Adcock 1979). Possibly due to high primary production in the littoral zone, it is generally believed that secondary production in near-shore areas and macrophyte beds is greater than in all other areas (Mathias 1971; Johnson 1974; Neveau & Lapchin 1979). The only contradiction seems to be for some stream ecosystems where highest rates of productivity are seen in mid-stream (e.g. Neves 1979).

MISCELLANEOUS ENVIRONMENTAL FACTORS

An important factor in streams and rivers seems to be the current velocity. Secondary production decreases with increasing water flow rate. With respect to lacustrine zooplankton production, Edmondson (1974), Makarewicz & Likens (1979), and Selin & Hakkari (1982) have suggested a positive relationship with intensity of solar radiation. Burgis (1971) and Paterson & Walker (1974) suggest that high zooplankton and benthos production rates should be found in the most stable ecosystems.

REFERENCES

Aston R.J. (1973) Field and experimental studies on the effects of a power station effluent on Tubificidae (Oligochaeta, Annelida). Hydrobiologia, 42, 225-242.

Brylinsky M. (1980) Estimating the productivity of lakes and reservoirs. In E.D.LeCren & R.H.Lowe-McConnell (eds.), The Functioning of Freshwater Ecosystems. IBP 22. Cambridge: Cambridge University Press.

Bunt, J. (1971) Microbial production in Polar regions. In: Hughes, D. E. and Rose, A. H. (eds.) *Microbes and Biological Productivity,* 333-354. Cambridge University Press, Cambridge, London, New York, Melbourne.

Burgis M.J. (1971) The ecology and production of copepods, particularly Thermocyclops hyalinus, in the tropical Lake George, Uganda. Freshw. Biol., 1, 169-192.

Edmondson W.T. (1974) Secondary production. Mitt. Int. Ver. Theor. Angew. Limnol., 20, 229-272.

Fogg, G. E. (1975) Primary productivity. In: Riley, J. P. and Skirrow, G. (eds), *Chemical Oceanography,* 2nd ed., vol. 2, 385-453. Academic Press, London, New York, San Francisco.

Golterman, H. L. (1975) *Physiological Limnology. An Approach to the Physiology of Lake Ecosystems.* Elsevier Scientific Publishing Company, Amsterdam, Oxford, New York.

Hall, C. A. S. and Moll, R. (1975) Methods of assessing aquatic primary production. In: Lieth, H. and Whittaker, R. H. (eds), *Primary Production in the Biosphere,* 19-55. Springer-Verlag, Berlin, Heidelberg, New York.

Hamill S.E., Qadri S.U. & Mackie G.L. (1979) Production and turnover ratio of Pisidium casertanum (Pelecypoda:

Sphaeriidae) in the Ottawa River near Ottawa- Hull, Canada. Hydrobiologia, 62, 225-230.

Jonasson P.M. (1978) Zoobenthos of lakes. Verh. Int. Verein. LimnoL, 20, 13-37.

Koblentz-Mishke, O. J., Valkovinsky, V. V., and Kabanova, J. G. (1970) Plankton primary production of the world ocean. In: Wooster, W. S. (ed.), *Scientific Exploration of the South Pacific*. Nat. Acad. Sci., Washington.

Makarewicz J.C. & Likens G. E. (1979) Structure and function of the zooplankton community of Mirror Lake, New Hampshire. Ecol. Monogr., 49, 109-127.

O'Brien F.I., Winner J.M. & Krochak D.K. (1973) Ecology of Diaptomus leptopuss.a. Forbes 1882 (Copepoda: Calanoidea) under temporary pond conditions. Hydrobiologia, 43, 137-155.

Paterson C.G. & Walker K..F. (1974) Seasonal dynamics and productivity of Tanytarsus barbitarsis Freeman (Diptera: Chironomidae) in the benthos of a shallow, saline lake. Aust. J. mar. Freshwat. Res., 25, 151-165.

Russell-Hunter, W. D. (1970) *Aquatic Productivity,* 1-306. Collier-Macmillan Limited, London.

Ryther, J. H. (1959) Potential productivity of the sea. *Science* **130**, 602-608.

Ryther, J. H. (1963) Geographic variations in productivity. In: Hill, M. N. (ed.), *The Sea,* vol. **2**, 347-380. J. Wiley and Sons, New York, London.

Selin P. & Hakkari L. (1982) The diversity, biomass and production of zooplankton in Lake Inarijarvi. Hydrobiologia, 86, 55-59.

Steemann Nielsen, E. (1953) On organic production in the oceans. *J. Cons. Perm. Int. Explor. Mer* **19**, 309-328.

Steemann Nielsen, E. (1963) Productivity, definition and measurement. 2. Fertility of the oceans. In: Hill, M. N. (ed.), *The Sea,* vol. 2, 129-164. J. Wiley and Sons, New York, London.

Strickland, J. D. H. (1958) Solar radiation penetrating the ocean. A review of requirements, data and methods of measurements, with particular reference to photosynthetic productivity. *J. Biol. Bd Can.* **15**, 453-493.

Strickland, J. D. H. (1965) Production of organic matter in the primary stages of the marine food chain. In: Riley, J. P. and Skirrow G. (eds), *Chemical Oceanography,* vol. l, 477-610. Academic Press, New York.

Strickland, J. D. H. (1972) Research on the marine planktonic food web at the institute of marine resources: a review of the past seven years of work. *Oceanogr. Mar. Biol. Ann. Rev.* **10**, 349-414.

Vishniac, W. (1971) Limits of microbial production in the oceans. In: Hughes, D. E. and Rose, A. H. (eds), *Microbes and Biological Productivity,* 355-366.Cambridge University Press, Cambridge, London, New York, Melbourne.