Proceedings "Progress in Belgian Oceanographic Research"
Brussels, March 1985

PLANKTON PRODUCTIVITY IN THE GULF OF CALVI (CORSICA).

P. DAUBY*
Marine Biology Laboratory
Université de Liège
B-4020 Liège, Belgium

ABSTRACT

Planktonic communities of the water of Calvi (north-west of Corsica) were studied during two year cycles. The succession of the different populations is described taking into account their origins. By the use of population dynamic methods, the production of the main groups is evaluated, and a comparison is made with the estimations obtained by respiration rate measurements. It appears that the concordance between the two methods is not so perfect, and that net growth efficiency of zooplankters must vary over the year according to food availability.

*Research Assistant at the Belgian National Fund for Scientific Research.

Since 1978, a lot of surveys have been made on the plankton of the area of Calvi (Corsica) in order to determine the annual evolution of populations, to estimate the production of organic matter, and to evaluate the flows of materials and energy through the first trophic levels of the pelagic ecosystem.

In this paper, we shall first present our last results about productivity estimations of the main groups of planktonic organisms, using populations dynamics methods; then we shall compare these results with the productivity estimations obtained using respiration rates data.

Materials and methods

The Gulf of Calvi (42°35'N:8°45'E) has an area of about 22 km² and is widely open to north, allowing a high degree of water exchange between inside and outside. The mean depth is about 50m, but it decreases very rapidly (slope of 20%) at the mouth of the gulf, owing to the existence of a deep submarine canyon. There is no significant inflow of freshwater into the gulf.

The composition of plankton was investigated on thirty-two occasions between March 1, 1983, and February 26, 1984, with an average rhythm of one haul bi-weekly. Zooplankton was collected by vertical tows from 100m to the surface, just at the beginning of the deep canyon. The sampler used was an assemblage of three WP2 international standard nets, with respective mesh sizes of 50, 180 and 470 μm; this kind of sampler allows the collection of many microzooplankters, and of all the life stages of Copepods or other herbivorous. Each sample was fixed in 10% formalin sea water.

Phytoplankton biomasses were estimated by fluorometrical determinations of chlorophyll a for water from different depths.

For respiration rates measurements, a second set of hauls was made on each sampling date. Contents of cod-ends were diluted in about 10l surface sea water; after 10 min.(settlement of dead organisms), eight BOD flasks were filled up with that dilution and kept in a dark temperate chamber. Zooplankton dry weight and oxygen concentration (Winkler's method) were determined at 0, 1, 2 and 4 hours after the starting of experiments.

Annual variations of planktonic communities and scheme of the food web

From the results of the 1983-1984 year cycle (DAUBY, 1985) and of the 1978-1979 one (DAUBY, 1980, 1982), the annual history of planktonic communities may be summarized as follows:

- At the beginning of March, with the increase of total daily radiation and nutrients concentrations, a bloom of phytoplankton cells (mainly Diatoms) is quickly observed, reaching 0.7 mg chlorophyll.m^{-3}. Populations of microzooplankters with rapid turn-over time (Tintinnids) are immediately developing, soon followed by larger herbivorous as Copepods (Calanus and Clausocalanus). During this algal bloom are also appearing larval stages of the Euphausiid Meganyctiphanes norvegica.
- During first half of spring time, phytoplankton populations are drastically decreasing (predation and exhaustion of nutrients) followed by the microzooplankton ones. Copepod populations are reaching their maximum, and other herbivorous groups are appearing (meroplankton). The only carnivorous is the Copepod genus Oithona.
- At the end of spring, a second phytoplankton bloom (Dinoflagellates) of smaller importance is observed (0.2 mg chlorophyll.m^{-3}). Copepod populations are relatively decreasing while other herbivorous groups are developing (meroplankton, Appendicularians, Thaliaceans). Simultaneously, carnivorous populations are varying (Cladocerans, Siphonophora).
- During summer and beginning of autumn, the maximum of diversity is noticed as well in phytoplanktonic as in herbivorous populations, with the advent of many Copepod species and miscellaneous larvae. Nevertheless, total biomass of zooplankton stays at a relatively low level.
- Second half of autumn and winter are characterized by a decrease of all groups. Biomass and diversity become minimal; the only significantly represented zooplankters are the two Copepod genera Clausocalanus and Oithona . During this period is also observed the coming up of the bathypelagic Pteropod Cavolinia inflexa to surface waters.

From these data on annual evolution of the different planktonic communities, a model of the structure of the food web can be established (fig.1). In this model, two compartments can be distinguished:

- the first one, indigeneous, gathers all the organisms which spend their whole life time in the waters of the gulf. These are perennial herbivorous groups (microplankters, main Copepods, Appendicularians) which abundance is dependent to algal populations, seasonal organisms (meroplank-

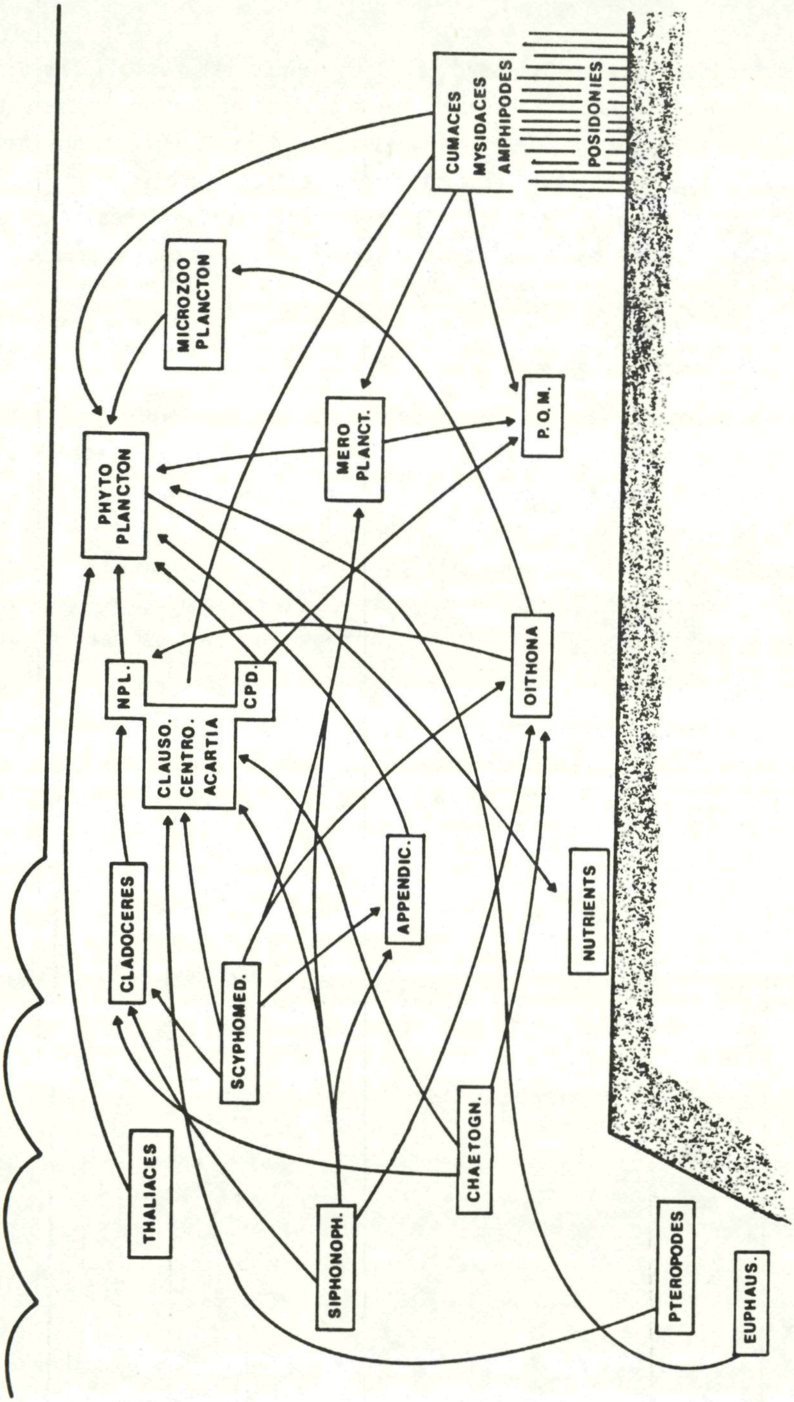

Fig.1: scheme of the main trophic relationships.

ton), and a few carnivorous species (Oithona and other small Copepods);
-the second one, exogenous, includes the organisms appearing in the waters of the gulf in relation with hydrodynamic conditions. These are mainly Cladocerans and gelatinous macroplankters either herbivorous (Thaliaceans) or carnivorous (Siphonophora, Ctenophora, jelly-fishes). Are also belonging to that compartment both bathypelagic groups, Pteropods and Euphausiids.

Production of the main planktonic groups

Primary production was estimated by the model of RYTHER and YENTSCH (1957), using our data on chlorophyll a concentrations, daily total radiation, and sea water extinction coefficient; the assimilation quotient was held equal to 3.7 (JACQUES, 1970). Results show a maximum of production in March-April (fig.2) with about 500 mg $C.m^{-2}.day^{-1}$; values fall down to 50 to 100 mg $C.m^{-2}.day^{-1}$ for the warm season, and to about 20 mg $C.m^{-2}.day^{-1}$ from October to February. Total annual primary production is near 40 g $C.m^{-2}$

However, when compared with data from other authors (NIVAL et al., 1975) for adjacent areas, our results seem to be 0.5 to 1 time underestimated. It should be highly desirable to re-evaluate primary production using more relevant methods, e.g. with C14, or to reconsider the value of the assimilation quotient.

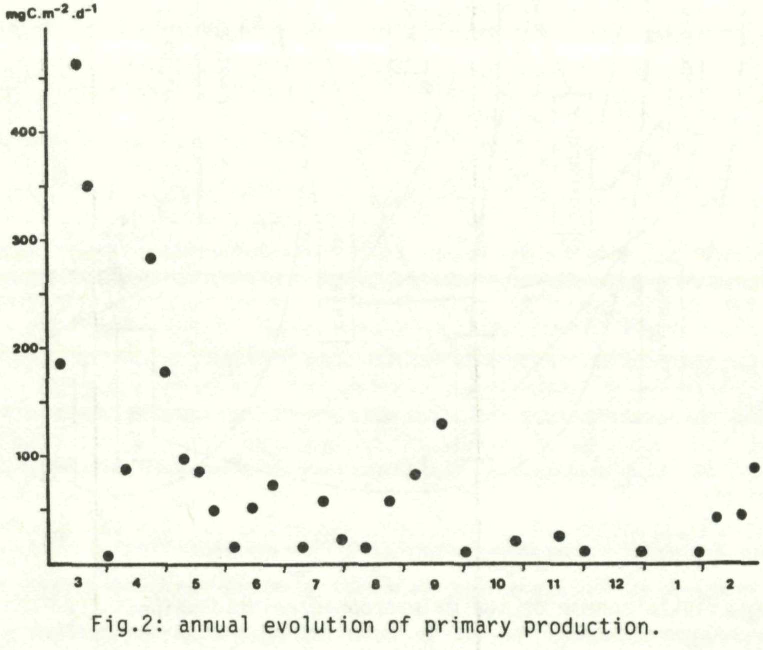

Fig.2: annual evolution of primary production.

Daily production of the main zooplankton groups was estimated on each sampling date by the cumulative groth method (WINBERG, 1971):

$$P = \frac{N \Delta \bar{w}}{t} ,$$

where N is the number of individuals, t is the life duration, and $\Delta \bar{w}$ is mean weight increment during the whole life span. For organisms with several recognizable instars, the equation becomes:

$$P = \sum_{n=1}^{i} \frac{N_n \Delta \bar{w}_n}{t_n} ,$$

where t_n is instar duration of stage n and $\Delta \bar{w}_n$ is weight increment during that stage.

A peculiar attention was paid to the production computation of the main herbivorous populations, i.e. Copepod ones, owing to their importance in total number (average: 75%) and biomass. From the instar numerations at each sampling date, it was possible to determine the number of generations through the year; five to six successive ones were so noticed according to species. Life durations were estimated in the same way, and a significant correlation with temperature was found; this relation may be expressed as a Belehradek's function (Mc LAREN, 1978). Instar durations were derived from generation times using the isochronality assumption (LANDRY, 1983). Weight increments were calculated from the length-weigth relationships established by NASSOGNE (1972) for the Copepods of the Gulf of Genova.

Daily production of the other zooplankters was computed from our number or biomass estimations and from litterature data about generation times, daily weight increments, or finite growth rates.

The production of the whole zooplankton community (fig.3, solid lines) reaches its maximum in mid-May, with about 150 mg $C.m^{-2}.day^{-1}$; during warm season, that daily production stays at a relatively high level (between 35 and 70 mg $C.m^{-2}.day^{-1}$) due to the positive temperature effect on growth rates; from November to March, zooplankton production averages up to 20 mg $C.m^{-2}.day^{-1}$.

The relative contribution of the different zooplankton groups in the total daily production of organic matter varies according to season. During the phytoplankton bloom, the Copepods are responsible for about the three fourths of total production; the remainder is produced by microzooplankters and different larvae. Spring time is characterized by an increase of the Copepods' share that can reach 90%. During the warm months, the importance

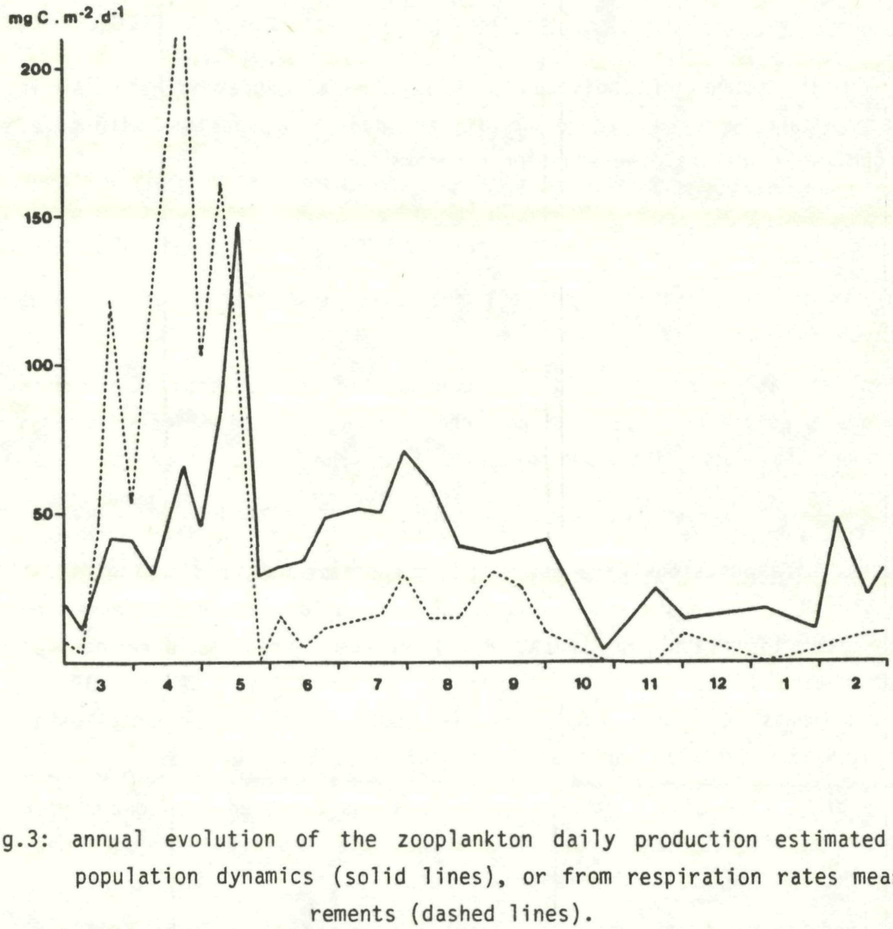

Fig.3: annual evolution of the zooplankton daily production estimated by population dynamics (solid lines), or from respiration rates measurements (dashed lines).

of these Crustaceans falls down in favour of Appendicularians; these organisms, though they take a weak contribution in total biomass, have a short generation time (about one week, FENAUX and GORSKY, 1983) and thus produce a large amount of organic matter (up to 50% of total production); the larvae of benthic animals are participating for 5 to 12%. The first half of the cold season shows a quite similar situation, except in November with the appearance of Pteropods which can produce up to a fourth of total matter.

Integrated over the year, the production of herbivorous zooplankton is near 12 g $C.m^{-2}$; the one of carnivorous is 1.2 g $C.m^{-2}$. So that ecological efficiency of primary consumers is between 14 and 20%, depending of the value of phytoplankton production, the one of secondary consumers averaging up to 10%.

Production and respiration

In 1956, WINBERG suggested to utilize the net growth efficiency coefficient (K2, ratio of matter produced to matter assimilated) to calculate production; as matter assimilated is either lost by respiration or used for growth, this coefficient may be defined as

$$K2 = \frac{P}{P+R},$$

where P is production and R respiration. From this equation, we can derive

$$P = R\,\frac{K2}{1-K2},$$

so that production may be directly estimated by respiration and a constant. The value of this one has been established for several plankters in different laboratory conditions, and is averaging 0.3.

When applied to Calvi's plankton, using our respiration rates measurements, the last equation provides daily production estimations far from previous ones (fig.3, dashed lines). In fact, these estimations are 2 to 3 times to high during algal bloom, and 2 to 4 times to low when phytoplankton is less abundant. Thus it appears that the K2 coefficient does not keep, for western Mediterranean waters, a constant value through the year, counter to what was supposed by some authors (IKEDA and MOTODA, 1978; HECQ, 1982) for other seas. To get a good harmony between both production estimation methods, the K2 coefficient must vary from 0.2 during months when food is sufficient, to 0.5 or 0.6 during food-limited periods. This inverse relationship between abundance of available food and net growth efficiency was yet noticed in laboratory conditions (PAFFENHOFER, 1976), and suggested that organisms (at least herbivorous plankters) are utilizing as more efficiently their food source as it is scarce; this last observation is also confirmed by the high value of herbivorous ecological efficiency.

Conclusions

Planktonic ecosystem of north-western Corsican waters seems to be typically oceanic, that stand out from following particularities:

- either phyto- or zooplankton biomasses are smaller than the ones observed in neighbouring neritic areas;
- populations diversity is weaker, with a few significant species; further-

more, these ones have a marked oceanic feature;

-well known neritic species are seldom or absent in these waters;

-meroplankton is really badly represented (maximum 5% of total zooplankton;

-there is a reciprocal interaction between phytoplankton and herbivorous plankters, each one beeing a limiting factor for the development of the other one.

These features of oligotrophy may surely be explained by the geographic situation of the sampling area, in the center of western Mediterranean basin, the shortness of the continental shelf, and the relative absence of terrigenous influences.

References

DAUBY, P., Oceanol. Acta, 3, 403-407, (1980)
DAUBY, P., Ann. Soc. roy. zool. Belg., 112, 69-77, (1982)
DAUBY, P., Ph D thesis, University of Liège, 291 pp., (1985)
FENAUX, R., and GORSKY, G., Ann. Inst. océanogr. Paris, 59, 107-116, (1983)
HECQ, J.H., Ph D thesis, University of Liège, 249 pp., (1982)
IKEDA, T., and MOTODA, S., Fish. Bull., 76, 357-368, (1978)
JACQUES, G., Vie Milieu, 21B, 37-102, (1970)
LANDRY, M.R., Limnol. Oceanogr., 28, 614-624, (1983)
Mc LAREN, I.A., J. Fish. Res. Bd Can., 35, 1330-1342, (1978)
NASSOGNE, A., Ph D thesis, University of Amsterdam, (1972)
NIVAL, P., NIVAL, S., and THIRIOT, A., Mar. Biol, 31, 249-270, (1975)
PAFFENHOFER, G.-A., Limnol. Oceanogr., 21, 39-50, (1976)
RYTHER, J.H., and YENTSCH, C.S., Limnol. Oceanogr., 2, 281-286, (1957)
WINBERG, G.G., Trudy Belorus. Gosudarstv. Univ. Minsk, 253 pp., (1956)
WINBERG, G.G., Methods for the estimation of production of aquatic animals, Academic Press, London, 175 pp., (1971)