TROPHIC STRUCTURE OF THE MASPALOMAS LAGOON (GRAN CANARIA, CANARY ISLANDS), A REGENERATED ECOSYSTEM OF BRACKISH WATER

By TERESA MORENO [1] & JOSÉ JUAN CASTRO [1]

With 2 figures and 5 tables

ABSTRACT. Fluxes of energy for the Maspalomas Lagoon ecosystem (Gran Canaria, Canary Islands) were obtained using the ECOPATH-II steady state ecosystem model. This brackish water ecosystem, which was regenerated in Summer 1992, is exposed to a seasonal variability of the main physico-chemical parameters, that is, salinity, temperature, pH and dissolved oxygen. The total system biomass is composed of Characeae algae, invertebrates (mainly amphipods and insects) and fishes. The biomass of each component was estimated *in situ*. Fish production was calculated empirically, whereas for other system groups information was taken from the available literature. Results indicate, that the total system biomass is overdimensioned in relation to the primary production. The lagoon represents a diversified, non-complex trophic chain based mainly on detritus, and because of its high instability it has the charateristics of an immature ecosystem.

INTRODUCTION

The Maspalomas Lagoon, situated in the southern part of Gran Canaria (27° 44' 00" N, 15° 35' 00" W), constitutes one of the scarce ecosystems of brackish water in the Canary Islands (Fig. 1). It is a coastal depression at the outlet of the ravine of Maspalomas and actually covers an area of 45.000 m². It is included in the area of Maspalomas Dunes, which was declared a Natural Area of National Interest by the Canarian Natural Zones Law (law n° 12/1987, BOC 85, 1.7.87).

There are referencies of this place since historical times (COLÓN, 1984; VERNEAU, 1992; BANNERMAN, 1922; KUNKEL, 1981). Since the sixties the lagoon has progressively

[1] Departamento de Biología, Universidad de Las Palmas de Gran Canaria, P.O. Box. 550, Las Palmas de Gran Canaria, Spain.

degraded as a consequence of the rapid development of tourism in the area. The construction in 1972 of a channel collecting the freshwater from the ravine resulted in a reduction of the former extended flooded area into a small Lagoon. It was heavily polluted by litter, concrete blocks and waste water, and events of eutrophization of unexplicated origin resulted in high fish mortalities. To mitigate a bad impression in a touristic area, the Lagoon was frequently forced opened to the sea in order to clean it, changing the environmental conditions and so, the natural dynamic of the system.
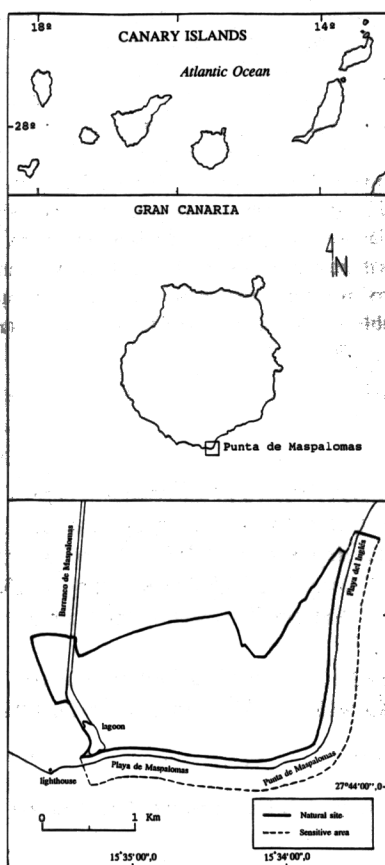

Fig. 1 - Location of the Maspalomas Lagoon in the Natural Site of Maspalomas Dunes.

In the summer of 1992 the Government of the Canary Islands started a project aiming to recover the Lagoon by use of a natural mechanism to regulate the ecosystem. This consisted in giving up the practice of opening the Lagoon to the sea and in making a continuous flow from an inlet from the freshwater under the ravine. Studies carried out on the recovery process so far have permitted the characterization of some of the biotic components of the ecosystem, like macroinvertebrates (GÁLVEZ and RUIZ, 1993) and aquatic vegetation (BETANCORT and GONZÁLEZ, 1995).

The aim of this study is to make a preliminary analysis of the trophic structure of the Maspalomas Lagoon ecosystem. Energy flows among living groups in the ecosystem were estimated during one year from May 1993 to May 1994 using the ECOPATH-II model (CHRISTENSEN and PAULY, 1992).

MATERIAL AND METHODS

The model ECOPATH-II is based on estimates of biomass and consumption of a species or group of species (POLOVINA, 1984) and the distribution of matter or nutrients among the compartments of an ecosystem (ULANOWICZ, 1986). Populations and their interrelation are modelled using a linear equations system, under the assumption that the ecosystem is in a steady state. The basic equation expresses that production equals predation plus losses and export of each compartment, and it is as follows:

$$B_i * (P_i/B_i) * EE_i - [\textstyle\sum_{j=1} B_j * (Q_j/B_j) * DC_{ji}] - EX_i = 0 \text{ (Eq. 1)}$$

where, B_i is the biomass of group i; P_i/B_i is the production/biomass ratio of (i); EE_i is the ecotrophic efficiency of (i); B_j is the biomass of predator j; Q_j/B_j is the consumption/biomass ratio of (j); DC_{ji} is the fraction of prey (i) in the average diet of predador j and EX_i is the export of (i). At least three of the parameters B_i, P_i/B_i, Q_i/B_i and EE_i have to be known.

The model is optimized by a series of algorithms based on the matrix of diet composition (CHRISTENSEN and PAULY, 1992). The model balances inputs and outputs of each group adjusting respiration as follows:

Consumption = Production + Respiration + un-assimilated food

With the model an estimation of detritus biomass can be approximated.

Basic Parameters.

Biomass.
Fish were collected seasonally from May 1993 to February 1995 using a beach-

seine net. Fish caught were anaesthetized, measured and weighted, and thereafter returned to the Lagoon. A sample was selected for subsequent analysis of stomach contents.

Visual censuses were carried out to estimate the biomass of the fish species that were not captured. The censuses were practised monthly (day and night) along transects, recording the number of each species and the approximated size of each individual. Biomass was calculated applying length-weight relationships obtained from biological samples.

Fish were grouped in length classes of 1 cm, using total length (TL). The methods of Bhattacharya (BHATTACHARYA, 1967) and NORMSEP (HASSELBLAD, 1966; PAULY and CADDY, 1985), included both in the FISAT software (GAYANILO *et al.*, 1994), were used to calculate the mean size of each cohort. The growth rates were determined applying the method of the modal progression to the temporal series of length frequencies (GULLAND and ROSENBERG, 1992).

Moreover, in May 1995 a massive death of fishes caused by a sudden anoxia, made it possible to estimate more accurately the number of individuals of each species and to obtain their initial biomass by retrocalculus. It was assumed, that 100% of the fish populations died in May 1995, and that natural mortality before this date was negligible considering the high total number of individuals of each population. Fish mean biomass was estimated for a single cohort of animals, as indicated by ALLEN (1971):

$$B_i = 1/T \ N_t \ W_t \ dt \quad \text{(Eq. 2)}$$

where, B_i is the mean biomass of a cohort of species i of N individuals during the time period, T, that was equivalent to one year, from May 1993 to May 1994. It was assumed, that the number of fishes was constant within this time interval, because natural mortality was supposed to be close to zero.

Data of invertebrates biomass were taken from GÁLVEZ and RUIZ (1993). Macroalgae biomass was calculated by BETANCORT and GONZÁLEZ (1995), during the period August 1992 to August 1994 and it includes a great part of the phytoplanktonic biomass that is compossed mainly by benthic species (GONZÁLEZ y BETANCORT, 1995; OJEDA, 1995).

Production

Production refers to the increase of tissue by a group over the period considered. It is a dynamic quantity, which is very difficult to measure directly (ALLEN, 1971). For a fish population formed by one cohort, that grows up following an exponential model, and for which the natural mortality is close to zero during a certain period, a simplified

model of production can be applied:

$$P_i = N_i/T \, (W_T - W_o) \qquad (Eq. \ 3)$$

where, N_i is the number of individuals of species i during the time period T. W_0 and W_T are the mean individual weight at the begining and at the end of the time period considered, respectively.

As an indirect estimate of the production rate of macroinvertebrates, GERKING (1962) measured the predation on these effectuated by fish. The minimum summer production of the benthic fauna was taken as the quantity, that is necessary in order to replace losses due to predation. He estimated, that the minimum yearly prey production was nearly 10 times the production of the predators. Therefore, the production of insects and amphipods in the present study was estimated multiplying a factor of ten to the fish production that was attributed to invertebrate consumption. That fraction of fish production is related to the importance of invertebrates in the fish diet.

Estimates of macroalgae productivity was calculated from variations in their biomass (WESTLAKE, 1965; WETZEL, 1981). The production of *Chara* sp. applied in the model for the Maspalomas Lagoon is an estimation given by WETZEL (1981).

Consumption.

Consumption is the intake of food by a group over the time period considered. A method for prediction of marine fishes consumption-biomass ratio (Q/B) was proposed by JARRE *et al.* (1991) and modified by PALOMARES and PAULY (1989), based on some easy to quantify characteristics of the animals. The expression is as follows:

$$\log_{10} Q/B = 4.885 - 1309.139 \, (1/T) + 0.423 \log_{10} A + 0.285 \log_{10} D - 0.111 \log_{10} W_\infty - 0.445 \log_{10} P \qquad (Eq. \ 4)$$

where, T is the mean habitat temperature (in °K), as suggested by Regier *et al.* (1990). A is a form index of the caudal fin of fishes, defined as h^2/S, where h is height and S, surface area, and it is related to the level of activity of each species. D is the relation between standard length and maximum body height. W_∞ is the asymptotic weight of the fish species in this medium (wet weight, in grams). P is the relative height of the caudal peduncle (height of the caudal peduncle/maximum body height), and is an index, which can be used to distinguish "burst" swimmers from continuous swimmers (PAULY, 1989; JARRE *et al.*, 1991).

The parameters A, D and P were calculated from the WHITEHEAD *et al.* (1986) illustrations (Table 1). W_∞ was calculated from the asymptotic length, L_∞, of the von

Bertalanffy growth curve transformed to weight by means of the length-weight relationship obtained in the Maspalomas Lagoon (MORENO and CASTRO, 1994) (Table 1). The consumption/biomass ratio (Q/B) of invertebrates (insects and amphipods) was calculated using a value of the ecotrophic efficiency close to 0.20 (ARREGUÍN SÁNCHEZ *et al.*, 1992).

TABLE 1 - Parameter values used to estimate consumption/biomass ratio of some fishes in the Maspalomas Lagoon (equation 4). A is the relation between the square height and the area of the caudal fin; D is the standard length/maximum body height ratio; W_∞ is the asymptotic weight and P is the relative height of the caudal peduncle.

Species	A	D	W_∞ (g)	P
Liza aurata	3.32	4.59	825	0.45
Diplodus sargus	2.73	2.02	447	0.19
Dicentrarchus punctatus	2.89	3.99	948	0.40

Ecotrophic efficiency.
The ecotrophic efficiency (EE) is a dimensionless parameter giving the part of the production, that has either passed up the trophic foodweb or has been exported (BAIRD *et al.*, 1991). It varies between 0 and 1. The lower bound indicates that the group is not caught nor eaten by any other group. Similarly, the upper bound indicates that the group is being heavily preyed upon.
The ecotrophic efficiency of detritus is defined as the ratio between the out- and inflow to the detritus group (CHRISTENSEN and PAULY, 1992). Under steady state conditions, this ratio should be equal to 1. Estimates of EE less than 1 indicate that more is entering the detritus group, than is exiting. The excess is assumed to end up as accumulated detritus and transformed into sediment.

Food conversion efficiency.
The (gross) food conversion efficiency (GE) is the ratio between production and consumption (P/Q) (CHRISTENSEN and PAULY, 1992).

Diet composition.
The diet composition was expressed as the proportion, on a weight basis, in which each prey contributes to the diet. Diet of fishes was determined by analyzing their stomach content. All food items from the stomachs were placed on filter paper to remove excess moisture and weighted. Prey items were identified to the lowest possible taxonomic level.

Total number of prey items were counted and wet masses were determined for each prey category. Indices of importance by wet mass (IM) were calculated as follows:

$$IM = [(\% \text{ wet mass}) (\% \text{ occurrence})]^{1/2} \text{ (CASTRO, 1993)}$$

where, % wet mass is the percentage of the wet weight of each prey category and % occurrence is the frequency of occurrence of a prey item in the stomachs.

Diet composition was expressed as the proportion of the indices of importance by wet weight of each prey category, all summing up to one. A total of 91 fish stomachs were analyzed, 66 of *Liza aurata*, 16 of *Diplodus sargus* and 9 of *Dicentrarchus punctatus* (MORENO and CASTRO, 1994).

On the basis of the big variety in feeding habits seen in flies (Diptera) (Wetzel, 1981), the diet of invertebrate groups is considered a mixture of macroalgae and detritus.

Flow diagram.

Four categories of flows can occur in a system: a) import, the inputs to a compartment from outside; b) the flow among different compartments within the system; c) the export out of the system of matter still usable and d) the amount of material, that is dissipated (ULANOWICZ, 1986). At steady state, the sum of all inputs must equal the sum of all outputs for each compartment. Moreover, total system throughput (T) is equal to the sum of the individual throughputs. The flow diagram is located on a trophic level axis. The lowest trophic level defined as 1 was assigned to primary producers and detritus, while consumers had a trophic level of 1 plus the weighted average of the trophic level of their prey (ODUM and HEALD, 1975).

Goal functions.

The development stage of an ecosystem can be characterized by a serie of attributes established by ODUM (1969), and which can be quantified by goal functions (ULANOWICZ, 1986; CHRISTENSEN, 1992). The goal functions used were:

1) Total system biomass (B), excluding detritus, was calculated as the sum of the biomasses of all groups. This function has a low value in developing ecosystems (ODUM, 1971).

2) Ecosystem primary production/respiration is the ratio between total primary production and total respiration (Pp/R) in a system. It is considered by ODUM (1971) to be an important ratio for description of the maturity of an ecosystem. In the early developmental stages of a system production is expected to exceed respiration leading a ratio greater than 1, while it approach 1 in mature systems (ODUM, 1971).

3) Ecosystem primary production/biomass is the ratio between a system's primary production and its total biomass (Pp/B). For immature systems it is expected, that production is greater than biomass. As a consequence, one can expect biomass to accumulate over time,

therefore the ratio diminish progressively. The more mature the system is, the more matter will be cycled (ODUM, 1969; ULANOWICZ, 1980).

    4) The biomass supported by the available energy flow in a system was estimated as the ratio between total system biomass and total system throughput (B/T) (CHRISTENSEN and PAULY, 1992). This ratio can be expected to increase to a maximum in the most mature stages of an ecosystem (ODUM, 1971).

    5) Net ecosystem production or ecosystem yield is defined as the difference between total primary production and total respiration. It will be large in immature ecosystems and close to zero in mature ones (ODUM, 1971).

RESULTS

    The brackish water Lagoon of Maspalomas is separated from the sea by a narrow sand barrier. The bottom is flat and soft with a mean depth, measured in May 1993, of about 1 m and a max. depth of 1.5 m. However, these values can increase or decrease about 10 % in winter and summer, respectively.

    The Lagoon is having marked seasonal changes. It reaches its maximal level of water in winter, when decreases the temperature and the salinity and increase the oxygen concentration. In contrast, in summer it reaches the lowest levels in water depth and concentration of dissolved oxygen and the highest values of temperature and salinity. Temperature oscillated between 18.0 and 32.2°C, salinity ranged from 22 to 43 ‰, pH shifts from 7.57 to 9.51 and the dissolved oxygen between 1.12 and 8.70 mg/l.

    The application of ECOPATH-II steady state ecosystem model to the Maspalomas Lagoon was based on the trophic structure of the fish community. The main components of this brackish water ecosystem from May 1993 to May 1994 were macroalgae, invertebrates and fishes.

    A Charophyta belonging to the Characeae family, (*Lamprothamnium succintum* A. BRAUN in ASCH.) was the dominant macroalgae species, as classified by BETANCORT and GONZÁLEZ (1995). It covered 70% of the bottom area and had a height of more than half a meter. It was put into the model as primary producer.

    Among the great variety of invertebrates, insects larvae (Diptera) and amphipods (Crustacea) were the most abundant groups in the Lagoon (GÁLVEZ & RUIZ, 1993). The fishes mainly preyed upon these groups. They were put into the model as primary consumers.

    A total of 20 fish species belonging to 12 different families have been recorded in the Lagoon (Table 2). The majority of them are marine, common in the infralittoral zone. *Poecilia reticulata* was the only freshwater species. The species used in the model were mullets (*Liza aurata* RISSO, 1810; *Chelon labrosus* RISSO, 1826 and *Mugil cephalus* LINNAEUS, 1758),White seabream (*Diplodus sargus cadenati* PAZ, BAUCHOT & DAGET,

1974) and Spotted seabass (*Dicentrarchus punctatus* BLOCH, 1792). They constituted 99% of the total biomass of fishes in the Lagoon (Table 2).

TABLE 2 - Mean biomass of fish species estimated from May 93 to May 94 using experimental fishings or visual censuses and the percentage of the total biomass by species.

Family	Species	Visual censuses B (Kg)	Catches B (Kg)	%
Anguillidae	*Anguilla anguilla* (LINNAEUS, 1758)	4.7	-	0.3
Serranidae	*Mycteroperca rubra* (BLOCH, 1793)	-	0.6	<0.1
Moronidae	*Dicentrarchus punctatus* (BLOCH, 1792)	-	123.9	8.5
Carangidae	*Trachinotus ovatus* (LINNAEUS, 1758)	-	1.0	0.1
Haemulidae	*Pomadasys incisus* (BOWDICH, 1825)	-	3.4	0.2
Sparidae	*Diplodus annularis* (LINNAEUS, 1758)	-	1.5	0.1
	Diplodus cervinus cervinus (LOWE, 1841)	-	0.1	<0.01
	Diplodus sargus cadenati (PAZ, BAUCHOT & DAGET, 1974)	-	130.3	9.0
	Diplodus vulgaris (GEOFFROY SAINT-HILAIRE, 1817)	-	0.1	<0.01
	Lithognathus mormyrus (LINNAEUS, 1758)	-	1.8	0.1
	Oblada melanura (LINNAEUS, 1758)	-	0.3	<0.01
Labridae	*Centrolabrus trutta* (LOWE, 1833)	-	1.7	0.1
Gobiidae	*Gobius niger niger* (LINNAEUS, 1758)	-	0.6	<0.01
	G. paganellus (LINNAEUS, 1758)	-	0.4	<0.01
Blenniidae	*Parablennius pilicornis* (CUVIER, 1829)	0.1	-	<0.01
Labrisomidae	*Labrisomus nuchipinnis* (QUOY & GAIMARD, 1824)	0.02	-	<0.01
Mugilidae	*Chelon labrosus* (RISSO, 1826)	-	303.9	20.9
	Liza aurata (RISSO, 1810)	-	659.0	45.3
	Mugil cephalus (LINNAEUS, 1758)	-	220.1	15.1
Poecilidae	*Poecilia reticulata*	0.5	-	<0.01
Total			1453.8 Kg	

Basic parameter values.

The parameters used in the model for the Lagoon of **Maspalomas** are: Biomasses (B) in grams, production/biomass (P/B) and consumption/biomass (Q/B) ratios, all averaged over a year (Table 3), and the diet composition matrix (Table 4).

In the modelled ecosystem of Maspalomas Lagoon, the ecotrophic efficiency of fishes was zero, because they were not preyed upon or exploited. The ecotrophic efficiency of insects was 0.661; the highest for amphipods (0.898) and the lowest for macroalgae (0.567) (Table 3). Moreover, the trophic efficiency of detritus was estimated to 0.566.

Values on the gross conversion efficiency (GE) (Table 3) indicate, that estimated fish consumption was 12 times higher than their production. For amphipods and insects, consumption was about 2 and 6 times their production, respectively.

TABLE 3 - Values of the basic parameters used in the model (Biomass, Production/Consumption and Consumption/Biomass ratios) and calculated by it (Ecotrophic efficiency and Gross efficiency) for each ecosystem group.

| Group	Biomass (gm^{-2}year^{-1})	P/B (year^{-1})	Q/B (year^{-1})	EE	GE
Mullets	27.20	0.662	5.112	0.000	0.129
Diplodus sargus	2.80	0.394	6.376	0.000	0.062
Dicentrarchus punctatus	2.70	0.365	5.301	0.000	0.069
Insects	12.11	2.125	20.000	0.661	0.106
Amphipods	1.00	6.435	13.000	0.898	0.495
Algae	1986.0	0.160	0.000	0.567	-

Detritus was the main component in the diet of both *Liza aurata* and *Dicentrarchus punctatus*, with proportions of 0.62 and 0.75, respectively (Table 4). It included the bread, that visitors continuously throw into the Lagoon. Detritus was introduced into the model as an import to the system.

Flow diagram

A graphical representation of flows (gm^{-2}year^{-1}) in the modelled ecosystem of Maspalomas Lagoon is seen Fig. 2. In this diagram, the area of each box is proportional to the biomass of the group it represents. Inflows correspond to food intake, and outflows are fluxes to the detritus pool and losses by respiration.

TABLE 4 - Matrix of diet composition.

Group	Insects	Amphipods	Algae	Detritus
Mullets	0.079	0.040	0.262	0.619
Diplodus sargus	0.149	0.008	0.598	0.245
Dicentrarchus punctatus	0.235	0.005	0.015	0.745
Insects	-	-	0.5	0.5
Amphipods	-	-	0.9	0.1
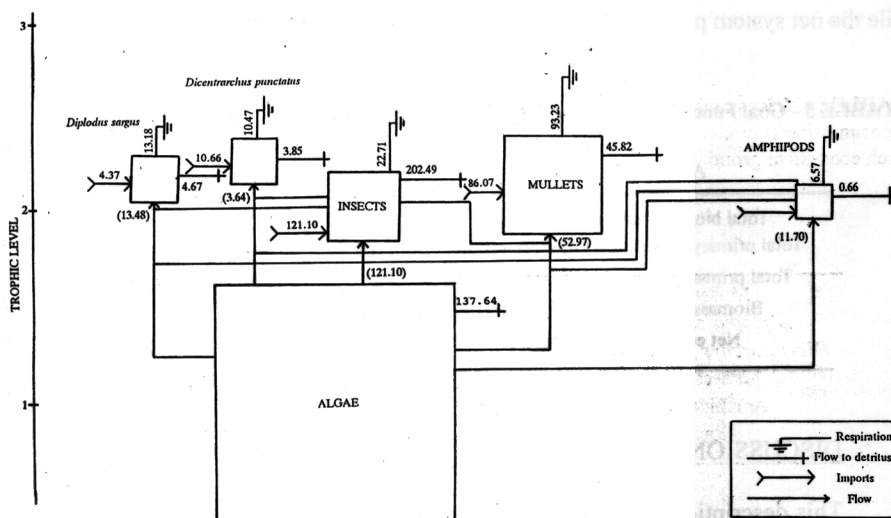
Fig. 2 - Flow diagram of the Maspalomas Lagoon ecosystem model. Flows are expressed in gm^{-2}year^{1}.

In the ecosystem modelled the benthic producers (Characeae) are placed at a trophic level of 1. Insects and amphipods are at a trophic level of 2, while levels of fish species are between 2.1 and 3.0 (mullets, 2.119; *Diplodus sargus*, 2.157 and *Dicentrarchus punctatus*, 2.240).

Results related to the quantity of food intaked show, that fishes are consuming 14.9% of primary production, 66.1% of insects production and 90.2% of amphipods production.

The flow to the detritus pool is composed by 51.2% of insects, 34.8% of macroalgae, 0.2% of amphipods and 13.8% of fishes. The contribution to the detritus from the insects is

estimated too high, because an unknown export to the outside is taking place, when they leave the aquatic phase.

Total system throughput reached 1139.3 $gm^{-2}year^{-1}$.

Goal functions.

Total system biomass, detritus excluded, was estimated to 2031.81 gm^{-2} (Table 5). 97.7% of this biomass is constituted of Characeae, 0.7% of invertebrates and 1.5% of fishes.

System primary production/respiration ratio was high (2.2), while system primary production/total system biomass ratio was very low (0.16 $year^{-1}$) (Table 5).

The biomass supported by the available energy flow was relatively low (1.78 $year^{-1}$), while the net system production was high (171.61 $gm^{-2}year^{-1}$) (Table 5).

TABLE 5 - Goal Functions calculated for the Maspalomas Lagoon.

Attribute-Function	Symbol	Unit	Value
Total biomass (detritus excluded)	B	gm^{-2}	2031.81
Total primary production/total respiration	Pp/R	-	2.17
Total primary production/total biomass	Pp/B	$year^{-1}$	0.16
Biomass per unit of energy flow	B/T	$year^{-1}$	1.78
Net ecosystem production	Pp - R	$gm^{-2}year^{-1}$	171.61

DISCUSSION

This description of the Maspalomas Lagoon ecosystem is based on estimations of the biomass and the fish production and on the components in the fish diet. A mass-balanced flow diagram evaluated by the network analysis of ECOPATH-II (CHRISTENSEN and PAULY, 1992) provides a description of fluxes and cycling of matter and the structure of the trophic food web. Some of the data used in the model were taken from the literature, such as production of the algae and of the invertebrate groups. Because of this, the quantity of flows calculated do not necessarily correspond to their real importance in the medium. Moreover, it is a static approach to the ecosystem, that do not take into account its dynamic nature nor its spatio-temporal organization. Nevertheless, the flow web analysis is a necessary methodology to be used before implementing simulation models. Those of the flow web models formulated in terms of analytically solvable differential equations are specially useful to address the coexistence of species in a fluctuating environment (EBENHÖH, 1988; YODZIS, 1989; GAEDKE, 1995).

The model of the ecosystem of the Lagoon of Maspalomas consists of a reduced number of biotic components. The physical and chemical conditions only favor the presence and development of few species of primary producers, mainly algae of the family Characeae (BETANCORT and GONZÁLEZ, 1995). As is common in relative small and shallow lagoons, these algae populations contribute significantly to the total biomass and production of the system (WETZEL, 1981). Fishes occupy the highest trophic levels, and they are controlling the populations of amphipods and insects. However, the biomass of the invertebrates in the Lagoon of Maspalomas is smaller than the fish biomass, which partly is due to the supply of organic matter from outside on which the most abundant fishes are sustained.

The total system biomass estimated *in situ* was very high in relation to the primary production, that was taken from the literature. The habit of tourists of feeding fish, an external source of energy to the system, has probably contributed to an over dimensioned fish biomass.

The Maspalomas Lagoon ecosystem is characterized by a great instability. This ecosystem is far from equilibrium and highly dependent on exterior inputs.

This model of the Lagoon is giving a mean picture, but is hiding the variations taking place during the year: The macroalgae progressively disappeared as a consequence of the variation in the physicochemical parameters, specially the pH (BETANCORT & GONZÁLEZ, 1995). There were observations of locally occurring water masses near the bottom, where the water had anomalous coloration (white, yellow or pink) and a concentration of dissolved oxygen decreasing almost to zero. This situation could be related to an excessive contribution of minerals brought by the run-off water from the ravine, and to the production of hydrogen sulfure (CLEMENT, 1986).

In May 1995, a process of eutrophization, associated to a quick increment in the inflow of freshwater to the Lagoon, caused a high phytoplankton production. At night, this caused a complete consumption of the scarce dissolved oxygen, that remained after a very warm day, leading to a massive mortality of the fish populations. During this episode all the fish populations died, except *Poecilia reticulata* due to its higher resistance to low concentrations of oxygen (ROSS and DOHERTY, 1994).

In February 1996, the connection between the Lagoon and the sea was reestablished due to a great volume of run-off water causing rupture of the sand barrier resulting in inflow of marine water. This connection made the recolonization of the Lagoon with marine species possible. The opening to the sea is the first spontaneous connection established, and with it a new cycle in the Lagoon begins. Its duration is still unknown.

It can be concluded, that the ecosystem in Maspalomas Lagoon is periodically renewing the biological cycle because of its natural unstable dynamic. As seen in this study the biomass of the fishes increased progressively until the system colapsed by a temporal anoxia. The biological cycle of algae and invertebrates is shorter than the life cycle of the fishes. Nevertheless, the opening of the lagoon to the sea after intense rainfall or tidal overflow allows its re-colonization of new marine individuals.

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