

TOWARDS MODELLING A CORAL REEF ECOSYSTEM: RELATIVE FOOD CONSUMPTION ESTIMATES FOR SOME BOLINAO REEF FISHES, PANGASINAN, PHILIPPINES^a

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ABSTRACT

The food consumption per unit biomass (Q/B) of ten different coral reef fish populations representing groups found at Bolinao Reef, Pangasinan Province, Philippines, is presented. Two methods of estimation were used, i.e., i) weight-specific food conversion efficiencies and/or daily rations turned into population estimates of Q/B, and ii) estimation based on a predictive model. A close agreement between the estimates from the two methods was observed. The food consumption of the fishes included here is related to their physical activity and food type.

INTRODUCTION

Reef ecosystems are characterized by complex interactions between groups of highly diverse biotic communities. They are a dynamic structure governed by external (i.e. climatic) changes, exploitation by humans and internal (i.e. inter- and intraspecific) factors.

The Bolinao Reef, and the Lingayen Gulf area in general, their species composition, oceanographic conditions, and various aspects of their fisheries, have been a topic of

concern to several authors (see Aprieto and Villoso 1982, Mines 1988, Lopez MS, Calud et al. 1989, Ochavillo et al. 1989, Maaliw et al. 1989). To complement these works, studies concerning the internal biological processes are required and some of these are currently being conducted, e.g., concerning energy flow from primary producers to invertebrate communities (Yap and Montebon, this symposium), biomass of zooplankton (McManus et al., this symposium), energy flow from primary producers to fish (Hernandez et al., this symposium). All these interrelated factors, put

together will, if suitably analyzed, lead to an overall model of the ecosystem, describing the energy or food transfer between trophic groups, biomass removed or produced at any given time, etc.

An essential parameter in ecosystem modelling, such as that used in ECOPATH (Polovina 1984, Polovina and Ow 1985) and ECOPATH II (Christensen and Pauly 1991) is the food consumption per unit biomass (Q/B) of a particular trophic group. This paper attempts to provide estimates of Q/B for 10 fish species found in the Bolinao Reef, using two different methods.

MATERIALS AND METHODS

Estimates of daily rations (R_d) and/or food conversion efficiencies (K_1) used here to derive relative food consumption estimates were taken either from the literature or from laboratory experiments. The fishes for which literature data were used all refer to tropical Indo-Pacific species reported to occur in Lingayen Gulf (Aprieto and Villosio 1982, Mines 1988), i.e. *Saurida undosquamis* (Synodontidae), *Epinephelus fuscoguttatus*, *Epinephelus tauvina* (Serranidae), *Lutjanus johnii* (Lutjanidae), *Siganus spinus* (Siganidae), and *Scomber japonicus* (Scombridae). The feeding experiments on *Dascyllus trimaculatus* (Pomacentridae) were conducted at the U.P. Marine Science Institute (Palomares 1987) and at the Institut für Meereskunde, Kiel University on *Dascyllus*

melanurus (Pomacentridae), *Myripristis murdjan* (Holocentridae) and *Zebrasoma scopas* (Acanthuridae) (Opitz, unpublished data).

The relative food consumption (Q/B) of the various species mentioned above was estimated using two models which differ in their data requirements. One was the model of Pauly (1986) which requires estimates of the von Bertalanffy growth function (VBGF), mortality estimates (Z), and estimate of a parameter, β , relating food conversion efficiency (K_1) and body weight, as shown in Fig. 1. This model has the form

$$Q/B = \frac{\int_{t_r}^{t_{max}} (dw/dt) e^{-Z(t-t_r)} dt}{\int_{t_r}^{t_{max}} W_t e^{-Z(t-t_r)} dt} \quad \text{Eqn. 1}$$

where t_r and t_{max} are the ages at recruitment and exit from the population, respectively; b is the exponent of a length-weight relationship; and K and t_0 are parameters of the VBGF.

Another method for estimating Q/B is through the empirical equation

$$\ln Q/B = -0.1775 - 0.2018 \ln W_t + 0.6121 \ln T + 0.5156 \ln A + 1.26F \quad \text{Eqn. 2}$$

of Palomares and Pauly (1989), where W_t is the asymptotic weight of the fish in the stock

in question (in g wet weight); T, the mean temperature of the habitat (in C°); A, the aspect ratio of the caudal fin (i.e. the ratio between the square of the height of the fin over its surface area (Fig. 2); and F, the feeding type, assigned a value of "0" in carnivores and "1" in herbivores. (Note that this equation can be used only for fishes which have the tunniiform, carangiform or subcarangiform modes of swimming, i.e. which use their caudal fin as their sole or main organ of propulsion.

RESULTS AND DISCUSSION

Q/B estimates from the two models used here are provided in Table 1. Except for *D. trimaculatus* and *Z. scopas* (Fig. 3), whose estimates of Q/B appear biased upward, equation (1) led to estimates that were very close to those derived from equation (2). Three distinct feeding types can be identified: fishes with low food consumption (*S. undosquamis*, *E. fuscoguttatus*, *E. tauvina*, and *L. johnii*); fishes with intermediate consumption (*M. murdjan*, *D. melanurus*, and *S. japonicus*); and fishes with high consumption (*S. spinus*). These clear differentiations in consumption levels can be attributed to differences in activity levels and food type.

The level of activity of fishes used here is the aspect ratio (A) of their caudal fin (Pakares and Pauly 1989). Low values of A are indicative of the passiveness, exemplified here by lizardfish and groupers, while high values of A indicate increased levels of activ-

ity, as in the mackerel.

Most of these passive fishes are demersal species. However, certain species, such as damselfish and soldierfish are generally aggressive animals often seen in an alert and active state. These fishes may thus have higher food intake than even some pelagic fishes such as mackerel.

The high Q/B estimates for the siganid can obviously be attributed to its herbivorous habits. Since fishes tend to convert animal food more readily than plant food into somatic tissue, less animal tissue needs to be ingested than plant tissue for the same increase of body weight.

The two outlying points on Fig. 3, whereby exceedingly high estimates were computed from data obtained from Eq. (1), are probably experimental artifacts i.e., a failure to simulate the natural conditions for these species (*D. trimaculatus* and *Z. scopas*), leading to abnormalities in their behavior and physiology during captivity (stress).

For "small pelagics" and "nearshore fishes", Polovina (1984) estimated annual Q/B to be 7.5 while Liew & Chan (1986) reported a value of 13.5. The estimate for the lone pelagic fish in this study, *S. japonicus*, was 14.6 (mean of estimates from both equations), close to that reported by the latter authors. On the other hand, both references gave lower Q/B estimates for "bottom fishes", 3.6 and 2.7, respectively, while their Q/B was estimated here to be 5.2 (mean for the lizardfish, the groupers and the snapper). Similarly, "reef fishes" have low Q/B values, 9.5 in Polovina

(1984) and of 8.3 in Liew & Chan (1986), compared with the relatively high value of 16.2 year⁻¹ for the mean for *M. murdjan* and *D. melanurus*.

Some inferences regarding food requirements of species in relation to their mode of activity and type of food consumed can be made based on the data presented above:

1) passive demersal fish require only small amount of food for maintenance and growth;

2) some reef fishes, classified here as "active demersals" may have relatively high metabolic levels and therefore require a high food intake, perhaps comparable to that of pelagic fish;

3) pelagic fish, represented here by mackerel, and which are more or less constant swimmers, have generally high energy cost and hence high food consumption rates, and;

4) herbivorous fish must consume large quantities of food to compensate for the low quality of the food they eat.

The models presented here appear to be appropriate for estimating the relative food consumption of Bolinao reef fishes and useful insights emerge when such estimates of food consumption are related to the general biology of the fish species in question.

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Table 1. Estimates of food consumption per unit biomass (Q/B, year⁻¹) using the two models discussed here; the aspect ratio (A) of the caudal fin of each of the ten species is also given.

Species	Common Name	A	Q/B(yea r ⁻¹)	
			Eq.(1)	E q.(2)
1) <u>S. undosquamis</u>	brush-toothed lizardfish	1.96	4.27	7.29
2) <u>M. murdjan</u>	big-eye soldierfish	3.53	19.31	13.1
3) <u>E. fuscoquattatus</u>	brown-marbled grouper	2.08	5.00	5.01
4) <u>E. tauvina</u>	greasy grouper	1.54	2.04	5.35
5) <u>L. johni</u>	John's snapper	1.91	4.89	5.13
6) <u>D. melanurus</u>	black-tailed damselfish	2.94	14.53	17.72
7) <u>D. trimaculatus</u>	white-spot damselfish	1.91	49.24	14.19
8) <u>Z. scopas</u>	sail-fin tang	2.25	28.29	12.41
9) <u>S. spinosa</u>	spinefoot	3.17	47.92	48.84
10) <u>S. japonicus</u>	Japanese mackerel	5.85	14.82	14.45

^aThis fish is the only herbivore considered here.

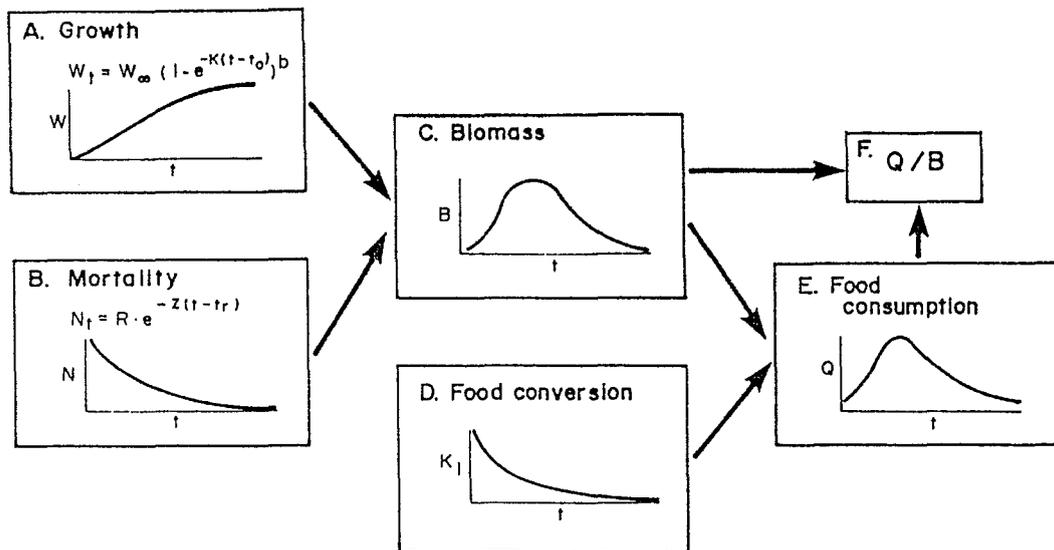
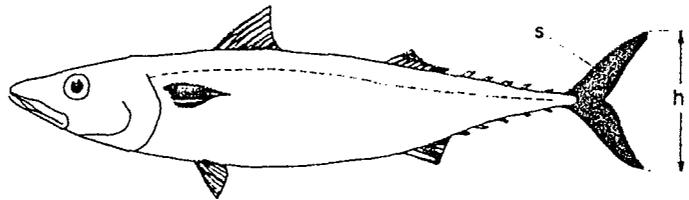


Fig. 1. Elements incorporated in derivation of equation (1), used to estimate the relative food consumption of fish populations (Q/B). *A*) The von Bertalanffy Growth Function (VBGF) is used to model the individual growth of fishes. Its first derivative (dw/dt) is used to express growth rates. *B*) A simple negative exponential model is used to describe the natural mortality in the population in question. *C*) Population biomass as a function of time is obtained via $A \times B$. *D*) Food conversion efficiency, K_1 , ($= (dw/dt) / R_d$) can be related to body weight via $K_1 = 1 - (W/W_\infty)^a$; combining this with the VBGF leads to K_1 as a function of age, or $K_{1(t)}$. *E*) The functions for $K_{1(t)}$ and for biomass (in *C*) can be combined to yield food consumption as a function of age, or Q . *F*) Integrating the process in *E* and dividing the integrated biomass (in *B*) leads to Q/B (see equation 1).

Scomber japonicus
Aspect ratio: 5.85



Epinephelus tauvina
Aspect ratio: 1.54

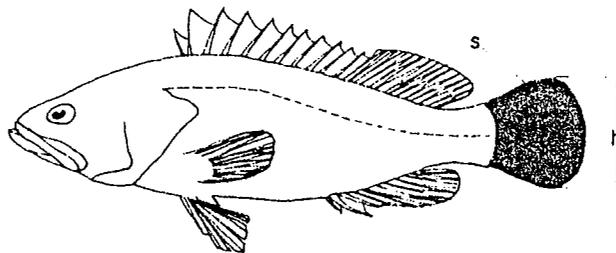


Fig. 2 Schematic representation of the method to estimate aspect ratio ($A = h^2/s$) of fishes, where "h" is the height of the caudal fin, and "s" is its surface area (shaded). Note high aspect ratio in pelagic, active *Scomber japonicus* vs. the low aspect ratio of the demersal, passive *Epinephelus tauvina*.

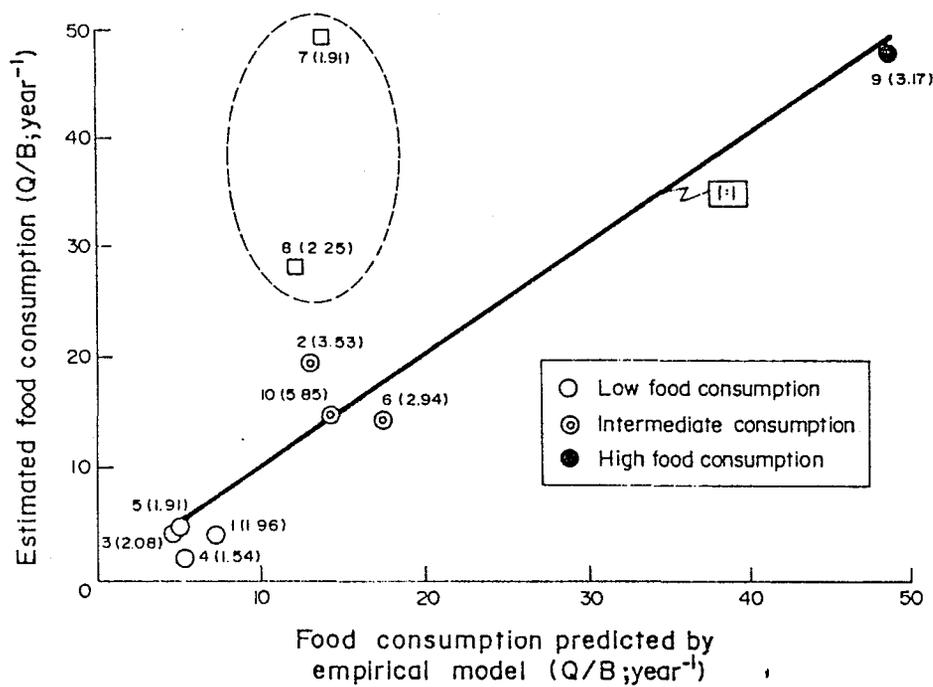


Fig. 3. Plot of the estimated relative food consumption (Q/B) of ten Bolinao reef fishes vs. Q/B values predicted by an empirical equation (Equation 2). Numbers in parenthesis correspond to the fishes' aspect ratios. Note outlying positions of the squares (No. 7 and 8).