The relationship between stock and recruitment in the shrimp stocks of Kuwait and Saudi Arabia (1)

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ABSTRACT

Similar long-term decreasing trends in recruitment are demonstrated for Kuwait and Saudi Arabia stocks of Penaeus semisulcatus. *In addition, the relationship between an estimate of the spawning stock abundance in any one year and the resulting recruitment appears to be quasi linear.*

It is however pointed out that this apparent stock/recruitment relationship may be largely spurious because of the existence of trends in recruitment not related to fishing.

KEY WORDS : *Penaeus semisulcatus* – Stock/recruitment relationship — Persian Gulf.

RÉSUMÉ

RELATION STOCK/RECRUTEMENT CHEZ LES CREVETTES DU KOWEÏT ET D'ARABIE SAOUDITE

Une tendance à la décroissance à long terme est signalée pour les stocks de Penaeus semisulcatus *du golfe Persique (Koweït et Arabie Saoudite). Par ailleurs, la relation entre l'abondance estimée du stock reproducteur pour une année donnée et le recrutement qui en découle, paraît presque linéaire.*

Il est cependant souligné que cette relation apparente stock/recrutement pourrait n'être qu'un artéfact, si l'on considère que des variations du recrutement, non liées à la pêche, ont été observées.

MOTS-CLÉS : *Penaeus semisulcatus* — Relation stock/recrutement — Golfe Persique.

INTRODUCTION

The catches from the shrimp stocks of the Gulf between Iran and the Arabian peninsula (the majority of which are *Penaeus semisulcatus*) have been declining since reaching a peak in the late 1960's, resulting in the closing down of most of the fishing companies in the Gulf.

Various suggestions for the decline have been made, ranging from recruitment overfishing to environmental degradation (VAN ZALINGE, 1980), although unequivocal conclusions are made difficult by the lack of reliable data, particularly for the early years of the fishery.

The last FAO/UNDP workshop (FAO/UNDP, *in press*), held in the Kuwait Institute for Scientific Research, has been an occasion for review of all the data sets available in order to identify the best possible one. The data were used for the elaboration of two production models for the Kuwait and Saudi Arabia shrimp stocks.

It can be seen from figures 1 and 2 that a charac-

(1) Paper presented at the workshop on the scientific basis for the management of penaeid shrimps; Key West (Florida), 18-24/11/1981.

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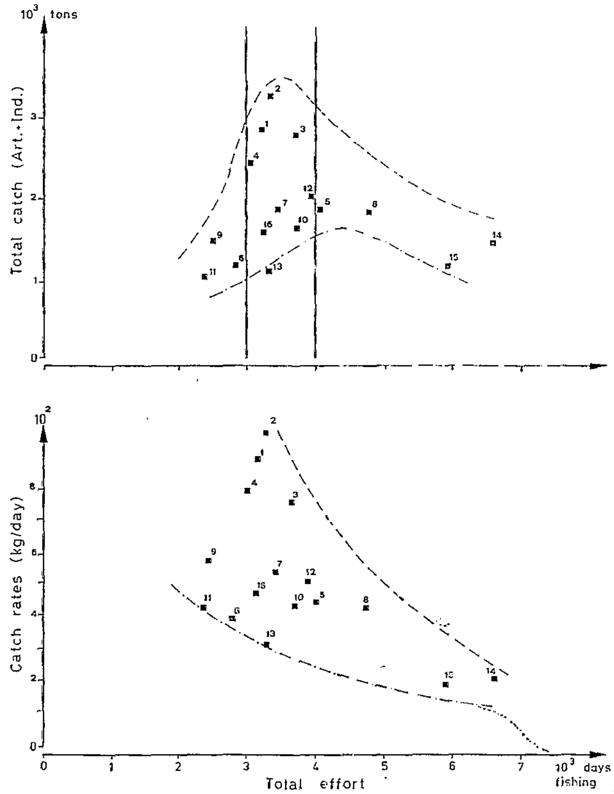

FIG. 1. — Production model for the Kuwait shrimp fishery showing the relationship between catch and effort (above) and catch rates and effort (below). Dotted lines are eye-fitted limits. Solid lines enclose the years during which effort has been relatively constant. Years are indicated 1-16, beginning in 1965-66 (*from* FAO/UNDP, *in press*)

Modèle de production de la pêcherie de crevettes du Koweït, montrant la relation entre capture et effort (en haut) et taux de capture et effort (en bas). Les tiretés constituent des limites fixées « à l'œil ». Les années pendant lesquelles l'effort a été à peu près constant se trouvent entre les deux lignes pleines. La chronologie des années est indiquée par les nombres 1 à 16, débutant en 1965/66 (d'après *FAO/UNPD,* in press)

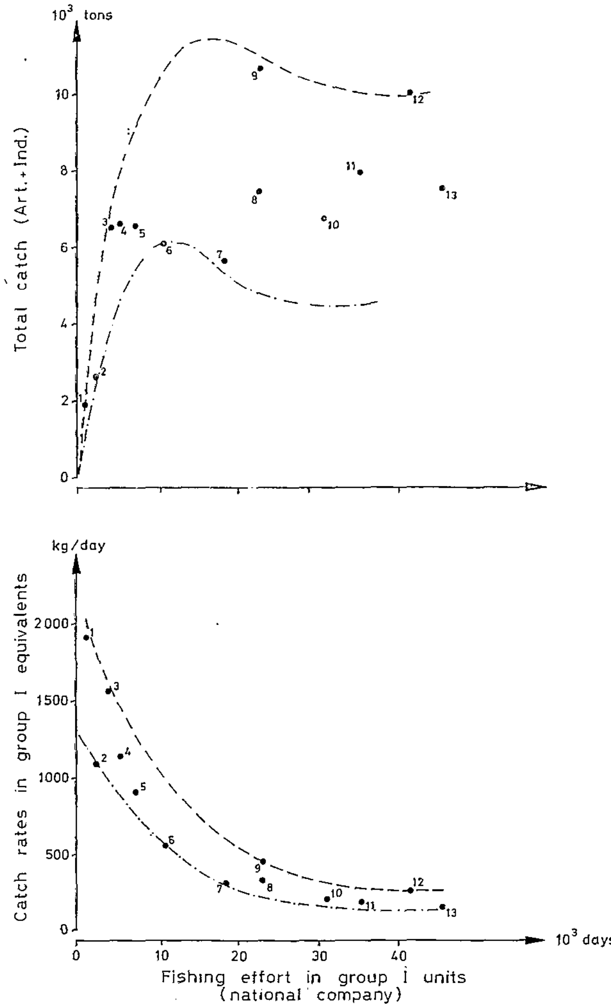

FIG. 2. — Production model for the Saudi Arabian shrimp fishery showing the relationship between catch and effort (above) and catch rates and effort (below). Dotted lines are eye-fitted limits. Years are indicated 1-13, beginning in 1965/66 (*from* FAO/UNDP, *in press*)

Modèle de production de la pêcherie de crevettes d'Arabie Saoudite, montrant la relation entre capture et effort (en haut) et taux de capture et effort (en bas). Les tiretés constituent des limites fixées « à l'œil ». La chronologie des années est indiquée par les nombres 1 à 13, débutant en 1965/66 (d'après *FAO/UNDP,* in press)

teristic of these two models is the wide variation in catches observed for a given level of effort. The phenomenon is more clearly seen in the Kuwait data where the effort has remained at about the same level for a long period of time. Since the shrimp remain in this fishery for only one year following the short period of recruitment of the main cohort, all the data points can be considered as in equilibrium and the departure from the trend are probably due, mainly, to changes in recruitment.

The analyses presented here are only preliminary. When more refined estimates become available in the future (particularly on spawning stock abundance), the analysis should be repeated in order to confirm the result. It is felt however that the main trends will remain.

METHODS

The measure of recruitment is always a difficult problem. It may however be overcome in the case of penaeids by using the following methods:

(a) dividing the yearly catch (in a biological year starting with recruitment) by the yield per recruit calculated from a knowledge of q (catchability coefficient) or F (fishing mortality), M (natural mortality), K and L∞ (Von Bertalanffy growth parameters) and L_c (size at the first capture); this procedure, advised by PAULY *(in press)*, is particularly useful for shrimp where the catch of the year is the product of a single recruitment pulse;

(b) dividing the catch-effort relationship by the yield per recruit function; as pointed out by SCHAEFER (1968), if a production model relating annual catch to annual fishing mortality is available (with a reasonably long set of data), and if the yield per recruit function against F is also known, the ratio of the equilibrium catch on yield per recruit for the range of F available provides the relation between R, the equilibrium recruitment, and F; since the relation between F and stock size is known from the production model, a relationship between abundance and recruitment can be calculated. The approach is very similar to the first one proposed by PAULY (see above); the validity of the stock-recruitment relationship obtained will largely depend on the accuracy of the production model available and it must be noted that the shape of the stock-recruitment relationship will partly be determined by the type of production model used (Fox or SCHAEFER, etc.); therefore, only good fits should be used and no extrapolation out of the range of data available should be considered;

(c) using annual catches or catch rates for periods of time when the fishing effort can be taken as reasonably constant;

(d) using the catch rate at the beginning of the fishing season in cases where the recruitment is limited to a short part of the year; this index of abundance is not significantly affected by fishing and is a good index of recruitment if the size/age at recruitment is fairly constant from year to year.

The clear advantage of these two last indices is that they are based on observed data and are not obtained by computations requiring additional hypothesis. They are therefore useful for checking the reliability of the other indices.

The methods described under *a*, *c* and *d* have been used in the present paper.

Estimation of recruitment

Available information on the age at entry to the fishery and the growth parameters W∞ and K have been used in conjunction with an estimate of the natural mortality rate M of 3 (calculated according to the method of PAULY, 1980) to calculate values of expected yield/recruit for each annual fishing mortality value for the years 1965/66-1980/81. Observed fishing effort values (in boat days) for each year had previously been converted to fishing mortality values using an estimate of the catchability, q of 0.00039 calculated by GARCIA and VAN ZALINGE *(in press)*, using a procedure derived from the "swept area" concept.

Recruitment to the fishery in Kuwait was estimated by dividing the observed catch during a biological year by the estimated yield per recruit for that year. The effects of an artisanal fishery starting in 1972 (using a smaller mesh size than the "industrial" fleet) and of the implementation of a five month closed season during the 1980-81 fishing season were taken into account by appropriate adjustments to the age at entry to the fishery. This recruitment index is affected by fishing since the annual value of F is used for the estimation of Y/R.

In addition to this calculated estimate of recruitment, the catch rate (in lbs of tails/boat day) for the first month of each season has also been used as an index of recruitment. This data was available for both the Kuwait and for the Saudi Arabian stocks and is largely independent of the level of fishing effort in the current year.

Finally, for Kuwait the yearly average catch rate observed in years when the effort stayed relatively stable (between 3 to 4×10^3 days, see fig. 1) has also been used for comparison.

Estimation of Spawning stock

The mean annual catch rate has been used as a first approximation to the abundance of the spawning stock each year. This introduces an error, the magnitude of which is related to the fishing effort although simple simulations indicate that, within the range of fishing mortality values observed in the years 1965/66-1980/81 the range of this error is small.

A better approximation of the spawning stock abundance might be the catch rate during the main spawning season.

RESULTS

The trends in the recruitment values and other indices for the Kuwait shrimp stocks were in close agreement (fig. 3).

Similarly, the recruitment index for Saudi Arabia (unfortunately not available for the very recent years) is in agreement with those from Kuwait. This is shown in fig. 4 where calculated recruitment

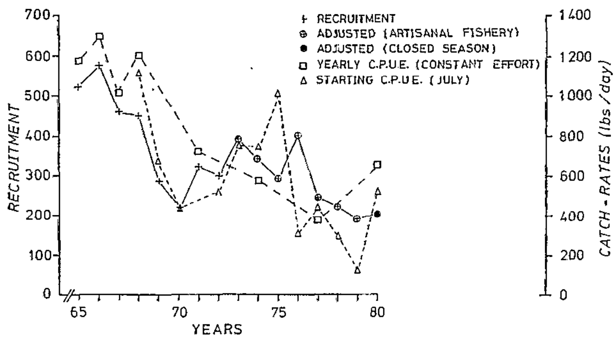

FIG. 3. — Trends in the various indices of recruitment for the Kuwait shrimp fishery

Tendances des divers indices de recrutement de la pêcherie de crevettes du Koweït

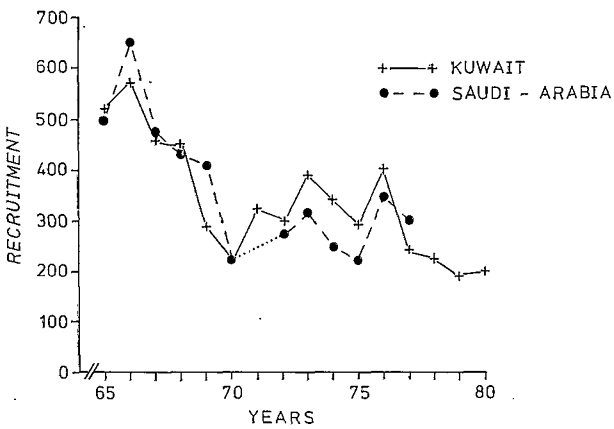

FIG. 4. — Comparison of recruitment trends in Kuwait and Saudi Arabia

Comparaison des tendances du recrutement au Koweït et en Arabie Saoudite

values (catch/(Y/R)) for Kuwait are compared with the observed catch rates at the beginning of the season for Saudi Arabia. Both data sets indicate a general decline in recruitment to the fishery during the period 1965/66-1980/81 despite a temporary partial recovery from 1970 to 1975/76.

Fig. 5 shows the relationship, for the Kuwait fishery, between the abundance of the spawning stock in one year and the resulting calculated (and adjusted) recruitment the following year. Within the observed range of spawning stock abundance, the relationship between spawning stock and subsequent recruitment is apparently quasi-linear.

CONCLUSION AND DISCUSSION

It is interesting to note that the decreasing trends in recruitment observed in Kuwait and Saudi

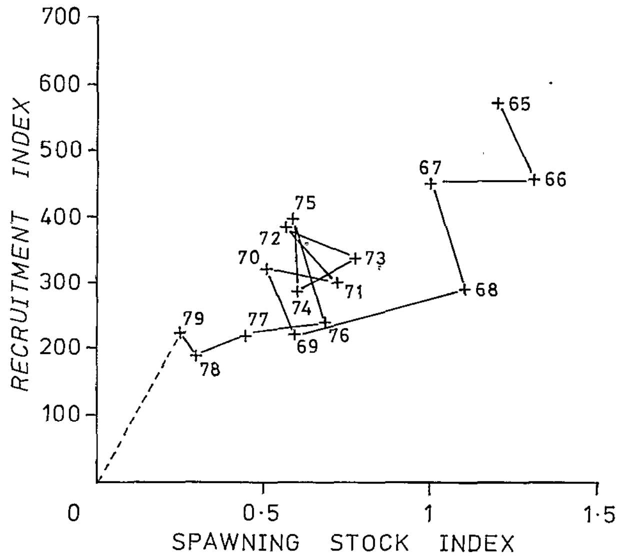

FIG. 5. — Relationship between spawning stock and resultant recruitment for the Kuwait shrimp fishery, 1965/66-1979/80

Relation entre le stock reproducteur et le recrutement qui en résulte, dans la pêcherie de crevettes du Koweït, de 1965/66 à 1979/80

Arabia show very similar patterns, despite a rather different history in terms of effort development. In addition, a decrease in recruitment is observed in Kuwait even when the effort can be considered as constant.

This can be taken as an indication that the reason for the recruitment decrease since the beginning of the fishery might have to be found largely in changes in the environment which can be either periodic (rainfall, etc.) or aperiodic (trends such a land reclaimation, decrease in Shott-el-Arab outflow by damming, etc.).

Concerning the apparent linear stock-recruitment relationship it should be noted that:

(a) it may come from the fact that both the stock size (C/f) and the recruitment R=C/(Y/R), used as dependent and independent variables, are affected by the annual fishing mortality exerted (F and f respectively); however the fact that this recruitment index follows similar trends as other recruitment indices more clearly independent of fishing (cf. fig. 3) indicates that this is not the main explanation. GARCIA *(in prep.)* analyses the importance of this effect in other sets of data;

(b) it may be an artefact for the following reasons:

— because of the existence of one year class only in the stock, the spawning biomass of one year is directly related to the recruitment at the beginning of that year;

— in that case a trend in Rn (recruitment at the beginning of year n) will induce a parallel trend in stock size Sn for any given level of fishing effort;

— as a consequence, the relationship between Sn and Rn+1 can be largely an artefact if a recruitment trend not related to fishing exists; GARCIA *(in press)* has shown that this apparent stock-recruitment trajectory in a single year class fishery will depend on both changes in recruitment unrelated to fishing (i.e. for "environmental reasons") and fishing effort.

In terms of management the consequence of these conclusions is that since recruitment is low, any measure likely to improve it is advisable. However, the success of the measure will largely depend on the extent to which the recruitment trends are a result of fishing effort. If, as is suspected, recruitment is in fact not strongly affected by stock size (and effort), then only the reversion of the causal environmental factors (provided they are reversible) will allow for a suitable recovery of the fishery.

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