Fish School Structure of Red Sanppers and Bigeye Snappers in the South China Sea

by

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Abstract

Towards the end of 1971, a systematic trawl survey was made in a narrow restricted area within the MFRD Reference Area. Throughout all the hauls red snappers and bigeye snappers were dominant in catch, as observed commonly in the South China Sea, and in most cases they were caught together in the South China Sea, and in most cases they were caught together in every haul. Moreover, it was often observed that when either of them showed an extremely high catch, the other was extremely low. The above seems to suggest that the center of a fish school may not coincide with that of another species, but the domain occupied by the former is partly overlapped with that of the latter inhabiting adjacently.

Using a simple mathematical model, some characteristic values on an average dispersion pattern of the species of fish schools on whose circumferences 50 kg/hour could be expected are almost the same and are 5 to 6 nautical miles. The maximum catch of red snappers and bigeye snappers which could be expected at the centers of the respective fish schools are 210 and 270 kg/hour respectively.

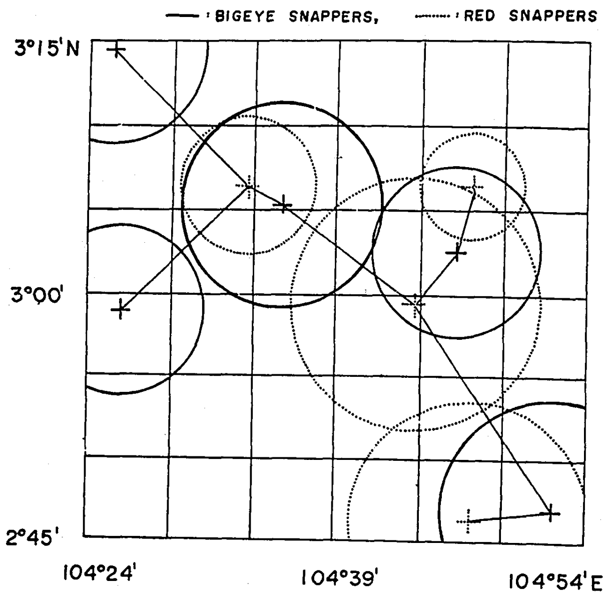

Fig. 2 Spatial arrangement of circular fish schools of red snappers and bigeye snappers.

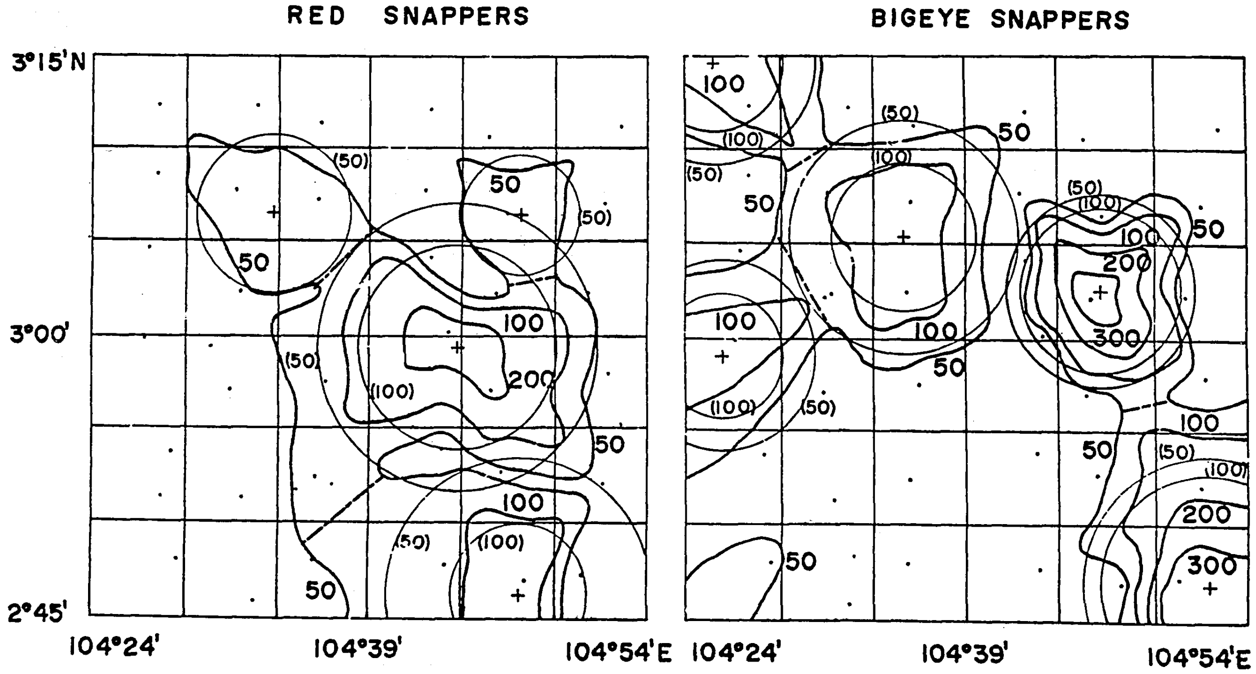

Fig. 1 Isopleths of catch and approximated circles for red snappers and bigeye snappers. Figures show densities of fish schools, parenthesized ones for circles.

Introduction

Red snappers, *Lutjanus* spp., and bigeye snappers, *Priacanthus*, spp., are the most dominant and economically important demersal fish species of trawl fishing in the southern part of the South China Sea. They constitute nearly 40% in weight of the total catch.

Both species are usually caught together in the same hauls. However, it has been frequently observed that when either of them shows extremely high catch, the other is extremely low. This suggests that some relationship on the spatial dispersion pattern exists between red snappers and bigeye snappers.

Intensive trawl fishing in small confined area

Towards the end of 1971, a series of experimental trawl fishing was conducted in a narrow restricted area, enclosed by 2°45'N and 3°15'N in latitude, and 104°24'E and 104°54'E in longitude. In this area iisobaths run from northwest to southeast and the depth increases gradually towards the northeast. However, the bottom is almost flat and the depth ranges 60 to 55 m. in most parts within the area. During the period a current of about one knot flowed in a southerly direction, because of the prevailing northeast monsoon.

The whole area was covered with thirty-six hauls of about one hour each for the first six days, and the research was repeated in certain areas with a further ten hauls durihg the last two days. The location of each trawl operation was arranged in almost equi-distance. As has been commonly observed in the South China Sea, red snappers and bigeye snappers were dominant and were caught together in most hauls.

Observed dispersion pattern of red snappers and bigeye snappers

Using the data of the first thirty-six hauls, the isopleths of catch were drawn for the respective species of fish. The dispersion patterns of both species shown by the isopleths suggest the existence of some fish schools for the respective species (Fig. 1). Although the patterns are irregular in size and shape, each fish school could be approximated to some isolated or partly overlapped circles. In the figure the circles of 50 and 100 kg/hour are illustrated.

The circles approximated to 50 kg/hour-contour for both species of fish are shown in Fig. 2. It is clearly seen that the circular fish schools of the two different species are overlapping. Another interesting feature is that the fish schools of both species were along the same isobath running from the northwest to the southeast corner of the trawled area.

Theoretical model

We introduce here a simple model that each fish species disperses to form several two-dimensional Gaussian distributions. Next we suppose that the two different species of fish schools A and B are located at a constant distance d between the centers of both fish schools, and the respective domains occupied by them are partly overlapping each other. For simplicity, our discussion will be confined to a one-dimensional problem (Fig. 3-a). Considering the coordinate system in Fig. 3-a, the following relation must be satisfied,

$$\xi + \eta = 1 \tag{1}$$

where $\xi = x/d$ and $\eta = y/d$. We distinguish between the densities of fish schools A and B by taking the subscripts A and B, and let the densities at the centers be ρ_0 and $k\rho_0$ for the species A and B respectively. Then we have the following relations:

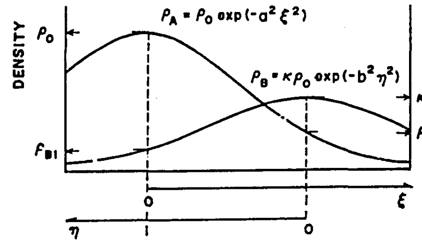

Fig. 3-a
Two adjacent fish schools overlapping each other.

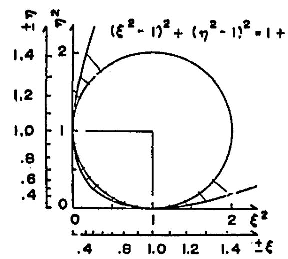

Fig. 3-b
Parabola
$(\xi^2 - 1)^2 + (\eta^2 - 1)^2$
$= 1 + 2\xi^2\eta^2$ shown
together with circle
$(\xi^2 - 1)^2 + (\eta^2 - 1)^2 = 1.$

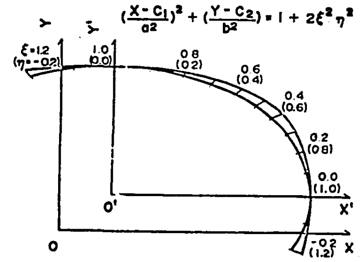

Fig. 3-c
Curve of
$(\frac{X - C_1}{a^2})^2 + (\frac{Y - C_2}{b^2})^2$
$= 1 + 2\xi^2\eta^2$ shown by
outer one and ellipse
$(\frac{X - C_1}{a^2})^2 + (\frac{Y - C_2}{b^2})^2$
$= 1$ by inner one.

$$\rho_A = \rho_0 \exp(-a^2 \xi^2) \quad (2)$$

$$\rho_B = k\rho_0 \exp(-b^2\eta^2) \quad (3)$$

where a and b are constants depending on the dispersion pattern. Denoting the densities of the fish schools A and B at $\xi = \eta = 1$ by ρ_{A1} and ρ_{B1} respectively, the following expressions can be obtained:

$$\frac{1}{a^2}(\ln \rho_A - \ln \rho_{A1}) = -(\xi^2 - 1) \quad (4)$$

$$\frac{1}{b^2}(\ln \rho_B - \ln \rho_{B1}) = -(\eta^2 - 1) \quad (5)$$

Taking the equation (1) into consideration, the above equations can be rewritten as follows'

$$(\frac{X - C_1}{a^2})^2 + (\frac{Y - C_2}{b^2})^2 = 1 + 2\xi^2\eta^2 \quad (6)$$

where $X = \ln \rho_A$, $C_1 = \ln \rho_{A1}$, $Y = \ln \rho_B$, and $C_2 = \ln \rho_{B1}$. Referring to Fig. 3-b and introducing a parameter $\theta = \tan^{-1}(1 - \eta^2)/(1 - \xi^2)$, the equation (6) can be solved graphically (Fig. 3-c). As shown in the figure, the curve of the equation (6) is in contact with an ellipse at the apices $(C_1, C_2 + b^2)$ and $(C_1 + a^2, C_2)$. The center of the ellipse is at the point (C_1, C_2) on the $X - Y$ plane and the major and minor axes are $2a^2$ and $2b^2$ respectively.

Assume that we collect samples continuously moving along the ξ –axis in Fig. 3-a. When either catch from the fish school A or B thus obtained is plotted against the other on a double-log section paper, the plots should align to form the curve given by the equation (6). From the curve we can determine all the constants contained in the equation (6). Moreover, equating the equations (2) and (3) and eliminating ρ_0, we can obtain the relation between the relative sizes of the two fish schools:

$$a^2\xi^2 - b^2\eta^2 = \ln(1/k) \quad (7)$$

From the equations (6) and (7), we can estimate the densities and the relative sizes of the fish schools. When the distance between the centers of fish schools is dtermined by the other method, the size of fish schools can be given in absolute values.

Results and Discussion

The catch of red snappers in each haul was plotted against that of bigeye snapper of the same haul on a double-log graph paper. As shown in Fig. 4, the plots distibute widely on the graph paper in such a manner that they cover almost the whole area enclosed by the rectangular axes and the outermost plots arranged to form nearly a part of an ellipse-like curve. The plots arranged in the outermost region and formed a part of the curve can be regarded as the similar ones to those on the axis connecting the centers of fish schools in the theoretical model. Actually the locations from which these plots were obtained were arranged almost linearly along the diagonal connecting the northwest and southeast corners of the area trawled. The other plots scattered in the inner part could be interpreted as the data at locations off the axis. Emphasis should be placed on that in the model we have dealt with a simple case of two fish schools. Actually, however, there are many fish schools for the respective species, therefore the curve from the actual data can be regarded as that of an average pattern for many fish schools.

As mentioned before, the curve of the equation (6) is in contact with an ellipse at its two apices. Therefore, once the coordinates of the apices are determined, the curve of the equation (6) can be given graphically. In the proximity of the two apices $(C_1, C_2 + b^2)$ and $(C_1 + a^2, C_2)$ the elliptic curve could be approximated by the parabolas $Y = a_0 + a_1X + a_2X^2$ and $X = b_0 + b_1Y + b_2Y^2$ respectively.

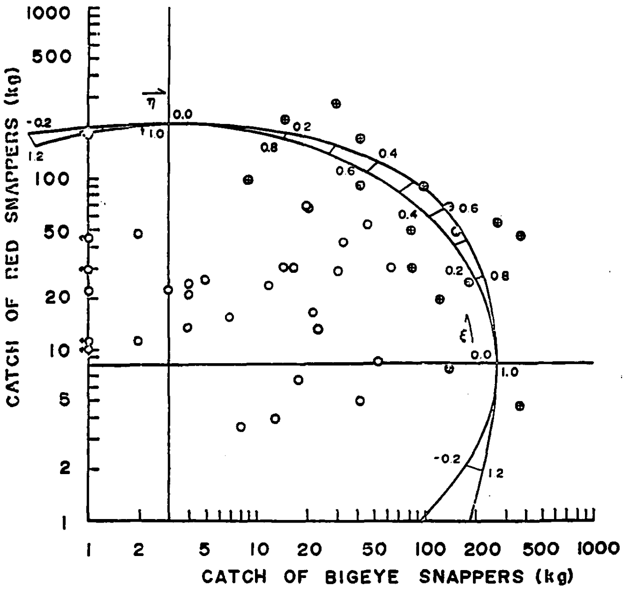

Fig. 4 Catch of red snappers plotted against that of bigeye snappers. Theoretical curve is approximated to outermost seventeen plots.

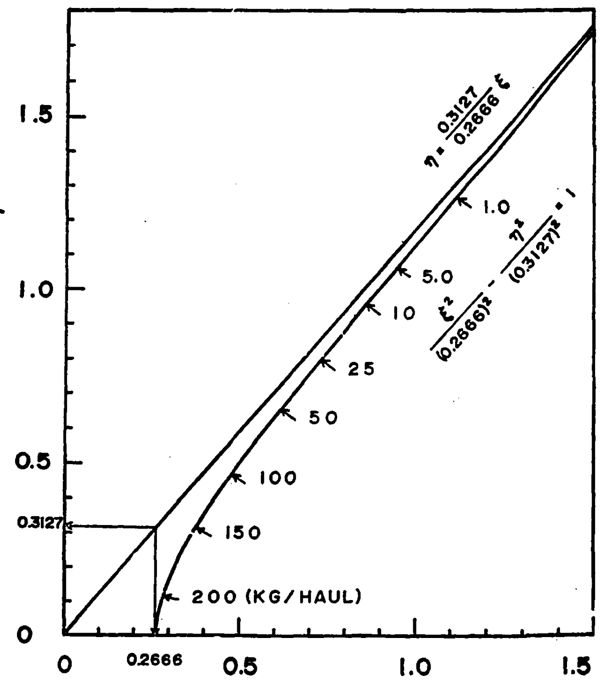

Fig. 5 Relation between relative sizes of fish schools of bigeye snappers and red snappers on an averaged pattern. Figures are for respective levels of densities of fish school.

Seventeen plots arranged in the outermost part on the double-log paper were selected arbitrarily and to these plots the above parabolas were fitted by the method of least squares. Thus the coordinates of two apices and therefore the constants C_1, C_2, a^2 and b^2 in the equation (6) were obtained. In Fig. 4 the curve of the equation (6) is shown together with the ellipse. The characteristic values thus obtained for the dispersion pattern of bigeye snappers and red snappers are as follows,

Bigeye snappers: $\rho_0 = 270$, $\rho_{A1} = 3$, $a^2 = 4.500$,

Red snappers: $\kappa\rho_0 = 210$, $\rho_{B1} = 8$, $b^2 = 3.268$,

where the densities are given in kg/hour. Substituting the constants $a^2 = 4.500$, $b^2 = 3.268$, and $1/\kappa = 1.377$ into the equation (7), we have the following numerical relation between ξ and η :

$$\frac{\xi^2}{(0.2666)^2} - \frac{\eta^2}{(0.3127)^2} = 1 \qquad (7)$$

The above relation is hown in Fig. 5 and in the figure different levels of densities of fish schools are inserted. From the figure the radii of circular fish schools of bigeye snappers and red snappers on whose circumferences 100 kg/hour catch could be expected are 0.48 d and 0.47 d respectively, where d is the mean distance between the centers of fish schools for the two different species located adjacently, while the radii for 50 kg/hour are 0.62d and 0.65d respectively.

From Figs. 1 and 2, each distance between the centers of two adjacent circles occupied by the different species was measured and the mean d was calculated to be 8.0 nautical miles. The radii of the two different fish schools on whose circumferences 50 and 100 kg/hour catch could be expected were measured and their means were calculated. The theoretical and observed radii for the respective species are compared in Table 1.

Table 1. Comparison between estimated and observed radii of circular fish schools

Species	for 50 kg/hour		for 100 kg/hour	
	Estimated	Observed	Estimated	Observed
Bigeye snappers	5.0	5.7	3.8	4.1
Red snappers	5.2	5.5	3.8	4.4

Raddi are given in nautical miles

The theoretical values are lower than the observed ones but the difference between them are at most 15%. Such a degree of discrepancy may be permissible when the accuracy of field data is taken into account.

Conclusion

Using a simple mathematical model, some characteristic values on an averaged dispersion pattern of red snappers and bigeye snappers were estimated, and comparison was made between the theoretical and the observed ones. The agreement between them is satisfactory within a range of practical accuracy. Summarising, the radii of fish schools for both species on whose circumferences 50 kg/hour could be expected are almost the same, and are 5 to 6 nautical miles. The mean distance between the centers of the two fish schools located adjacently is about 8 nautical miles. The maximum catch of red snappers and bigeye snappers which could be expected at the centers of the respective fish schools are 210 and 270 kg/hour respectively.

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Preliminary Observation on the Distribution and Catch of the Shovel-Nosed Lobster, *Thenus orientalis* Lund in South China Sea

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Abstract

The shovel-nosed lobster, *Thenus orientalis* lund, is a widely distibuted and a commercially important crustacean in the South China Sea. To study its habitat, distribution and catch the data obtained by trawl operations carried out by Thai research vessels in 1967–1968 and by R/V CHANGI in 1972 were analysed.

In the South China Sea it is most abundant in the coastal waters of the Malay Peninsula, South Vietnam and Sibu Bay of Sarawak at depth of less than 50 m. and relatively good catch has been obtained from waters with sandy rather than muddy bottom. The catch at night time is higher than that in the daytime. This phenomenon may be related to the feeding behaviour of this species as observed in the case of prawn.

1. Introduction

The shovel-nosed lobster, *Thenus orientalis* Lund, a commercially important crustacean, is commonly found in the tropical and subtropical waters. Although it is abundant and has become valuable in the Southeast Asian countries, very little is known about the species. In view of its importance the Marine Fisheries Reseatch Department, Southeast Asian Fisheries Development Center (SEAFDEC), carried out preliminary studies on its habitat and distribution in the South China Sea.