TEMPORAL CHANGES IN PELAGIC BIOMASS OF *PLEURONCODES PLANIPES* STIMPSON (DECAPODA ANOMURA, GALATHEIDAE) OFF BAJA CALIFORNIA, MEXICO

BY

MAURICE BLACKBURN

Institute of Marine Resources, University of California, La Jolla, California, U.S.A.

Adults of the galatheid *Pleuroncodes planipes* Stimpson are very abundant off the west coast of Baja California, Mexico (Boyd, unpublished; Longhurst, 1967; Blackburn, 1969). They occur in the water column and on the bottom; the largest are exclusively benthic (Boyd, 1967). Vernacular names include "red crab" and "langostilla".

Blackburn & Thorne (1974) reported preliminary studies of pelagic nekton of a small area off Baja California from April 11 to April 30, 1973. *Pleuroncodes planipes* comprised 90% or more by weight of each of their samples, which were obtained with a micronekton net. The remainders were fish, mostly anchovy (*Engraulis mordax* Girard). A cooperating Soviet research vessel obtained very similar results with a commercial-sized pelagic trawl. It was concluded that the pelagic nekton was almost entirely *Pleuroncodes*. Its biomass in several net hauls was compared with simultaneous acoustic measurements of nekton in the water column. A significant linear regression was found, and was then used to estimate biomass from acoustic data alone. Temporal changes in the biomass were discussed in a preliminary way.

The present paper analyzes changes in the mean pelagic biomass of *Pleuroncodes planipes* in more detail from the collected samples, which were not dealt with before. Data on size-composition and growth of *P. planipes* are presented.

METHODS

The micronekton net used was the same as the 1.5 m net described by Blackburn (1968, 1969) except that it was smaller, namely 1.22 m on each side of the square mouth. It was hauled at 9.3 km/hr. A filtration coefficient (water acceptance) of 75%, as found by Blackburn for the 1.5 m net at the same speed, was assumed. Volume of water strained was estimated from the mouth-area, horizontal distance towed, and filtration coefficient. Some hauls were oblique through the 0-50 m layer and others were horizontal at some desired depth. Details of hauls, not important here, were given by Blackburn & Thorne (1974). Displacement volume of *Pleuroncodes* in each sample was measured immediately after capture, yielding concentrations in ml/m^3. They were finally expressed in g/m^3, assuming a mean wet weight of 1 g/ml.

About 140 *Pleuroncodes* were preserved in formalin from the catch of each net haul which contained that many. The preserved individuals were selected at random. They were later measured for total carapace length (TCL) as defined by Boyd (unpubl). This is the length of carapace from its posterior midpoint to the tip of the rostrum. According to Boyd this measurement is 1.29 times the measurement he called standard carapace length (SCL), in which most of his results are given. SCL is essentially TCL minus length of rostrum. Fig. 2 gives a conversion from TCL to SCL.

Acoustic data were obtained with a 120 kHz Simrad Scientific Sounder. The transducer (down-looking) was mounted in a 1.22 m Braincon V-fin and towed over the stern at 10 m below the surface. Echo signals were processed with the Digital Data Acquisition and Processing System (Moose, Ehrenberg & Green, 1971; Moose, Thorne & Nelson, 1971). The system integrated the signals in 10 contiguous depth intervals each of 10 m width, beginning 7 m below the transducer (17 m below sea surface). Integrations were digitally output every 10 minutes. Acoustic data were not obtained in the 0-17 m water layer, because no up-looking transducer was available.

Fig. 1 shows the ship tracks 1 to 4 along which net hauls were made. The tracks were covered successively for net hauls on the 4 dates shown in fig. 2 and table II. Track 4 was used also in making the repetitive acoustic surveys of the area, on the 8 dates shown in table I.

All net haul and acoustic data presented in this paper were obtained at night. Night operations were preferred because part of the biomass was expected to be on the bottom during the day, as was the case for the single acoustic survey that was made by day. On that occasion (April 30) mean biomass at 17 m to bottom was 59 g/m³, compared with 100 and 102 g/m³ for the same track on the two adjacent nights (table I).

TABLE I

Estimated mean pelagic nekton biomass (g/m³) in different parts of the water column: based on acoustic data except as stated

Level (m)	April 11-12	April 16-17	April 17-18	April 18-19	April 26-27	April 28-29	April 29-30	April 30-May 1
0-17	10*	0*	+	+	+	4*	4*	4*
17-47	74	35	19	46	61	45	44	60
47-bottom	19	63	28	27	48	70	56	42
Total:	103	98	47†	73†	109†	119	104	106

* Based on net hauls at 10 or 20 m on the same night or an adjacent night.
+ Unknown, assumed low.
† Possibly too low because of +.

RESULTS

Table I gives the best available estimates of mean biomass of pelagic nekton, assumed to be entirely *Pleuroncodes planipes*, along track 4 on the 8 nights when it was traversed. Biomass actually on the bottom is not included, because it was unmeasureable by the methods used. Values are in g/m³. Estimates for the
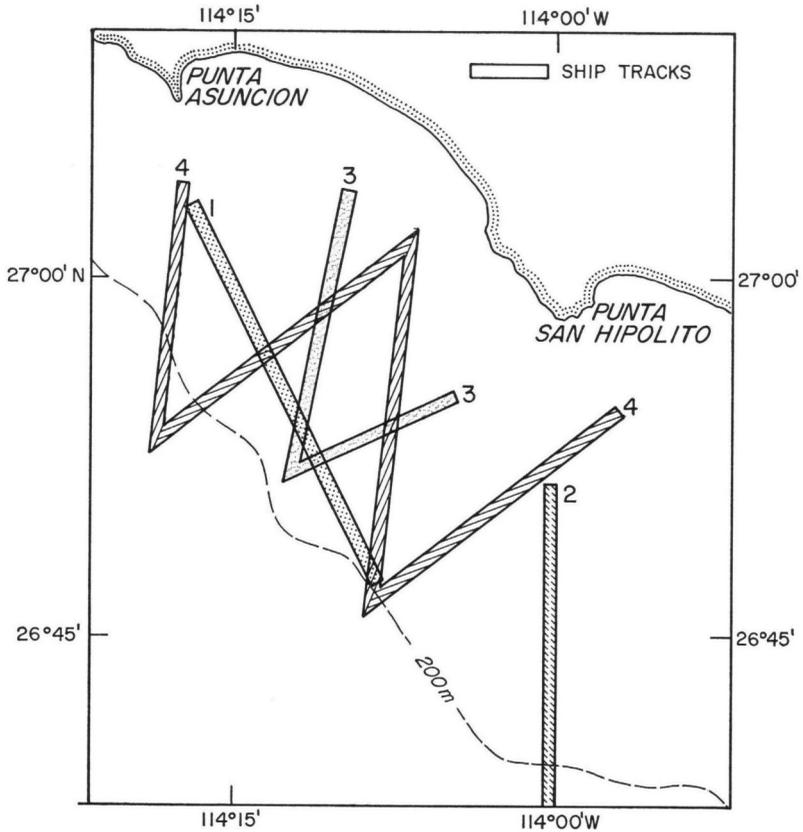
Fig. 1. Area of study, showing ship tracks 1 to 4 on which net hauls were made. Repetitive acoustic surveys were also made on track 4.

0-17 m layer are based entirely upon net hauls and are not available for all dates.

Mean biomass for the whole water column was almost the same at the beginning and end of the period, but it fell and then partly rose again during a series of three nights during the period, at least below 17 m (April 16/17 to April 18/19, table I). These changes occurred so suddenly that they have been ascribed to movement of part of the *Pleuroncodes* population down to and then up from the bottom (Blackburn & Thorne, 1974). The biomass at 17 to 47 m declined and rose again over the same period, indicating a general downward and then upward movement of *P. planipes*.

It is now possible to analyze these changes in pelagic biomass in more detail, utilizing length frequency data of *P. planipes* in preserved samples taken from the net hauls. Length frequency curves were generally very similar for samples taken on the same night, regardless of locality and depth. Thus all samples taken on the same night were combined. From 7 to 11 samples were obtained on each of 4 nights. Fig. 2 shows the resulting 4 length frequency curves on a percent basis, unsmoothed.

Fig. 2 shows a length-group (I) which agrees in size with the principal group recognized by Boyd (unpublished) in a study of *Pleuroncodes planipes* from Baja California. According to Boyd this group is slightly over one year old in April. The reproductive season is November to April with a peak in February. The young of the year of birth are still small plankters in April and thus are not represented in my samples. The shape of the curves indicates the existence of a second group (II) over about 21 mm SCL. The crabs in this group are too large to be one year old, but it is not certain that they are two years old. Boyd (unpublished; 1967) recognized a group at 25 to 32 mm SCL which he considered to be about two years old, but these were larger than my group II and exclusively benthic.
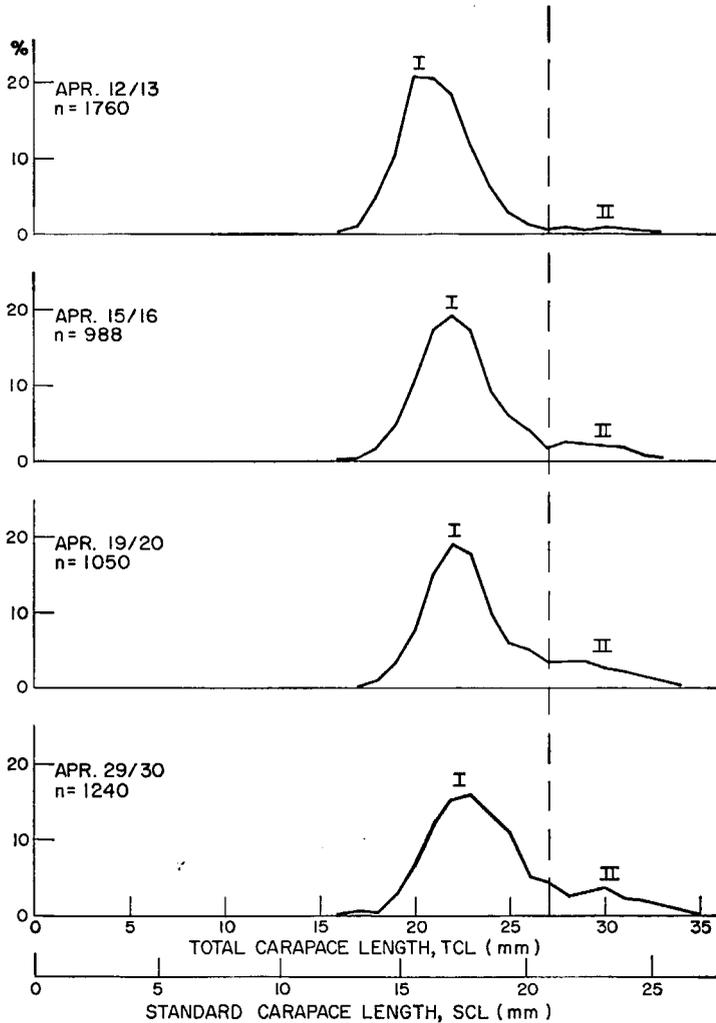

Fig. 2. Length frequencies (%) of *Pleuroncodes planipes* Stimpson in combined samples (total = n) on the stated dates. The broken line approximately separates size-groups I and II.

In fig. 2 it is assumed for convenience that groups I and II are separated at 27 mm TCL, and half the measurements at that size were assigned to each group. TCL means for groups I and II were converted to mean SCL, and then to mean live weight from data of Boyd (unpublished). Shrinkage of preserved specimens before measurement was ignored in making the conversions, because the carapace should not shrink much.

Table II gives means of TCL, SCL, and weight, and also the percent of total biomass represented by each size-group by number and weight. Mean SCL for

TABLE II

Means of total carapace length (TCL), standard carapace length (SCL) and live weight (W) for size-groups I and II of samples; also % of groups I and II in samples by number (n) and weight

Sample Date	Group	TCL (mm)	SCL (mm)	W (g)	% n	%W
April 12-13	I	21.17	16.41	1.94	97.4	92.8
	II	29.35	22.75	5.61	2.6	7.2
April 15-16	I	22.15	17.17	2.24	90.3	78.8
	II	29.35	22.75	5.61	9.7	21.2
April 19-20	I	22.45	17.40	2.35	84.3	68.9
	II	29.49	22.86	5.70	15.7	31.1
April 29-30	I	22.84	17.71	2.48	83.1	67.2
	II	29.87	23.16	5.94	16.9	32.8

group I increased from 16.4 to 17.7 mm in 18 days, equivalent to 2.2 mm per month. Similarly the estimated increase in SCL for group II is 0.7 mm per month. These are compared with Boyd's (unpublished) estimates of growth of *P. planipes* at 15-20 and 20-25 mm SCL, which were respectively 1.5-2.1 and 0.8-1.1 mm SCL per month. His observations were made on captive specimens which always had excess food. The present values are slightly higher than Boyd's for group I and slightly lower for group II, and are used below.

TABLE III

Estimated mean pelagic biomass (g/m³) in total water column for size-groups I and II at 4 periods: A, based on observed total biomass and percentages of it in groups; B, based on initial group biomasses from A extrapolated for growth, according to observed changes in mean weight

Method	Apr. 11/12-12/13 I	II	Total	Apr. 15/16-16/17 I	II	Total	Apr. 18/19-19/20* I	II	Total	Apr. 29/30 I	II	Total
A	95.6	7.4	103.0	77.2	20.8	98.0	50.3	22.7	73.0	69.9	34.1	104.0
B	95.6	7.4	103.0	110.4	7.4	117.8	115.8	7.5	123.3	122.2	7.8	130.0

* A values possibly too low; see table I.

One may now consider the following pairs of successive nights: April 11/12 and 12/13, April 15/16 and 16/17, and April 18/19 and 19/20. An estimate of biomass is available for one night in each pair and mean lengths and weights are available for the other night (tables I and II). It is assumed that biomass, length,

and weight did not change appreciably during each of these 2-day periods. In addition biomass, length, and weight data are available for the night of April 29/30. Then in table III one may compare: (A) observed biomasses of groups I and II in each of the 4 periods, from tables I and II, and (B) corresponding biomasses extrapolated from initial observed biomass, according to rates of growth in weight indicated in table II. The growth is considered to represent assimilation minus excretion minus moulting minus respiration. No allowance need be made for loss of gametes because it is negligible after March, as found by Boyd (unpublished) and me. Ovigerous *P. planipes* did not exceed 5% of the total number of specimens in any sample in this study.

DISCUSSION

Table III shows that the observed biomass of group I was always much less than the amount estimated from the growth rates. In fact it declined. The differences could be due to mortality, active or passive emigration from the area, and descent to the bottom. The very large difference for April 18/19-April 19/20 probably represents mainly a descent, for reasons already given. The difference for April 15/16-April 16/17 is perhaps too large because it is based on a suspiciously high apparent growth rate, i.e., from 16.4 to 17.2 mm SCL in 4 days. The data for April 29/30 show that the initial biomass of 96 g/m³ fell by 27% in 18 days, compared with an expected increase of 27% if there were no mortality or movement. These percentages are probably only approximate, because of the various sources of error and assumptions made.

Active emigration from the area seems unlikely because *Pleuroncodes* are weak swimmers, and food and other conditions appeared to be suitable for them. They are facultative herbivores and occur especially in upwelling areas, such as the one studied (Longhurst, Lorenzen & Thomas, 1967; Blackburn, 1969). The only sources of possible mortality noted were porpoises, some species of which eat *P. planipes* (W. Perrin, personal communication). Passive emigration by drift with currents was discussed by Longhurst (1967). It occurs but most of the known instances refer to *P. planipes* younger and smaller than group I. Longhurst speculated that individuals comparable to group I avoid being carried out of coastal areas by spending part of their time on the bottom.

If mortality or emigration or both actually reduced the biomass of group I by 27% in 18 days and continued at that rate, the biomass would be negligible by the end of August. However group I remains very abundant in the area studied at the end of August, despite the presence of additional abundant predators (tunas) in July and August (Blackburn, 1969, and unpublished). Thus the rate of reduction of biomass suggested in table III cannot be typical and may not have occurred at all. Much of the difference between observed and expected biomass of group I on April 29/30 is probably due to part of the biomass remaining on the bottom, i.e. the same explanation as for April 18/19-April 19/20.

The observed biomass of group II was always much higher than that expected

from the growth rates (table III). There must have been a net immigration of this group into the area or a movement up from the bottom, especially between the nights of April 12/13 and April 15/16 (fig. 2).

The maximum concentration of *Pleuroncodes* observed by Blackburn & Thorne (1974) was about 10 g/m³, much higher than previously reported. This was an average during 10 minutes in a water layer 10 m thick. It is of interest that still higher concentrations occur. The U. S. National Marine Fisheries Service made trawl hauls in April 1973 at Bahia Magdalena, another upwelling area on the Baja California coast, in water about 18 m deep. Assuming 100% water acceptance the mean concentration of *P. planipes* in 21 hauls was 34 g/m³ (S. Kato, unpublished).

RÉSUMÉ

L'échantillonnage pendant 18 jours de *Pleuroncodes planipes* a révélé des changements dans la composition par taille de la population adulte. Deux groupes, l'un âgé d'un an (I) et l'autre vraisemblablement de deux ans (II), ont été identifiés. La croissance de chaque groupe de taille s'accorde assez bien avec celles déterminées antérieurement. La mortalité et l'émigration étant sans doute suffisamment faibles, l'augmentation de la biomasse totale pendant la période d'observation a pu être déterminée à partir du taux de croissance en poids. Cependant la biomasse entre le fond et la surface de la mer, mesurée par échosondage, n'a pas changé au total. Celle du groupe I a diminué tandis qu'elle a augmenté dans le groupe II. On peut attribuer le changement affectant le groupe I à un déplacement d'une partie des individus vers le fond, où ils ne peuvent plus être mesurés par échosondage. Le changement survenu dans le groupe II peut s'expliquer soit par une immigration soit par une ascension en provenance du fond.

REFERENCES

BLACKBURN, M., 1968. Micronekton of the eastern tropical Pacific Ocean: family composition, distribution, abundance, and relations to tuna. Fish. Bull. U. S. Fish and Wildlife Serv., **67** (1): 71-115.

——, 1969. Conditions related to upwelling which determine distribution of tropical tunas off western Baja California. Fish. Bull. U. S. Fish and Wildlife Serv., **68** (1): 147-176.

BLACKBURN, M. & R. E. THORNE, 1974. Composition, biomass and distribution of pelagic nekton in a coastal upwelling area off Baja California, Mexico. Tethys, **6** (1-2): 281-290.

BOYD, C. M., unpublished. The biology of a marine decapod crustacean, Pleuroncodes planipes Stimpson, 1860. University of California, San Diego, 1962, doctoral dissertation, 123 p.

——, 1967. The benthic and pelagic habitats of the red crab, Pleuroncodes planipes. Pacif. Sci., **21** (3): 394-403.

LONGHURST, A. R., 1967. The pelagic phase of Pleuroncodes planipes Stimpson (Crustacea, Galatheidae) in the California Current. Rep. Calif. Coop. Ocean. Fish. Invest., **11**: 142-154.

LONGHURST, A. R., C. J. LORENZEN & W. H. THOMAS, 1967. The role of pelagic crabs in the grazing of phytoplankton off Baja California. Ecology, **48** (2): 190-200.

MOOSE, P. H., J. E. EHRENBERG & J. H. GREEN, 1971. Electronic system and data processing techniques for estimating fish abundance. Proc. I.E.E.E. Symposium on Engineering in the Ocean Environment: 33-36.

MOOSE, P. H., R. E. THORNE & M. O. NELSON, 1971. Hydroacoustic techniques for fishery resource assessment. Jour. Mar. Tech. Soc., **5** (6): 35-37.