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MEASUREMENT OF SECONDARY PRODUCTION IN MARINE AMPHIPODS BY MODIFIED HYNES METHOD

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ABSTRACT

The modified Hynes method of measuring secondary production, originally devised by freshwater ecologists, appears to be suitable for use with marine benthic amphipods. The main advantage of the method is that it does not require age, but only suitable size, classes as raw data. A method is also outlined which overcomes sieving selection on ≥0.8 mm^2 sieves. The method requires knowledge of the life history and reproductive bionomic details of the species studied as well as absence of significant migration by it from the study area.

Use of the modified Hynes method is demonstrated with data from the deposit-feeding amphipod *Casco bigelowi* and yields wet biomass values of 7.32 $g/m^2/yr$ and 1.62 $g/m^2/yr$ at two separate locations. P:B ratios for the same locations were 4.7 and 3.6, respectively.

INTRODUCTION

Increasing attention is being given to near-shore marine environments of the Continental Shelf because it is here that much of the world's fisheries are located and where resource-use conflicts most frequently arise. Examples of such conflicts are fisheries versus industrial waste or domestic sewage, fisheries versus mineral or oil extraction activities and fisheries versus tidal power development. Intelligent management of the Continental Shelf to minimize or eliminate conflicts requires at least a generalized spatial knowledge of the area to be managed.

Three important contributions to this knowledge from the sub-discipline of benthic ecology should be:

- A qualitative, or functional, description of defined areas of the Continental Shelf in terms of direct or indirect fisheries value. This requires a trophic analysis of the benthic communities present to understand their indirect value in fisheries production.

- A quantitative value of secondary production by the dominant, infaunal, benthic organisms present in a defined area.

- The response of benthic organisms to perturbing factors introduced by man's activities on the Continental Shelf.

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*Paper presented by Dr. Robert H. Cook

This paper is concerned with a practical method of achieving the second objective; that of measuring secondary, heterotrophic production by sublittoral organisms, particularly amphipods. This latter group (Class Crustacea, Order Amphipoda) has largely been ignored in making estimates of production and annual turnover ratios (Wildish and Peer, in prep.) and yet are often dominant benthic organisms as well as being an important component of the diet of bottom-feeding fish.

Three difficulties have to be overcome in making estimates of secondary production for amphipods. These are:

- Size selectivity of the sieve mesh used. Thus, small juveniles are not adequately sampled with an 0.8 mm^2 mesh sieve until they become 4-5 mm in body length.
- The difficulty of determining amphipod age other than by arbitrary size-class analysis (see Fig. 1.).
- The possibility of migration to, or from, the sample area studied.

The purpose of this paper is to describe a method which overcomes the first two of these difficulties and involves calculation of initial population density of the cohort by multiplying ovigerous female density by the mean brood number and use of the modified Hynes method to determine production. The Hynes method does not require age cohort analysis, although it does depend on a detailed knowledge of reproductive bionomics and life history. The Hynes method has been widely used and modified by freshwater ecologists (Hynes and Coleman 1968; Hamilton 1969, Benke 1979; Waters 1979).

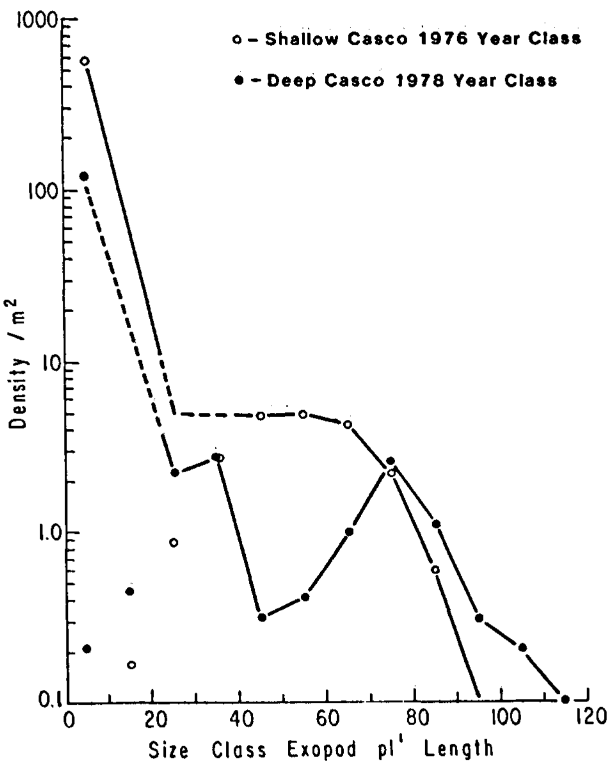

Fig. 1. Size classes, as length of the exopodite of the first pleopod (pl^1) in micrometer units (1 unit = 0.025 mm), and estimated or observed density of two populations of <u>Casco bigelowi</u>.

MATERIALS AND METHODS

Two sampling locations were used as follows:

- "Shallow" location. 45°09.3'N, 66°57.5'W in the Digdeguash estuary. The location was recognized by shore landmarks and 15-18 replicate grabs were taken on each of 11 trips from an anchored vessel between July 1977 and November 1979. Sampling depth varied between 4 to 12 meters depending on the stage of the tide (see #32 in Wildish et al. 1980).

- "Deep location." 44°55.7'N, 66°32.5'W in the Bay of Fundy. This location was marked with a permanently moored buoy to which the research vessel tied up during sampling. Ten to 20 replicate grabs were taken on each of the five sampling trips. Sampling depth ranged from 73-80 meters.

Grab samples were taken with the Hunter grab (Hunter and Simpson 1976) which has an 0.1 m^2 opening (31 x 31 cm), maximum digging depth of 16 cm and full volume of up to 16 litres of sediment slurry. Individual replicates were sieved on a 0.8 mm^2 mesh and sorted when they were transferred to 30% ethanol.

Individual amphipods were examined under a binocular microscope at 16-45X magnification, the first pleopod removed and mounted flat on a slide and the outer ramus or exopodite measured by micrometer. Length measurements are in micrometer units (1 unit = 0.025 mm). The eggs of individual ovigerous females were counted where a complete brood was present and other reproductive data collected as described by Wildish (1980). Wet weights of individual Casco were determined on subsamples after lightly blotting the ethanol-preserved specimens. Body length was also measured in these individuals on the stretched length from the tip of the telson to the anterior part of the cephalon.

RESULTS

Shallow location

The size/frequency histograms for temporal sampling at this location (not shown) are based on 238 replicates and 502 individual Casco. Size sampling bias was evident up to pleopod 1 exopodite lengths of ~40 micrometer units (Fig. 1). This is caused both by loss on the sieve and because the smaller juveniles live deeper in the sediment (see Wildish 1980) and are inadequately sampled by the grab.

The initial population size is estimated as follows: for the July 1977 sampling date, there were 11 ovigerous females/m^2 with a mean body length of 19.5 mm. From the relationship previously determined (Wildish 1980) relating body length (X) against number of eggs per brood (Y): Y =51. Thus, 51 x 11 = 561 is the initial population size entered in Fig. 1 and the next three size-class densities are estimated as in Fig. 1 and the results entered in Table 1A with the observed densities of other size groups.

Mean wet weight biomass on a subsample of the population was determined as a function of the first pleopod, exopodite length (Fig. 2). The relationship is logarithimic and the mid-size class weight from the graph for each of the size groups is entered in Table 1A.

Table 1. Modified Hynes estimate of production for *Casco bigelowi*. A. Shallow location. B. Deep location. The numbered column captions are given at the bottom of the table.

A

1	2	3	4 mg	5 g/m2	6 mg	7 g/m2	8	9 g/m2
0-0.9	(561)	506	(0.5)	0.281	1.9	0.961	9	8.6490
1-1.9	(55)	50	3.2	0.176	6.6	0.330	9	2.9700
2-2.9	(5)	0.10	10.0	0.050	16.0	0.002	9	0.0180
3-3.9	(4.90)	0.15	22.0	0.108	30.0	0.005	9	0.0450
4-4.9	4.75	-0.25	38.0	0.181	47.5	-0.012	9	-0.108
5-5.9	5.00	0.71	57.0	0.285	69.5	0.049	9	0.441
6-6.9	4.29	2.06	82.0	0.352	98.5	0.203	9	1.827
7-7.9	2.23	1.64	115.0	0.256	137.5	0.226	9	2.034
8-8.9	0.59	0.59	160.0	0.094	195.0	0.115	9	1.035
			(230.0)					

B

1	2	3	4 mg	5 mg/m^2	6 mg	7 mg/m^2	8	9 g/m^2
0-0.9	(120)	105.0	(0.5)	60.0	1.0	105.0	12	1.2600
1-1.9	(15)	12.8	1.4	21.0	2.7	34.6	12	0.4152
2-2.9	2.2	-0.6	4.0	8.8	6.5	-3.9	12	-0.0468
3-3.9	2.8	2.5	9.0	25.2	11.5	28.8	12	0.3456
4-4.9	0.3	-0.1	14.0	4.2	18.5	-1.9	12	-0.0228
5-5.9	0.4	-0.6	23.0	9.2	29.0	-17.4	12	-0.2088
6-6.9	1.0	-1.8	35.0	35.0	43.0	-77.4	12	-0.9288
7-7.9	2.8	1.7	51.0	142.8	60.0	102.0	12	1.2240
8-8.9	1.1	0.8	69.0	75.9	79.0	63.2	12	0.7584
9-9.9	0.3	0.1	89.0	26.7	100.5	10.1	12	0.1212
10-10.9	0.2	0.1	112.0	22.4	123.5	12.4	12	0.1488
11-11.9	0.1	0.1	135.0	13.5	147.5	14.8	12	0.1776
			(160.0)					

1. Size group, 2. Density as No/m^2, 3. Loss at each size, 4. Mean biomass, 5. Standing crop, 6. Converison biomass, 7. Biomass lost, 8. Number of times loss occurs, 9. Production.

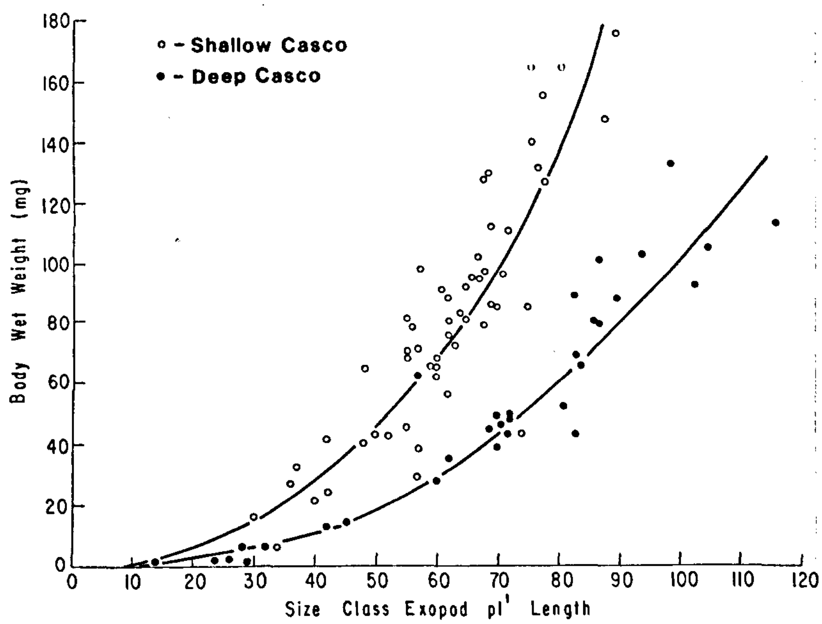

Fig. 2. Wet body weight and length of the exopodite of the first pleopod in micrometer units (1 unit = 0.025 mm) for two populations of Casco biglowi.

Procedure for calculations in Table 1.

Columns 1, 2 and 4 represent the raw data obtained as described above. Suitable size-class groupings for column 1 are those which give 8-20 groups.

Column 3 is obtained by subtracting the bottom value of the first pair in column 2, followed by successive pairs down the column. A negative value is recorded by the amount the bottom value is greater than the upper value.

Column 5 - multiply columns 2 and 4.

Column 6 - determined as half the sum of successive pairs of mean biomass values down column 4.

Column 7 - multiply columns 3 and 6.

Column 8 - each entry is equivalent to the total number of size groups used in column 1.

Column 9 - multiply columns 7 and 8.

The total of column 5 represents the standing crop as annual mean biomass (B) and of column 9 the total production ($\bar{P}$) for the period considered. To obtain the annual production (P), $\bar{P}$ must be multiplied by the production interval of Benke (1979) which for Casco bigelowi is 0.5, that is the generation time is 2 yr (Wildish 1980).

Thus:

P = 16.9110 x 0.5 = 8.4555 $g/m^2/yr$ and the annual turnover ratio (P/B) is: P/B = 8.4555/1.7825 = 4.7.

Deep location

The size frequency histograms (Fig. 3) for this location are based on a

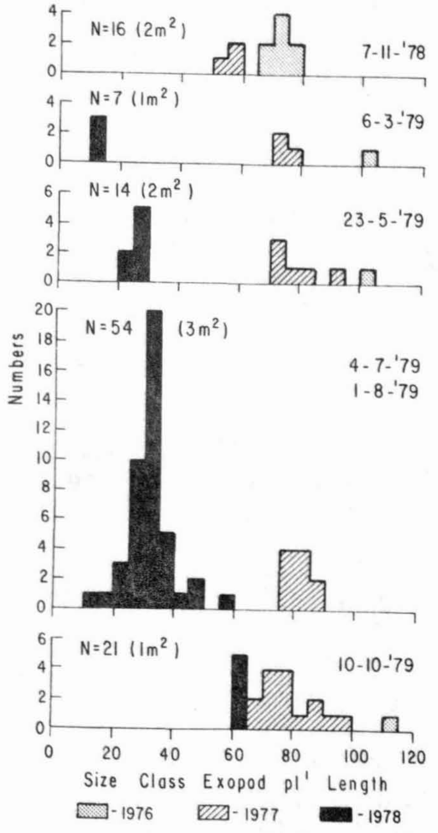

Fig. 3. Length frequency histograms for the exopodite of the first pleopod in micrometer units (1 unit = 0.025 mm). Numbers are not corrected to per m^2 and cohort classes are tentative estimates.

much smaller sample (112 Casco for a total area sampled of $9m^2$). Size-related sample bias was thought to involve only the first two size groups (Fig. 1) and to be due to sieving losses only. From knowledge of the sediments at this location (Wildish, unpubl.), it was known that only the top 10 cm of sediment were occupied by benthic animals and hence the grab adequately sampled Casco. However, Casco were sparsely distributed here, at a nearest neighbour distance equal or greater than the grab dimensions, thus, possibly resulting in uneven captures of some size groups. Since the results are also affected by the infrequent and small sample sizes, further sampling efforts are presently underway and the estimate presented here should be regarded as preliminary.

Initial population size is estimated from the ovigerous female density in November, 1978, which was $3/m^2$. These females had a mean body length of 15.0 mm and hence Y = 40 as estimated from the empirical relationship (Wildish 1980). Initial population size entered in Fig. 1 was therefore 3 x 40 = 120. Wet weight determination on a subsample of the deep population is shown in Fig. 2. For the same size class, the shallow population is considerably heavier than for the deep one. If body wet weight is plotted against body length, both populations follow the same trend (Fig. 4). This indicates that the deep Casco are more spindly in body shape, as well as lighter, than the shallower forms at the same exopod pleopod 1 length.

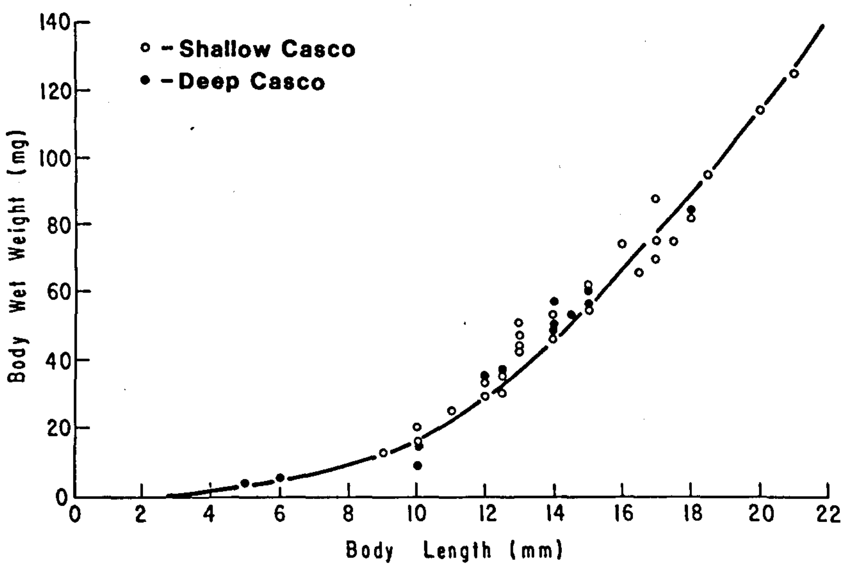

Fig. 4. Wet body weight and body length in subsamples of shallow and deep *Casco bigelowi*.

From Table 1B, $\bar{P}$ = 3.2436 and hence: P = 3.2436 x 0.5 = 1.6218 and the annual turnover ratio is: P/B = 1.6218/0.4447 = 3.6.

CONCLUSIONS

The validity of the estimates presented here (Table 2) depend on the fact that, during field sampling, measures of density are not affected by significant migrations into or out of the sampling area. This assumption

Table 2. Annual production and production:biomass turnover ratios based on wet weight data for *Casco bigelowi*.

Population	P annual	P:B
"Shallow"	7.3188	4.7436
"Deep"	1.6218	3.6470

does appear to be true at least for the shallow location, although two co-occurring amphipods, *Leptocheirus pinguis* and *Pontoporeia femorata* showed evidence of such migration (Wildish 1980).

Production at the shallow location is over 4X the value at the deep location although the difference in P:B ratio is less: the shallow being 1.3X greater than the deep location.

An independent assessment of the accuracy of the method with these data is not available. However, Cushman et al. (1979) in a computer simulation of a benthic insect population rated the method used here as close to ones in which age class distinctions could be made and mortality or growth followed throughout the life history.

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