Moulting and growth of *Euphausia pacifica* and *Thysanoessa spinifera* in the Northern California Current

C. Tracy Shaw[1], Leah R. Feinberg[1], Jaime Gomez-Gutierrez[2] and William T. Peterson[3]

[1]Cooperative Institute for Marine Resources Studies, Hatfield Marine Science Center, 2030 S. Marine Science Drive, Newport, OR 97365

[2]College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR 97331

[3]Northwest Fisheries Science Center, Hatfield Marine Science Center, 2030 S. Marine Science Drive, Newport, OR 97365

email: tracy.shaw@noaa.gov

INTRODUCTION

Oregon coastal waters are a dynamic upwelling system where conditions can change rapidly. Understanding vital rates of euphausiids is central to understanding how euphausiids are affected by this environment. In this study we looked at moulting and growth of *Euphausia pacifica* and *Thysanoessa spinifera*, the two most common species of euphausiids encountered in our study area. The moulting and growth experiments discussed here include both species and encompass life stages from juvenile to adult.

Moulting is an integral part of life for euphausiids. They moult in order to grow and develop and continue to moult throughout their adult life. They may grow, shrink or remain the same size after each moult. Moulting may even serve as a mechanism for removing toxins from their bodies. In this study we looked at how moulting and growth were related to time of year, body length of animal and chl *a* concentration.

Adult *T. spinifera* in the process of moulting.

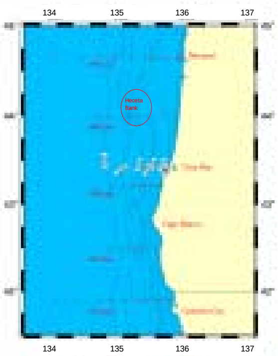


Fig. 1. Study area off Oregon and Northern California.

Cruise	Region	Station	Date	# euphausiids in experiment
MESO 1	SB	CR5	05/31/00	30
	CC	RP3	06/02/00	37
	CC	UR7	06/07/00	17
	CC	7A-2	06/08/00	29
MESO 2	SB	CR3	07/30/00	16
	SB	RR3	07/31/00	30
	CC	FM5B	08/02/00	28
	CC	FM4B	08/02/00	20
	HB	BOB3	08/04/00	33
	HB	BOB4	08/05/00	24
	HB	BOB2B	08/05/00	30
	CC	Z3	08/08/00	23
	CC	7A-7	08/09/00	29
	CC	7A-4	08/09/00	28
	SB	8A4	08/10/00	29
MESO 3	HB	BOB5	05/30/02	32
	SB	RR2	06/01/02	30
	SB	RR3	06/02/02	29
		PR3	06/03/02	29
	SB	CR4B	06/04/02	30
	NH	NH20	06/05/02	29
	NH	NH15	06/08/02	29
	SB	GD16	06/10/02	30
	SB	GD4	06/10/02	30
	SB	GD14	06/11/02	29
	SB	8A4B	06/12/02	28
	SB	RR5	06/13/02	29
	SB	RR8	06/13/02	29
	SB	RR6&CR7	06/14/02	29
	SB	9-5B	06/16/02	29
MESO 4	HB	BOB4	08/02/02	30
	CC	FM5B	08/03/02	29
	CC	FM7	08/04/02	30
	SB	9-7B	08/05/02	30
	SB	CR2	08/06/02	20
	SB	CR3	08/06/02	25
	SB	CR4	08/06/02	30
		EN3	08/07/02	22
		2-4	08/09/02	30
		2-5	08/09/02	30
	NH	NH20	08/09/02	29
	HB	HH3	08/10/02	30
ELAKHA	NH	NH20	03/12/01	19
	NH	NH20	07/18/01	25
	NH	NH20	07/30/01	29
	NH	NH20	08/05/01	28
	NH	NH20	01/29/02	15
	NH	NH20	01/29/02	36
	NH	NH20	03/27/02	30
	NH	NH20	04/30/02	30
	NH	NH25	03/12/01	17
	NH	NH25	04/12/01	21
	NH	NH25	05/18/01	39
	NH	NH25	06/26/01	27
	NH	NH25	07/30/01	28
	NH	NH25	08/05/01	28
	NH	NH25	09/18/01	29
	NH	NH25	03/04/02	19
	NH	NH25	05/09/02	30
	NH	NH25	07/23/02	30
LTOP	SB	CR2	04/07/02	23
	SB	CR4	07/31/02	28
	HB	HH4	09/10/01	23
	HB	HH5	09/09/01	24
	HB	HH5	04/09/02	31
	NH	NH25	04/05/02	30
	NH	NH35	09/04/01	29
	NH	NH35	02/20/02	26
		Total animals incubated		1873
		Average per experiment		28

Table 1. Dates and locations of molting rate experiments. SB=South of Cape Blanco, HB=Heceta Bank, NH=Newport Hydrographic line, CC=Central Coast.

field	lab
21	23

Table 2. Average percent of population moulting per day from field and laboratory studies.

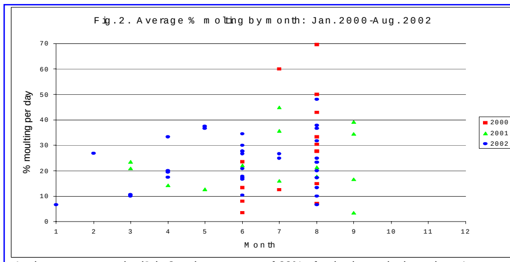
METHODS

Between May 2000 and the present we have conducted 68 moulting rate experiments at sites off the Oregon coast (Table 1, Fig. 1). There were two long summer cruises each in 2000 (MESO 1 & 2) and 2002 (MESO 3 & 4), accounting for the larger number of experiments in those years as compared to 2001 (Table 1). Animals were caught in oblique tows using a MOCNESS, Bongo or 1m ring net. Animals were gently removed from the catch and placed individually in 500 ml jars filled with filtered seawater. A standard size experiment contained 30 individual animals. Animals were incubated at temperatures between 10-12°C for 48 hours and checked every 12 hours for moults. When an animal moulted, it was preserved with its moult in 5% formalin. Live animals that had not moulted by the end of the experiment were preserved together. Dead animals were discarded and not included in the total animals in an experiment. Experiments frequently included animals of both species as they are difficult to speciate by eye.

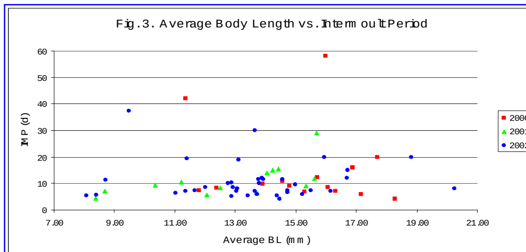
Animals that moulted were measured in the lab using a dissecting scope. Species, developmental stage, sex, body length, animal telson and moult telson length were recorded for each animal. Growth was determined by measuring the difference in length of the animal telson and moult telson. Animals had been preserved in 5% formalin for at least a week prior to measurement.

Intermoult period is calculated using: IMP=1/(M/A/D), where M=number of animals moulting in an experiment, A=total number of animals in the experiment and D=length of the experiment in days.

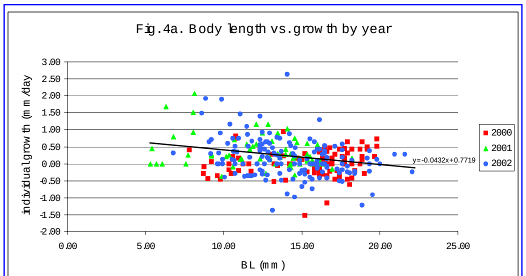
Individual growth per day is calculated using: mm growth/day=(% growth/IMP)/IMP(d)

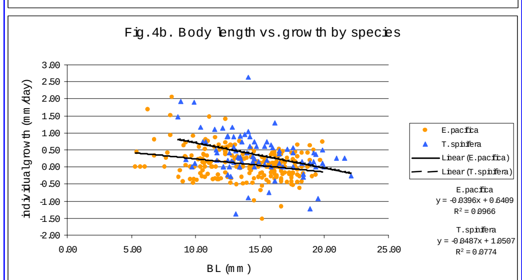


In the summer months (July-Sept.) an average of 28% of animals moulted per day. An average of 21% moulted per day at other times of year. Sampling intensity was highest during the summer months, providing a better opportunity to capture variability. This variability is probably influenced by food availability but may also be a result of synchronous moulting within a population. If a population moults synchronously and is caught at the end of a moult cycle, a 48 hour experiment will not capture this variability.

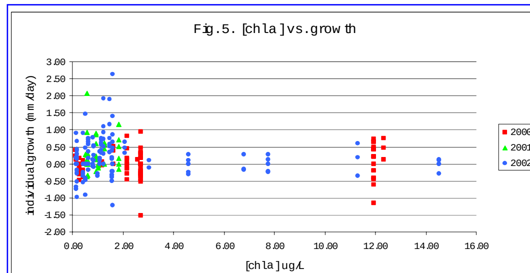


Intermoult period was fairly constant over all size classes and developmental stages for both species, suggesting that it is not strongly affected by the size or age of the animal (Fig. 3). This result is supported by field and laboratory moulting rates (Table 2). The field rate was calculated from juvenile and adult animals while the lab rate was calculated from furcilia developing to juvenile. The close agreement between these values further supports the theory that moulting rate remains approximately constant over the life of the euphausiid and is not strongly affected by length, life stage or species. The IMP values $\geq$20d are probably too high to reflect a real intermoult period. These animals may have been in poor condition or damaged or stressed during capture.

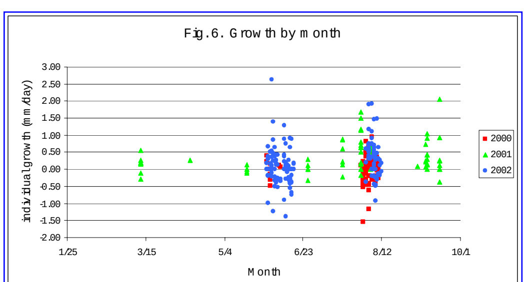




Individual growth tends to decrease as animals get larger (Fig. 4a). This is true for both species, *E. pacifica* and *T. spinifera* (Fig. 4b). Negative growth occurs more frequently in larger animals of both species (Fig. 4a, b).



The highest growth values in these experiments were similar at low and high chl *a* concentrations (Fig. 5). This may indicate that there is a maximum chl *a* concentration above which no growth advantage is incurred. Another possibility is that at low chl *a* concentrations these euphausiids exploit another food source, possibly copepods or microzooplankton. In either case, these results suggest that chl *a* concentrations may not accurately reflect euphausiid diet, especially when they are at low levels. If *E. pacific* and *T. spinifera* are like other euphausiid species where the growth increment is set several days before moulting occurs (Buchholz et al. 1989) the food environment in which they are caught may not reflect the conditions in which they were feeding during their previous intermoult period.



This graph combines data for *E. pacifica* and *T. spinifera* moulters. In spring (Mar.–May) animals generally maintained their size at moult, growing or shrinking only slightly. In summer (June-Sept.) the range of growth increments (positive and negative) was much wider, although many animals remained within the same growth range as the spring moulters.

DISCUSSION

Euphausiids are able to shrink when they moult, possibly as a mechanism for coping with low food availability (Ikeda and Dixon 1982). Negative growth occurred regularly during these experiments (Fig. 4). Negative growth did not always occur at low chl a concentrations (Fig. 5), suggesting that lack of food was not the only possible cause. Negative growth was seen more frequently in larger animals (Fig. 4) and during the summer months (Fig. 6). This may be a result of larger animals investing energy in reproduction instead of growth. Thus, negative growth may not always indicate poor physiological or environmental conditions for euphausiids.

CONCLUSIONS

- Moulting may be synchronous within a population, leading to results skewed by time of capture.
- Negative and positive growth occurs at both low and high chl *a* concentrations, suggesting that euphausiids are exploiting other sources of food, possibly other zooplankton.
- Duration of intermoult period seems to remain fairly constant regardless of animal size or life stage.
- Negative growth in adults may result from channeling energy to reproduction rather than growth.

FUTURE PLANS

- Continue to conduct moulting experiments and obtain more data for underrepresented seasons.
- Conduct moulting experiments on furcilia in the field.
- Attempt to conduct future moulting experiments by species when possible.
- Investigate possible differences in moulting or growth rates between *E. pacifica and T. spinifera*.
- Compare our growth rates with those found by other researchers.
- Investigate role of carnivory in euphausiid feeding.
- Test whether reproductively active animals tend to shrink when they molt.

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