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COMPARISON OF LIGHT TRAPS AND PLANKTON TOWS FOR SAMPLING BRACHYURAN CRAB LARVAE IN AN ALASKAN FJORD

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ABSTRACT

We compared the effectiveness of light traps and plankton tows for sampling brachyuran crab larvae in Bartlett Cove, Glacier Bay, Alaska, U.S.A. during three nights each in July and August 2001 and June, August, and September 2002. Proportions of species and stages were used to compare larvae caught by light traps and plankton tows. Absolute numbers of larvae are difficult to compare because of the difference in sampling volume and duration of each method. Both methods captured early and late-stage larvae of four brachyuran families, Cancridae, Grapsidae, Pinnotheridae, and Majidae. However, light traps collected many late-stage (megalopae) cancrinid larvae, which were rarely collected by plankton tows, suggesting that late-stage larvae may be undersampled by plankton tows. In contrast, plankton tows collected many early stage (zoeae) pinnotherid larvae, which may be undersampled by light traps. These results follow the same pattern as that found for tropical fish larvae, that light traps are a useful sampling device for settlement-size larvae. Light traps provide a simple method to collect high resolution temporal data on late-stage larval abundance, and their use has improved our ability to discern recruitment dynamics for decapod crustaceans.

KEY WORDS: crabs, ecology, fisheries biology, larvae

INTRODUCTION

Studies of temporal and spatial patterns of crustacean larval distribution have largely used plankton nets to collect larvae (Jamieson and Phillips, 1993; Eggleston and Armstrong, 1995; Botsford and Hobbs, 1995; Garrison, 1999; Ouellet and Allard, 2002). However, little is known about how the method employed to collect crustacean early life stages may select for certain taxa and size classes. Comparative studies in fish that use passive collection methods, such as plankton tows, bongo nets and reef crest nets often underestimate the abundance of taxa and developmental stages of larvae with strong swimming abilities that can avoid nets. Active aggregation methods, like light traps, are more successful at collecting late-stage, positively photoactive fish larvae that are able to swim into traps (Thorrold, 1992; Choat et al., 1993; Hickford and Shiel, 1999; Anderson et al., 2002; Hernandez and Shaw, 2003). The relative ease of collecting high resolution temporal data and the increased ability to sample settlement-size larvae has made light traps a useful tool for discerning fish recruitment dynamics (Doherty, 1987; Choat et al., 1993; Hickford and Shiel, 1999; Anderson et al., 2002). The high rate of capture of crustaceans as well as fishes (Miller and Shanks, 2004) and the success of Reyns and Sponaugle (1999), Roegner et al. (2003), and Jeffs et al. (2003) in using light traps to capture tropical and temperate brachyuran larvae indicate that light traps are a useful tool for sampling crustacean larvae. Potential biases of using light traps to sample crustacean larvae are not known. This study addresses these biases by comparing the effectiveness of light traps and plankton tows

for collecting brachyuran larvae. Relative abundance of brachyuran families and developmental stages were simultaneously collected by the two methods in an estuarine, glacial fjord system in Southeast Alaska. This comparison will help interpret biases in brachyuran larval data using light traps or plankton tows and improve recruitment measurements for commercially important crustaceans.

MATERIALS AND METHODS

Study Area

The study was conducted in Bartlett Cove, Glacier Bay, Alaska (58°27'N, 136°53'W) (Fig. 1), which lies near the mouth of Glacier Bay and is influenced by Cross Sound and the Gulf of Alaska to the west, Icy Strait to the east and glaciated fjords within Glacier Bay to the north. Glacier Bay is well-suited for this experiment, since it is a marine protected area for commercially important crabs. Both light trap and plankton tow collections were conducted from or adjacent to a large floating dock in approximately 8 m water depth (MLLW).

Light Traps

Three replicate light traps were moored to the dock in Bartlett Cove and sampled each night on 22–24 July and 24–26 August 2001; and 22–24 June, 8–10 August and 25–26 September 2002 (n = 42). *Cancer magister* Dana, 1852, *C. oregonensis*, Dana, 1852, and *Fabia subquadrata*, Dana, 1851, the most abundant brachyuran larvae at the sample site (Fisher, 2006), first occur in the plankton in late April and have a development time of 154 days, 133 days, and 125 days respectively (Fisher, 2006). In addition, late-stage larvae of *C. magister* were abundant in large pulses during the dark phase of the moon in late summer and fall at this site (G. L. Eckert, personal observation). Our sampling dates, therefore, were selected because of the higher probability of finding late-stage zoeae and megalopae of these species at this time. We modeled our light trap design after that of Roegner et al. (2003) (Fig. 2). The body of the trap was made from a translucent 19 L plastic jug, 25 cm × 25 cm × 45 cm (l × w × h), with a translucent plastic funnel (top 104 mm diameter; stem 9 mm diameter) on each of four sides

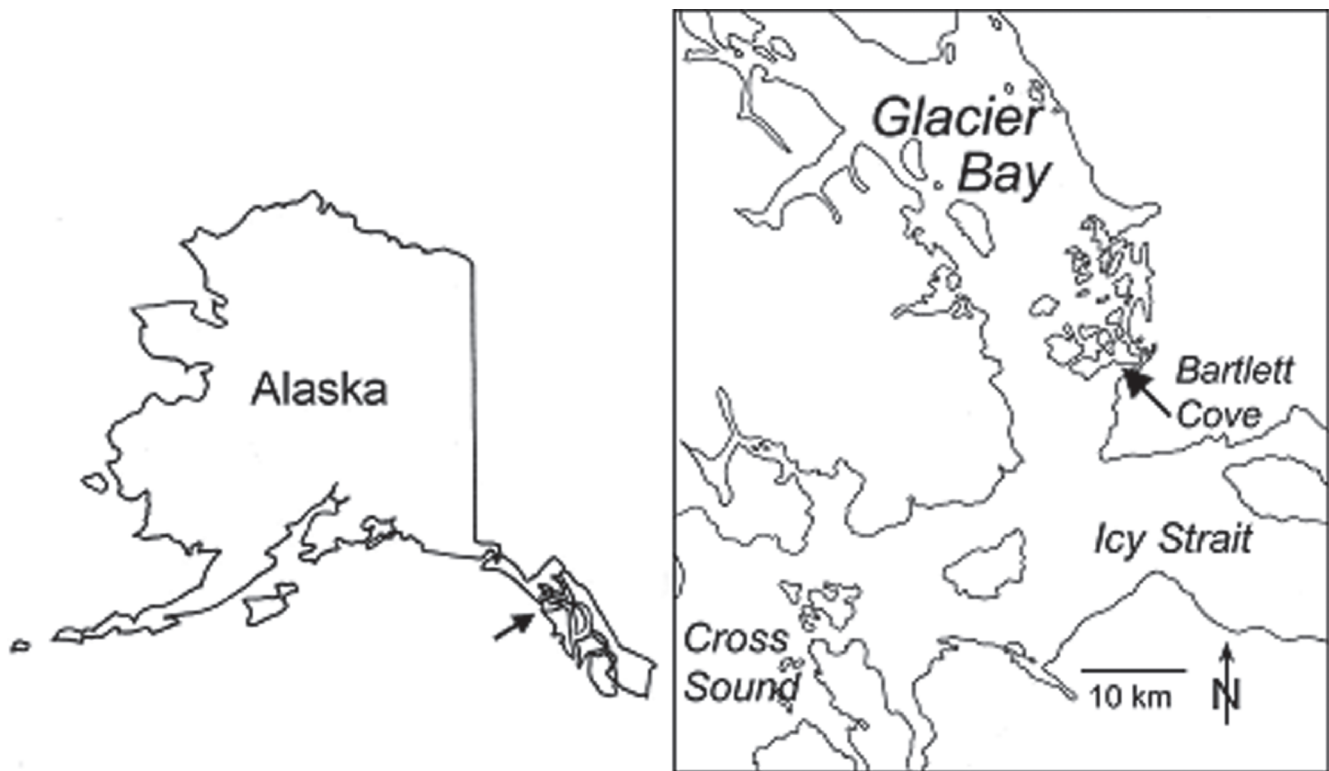


Fig. 1. Study site. Samples were collected in Bartlett Cove (arrowhead), near the mouth of Glacier Bay, Alaska.

(2002 design) or six funnels (top 65 mm diameter; stem 13 mm diameter) on one side (2001 design). The funnels were large enough to admit the largest brachyuran megalopae but small enough to exclude fish and other organisms attracted to the light. The funnels were more translucent than the body of the trap which may have aided larval attraction to the entrance. Foam floats ensured that funnel entrances floated 20 cm from the surface of the water, and lead weights attached to the bottom maintained the trap in an upright position. An automated AC-powered fluorescent light (13 watts), sealed in a clear waterproof acrylic cylinder, illuminated each night from 21:30 to 06:30. For the purposes of this study, we cleaned the light traps and initiated sampling immediately before plankton tow sampling at dusk and then collected light trap samples the next morning. Each trap was pulled

upright out of the water, and the contents were emptied through the 250 μm mesh glued into a 7.6 cm diameter detachable PVC cylinder at the base of the trap. Samples were preserved in 80% ethanol, and brachyuran crab larvae were identified using a dissecting microscope to species and stage according to Lough (1974).

Plankton Tows

Three replicate plankton tows were collected in Bartlett Cove, parallel to the dock with the light traps, on the same nights as light trap samples starting at dusk, except that only two replicates were conducted on each night in August 2001 ($n = 39$). A 50 cm diameter, 333 or 500 μm mesh net was towed at the surface at an average speed of 0.6 m s^{-1} . A flow meter (General Oceanics 2030) was suspended in the mouth of the net to determine the volume sampled, which was used to normalize the abundance estimates. Tows lasted approximately 5 min; time was limited based on potential for clogging by a high density of phytoplankton (Smith et al., 1968). A coarser gauge of mesh was used in the nets than in the light traps, but in trials using *Cancer magister* and *C. oregonensis* larvae, 500 μm mesh was found to retain even the smallest zoeal instars (J. L. Fisher, personal observation). An average volume of 63 ($\text{SD} \pm 20$) m^3 was sampled in each tow. Samples were preserved and processed as described above for light trap sampling.

RESULTS

The two methods collected larvae from four brachyuran families: Cancridae, Grapsidae, Pinnotheridae, and Majidae. Both methods detected various stages of six taxa (Table 1), but only the light traps collected *Cancer productus*, Randall, 1839. The two methods collected different developmental stages, with more early stage larvae caught by plankton nets and more late-stage larvae collected by light traps (Table 1). The light trap samples collected a total of 1725 larvae: 318 zoeae and 1407 megalopae (Table 1). Light traps caught megalopae at a significantly higher rate than zoeae (3.4 and 0.8 larvae hour^{-1} , respectively; $P < 0.05$, t test). The most

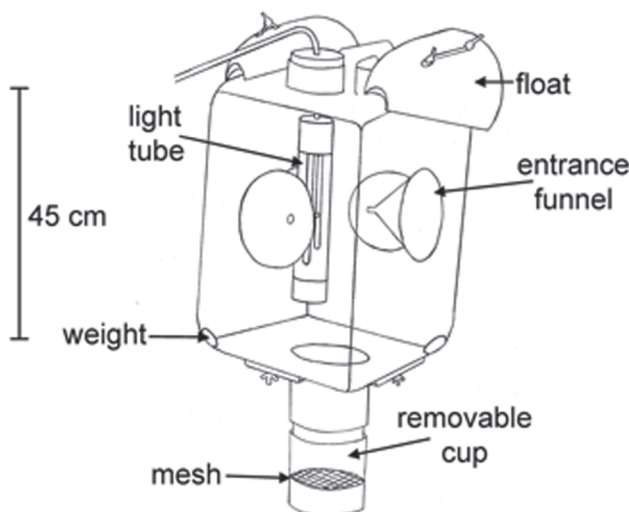


Fig. 2. Diagram of light trap (2002 design).

Table 1. The number of larvae, by taxon and developmental stage, caught by simultaneous light traps and plankton tows. Data are pooled for all sample dates. Number of zoeae (zoeae) subdivided into zoeal instars (1-5) and combined (all), number of megalopae (meg.), and total number of individuals within a taxon (total). - no further zoeal instars in this taxon. * not identified to zoeal instar.

Family	Species	Light Traps							Plankton Tows							
		zoeae						meg.	total	zoeae						
		1	2	3	4	5	all			1	2	3	4	5	all	meg.
Cancridae	<i>Cancer magister</i>	29	1	0	0	0	30	1390	1420	27	1	0	0	0	28	1
Cancridae	<i>Cancer oregonensis</i>	1	1	4	24	30	60	2	62	0	0	7	12	2	21	2
Cancridae	<i>Cancer productus</i>	0	1	0	0	0	1	8	9	0	0	0	0	0	0	0
Grapsidae		3	0	-	-	-	3	0	3	6	0	-	-	-	6	0
Pinnotheridae		*	*	*	*	*	215	5	220	*	*	*	*	*	1077	1
Majidae	<i>Pugettia</i> sp.	5	4	-	-	-	9	0	9	10	3	-	-	-	13	3
Majidae	<i>Chionoecetes bairdi</i>	0	0	0	0	0	0	2	2	0	0	0	0	0	0	1
Total		35	7	4	24	9	318	1407	1725	43	4	7	12	2	1145	8

common taxa collected by the light traps were *Cancer magister* (82.3%) and Pinnotheridae (12.8%) (Fig. 3). Of the *C. magister* larvae, nearly all of them were megalopae (97.9%), whereas nearly all the Pinnotherid larvae were

zoeae (97.7%). The plankton tow samples collected a total of 1153 larvae: 1145 zoea and 8 megalopae (Table 1). Plankton tows caught zoeae at a significantly higher density than megalopae ($0.797 \text{ larvae m}^{-3}$ and $0.006 \text{ larvae m}^{-3}$

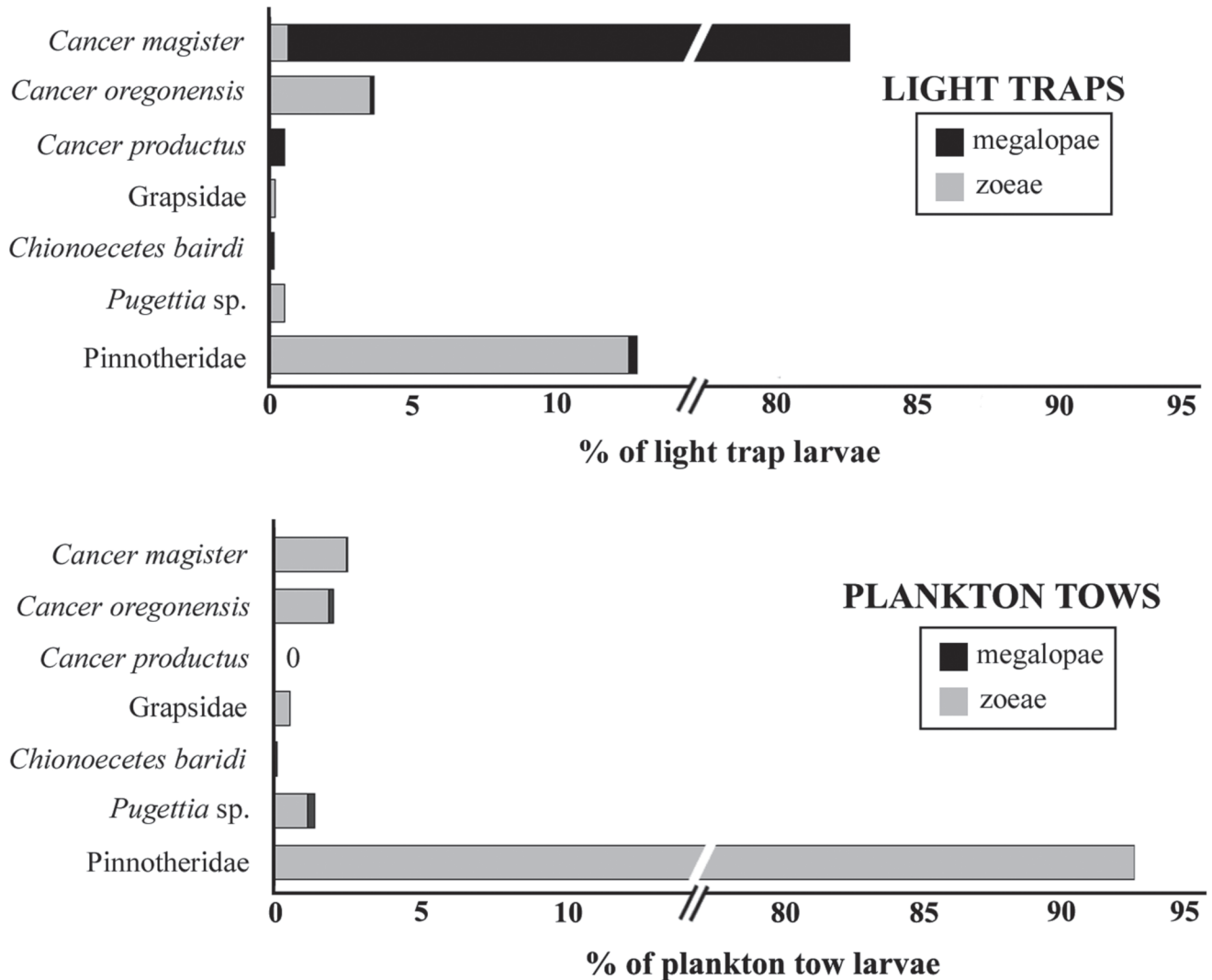


Fig. 3. Percent of the total number of brachyuran larvae caught using light traps and plankton tows, by taxon and developmental stage (zoeae or megalopae). Note broken axis.

Table 2. Total number of *Cancer magister* larvae sampled by light traps (LT) and plankton tows (PT). Data pooled by month.

Stage	Jul-01		Aug-01		Jun-02		Aug-02		Sep-02	
	LT	PT	LT	PT	LT	PT	LT	PT	LT	PT
zoeae	0	0	0	0	29	26	1	2	0	0
megalopae	1	0	1324	0	5	0	29	0	31	1

respectively; $P < 0.01$, t test). The most common taxon collected by plankton tows was Pinnotheridae (93.5%), while all other taxa were rare (each $< 4\%$). Nearly all Pinnotherid larvae were zoeae (99.9%) (Fig. 3).

DISCUSSION

The taxa and developmental stages of brachyuran larvae collected depended on the method employed. While both methods detected nearly all of the taxa observed, light traps collected mostly cancrinid megalopae, while the plankton tows collected mostly pinnotherid zoeae. It is difficult to compare absolute numbers of larvae caught by plankton nets and light traps in this study because of the difference in sampling volume and duration, however proportions of species and stages provide a useful comparison. Our trends are analogous to those reported for fish larvae, where late-stage larvae were collected in greater abundance with light traps, and early-stage larvae were collected in greater abundance with plankton tows (Thorrold, 1992; Choat et al., 1993; Hickford and Shiel, 1999; Hernandez and Shaw, 2003).

A major difference between the two methods is that light traps accumulate samples over an extended duration, whereas plankton tows measure density over a short duration. Plankton tows are especially sensitive to fine-scale fluctuations in temporal and spatial distributions, since tows only sample a short window in space and time. Light traps excel at measuring relative abundance for species and stages that may be patchy in time and space and are, therefore, difficult to quantify with standard plankton tows. We acknowledge that the sampling time differed between the two methods, but we compared the most commonly used protocols, in which several, short replicate tows are conducted per day and light traps sample for hours. Both methods represent a single sampling event per day, but the light traps have an advantage in that they integrate over time (Gaines and Bertness, 1993). As a result, in our study the light traps captured the sharp peak in *C. magister* larval abundance in August 2001, which was not captured by the plankton net sampling. Choat et al. (1993) reported similar results in that strong peaks in larval fish abundance were detected with light traps but not with plankton tows. Therefore, light traps may be more useful than plankton nets for monitoring the abundance of temporally and spatially variable late-stage brachyuran larvae.

A major disadvantage of light traps is an inability to make direct comparisons across studies under different conditions or among light trap designs. Light traps are not ideal in all situations; they are likely to be less effective in high current or high turbidity environments (Lindquist and Shaw, 2005) and are restricted to sampling strong, positively phototactic

swimmers. Light trap efficiency varies with light trap design, making it difficult to directly compare studies using different designs (Meekan et al., 2000). The traps used in our study are relatively small compared to those based on Doherty (1987) and are simple, inexpensive, and contain attractive entrances which may increase their catching efficiency. Meekan et al. (2001) found that the smaller of their two similar traps collected crab megalopae at approximately three times the rate of the larger trap, possibly because the small trap had a greater surface area ratio of entrance to wall. The rate of entrapment may be constrained by the chance of an organism encountering an entrance (Hernandez and Lindquist, 1999). The small Meekan et al. (2001) trap was approximately five times as large as ours by volume.

Of the late-stage larvae collected in this study, most were *Cancer magister* megalopae and caught by light traps in one time interval, from 24–26 August 2001 (Table 2). While the abundance of all larvae varied by sampling period, *C. magister* fluctuated the most, being nearly forty times more common in the late August sampling period. Of the crustacean larvae sampled, cancrinid megalopae are the strongest swimmers. *Cancer magister* megalopae can reach speeds of up to 45 cm s^{-1} (Fernandez et al., 1994). Cancrids are also strongly positively phototactic (Jacoby, 1982). The strong swimming ability and photopositive behavior of *C. magister* may have contributed to the success of the light traps in collecting these late-stage larvae compared to plankton nets. While few megalopae of *C. magister* were collected with plankton tows in this study, other studies have been successful in collecting the megalopae of *C. magister* with surface plankton tows (Fernandez et al., 1994; Hobbs and Botsford, 1992). This suggests that patchiness in the spatial and temporal patterns of abundance of megalopae may also have contributed to the relative success of the light traps, which sampled over the full course of a night.

The taxonomic composition of larvae sampled by the two methods reflected the composition of adults and larvae expected in the area with one exception. The presence of grapsid larvae was unexpected, since adult grapsids have been reported only in outer waters and not in Glacier Bay. This observation suggests that grapsid larvae may be transported from the outer coast into Glacier Bay. The fate of these larvae is unknown since, to our knowledge, no adults have been found in Glacier Bay.

Light traps are poised to become a more widely-used methodology for collecting a diversity of late-stage decapod crustaceans that are strong and positively phototactic swimmers (Phillips, 1975; Phillips and Olsen, 1975; Sulkin, 1984; Cobb et al., 1989). Plankton net samples may, in fact, underestimate the abundance of late-stage decapod larvae. Decapod larvae undergo daily vertical migrations (reviewed in Queiroga and Blanton, 2005) which complicates the use of discrete sampling such as a towed net. The continuous sampling of a light trap over the course of a night reduces the chance of missing brief periods of high density and is better suited for tracking patterns in localized larval abundance of strong-swimming larvae over extended periods of time. Stationary nets are another potentially useful tool for collecting late-stage larval samples over an extended period of time (Johnson and Shanks, 2002;

Queiroga and Blanton, 2005). Interestingly, light may be effectively combined with other attractive stimuli such as sound to collect different crustacean assemblages (Jeffs et al., 2003). Light traps are a simple method for collecting high resolution temporal data on larval abundance, and their use could improve our ability to discern recruitment dynamics for decapod crustaceans. What is now needed is standardization of one light trap design, including calibration of sampling efficiency under varying conditions, so that results could be compared across studies by investigators in different locations at different times.

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