Summary of Special Projects Carried Out by an Observer Onboard a Crab Boat in the 1996 Western Aleutian Area *Chionoecetes tanneri* Fishery

By

Laurence C. Byrne

and

David Cross

Regional Information Report[1] No. 4K97-17

Alaska Department of Fish and Game
Commercial Fisheries Management and Development Division
211 Mission Road
Kodiak, Alaska 99615

March 1997

[1] The Regional Information Report Series was established in 1987 to provide an information access system for all unpublished division reports. These reports frequently serve diverse ad hoc informational purposes or archive basic uninterpreted data. To accommodate timely reporting of recently collected information, reports in this series undergo only limited internal review and may contain preliminary data; this information may be subsequently finalized and published in the formal literature. Consequently, these reports should not be cited without prior approval of the author or the Commercial Fisheries Management and Development Division.

AUTHORS

Laurence C. Byrne is a biometrician who analyzes shellfish observer data for the Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, 211 Mission Road, Kodiak, AK 99615.

David Cross is a shellfish observer for Alaskan Observers, 130 Nickerson, Room 206, Seattle, WA 98109

ACKNOWLEDGEMENTS

We thank Allen Oakley, skipper of the Early Dawn, and his crew, Pat Robinson, Josh Hatch, Steve Gordon, Justin Winpress, and Isaac Maas for their hospitality and assistance in collecting this data, and for allowing us to publish it. Alaska Department of Fish and Game (Kodiak) biologists Doug Pengilly, Bill Donaldson, Dave Jackson and Donn Tracy suggested special projects and reviewed the final report. Larry Boyle, Mike Ward, George Pappas, Mike Ruccio and Holly Moore of ADF&G in Dutch Harbor helped with logistics, scheduling and equipment. Lucinda Neel prepared the final report for publication.

TABLE OF CONTENTS

	Page
LIST OF TABLES	i
LIST OF FIGURES	ii
INTRODUCTION	1
METHODS	1
RESULTS AND DISCUSSION	2
Shell age	2
Parasitization	3
Injury, Limb Loss and Mortality	3
Maturity	5
Males	5
Females	6
Legal Size of *L. couesi*	6
Effectiveness of Escape Mechanisms in Pots	6
CPUE by Depth and Soaktime	7
Handheld GPS	8
C. tanneri Discards	8
L. couesi Carapace Color	9
Effectiveness of Using Observers for Special Projects	9
LITERATURE CITED	11
TABLES	12
FIGURES	17

LIST OF TABLES

Table		Page
1.	Number and percentage of total observer-sampled crab by species, sex, shell age and area fished.	12
2.	Injury, limb loss, limb regeneration and mortality rates for three species of crabs from observer-sampled pots on the F/V Early Dawn, June, 1996. Percentages are of total crabs except where listed by sex.	13
3.	Presence or absence of grasping marks on female *C. tanneri* by egg condition, egg development and area fished. Numbers in parentheses are breakdown by new shell, old shell, and very old shell crab. n=135 females.	14
4.	Mean CPUE (crabs per pot) by sex-size class of the three targeted crab species caught in experimental gear with escape mechanisms. n=8 replications	15
5.	Results from three regression models: CPUE on depth; CPUE on soaktime; and CPUE on depth and soaktime. * indicates effect significant at 0.05; ** indicates significance at 0.01; NS indicates not significant at the 0.05 level. + / - indicates a positive or negative relationship with CPUE	16

LIST OF FIGURES

Figure		Page
1.	Location of pots sampled by observer deployed on the F/V Early Dawn, June, 1996.	17
2.	Size frequency plots for male and female *C. tanneri* from observer-sampled pots on the F/V Early Dawn, June, 1996	18
3.	Size frequency plots for male and female *L. couesi* from observer-sampled pots on the F/V Early Dawn, June, 1996	19
4.	Size frequency plots for male and female *L. aequispina* from observer-sampled pots on the F/V Early Dawn, June, 1996	20
5.	Plot of ln (chela height) vs ln (carapace width) for male *C. tanneri* from observer-sampled pots on the F/V Early Dawn, June, 1996	21
6.	Plot of ln (chela height) vs ln (carapace length) for male *L. couesi* from observer-sampled pots on the F/V Early Dawn, June, 1996	22
7.	Plot of chela height vs carapace length of *L. couesi* males showing overlap in carapace length for sublegal and legal males	23

INTRODUCTION

Researchers and managers are often interested in specific aspects of crab biology which can not be addressed with the data that shellfish observers routinely collect. In such cases, a few observers will be asked to collect data for special projects. Special projects are gaining in popularity among crab biologists as they realize what a practical tool they can be for acquiring otherwise costly and difficult to obtain information. An Alaska Department of Fish and Game (ADF&G) biometrician was invited to accompany the crew, including a mandatory shellfish observer, for a trip onboard a fishing vessel during the Western Aleutian Area *Chionoecetes tanneri* fishery in mid-June, 1996. The primary objective for the biometrician was to get a feel for the sampling procedure on a working crab boat. He also helped collect data for special research projects as suggested by ADF&G shellfish biologists in Kodiak and Dutch Harbor. This report summarizes the results of special projects carried out on that trip that address specific questions on the biology of three crab species.

METHODS

The F/V Early Dawn is a 108 ft boat which longlines pots for *C. tanneri* (grooved Tanner crab), *Lithodes couesi* (scarlet king crab) and *Lithodes aequispina* (golden king crab) in the Western Aleutian, Eastern Aleutians and South Peninsula Areas. All sampling was conducted by the shellfish observer during a 12 day trip from June 5-17, 1996. The ADF&G biometrician acted as the data recorder, took photographs and video, collected specimens and generally observed activities. Pots were fished at depths of 250 to 500 fathoms between approximately 171° W and 180° along the Aleutian Island chain (Figure 1). Fishing occurred in two large areas: one north and northeast of Amlia Island and the other near Tanaga Island, with pots sampled to the south and northwest of this island.

The F/V Early Dawn fished eight strings of 50 pots each. The pots were circular, domed, about three feet high and with a 7' diameter. All crab in sampled pots underwent the normal observer sampling regimen, which includes measuring carapace length (CL) or carapace width (CW) to the nearest millimeter. Additionally, each crab was categorized by species, sex, legal status, parasites, shell age and female reproductive status, including eyed or uneyed eggs, egg condition and clutch fullness (ADF&G 1993). Additional sampling tasks for special projects were recording injured, missing or regenerated limbs (all crab), grasping marks and abdominal flap measurements (*C. tanneri* females only), chela height (*L. couesi, C. tanneri* and *C. angulatus* males), egg color (*C. tanneri*), both carapace width and length (*C. tanneri and L. couesi*), presence of snailfish eggs in (*L. aequispina*) and testing the effectiveness of rings and large mesh as escape mechanisms in the pots.

The data recording procedure for missing, injured or regenerated limbs usually required four parts: side [right(R), left(L) or carapace(C)]; appendage # [1-5 for *C. tanneri;* 1-4 for *L. couesi* or *L. aequispina*]; type [injury(I), missing(M), regenerated(R)]; and age [fresh(F) or old(O)]. For a carapace injury the appendage space was left blank. An injury was defined as any noticeable crushing, gashing, ripping or missing section(s) of an appendage. An appendage was called missing if all of the limb was absent from below the carapace margin (autotomy plane). Examples: R3IO (old injury on 3rd leg on right side); L1R (regenerated left chela); CIF (fresh carapace injury).

Eight pots were modified with escape mechanisms: four with three escape rings each (5.75" diameter) inserted just above, and spaced equidistant around, the base; and four with large mesh (9" stretched diagonally) vertical panels exposed. Modified pots were marked with two strands of yellow surveyor's tape to assure that the crew would set the contents aside for sampling. These pots were used in a comparison of CPUE with the unmodified pots fished in the same string. Small mesh pots (shrimp pots with 1" mesh) were also planned for the comparison but were thrown out of the experiment after the second replication, when no crab were caught in them, and they were considered to be ineffective. Two modified pots (one of each type) were interspersed in four strings. Modified pots within a string were separated by at least ten unmodified pots, so that the observer was not overwhelmed by sampling chores.

Other tasks included field-testing a handheld Global Positioning System (GPS) unit for effectiveness in supplying coordinates for sampled pots, and observing discarded crab (especially *C. tanneri*) to ascertain if they sank immediately or floated away.

RESULTS AND DISCUSSION

A total of 120 pots were sampled, in which 585 *L. couesi* (46.4% males, 53.6% females), 480 *C. tanneri* (54.1%, 45.9%), 714 *L. aequispina* (71.9%, 28.1%), and 7 *C. angulatus* (all males) crabs were caught. Carapace length/width frequency histograms are presented in Figures 2-4 (*C. angulatus* not included). Average sizes (CL) for *L. couesi* were 128.1 mm for males and 112.4 mm for females. Legal males outnumbered sublegal males 205 to 67. Average sizes (CL) for *L. aequispina* were 93.5 mm for males and 87.3 mm for females. Sublegal males outnumbered legal males 301 to 15. Average sizes (CW) for *C. tanneri* were 138.8 mm for males and 105.0 mm for females. Legal males outnumbered sublegal males 327 to 19.

Shell age

Shell ages give an indication of recruitment into the harvestable population, and hence reflect a stock's overall health and potential for exploitation. Shell aging for *C. tanneri* has proven to be a more difficult problem than encountered in other Tanner crab, such as *C. opilio* and *C. bairdi*, probably related to the bottom type and the great depth at which these crabs are found. Shells (and dactyls) showed a very narrow range of wear and abrasion, and carapaces were generally clean and unfouled, except on the few very old specimens encountered. The breakdown of shell ages is presented in Table 1. Shell ages for both *L. couesi* and *L. aequispina* were >96.0% new shell for both sexes, overall and in both areas individually. *C. tanneri* males were mostly new shell (78.6%), overall and in both areas, but old shell (56.3%) predominated the overall catch of *C. tanneri* females. The same percentages also hold true for the Tanaga Island area, where nearly 90.0% of the female *C. tanneri* were caught. In the Amlia Island area, >70% of the females were old shell. Three soft shell crab were caught: two male *C. tanneri*, and one male *L. aequispina*, both in the Amlia Island area. All double skip molt crab (18 total) were *C. tanneri*, evenly divided between male and females. All but one came from the Tanaga Island area. The high percentage of old shell females makes sense since we assume female *C. tanneri* undergo a terminal molt at maturity. Only two of the 135 *C. tanneri* females examined were barren with silky setae, and only one female was categorized as a juvenile based on abdominal flap measurements.

Parasitization

Overall, 55.5% of the *C. tanneri* were infected by some parasite. The most common infection was from 'torch' (49.1% overall). More than 80% of the female *C. tanneri* sampled had this parasite compared to 38% of males. Approximately 5% of the *C. tanneri* had 'poppy seed disease'. By contrast, 90% of all *L. couesi* (95.7% of the males and 85.9% of the females) and 95% of the *L. aequispina* (about the same percentages for both males and females) were uninfected with parasites on a macroscopic level. For *L. couesi, Briarosaccus callosus* was present in 2.7% of the males and 6% of the females. Overall, 4.5% of the *L. couesi* crab sampled had the *B. callosus* parasite. This compares with 0.7% infected females and a much lower percentage of infected males as reported by Somerton (1981), studying *L. couesi* on seamounts in the Gulf of Alaska. Torch was present in 3.6% of the *L. couesi* crabs sampled. *B. callosus* was present in 4.7% of the male and 2.7% of the female *L. aequispina* crabs (3.7% overall).

Infection rates for *L. couesi* and *L. aequispina* between the two fishing areas were virtually identical. However, for *C. tanneri* 15% more crabs were infected with parasites in the Tanaga Island area compared to the Amlia Island area. It should be noted that only 43 *C. tanneri* were sampled in the Amlia Island area compared to 438 around Tanaga Island.

'Black mat disease' was not recorded for any crab in a sampled pot. However, all small *C. tanneri* (females < 80 mm CW and males < 90 mm CW) were put aside by the crew and measured as they were encountered. Eighty-three females and 84 males were sampled in this manner, all from the Tanaga Island area. 'Most' of the female had black mat disease, although the exact proportion is not available. None of the males were noted with this disease.

Injury, Limb Loss and Mortality

It is important to have some background information on injury, limb loss and mortality rates on crab stocks to assess the effect of fishing over time. In the area between 171° W and 180° in the Aleutian Islands (Figure 1), directed effort towards *C. tanneri* has occurred only since 1995, and it is doubtful that *L. couesi* was ever the target species before 1996. *L. aequispina* has been targeted for many years in the Aleutian Islands. Because both *C. tanneri* and *L. couesi* are fished deeper than *L. aequispina,* the stock of these two species in this area could be considered relatively unaffected by fishing at the time of sampling.

The freshly injured limb rate, not including missing limbs, was highest for *L. couesi* (5.2%), much lower for *L. aequispina* (1.7%), and lowest for *C. tanneri* (0.2%) (Table 2). At most one limb was freshly injured on *L. couesi* and *C. tanneri*, and only one *L. aequispina* had more than one limb freshly injured. Including old injuries, the injury rates are 2.9% for *C. tanneri*, 6.7% for *L. couesi* and 2.4% for *L. aequispina*. *C. tanneri* and *L. aequispina* both had up to three injured limbs. *L. couesi* had at most two injured limbs. Injury rate was fairly constant for both sexes of any species.

Approximately 95% of both *L. couesi* and *L. aequispina* were wholly intact compared to 37% of the *C. tanneri* that had one or more missing limbs. For *C. tanneri,* 25.1% had one missing limb, 8.9% had two missing limbs and 2.9% had three or more missing limbs. Limb loss for *C. tanneri* could not be directly attributed to fishing activity (capture and handling) on this trip. Missing limb rates for crab in Bering Sea studies have been reported as between 7% and 26% for red king crab, *Paralithodes camtschatica,* and between 35% and 49% for tanner crab (Edwards 1972; R. MacIntosh, NMFS Kodiak, per. comm.).

Autotomy, the reflexive dropping of limbs, is well documented in tanner crabs, *C. bairdi*, and is thought to be a means to avoid predators and minimze the effects of wounds (Juanes and Smith 1995). Although we did notice some *C. tanneri* that dropped legs as they were being pulled from the pot, we could not apportion limb loss between background levels and fishing activities (capture and handling) on this trip.

Overall, regenerating limb rate was less than 7% for all species: 4.1% for *L. couesi*, 0.4% for *C. tanneri*, and 6.3% for *L. aequispina*. Two male *L. couesi* were noted with regenerating legs; 23 female *L. couesi* had regenerating legs. Only one male and one female *C. tanneri* had legs in this condition. Regeneration rates for *L. aequispina* by sex were almost identical (28 males and 29 females). Rates were similar for the two areas except for female *L. couesi.* In the Amlia area 20 (8.3%) females had regenerating limbs compared to only three (3.5%) in the Tanaga area. Regeneration rates should be considered as conservative since fully regenerated (or nearly so) legs were probably not recorded.

No *L. aequispina* and only one female *L. couesi* (0.3% mortality for females, 0.2% overall) were dead in bycatch sampled pots. Overall, 16 out of 481 (3.3%) *C. tanneri* from sampled pots were measured and recorded as dead. Additionally, two *C. tanneri* carapaces of unknown sex and one unretained moribund male came up in sample pots. If these three crab are taken as mortalities, the overall rate increases to 3.9%. The mortality rate was similar for both sexes (3.5% for males, 3.0% for females).

Maturity

Males

An essential piece of information that shellfish biologists and managers consider when setting a legal size limit is the size at which 50% of males are mature (SM50). Size limit is set at SM50 + 1 growth increment as a minimum, meaning mature males are given at least one year to reproduce before they become part of the exploitable portion of the population. For instance, the 7" size limit for Kodiak red king crab was set at SM50 + 3 to provide 3 years of mating activity before entering the commercial fishery (W. Donaldson, per. comm.). SM50 for crabs can be determined from the relationship between chela height and carapace width (Tanner crabs) or carapace length (king crabs).

Right chela height measurements were taken on all sampled *C. tanneri* and *L. couesi* males. A scatterplot of ln chela height against ln carapace width for male *C. tanneri* yields two distinct lines (Figure 5). The lower line describes the growth pattern of immature males and the upper line describes the relationship for mature males. The two distinct lines suggest that when a *C. tanneri* male molts into a certain morphometrically mature sized carapace, his chela disproportionately increases into its mature size, shifting from the lower to the upper line. This is the first instance that such data from Aleutian Islands *C. tanneri* have been reported. Also plotted is the data point for a molting *C. tanneri* male that was collected with the old carapace in the process of being shed. This specimen fits on the lower line indicating, that by the size of the still unmolted chela, the specimen is morphometrically immature. It appears, by the relative position of the data point at the end of the lower line, that if the crab had completed its molt it would have reached morphometric maturity.

By plotting a logistic curve to the data, based on the percent morphometrically mature at each carapace size, the estimated CW at which 50% of the males are morphometrically mature is 115.4 mm for both areas combined. Considering just the male crabs from the Tanaga Island area the size of morphometric maturity is 118.0 mm. The logistic curve method does not work well with the crabs from the Amlia Island area or for both areas pooled because of a disproportionately low number of immature crabs (only two immature males came from the Amlia area). The size at morphometric maturity for *C. tanneri* males has been reported as 118.7 mm from the Bering Sea (Somerton and Donaldson, 1995) and 118.0 mm from the Oregon Coast (Tester and Carey, 1986). There are indications from observer samples in other Alaskan *C. tanneri* fisheries (i.e., South Peninsula, Dutch Harbor, Bering Sea) that the size of male morphometric maturity is also around 118 mm in those areas where samples for both mature and immature crabs are of adequate and fairly equal size (L. Byrne, per. obs.).

The scatterplot of male *L. couesi* chela height data is not as clear as that for *C. tanneri* (Figure 6), probably because not enough immature males were included in the sample. Morphometric size at maturity was not determined for *L. couesi* males.

Females

It is believed that female *C. tanneri* have a terminal molt (i.e., they will not molt again) in reaching sexual maturity. Shortly after this molt, the male grasps the female's legs in the mating process. The grasping marks are not permanently imprinted on the legs of the female still in the soft shell condition. However, the marks are retained on the legs in subsequent matings after the shell has hardened. Biologist use this information to help classify females as primiparous (bearing their first clutch) or multiparous (bearing subsequent clutches). Presence or absence of grasping marks was noted on 134 of 135 female *C. tanneri* sampled. Grasping marks were present on 115 (85.8%) animals, and absent on 19 (14.2%). By area, 100% of the females sampled in the Amlia area had grasping marks (14 of 14); Tanaga Island females showed 87.8% frequency of grasping marks (101 of 120). The breakdown of grasping marks by egg condition, egg development, and shell age is presented in Table 3.

Legal Size of L. couesi

The legal size of *L. couesi* is measured across the carapace including the spines. Elongated spines on the carapace perimeter are a characteristic of this species and can make an appreciable difference in the legal size measurement. Males with small CL measurements could have spines up to 30 mm in length on either side of the carapace. Males with larger CL measurements might have smaller spines. The result is that some smaller males exceed the legal size and are retained while other larger males with smaller spines are discarded. The CL size range where this overlap occurred was 112 - 129 mm (Figure 7), which probably equates to the size increment in one molt cycle (W. Donaldson, ADF&G Kodiak, per. comm.). The overlap in CL measurements between legal and sublegal males was three millimeters for *C. tanneri* and one millimeter for *L. aequispina*. One of the consequences of measuring *L. couesi* outside the spines is that it allows some larger, presumably more reproductively fit, males to return to the sea.

Effectiveness of Escape Mechanisms in Pots

Escape rings have been shown to be effective in reducing bycatch in the Adak *L. aequispina* fishery (Beers 1992). Reduced bycatch means that the crew spends less time sorting through catch for legal-sized crabs and also reduces the bycatch mortality rate. Interpretation of the following results is dependent on the range of soaktimes and depths fished for the experimental pots. Even though experimental pots were placed in the same string, depths at which each pot fished could vary depending on the terrain. Median depths for pots with large mesh panels exposed was 408 fm (range 319 - 491 fm). Median depth for pots with rings was 395 fm (range 301 - 491 fm). Soaktimes ranged from 19 to 103 hr (median 52.5 hr). Table 4 presents the mean CPUE's for the three targeted species of crabs by gear type. Since the sample size was small (n=8), a non-parametric Kruskal-Wallis test of medians was performed (Conover 1971). Only one test showed a significant difference in gear type. Significantly fewer female *L. couesi* were caught in pots with escape rings than in the regular dome pots or in pots with large mesh panels (P=0.07). The lack of other significant results is probably due to the small sample size and the variability of the data. More tests would probably be significant with increased replications. For instance, it appears from Table 4 that both escape mechanisms were effective in reducing the number of sublegal and female *L. aequispina* caught. Also, nearly twice as many legal male *L. couesi* were caught in gear with escape mechanisms than in the unmodified pots, but this could be an artifact of one or two large catches due to placement of the modified pots in the string.

CPUE by Depth and Soaktime

Investigation of the relationship between CPUE, soaktime (time between setting and pulling a pot) and depth considered simultaneously was accomplished with a multiple regression of CPUE on depth, soaktime and the interaction between depth and soaktime. If the interaction is significant, then the relationship between the dependent variable (CPUE) and the independent variables (depth, soaktime) cannot be simultaneously interpreted. A regression with a significant interaction implies that there is a family of regression equations for each level of an independent variable. For example, there exists a separate relationship between CPUE and depth for every level of soaktime. Likewise, there is a different relationship between CPUE and soaktime for every value of depth. If the interaction is not significant, then there is only one relationship between the dependent variable and each independent variable (Aiken and West, 1991). For those models with a significant interaction, rely on the results from the simple regressions.

Interactions were not significant in four of the nine models (Table 5). Results from these models can be interpreted as follows: CPUE of female *L. couesi* significantly decreased as soaktime increased; CPUE of legal male *L. aequispina* increased with soaktime; CPUE of both sublegal male and female *C. tanneri* increased with soaktime. In each of these models, soaktime was highly significant and depth was nonsignificant when considered together, indicating that soak time was the more important variable effecting CPUE.

Simple linear regressions were run for those multiple regression models with a significant interaction (Table 5). There was a significant inverse relationship between numbers caught and depth for female ($P<0.01$) and sublegal male ($P<0.01$) *L. aequispina*, i.e., the deeper the pot the fewer the crab. A significant positive linear relationship exists between depth and CPUE of sublegal *L. couesi* ($P<0.01$). There was no significant linear relationship between depth and CPUE for female or legal male *L. couesi*, or for any sex-size class of *C. tanneri*.

Soaktime was a significant variable in explaining the variability in CPUE of *L. couesi* and *C. tanneri*. The relationship was positive at the 0.01 level of significance for all sex-size classes of *C. tanneri*. The relationship was negative and significant at the 0.05 level for all sex-size classes of *L. couesi*. Soaktime was significantly related to number of legal *L. aequispina* ($P<0.01$), but was not related to number of sublegal males or females at the 0.05 level of significance.

Handheld GPS

The Alaska Board of Fisheries has asked ADF&G to investigate the possibility of observers being issued GPS units to acquire locations of pot samples. The unit tested was a handheld Garmin 40. The latitude and longitude (lat-long) coordinates obtained from the unit agreed exactly with the Early Dawn's GPS output. However, the unit took at least 5 minutes to come up and if the satellite link was lost, meaning that if something obstructed the 'view' of the unit, the location was lost. After using the handheld on several strings over the course of the trip some problems became apparent. For instance, you couldn't put the unit in a pocket or backpack. It always had to be exposed. The unit also wouldn't access satellites if it was too close to the metal superstructure of the boat or the crane used for stacking pots. It had to be used in the stern of the boat. From a practical viewpoint, the handheld unit couldn't be used to get lat-long coordinates for every pot sampled because it took too long to come on line and it wouldn't give an instantaneous readout unless it could be left in a protected place which had an unobstructed 'view' of the satellites. On a working crab boat in the Aleutians that doesn't seem very probable. You could attain a lat-long for the beginning of every string in which a pot was sampled, which may be of some benefit.

C. tanneri Discards

Little is known about the survival of discarded *C. tanneri* female and sublegal male bycatch. These crabs are trapped in pots at great depths, brought to the surface and then discarded. Although we didn't conduct any formal experiment involving survival of *C. tanneri* discards, we did make some observations on floating discards. *C. tanneri* discards sank faster if discarded posterior border first. If 'burped' in this manner a trail of bubbles could be seen coming out of the mouth and the crab sank out of view in a relatively short time. If discarded in some other orientation (rostrum first, for example), the crab would sink only about a foot under the water and float out of sight in that orientation and at that level. If the crab could right and 'burp' itself, inducing bubbles from its mouth, then it would sink quickly. Females sank faster than males. *L. couesi* and *L. aequispina* sank appreciably faster than *C. tanneri*. Two discarded *C. tanneri* sublegal males floated away on the surface of the water. Both crabs floated within a group of Northern Fulmars (*Fulmaris glacialis*), pelagic seabirds, which flock to the boat as the pots are pulled to feed on the jettisoned bait. In both cases the birds showed no interest in the floating crabs.

Results from a special project carried out by an observer on a vessel in the Dutch Harbor Area, suggest that *C. angulatus* discards can survive the experience of being trapped and discarded if 'burped'. In the experiment, the observer put female and sublegal male *C. angulatus* into a tote of seawater. The crab were tagged and 'burped' before being put back into a pot which was set and allowed to soak with the other normally fished pots at depths greater than 500 fm. All females and sublegal males appeared lively and unharmed after the pot was pulled following a three day soak (G. Pappas, ADFG Dutch Harbor, per. comm.). The survival of 'unburped' discards is unknown.

L. couesi Carapace Color

Other observational data collected on the trip involved the carapace color of *L. couesi*. Somerton (1981) studying *L. couesi* caught on seamounts in the Gulf of Alaska, reported an 'occasional' pink specimen (as opposed to scarlet). We did not record carapace color. However, we estimate that on our trip close to half of the specimens sampled had scarlet carapaces and the remaining specimens ranged in color from faded scarlet to pink to almost white. Somerton trapped *L. couesi* from 210 to 465 fm. Pots in which *L. couesi* were caught on our trip ranged from 320 to 500 fm in depth. Since we didn't quantify carapace color we can't associate color with depth, but in theory shell color should cover a spectrum of colors along a depth gradient. The reason is attenuation of various wavelengths of light with depth. At shallower depth, where more light penetrates, predators rely on visual cues and darker shells (with red, brown and blue pigments) serve a cryptic purpose. Further along the depth gradient, red pigments are the best protection from predators. At depths where essentially no light penetrates, shells are pink or white (Marshall 1954; Zenkevich and Birstein 1956). Since we fished at deeper depths than Somerton we would expect to see more *L. couesi* carapaces with little or no pigmentation.

Effectiveness of Using Observers for Special Projects

Special projects that observers have successfully undertaken in various Alaskan fisheries include: carapace width, length and height measurements of *C. tanneri* to determine a minimum size for escape rings which were mandated by the Alaska Board of Fisheries; tagging of red king crab in the Western Aleutian District to get a feel for population size; chela height measurements in all *C. tanneri* fisheries for size of maturity calculations; genetic specimen collection on most commercially important crab stocks in the westward region to establish geographic boundaries between stocks; and *C. tanneri* maxilla collection for a study on terminal molt.

Special project data collected on this trip included: chela heights of males to determine morphometric maturity for *C. tanneri* and *L. couesi*; missing limb, injury and mortality rates to establish background rates for unexploited crab stocks; catch of crabs in pots with escape rings and mesh to assess the effectiveness of these mechanisms; and the presence or absence of grasping marks on female *C. tanneri* to gain insight into a stock's reproductive health. In addition, structured experiments to investigate the mortality rates of discarded *C. tanneri* would have been conducted had more *C. tanneri* been encountered over the entire length of the trip. The observer skillfully collected and edited all of the appropriate data for each project.

The only data that might be considered suspect is the shell-aging and categorization of grasping marks of *C. tanneri*. Results displayed Table 2 were not as expected by ADF&G biologists. Grasping marks should have been present in predominantly old shell females. The lack of agreement between the actual and theoretical data is probably better attributed to an inadequate explanation of grasping mark identification and shell aging in *C. tanneri*, than to the inability of the observer to perform the special project.

The amount of time that an observer has spent sampling onboard vessels is highly correlated with his/her ability to collect data for special projects. David Cross had over two years experience in the observer program at the time of this trip. Several trips during that period were on vessels participating in a *C. tanneri* fishery. Familiarity with all the species of crab encountered, sampling protocol and general conditions aboard a crabbing boat allowed him to easily shift between routine (e.g., carapace measurements, parasites) and special (limb loss, chela heights) sampling duties.

Even though the presence of an extra person serving as the data recorder made it possible to collect substantially more data than on a 'normal' trip where a single observer sampled and recorded data, the variety of the ancillary data collected on this trip, in addition to that regularly collected by observers, attests to the type of special projects possible through the observer program. The scope of projects which observers can carry out is limited only by the imagination of the biologists who think of them and the range of questions that they need answered.

LITERATURE CITED

Aiken, Leona S. and Stephen G. West. 1991. Multiple regression: testing and interpreting interactions. Sage Publications. Newbury Park, CA. 212 pp.

Alaska Department of Fish and Game. 1993. ADF&G Observer manual for Alaskan crab processors. ADF&G. Dutch Harbor, AK. 132 pp.

Beers, Dean E. 1992. Annual biological summary of the westward region shellfish observer database, 1991. Alaska Department of Fish and Game. Kodiak. Regional Information Report No. 4K92-33. 59 pp.

Conover, W.J. 1971. Practical nonparametric statistics. John Wiley and Sons. New York. 462 pp.

Edwards, J.S. 1972. Limb loss and regeneration in two crabs: the king crab *Paralithodes camtschatica* and the Tanner crab *Chionoecetes bairdi*. Acta Zool., Vol. 53. pp 105-112.

Juanes, Francis and L. David Smith. 1995. The ecological consequences of limb damage and loss in decapod crustaceans: a review and prospectus. J. Exp. Mar. Biol. Ecol. 193: 197-223.

Marshall, N.B. 1954. Aspects of deep sea biology. Hutchinson's scientific and technical publications. London. 380 pp.

Somerton, David A. 1979. On the use of relative growth to determine the size of sexual maturity in crabs. Center for Quantitative Sciences. U. of Wa. Seattle. 15 pp.

Somerton, David A. 1981. Contribution to the life history of the deep-sea king crab, *Lithodes couesi*, in the Gulf of Alaska. Fishery Bulletin 79(2):259-269.

Somerton, David A. and William Donaldson. 1996. Contribution to the biology of the grooved and triangle Tanner crabs, *Chionoecetes tanneri* and *C. angulatus*, in the eastern Bering Sea. Fishery Bulletin 94:348-357.

Tester, P. and A. Carey. 1986. Instar identification and life history aspects of juvenile deepwater spider crabs, *Chionoecetes tanneri* Rathbun. Fishery Bulletin 84:973-980.

Zenkevich, L.A. and J.A. Birstein. 1956. Studies of deep water fauna and related problems. Deep Sea Res. 4:54-56.

Table 1. Number of observer-sampled crab by species, sex, shell age and area fished.

Shellage	Overall		Amlia Island		Tanaga Island	
	Male	Female	Male	Female	Male	Female
L. couesi						
Soft	0	0	0	0	0	0
New	266(98.2%)	313(100%)	146(96.7%)	228(100%)	120(100%)	85(100%)
Old	5(01.8%)	0	5(3.3%)	0	0	0
Very Old	0	0	0	0	0	0
L. aequispina						
Soft	0	1	0	1(0.4%)	0	0
New	386(100%)	327(100%)	294(100%)	251(99.6%)	92(100%)	76(100%)
Old	0	0	0	0	0	0
Very Old	0	0	0	0	0	0
C. tanneri						
Soft	2(0.6%)	0	2(7.1%)	0	0	0
New	272(78.8%)	50(37.0%)	23(82.2%)	4(28.6%)	249(78.5%)	46(38.0%)
Old	62(18.0%)	76(56.3%)	2(7.1%)	10(71.4%)	60(18.9%)	66(54.6%)
Very Old	9(2.6%)	9(6.7%)	1(3.6%)	0	8(2.5%)	9(7.4%)

Table 2. Injury, limb loss, limb regeneration and mortality rates for three species of crabs from observer-sampled pots on the F/V Early Dawn, June, 1996. Percenatages are of total crabs except where listed by sex.

	C. tanneri	*L. couesi*	*L. aequispina*
Injury rate			
Overall injury rate (fresh and old)	2.9%	6.7%	2.4%
Maximum number of injured limbs	3	2	3
Overall fresh injury rate	0.2%	5.2%	1.7%
Maximum number of freshly injured limbs	1	1	2
Limb loss rate			
Overall limb loss rate	37.0%	3.2%	5.2%
1 missing limb	25.1%	2.9%	4.7%
2 missing limbs	8.9%	0.4%	0.3%
3 or more missing limbs	2.9%	0.0%	0.2%
Regenerating limb rate			
Overall regeneration rate	0.4%	4.1%	6.3%
Females with regenerating legs	1	23	29
Males with regenerating legs	1	2	28
Mortality rate			
Overall mortality rate	3.9% [a]	0.2%	0.0%
Female mortality rate	3.0%	0.3%	0.0%
Male mortality rate	3.5%	0.0%	0.0%

[a] Includes 3 *C. tanneri* of undetermined sex.

Table 3. Presence or absence of grasping marks on female *C. tanneri* by egg condition, egg development and area fished. Numbers in parentheses are breakdown by new shell, old shell, and very old shell crab. n=135 females.

	Grasping Marks	
	Present	**Absent**
Egg Condition		
Overall		
Dead eggs not apparent	93 (35,56,2)	15 (8,7,0)
Dead eggs < 20%	6 (1,4,1)	2 (0,2,0)
Dead eggs > 20%	2 (0,1,1)	1 (0,0,1)
Barren with clean 'silky' setae	1 (1,0,0)	0
Barren with 'matted' setae empty egg cases	13 (4,5,4)	1 (0,1,0)
Amlia Island		
Dead eggs not apparent	13 (3,10,0)	0
Dead eggs < 20%	1 (1,0,0)	0
Dead eggs > 20%	0	0
Barren with clean 'silky' setae	0	0
Barren with 'matted' setae empty egg cases	0	0
Tanaga Island		
Dead eggs not apparent	80 (32,46,2)	15 (8,7,0)
Dead eggs < 20%	5 (0,4,1)	2 (0,2,0)
Dead eggs > 20%	2 (0,1,1)	1 (0,0,1)
Barren with clean 'silky' setae	1 (1,0,0)	0
Barren with 'matted' setae empty egg cases	13 (4,5,4)	1 (0,1,0)
Egg Development		
Overall		
Eyed eggs	3 (0,2,1)	0
Uneyed eggs	98 (36,59,3)	18 (8,9,1)
No eggs	14 (5,5,4)	1 (0,1,0)
Amlia Island		
Eyed eggs	0	0
Uneyed eggs	14 (4,10,0)	0
No eggs	0	0
Tanaga Island		
Eyed eggs	3 (0,2,1)	0
Uneyed eggs	84 (32,49,3)	18 (8,9,1)
No eggs	14 (5,5,4)	1 (1)

Table 4. Mean CPUE (crabs per pot) by sex-size class of the three targeted crab species caught in experimental gear with escape mechanisms. n=8 replications.

	Escape Gear		
Species / sex-size	None	Large Mesh Panel	Escape Rings
L. aequispina			
Legal males	0.04	0.13	0.38
Sublegal males	12.95	2.75	2.62
Females	13.53	4.38	2.63
L. couesi			
Legal males	1.87	3.25	3.50
Sublegal males	0.50	0.50	0.75
Females	3.33	3.75	0.88
C. tanneri			
Legal males	0.41	0.13	0.13
Sublegal males	0.06	0.00	0.00
Females	0.00	0.00	0.00

Table 5. Results from three regression models: CPUE on depth; CPUE on soaktime; and CPUE on depth and soaktime. * indicates effect significant at 0.05; ** indicates signficance at 0.01; NS indicates not significant at the 0.05 level. + / - indicates a positive or negative relationship with CPUE.

	Effect		
Species / sex-size	depth	soaktime	interaction
L. couesi			
legal males	NS	* (-)	*
sublegal males	** (+)	* (-)	*
females	NS	** (-)	NS
L. aequispina			
legal males	NS	**(+)	NS
sublegal males	** (-)	NS	*
females	** (-)	NS	*
C. tanneri			
legal males	NS	** (+)	*
sublegal males	NS	** (+)	NS
females	NS	** (+)	NS

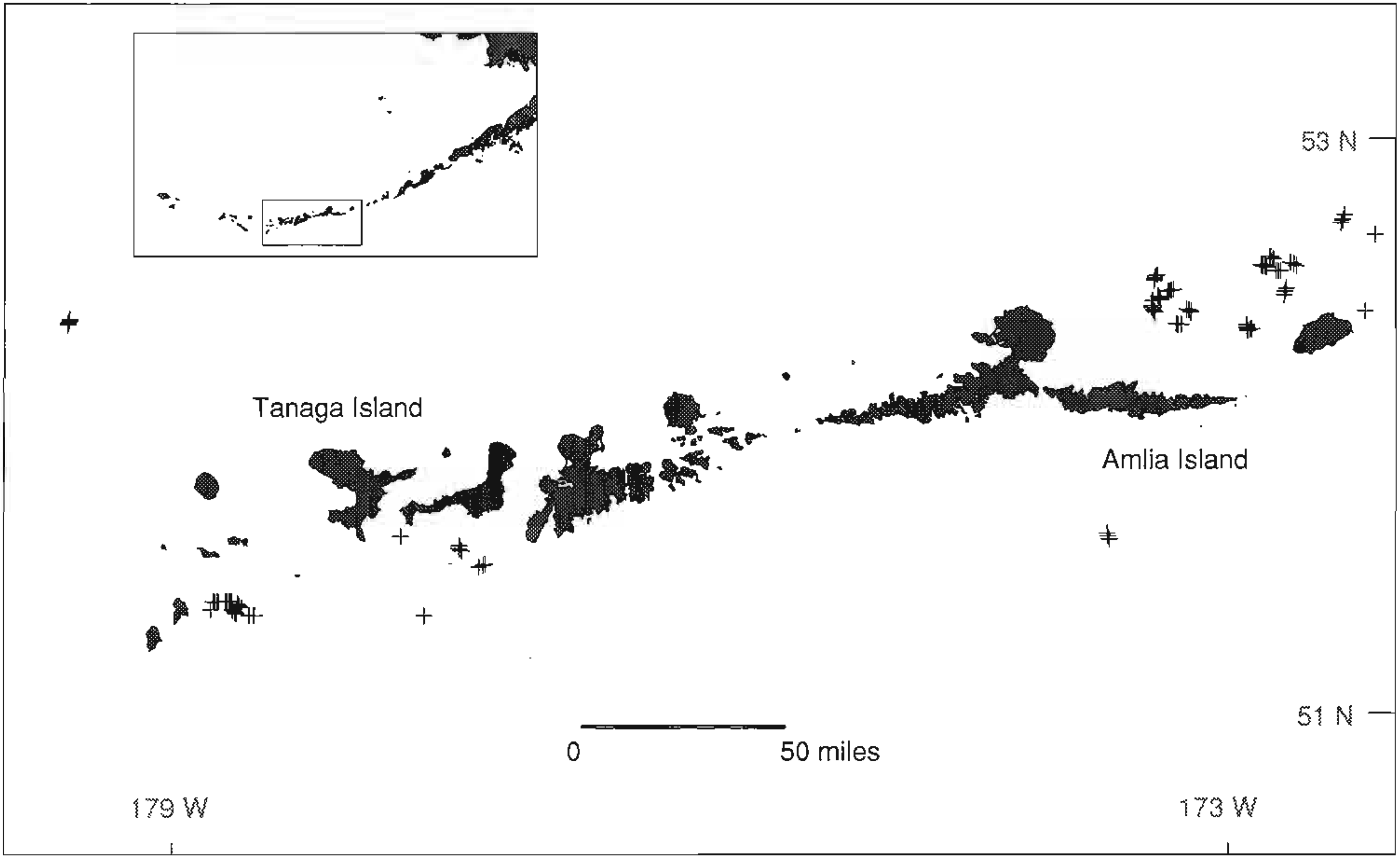

Figure 1. Locations of pots sampled by observer deployed on the F/V Early Dawn, June, 1996.

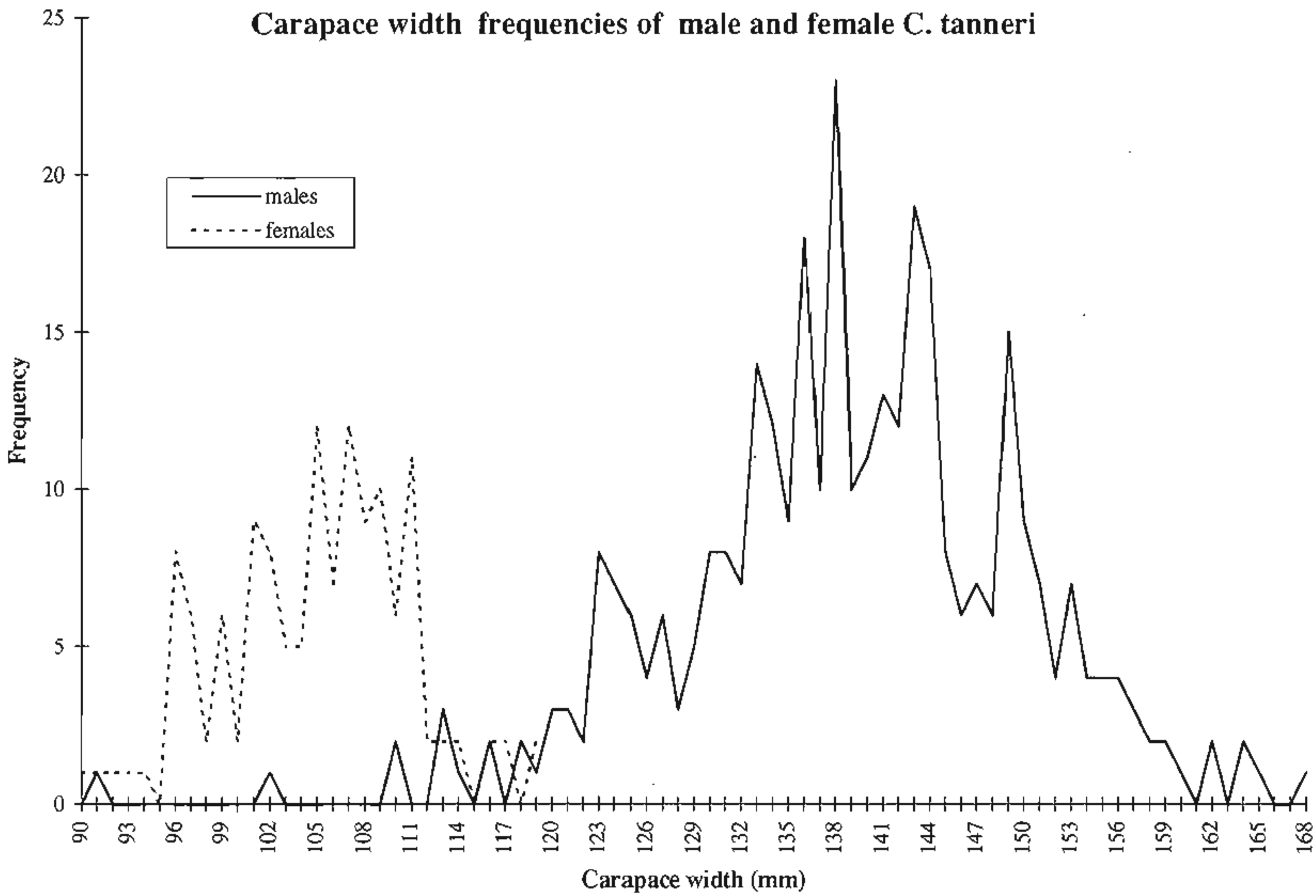

Figure 2. Size frequency plots for male and female *C. tanneri* from observer sampled pots on the F/V Early Dawn, June, 1996.

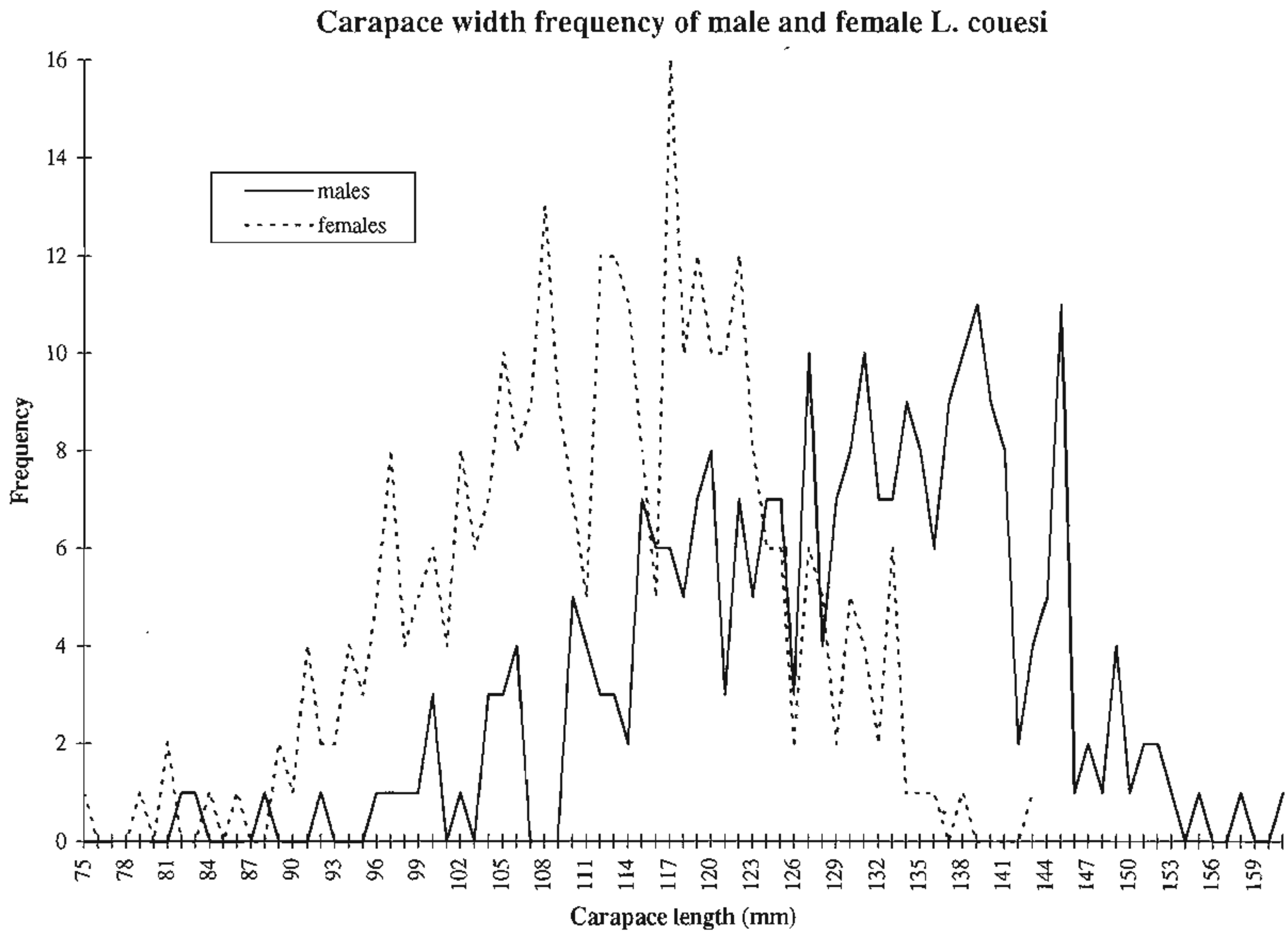

Figure 3. Size frequency plots for male and female *L. couesi* from observer sampled pots on the F/V Early Dawn, June, 1996.

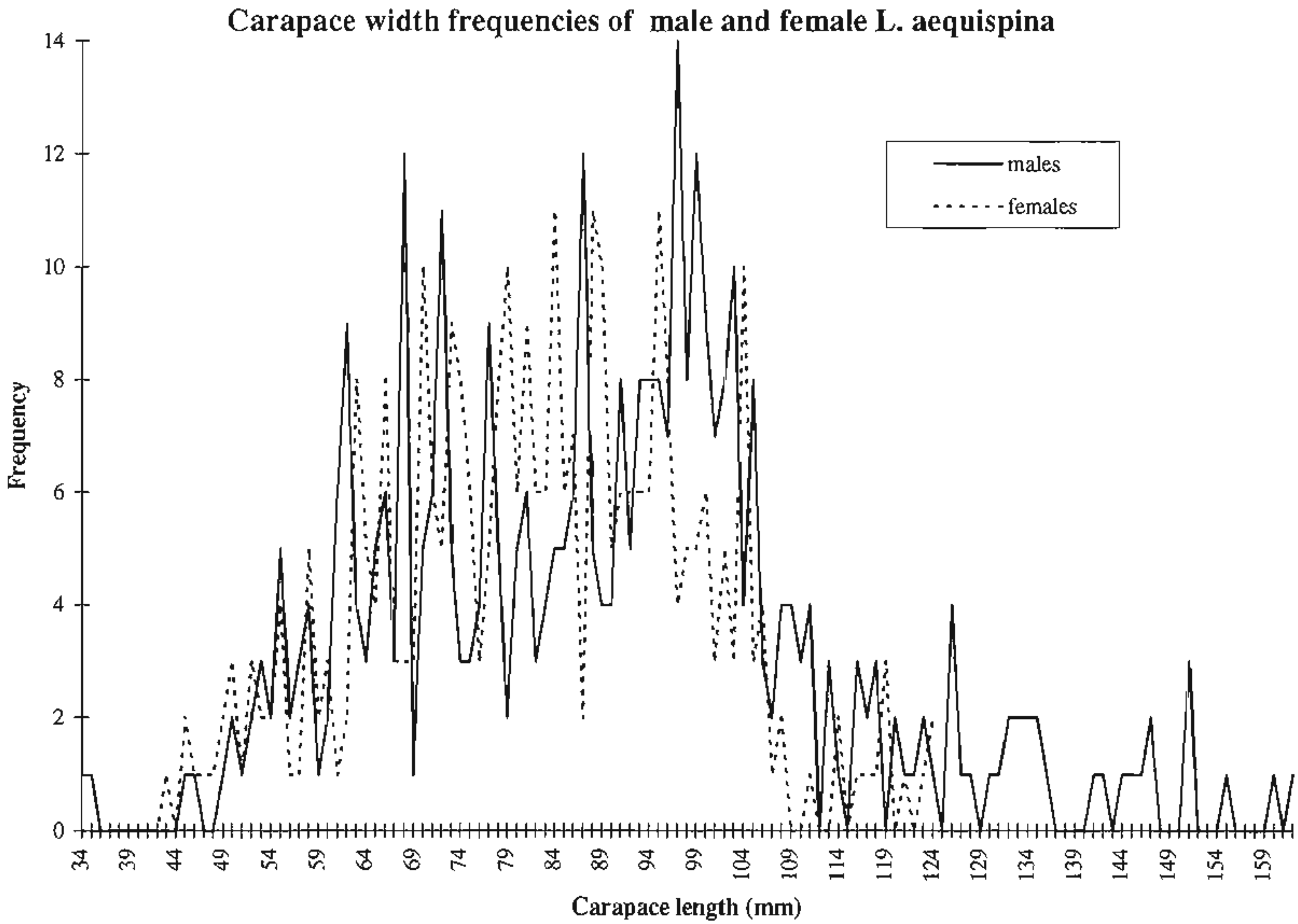

Figure 4. Size frequency plots for male and female *L. aequispina* from observer sampled pots on the F/V Early Dawn, June, 1996.

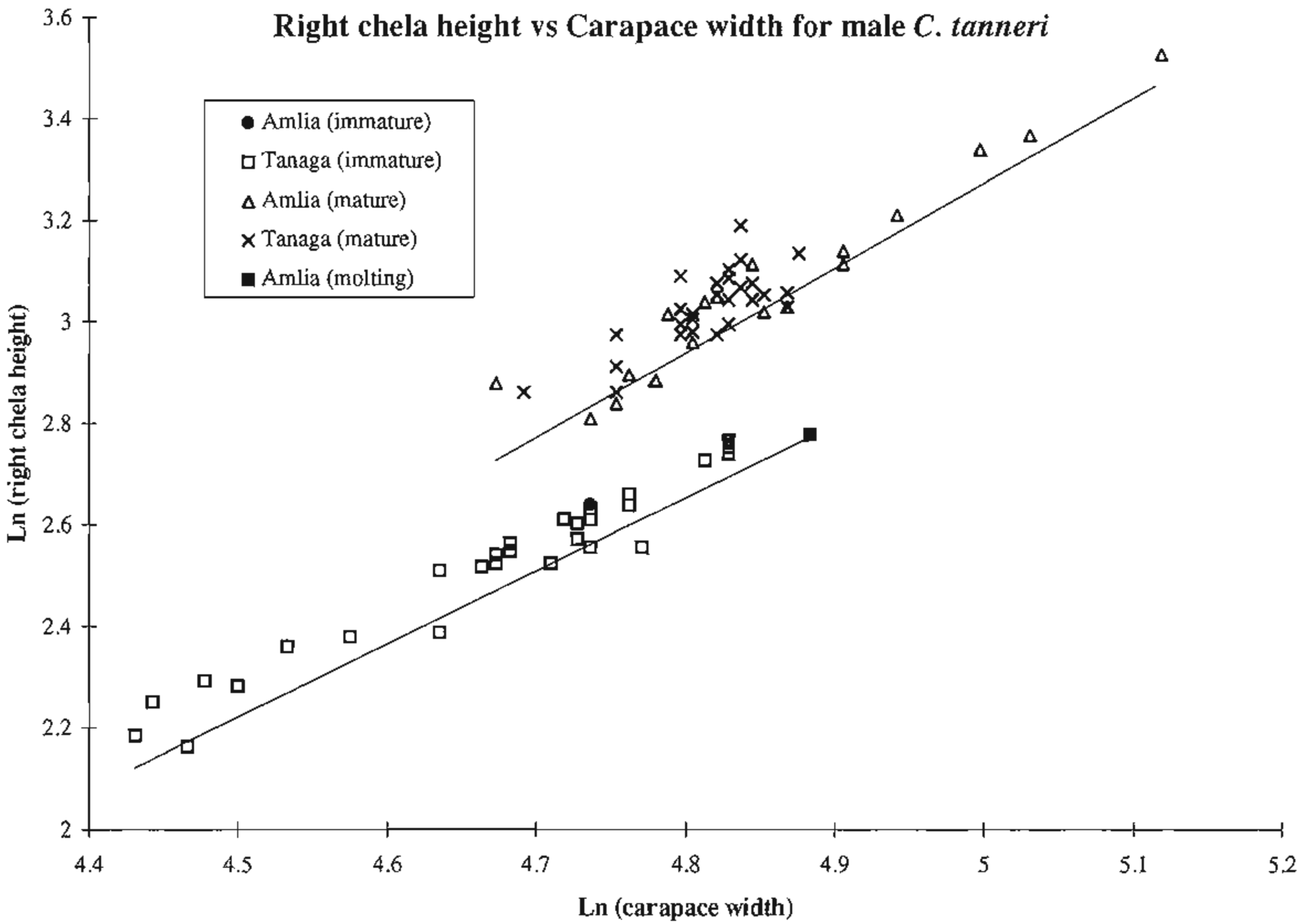

Figure 5. Plot of ln (chela height) vs ln (carapace width) of male *C. tanneri* from observer sampled pots on the F/V Early Dawn, June, 1996.

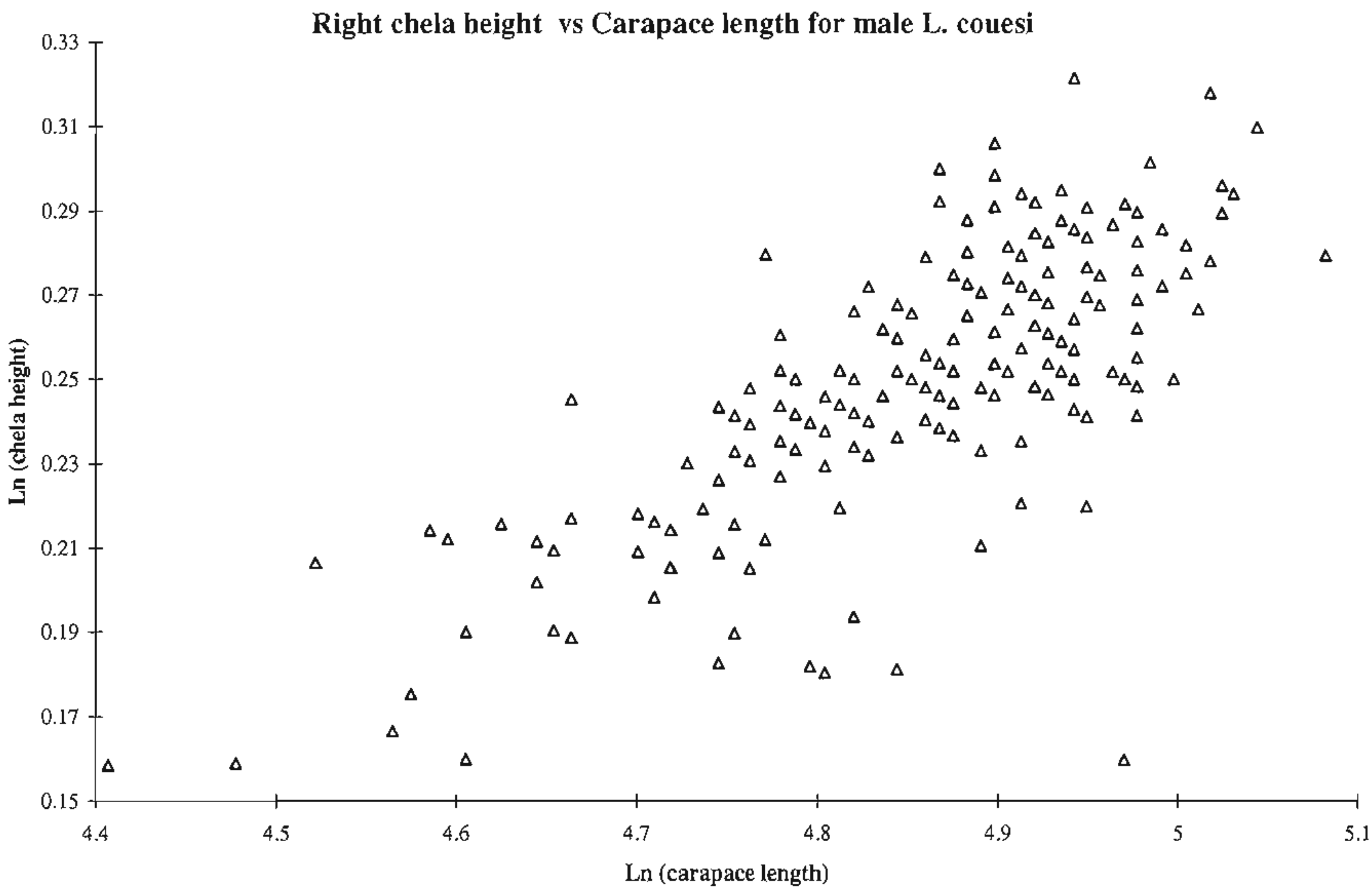

Figure 6. Plot of ln(chela height) vs ln(carapace length) of male *L. couesi* from observer-sampled pots on the F/V Early Dawn, June, 1996.

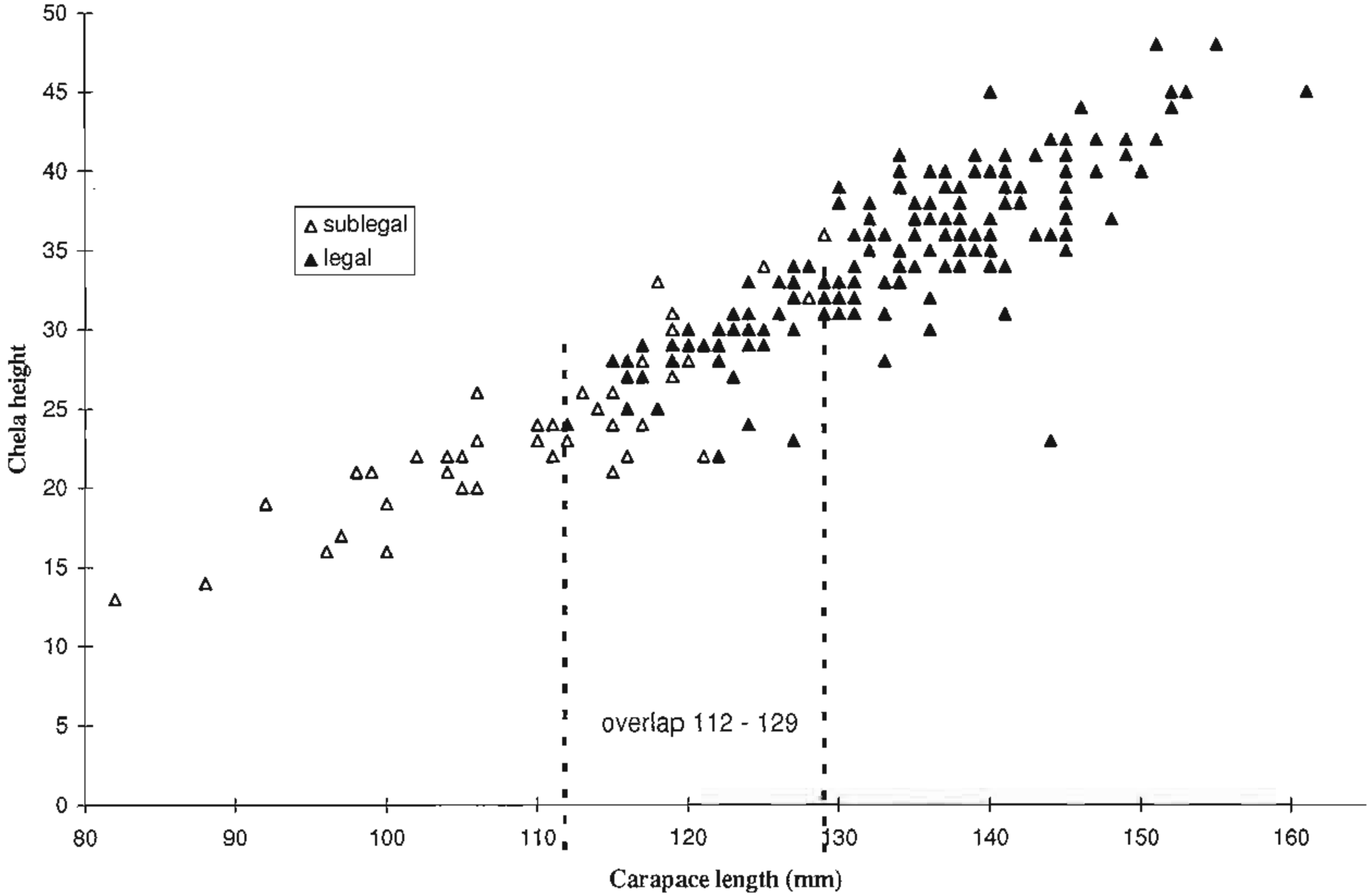

Figure 7. Plot of chela height vs carapace length of male *L. couesi* showing overlap in carapace length for sublegal and legal designations.

The Alaska Department of Fish and Game administers all programs and activities free from discrimination on the basis of sex, color, race, religion, national origin, age, marital status, pregnancy, parenthood, or disability. For information on alternative formats available for this and other department publications, contact the department ADA Coordinator at (voice) 907-465-4120, or (TDD) 907-465-3646. Any person who believes s/he has been discriminated against should write to: ADF&G, PO Box 25526, Juneau, AK 99802-5526; or O.E.O., U.S. Department of the Interior, Washington, DC 20240.