Exxon Valdez Oil Spill
Restoration Project Annual Report

Assessment of Spot Shrimp Abundance in Prince William Sound a Decade after the *Exxon Valdez* Oil Spill

Restoration Project 99401
Annual Report

This annual report has been prepared for peer review as part of the Exxon Valdez Oil Spill Trustee Council restoration program for the purpose of assessing project progress. Peer review comments have not been addressed in this annual report.

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Assessment of Spot Shrimp Abundance in Prince William Sound
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Study History: This project began 1999. Preliminary sampling for the selection of study sites was conducted in August 1999. Complete sampling of all study sites was conducted in October 1999. This is the first annual report to be issued by the project.

Abstract: To estimate the abundance of spot shrimp and determine the structure of the spot shrimp population in Prince William Sound (PWS) we sampled shrimp at 12 sites in western Prince William Sound using shrimp pots. Sampling was conducted in October 1999 at about the same time that the Alaska Department of Fish and Game (ADF&G) conducted their annual survey thereby allowing realistic comparison of their catch statistics with ours. Six of the 12 sites were sites ADF&G traditionally samples in the annual survey. Six sites were added by us after a site selection cruise in August 1999. We used methods similar to those of ADF&G except in the type of pot; ours was conical, theirs was rectangular. Subsequent statistical comparison of ADF&G's catch data with ours for the same sites in October 1999 revealed that the catches did not differ, indicating that the effect of pot type was probably minimal. In the interest of standardization within the ADF&G as a whole, we recommend that ADF&G in Cordova change to the conical pot. Although the means of the 1998 and 1999 summarized ADF&G annual survey data on number of spot shrimp per station and weight of the shrimp catch per station appeared to increase between years our statistical analysis revealed no significant differences between years. We found no significant differences between ADF&G's traditional sites and our new sites in October 1999 for mean number of spot shrimp per pot, mean weight of spot shrimp per pot, mean carapace length of males, transitional shrimp and females, and fecundity, suggesting that our new sites could be added to a larger suite of sites from which six sites could be randomly chosen for the ADF&G annual survey, thereby eliminating the lack of independence in ADF&G's historical data.

Key words: *Pandalus platyceros*, spot shrimp, abundance, CPUE, size-frequency distribution, population structure.

Project Data: (will be addressed in the final report)

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EXECUTIVE SUMMARY

The goal of the spot shrimp project is to determine the extent to which spot shrimp abundance has recovered since the population decline which began just prior to 1989. Our objectives in FY2000 were to: 1. estimate the abundance of spot shrimp at 12 sites in western Prince William Sound (PWS), 2. determine the sex and size composition of spot shrimp at the study sites. 3. estimate spot shrimp fecundity and relative number of egg-bearing females at the study sites, and 4. compare abundance data and data on population structure obtained for this project with that collected by ADF&G. We accomplished these objectives by sampling the six sites traditionally included in ADF&G's annual survey using a methodology similar to that of ADF&G. In addition, we added six new sites selected during a preliminary cruise in August 1999. We sampled spot shrimp using two strings of 11 pots each at each site in October 1999. Our methods differed from those of ADF&G only in the type of pot used. We used a conical pot identical to that used by ADF&G in southeastern Alaska. In PWS ADF&G uses a rectangular pot. In a side-by-side comparison of the conical and rectangular pots we found the rectangular pot to be less effective than the conical pot in catching spot shrimp. However, our pot was somewhat smaller and had larger openings in the mesh forming the entrance tunnels. Subsequent comparison of our data with a summary of ADF&G's data at the same sites also collected in October 1999 revealed no significant difference between our estimate of the number of spot shrimp per pot or weight of the shrimp catch per pot and that of ADF&G. Nevertheless, in the interest of standardization within the Alaska Department of Fish and Game as a whole, we recommend that ADF&G in Cordova change to the conical pot as soon as resources become available to do so. Statistical comparison of the summarized ADF&G annual survey data from 1998 and 1999 provided to us by ADF&G revealed no significant increase in the number of spot shrimp per station or weight of the shrimp catch per station between 1998 and 1999. Although examination of the mean values for these variables appeared to suggest that population recovery may have been starting in 1999, we do not have the evidence to indicate an increase in spot shrimp abundance between 1998 and 1999. We found no significant differences between ADF&G's traditional six sites and our six new sites in October 1999 for several variables related to the spot shrimp populations at those sites including: mean number of spot shrimp per pot, mean weight of spot shrimp per pot, mean carapace length of males, transitional shrimp and females, and fecundity. This suggests that our six new sites could be added to the traditional sites of ADF&G to form a suite of 12 or more sites from which six sites could be randomly chosen for the ADF&G annual survey, thereby precluding statistical difficulties from lack of independence that follows from sampling the same sites each year. Our estimates of spot shrimp fecundity were frequently substantially higher than previously published estimates for the ADF&G traditional sites from 1989-1991. We were unable to test the difference between those estimates and ours because we lacked the raw data on fecundity used to calculate those estimates. If the differences were real they may represent true interannual differences in the mean fecundity of the shrimp populations at these sites suggesting that spot shrimp fecundity may be an important variable to monitor on a periodic basis. Fecundity is not currently being monitored during ADF&G annual surveys.

INTRODUCTION

The commercial spot shrimp (*Pandalus platyceros* Brandt, 1851) fishery in Prince William Sound (PWS) began in the 1950's and remained small until the late 1970's. After 1975 the fishery expanded rapidly. The harvest increased from 5.8 tonnes in 1978 to more than 110 tonnes in 1986 as the number of vessels participating in the fishery increased ninefold to 80 vessels (Trowbridge 1994, Kimker et al. 1996). Area closures after the *Exxon Valdez* oil spill resulted in a precipitous decline in the harvest in 1989. Low stock abundance necessitated closure of the fishery in 1990 by emergency order (Orensanz et al. 1998). A reduced fishery involving 15 vessels took place in the fall of 1991, but the season was closed early when a reduced guideline harvest level was reached. Catch per unit effort (CPUE) averaged 0.4 kg of whole shrimp per pot during the 1991 season. The fishery was closed in 1992 and remains closed (Trowbridge 1994, Orensanz et al. 1998). The decision point for reopening the fishery has been set tentatively at a survey CPUE of 0.6 kg/pot (Trowbridge 1994).

Annual surveys of the abundance of spot shrimp in PWS begun in 1989 by the Alaska Department of Fish and Game (ADF&G) continue to the present. The surveys sample spot shrimp at six to eight sites in the seven major statistical reporting areas that divide the Traditional Harvest Area in western PWS (Trowbridge 1992, 1994). From 1989 to 1993 the survey CPUE has declined from 0.6 kg/pot to 0.2 kg/pot. During the same period the percentage of large shrimp (females) increased from 4 to 20% indicating a somewhat reduced recruitment in the near term after 1993 (Trowbridge 1994). In the present study we sought to assess the extent to which spot shrimp abundance had recovered since the population decline which began just prior to 1989. Our objectives were to estimate relative abundance, describe population structure and determine the fecundity of spot shrimp in western Prince William Soiund.

OBJECTIVES

1. Estimate abundance (CPUE) of spot shrimp by weight and number of individuals.

2. Determine the sex and size composition of spot shrimp at the study sites.

3. Estimate spot shrimp fecundity and relative number of egg-bearing females at the study sites.

4. Compare abundance data and data on population structure obtained under the present project with that collected by ADF&G.

METHODS

Study Sites

Shrimp pots were fished at six sites in northern and western PWS previously surveyed by ADF&G and at six additional sites (Figure 1). The sampling sites were located in Unakwik Inlet, at Golden in Port Wells, in lower Culross Passage, in Herring Bay, at northeast Chenega Island and at northern Green Island. Six additional sites at Wells Bay, Eaglek Bay, McClure Bay, near East Finger Inlet in Port Nellie Juan, northwest Perry Island and at the mouth of Jackpot Bay were added to the existing traditional ADF&G sites (Table 1; Figure 1).

A preliminary sampling cruise was conducted on 3-9 August 1999 to select sites to be added to the traditional sites included in the ADF&G annual survey. The main sampling cruise was conducted on 19-29 October 1999 (Table1).

Sampling Procedures

Sampling methods were modified after Trowbridge (1992, 1994). Two strings of shrimp pots were set at each site. Each string was designated a sampling station. A string consisted of 11 pots spaced 18.9 m (62 ft) apart along a groundline and buoyed at both ends. Standard, conical (in the shape of a truncated cone), nesting pots were used (Figure 2). The diameters of the base and top of each pot were 107 cm (42 in) and 91 cm (36 in), respectively. The frame of the pot was mild steel with a black plastic coating and covered with a tar-coated mesh having stretched openings of 2.9 cm (1 1/8 in). Two opposing tunnels the inner ends of which each had an opening 7.6 cm (3 in) in diameter were set into the side of the pot. A single 1 L perforated plastic jar containing chopped herring was placed in each pot at the time of deployment. The pots were fished in the depth range 27-183 m (15-100 fm) for a minimum of 18 h at each site.

Our pots differed from those used by ADF&G which are rectangular pots measuring 41 cm x 41 cm x 91 cm (16 in x 16 in x 36 in) with 2.9 cm (stretched mesh) openings in the mesh enclosing the tunnels (for added details see Trowbridge 1994). To compare the relative efficiency of the two pot designs we interspersed pots similar in configuration to those of ADF&G in our pot strings. We were unable to obtain pots identical to those of ADF&G . The rectangular pots that we used differed from those of ADF&G chiefly in being somewhat smaller (33 cm x 33 cm x 81 cm) and in having larger openings (3.3 cm stretched opening) in the mesh enclosing the tunnels. Two rectangular pots were added to each of the two pot strings fished at each site. The rectangular pots were attached to the ground line midway between the third and fourth (ordered shallow to deep) and the seventh and eighth conical pot on each string.

Upon retrieval of the pot strings all pandalid shrimp in each pot were speciated. Spot shrimp were counted and the catch weighed to the nearest two grams on a Marel electronic balance equipped with a motion compensating algorithm. Other species of pandalid shrimp (eg. *P. eous* and *P. hypsinotus*) were counted. All non-shrimp bycatch was speciated and counted. The carapace length of all spot shrimp were measured to the nearest mm. Carapace length was

measured with calipers except when catches were too large to do so efficiently, in which case, all shrimp not measured with calipers were photographed with a digital camera and the carapace length later determined from the digital image with Optimus image analysis software. A subsample of each catch was collected for staging and sexing. Additional observations of ovigerous spot shrimp included egg condition (eyed vs uneyed) and egg color. The egg clutches of about 20 ovigerous females, if available, were sampled at each site for estimates of fecundity. The egg clutches were collected by clipping all of the pleopods on the female bearing eggs and immersing the pleopods with eggs in a 118 ml jar containing 10% seawater-buffered formalin.

Nonovigerous shrimp returned to the laboratory were examined for stage of development. The right first and second pleopods were removed from the abdomen of each shrimp and examined under a dissecting microscope. The stage of development was recorded based on the morphology of the pleopods according to the scheme of Hoffman (1972). The carapace length of each shrimp staged in this way was measured to the nearest 0.1 mm with a digital or dial caliper. Fecundity of the egg clutches fixed in formalin in the field was determined by counting all of the eggs in each clutch under a dissecting microscope.

Data Analysis

Paired t-tests were used to compare the CPUEs of rectangular pots versus conical pots. The sampling unit for this analysis was the station. Analysis of variance was used to test for differences in CPUE (No. of individuals/pot and weight/pot) between sampling groups and years. The sampling unit was the site. Homogeneity of variance was tested with Levene's test (Levene 1960). If necessary, data were log-transformed [log (y + 1) if the data included zeros] to stabilize variances. Linear regression was used to test for temporal trends in CPUE.

RESULTS

Conical Pots vs Rectangular Pots

Rectangular pots had smaller catches than did conical pots (Table 2). When all stations were considered together the mean number of spot shrimp per pot (NPP) in the conical pot (NPP = 11.8 shrimp/pot) was 2.5 x that of the adjacent rectangular pot (NPP = 4.7 shrimp/pot) nearest in depth (paired t-test, $t = 4.15$, $df = 22$, $p > 0.001$). Similarly, the mean weight of the spot shrimp catch per pot (WPP) in the conical pot (WPP = 290 g/pot) was 2 x that of the rectangular pot (WPP = 144 g/pot; paired t-test, $t = 3.61$, $df = 22$, $p > 0.01$). The weights of both variables were transformed [log (y + 1)] for the analyses. For all subsequent analyses covered in this report only data from the conical pots was used.

Catches at Traditional Sites vs New Sites

The catch of spot shrimp varied greatly between sampling sites both within the group of traditional sites and within that of new sites. Among the traditional sites the greatest total number

and weight of spot shrimp were caught at Culross Passage (Table 3). The lowest total numbers of shrimp were caught at North Chenega Island and Green Island where catch weights were also lowest. At the new sites, the greatest total number of shrimp was caught at Wells Bay (Table 3). Both Wells Bay and Perry Island had the greatest catch weight of spot shrimp. The lowest total number and weight of spot shrimp caught at the new sites were at Eaglek Bay where only four male spot shrimp were caught (Table 3).

Although the mean spot shrimp catch at the newly added sites appeared somewhat greater than that at the traditional ADF&G sites, the difference was not significant. The mean number of spot shrimp per pot (NPP = 15.4 shrimp/pot) at the new sites did not differ from that at the Traditional sites (NPP = 11.8 shrimp/pot; ANOVA, $F = 0.26$, $df = 1,10$, $p > 0.05$). Similarly, the mean weight of the spot shrimp catch per pot at the new sites (WPP = 374 g/pot) did not differ from that at the traditional sites (WPP = 258 g/pot; ANOVA, $F = 0.52$, $df = 1,10$, $p > 0.05$).

Population Structure

Males outnumbered females in the catches at all sites. At the traditional ADF&G sites males ranged from 76% (Golden) to 93% (Culross Passage) of the total catch (Table 3). At the newly added sites males composed from 54 % (Perry Island) to essentially 100% (Eaglek Bay and Port Nellie Juan) of the total catch. Females were present in the catches at all sites but Eaglek Bay. The majority of females in those catches were ovigerous. Nonovigerous shrimp never exceeded 25% (Green Island) and usually represented less than 10% of the females in the total catch at a site (Table 3). Shrimp transitional between male and female were rare, never representing more than about 5% of the total catch at a site.

Mean carapace length (CL) of male, transitional and female spot shrimp generally did not vary greatly between sites (Figure 3). Males showed the greatest between-site variability in carapace length at the newly added sites. Mean CL of males at the new sites ranged from 24.2 mm (Port Nellie Juan) to 33.5 mm (Perry Island). No difference was observed in the site-group mean for males (MCL) between traditional (MCL = 30.6 mm) and new (MCL = 28.5 mm) sites (ANOVA, $F = 1.7$, $df = 1,10$, $p > 0.05$). Shrimp transitional between male and female had the greatest between-site variability in CL at the traditional sites, ranging in CL from 34.0 mm (Unakwik Inlet) to 40.0 mm (Golden). Transitional shrimp were in the catches at eight of the 12 sites sampled. The site-group mean CL of transitional shrimp (TCL) was similar at traditional (TCL = 37.1 mm) and new (TCL = 38.7 mm) sites (ANOVA, $F = 1.2$, $df = 1,6$, $p > 0.05$). Females showed the least variability in mean carapace length of the three segments of the population (Figure 3). At traditional sites the mean CL of females ranged from 42.2 mm (Culross Passage) to 45.0 mm (Golden). At new sites the CL ranged from 42.0 mm (Port Nellie Juan) to 45.1 mm (Jackpot Bay). Not surprisingly, no differences were observed in the site-group mean for females (FCL) between traditional (FCL = 43.7 mm) and new (FCL = 43.6 mm) sites (ANOVA, $F = 0.01$, $df = 1,9$, $p > 0.05$).

Size-frequency Distribution

The carapace length-frequency distributions of spot shrimp from sites where our pot catches were relatively large can be divided into two patterns based on the relative abundance of male versus female shrimp. Males clearly dominated the catch at Port Nellie Juan, Culross Passage, Jackpot Bay and Herring Bay (Figure 4). At these sites males represented >85% of the catch, ranging from 86% at Herring Bay to nearly 100% at Port Nellie Juan. The mode of the size-frequency distribution was lowest at Port Nellie Juan (23 mm) and highest at Culross Passage (30-32 mm). The distribution of Culross Passage also showed a secondary mode at 27 mm. The modes of the distributions of Jackpot Bay and Herring Bay were 25-27 mm and 27 mm, respectively (Figure 4).

Most of the males at the male-dominated sites were fully functional (stages 5and 6;≥ 65%) except at Jackpot Bay where most males (65%) were stage 4 (Figure 4). Stage 2 and stage 3 males were rare at the male-dominated sites. Stage 2 males were present in the catches from Port Nellie Juan and Culross Passage (≤ 3 shrimp/site). Stage 3 males were present at Port Nellie Juan, Culross Passage and Jackpot Bay (≤ 9 shrimp/site; Figure 4). No stage 1 males were captured in the pots.

Because females represented a minor part of the catch (< 15%) at the male-dominated sites it was more difficult to specify the modal size of the females than it was that of the males. The modal carapace length of females was about 42 mm at Port Nellie Juan, Culross Passage and Herring Bay (Figure 4). The modal size was somewhat larger (45 mm) at Jackpot Bay. Virtually all of the females were ovigerous at the male-dominated sites. Three of the females (12%) from Jackpot Bay were nonovigerous. No nonovigerous females were captured at Port Nellie Juan, Culross Passage or Herring Bay (Figure 4). Shrimp transitioning from male to female were also rare in the catches from the male-dominated sites. Transitional shrimp represented from 0.4% to 4% of the catch from Culross Passage Jackpot Bay and Herring Bay. No transitional shrimp were present in the catch from Port Nellie Juan (Figure 4).

Females never dominated the catch at any site. However, they were relatively more abundant at Golden, McClure Bay, Wells Bay and Perry Island than at the sites that were clearly dominated by males. Females represented from 22% to 44% of the catch at these sites (Figure 4). The modal lengths of the females were 44 mm at Golden, Wells Bay and Perry Island and 42 mm at McClure Bay. Nearly all females were ovigerous at these sites. The percentage of female shrimp that were nonovigerous ranged from 1.5% at Golden to 7.9% at Perry Island (Figure 4). Transitional shrimp were also rare in catches with relatively many females. The percentage of the catch composed of transitional shrimp ranged from 0 at Wells Bay to 3% at McClure Bay (Figure 4).

The modal carapace length(s) of males at the sites with high female catches was generally somewhat greater than that at male-dominated sites. Modal size at Golden and McClure Bay was 29 mm and 30 mm, respectively (Figure 4). The size-frequency distribution for males caught at Wells Bay showed a modal carapace length (CL) at 25 mm with a lesser mode at 36 mm. The

size-frequency distribution for males at Perry Island showed no distinct mode; males in the size range 32-39 mm CL occurred most frequently in the catch there (Figure 4).

Similar to the male-dominated sites, most males at the sites with high female catches were fully functional. The percentage of males in stages 5 and 6 combined ranged from 71% at Wells Bay to 92% at Perry Island (Figure 4). Stage 4 males made up most of the rest of the male catch at all four sites. Males in stages 2 and 3 were rare just as they were at the male-dominated sites (Figure 4).

Catches at four sites (Unakwik Inlet, Green Island, North Chenega Island and Eaglek Bay) were too small (catch < 80 shrimp/site) to completely characterize the size-frequency distributions there. Females represented 21% of the catch at North Chenega Island, but catches at the other sites were either exclusively (Eaglek Bay) or predominently (88%; Unakwik Inlet and Green Island) male (Figure 5). Females were too few in the catches from these sites to identify a modal size. Female carapace length ranged from 40-45 mm at Unakwik Inlet, 41-49 mm at Green Island and 41-48 mm North Chenega Island. The size-frequency distribution for Unakwik Inlet showed a modal class composed of functional males (mostly at stage 5) at 33 mm CL. Because of the low number of shrimp caught at Green Island and North Chenega Island, modal sizes could not be identified with confidence there. Males caught at Green Island and Unakwik Inlet were mostly (> 66%) at stage 5. At Unakwik Inlet the majority (54%) of males were at stage 6; 39% were at stage 5 (Figure 5). Only four spot shrimp were caught at Eaglek Bay: all were stage 4 males.

Fecundity

Excluding Port Nellie Juan where only one ovigerous female was captured, mean fecundity at those sites where ovigerous females were captured ranged from 2614 to 3580 eggs (Figure 6). No females were caught in Eaglek Bay. Females at Golden had the highest mean fecundity (3580 eggs). Those females also averaged the greatest carapace length (45 mm) among those caught at the traditional sites (Figure 3). Among females caught at the new sites those at Jackpot Bay had the highest mean fecundity (3350 eggs) and the greatest mean carapace length (45.1 mm). The lowest mean fecundity was observed at Culross Passage (2614 eggs) where mean carapace length of females was 42.2 mm. We observed no difference in the site-group mean for fecundity (FE) between traditional (FE = 2918 eggs) and new (FE = 2850 eggs) sites (ANOVA, $F = 0.1$, $df = 1,9$, $p > 0.05$).

DISCUSSION

The rapid decline in the commercial catch of spot shrimp after the peak harvest of over 110 tonnes in 1986 (Figure 7) has been offered as an example of the vulnerability of Alaskan crustacean stocks to depletion through overfishing (Orensanz et al. 1998). The Alaska Department of Fish and Game (ADF&G) has continued to monitor the stock in western Prince William Sound (WPWS) with annual surveys since the closure of the commercial fishery in 1992 (Trowbridge 1994; Table 4). Although the stock in WPWS has remained depressed since the fishery closure, there is not unequivocal evidence that it has continued to decline since 1992. We were unable to test, statistically, whether a post-closure decline in the stock was evident in the ADF&G data in the first few years after the fishery closure because no estimates of between-site variability were available to us prior to 1995 (Table 4). However, J. Brady kindly gave us summaries of ADF&G survey data collected from 1995 to 1999 that allowed us to estimate between-site variability within years (Figure 8). Statistical tests revealed no significant trend in the number of spot shrimp per station (regression $R^2 = 0.35$, df = 1,28, $p > 0.05$) in the ADF&G survey data between 1995 and 1998. However, the weight of the spot shrimp catch per station (regression $R^2 = 0.51$, df = 1,28, $p < 0.01$) from the survey decreased between 1995 and 1999. Examination of Figure 8 suggested that the survey catch at the traditional ADF&G sites may have rebounded between 1998 and 1999. However, neither the number of spot shrimp per station (ANOVA, $F = 1.04$, df = 1,12, $p > 0.05$) nor the weight of the spot shrimp catch per station (ANOVA, $F = 1.99$, df = 1,12, $p > 0.05$) differed significantly between 1998 and 1999 in the ADF&G annual survey data.

The present study obtained mean spot shrimp catches similar in size to those of ADF&G in October 1999. At the traditional survey sites neither our estimate of the mean number of spot shrimp per pot (NPP = 11.8 shrimp/pot; ANOVA, $F = 0.054$, df = 1,10, $p > 0.05$) nor our estimate of the mean weight of the spot shrimp catch per pot (WPP = 0.26 kg/pot; ANOVA, $F = 0.088$, df = 1,10, $p > 0.05$) differed from those obtained during the 1999 ADF&G annual survey (NPP = 13.4, WPP = 0.22 kg/pot; Figure 9).

A similar result obtained when we expanded the analysis to include all sites sampled by ADF&G and us. In addition to the six traditional sites ADF&G sampled a site near the southern end of Chenega Island and one in Prince of Wales Passage in October 1999. When we compared catches from the eight sites sampled by ADF&G with those from the 12 sites (six traditional and six new sites) that we sampled we found no difference between the two groups of samplers. Neither the mean number of spot shrimp per pot (NPP = 13.6 shrimp/pot; ANOVA, $F = 0.056$, df = 1,18, $p > 0.05$) nor the mean weight of the spot shrimp catch per pot (WPP = 0.32 kg/pot; ANOVA, $F = 0.049$, df = 1,18, $p > 0.05$; weights log-transformed for analysis) differed from those obtained by ADF&G (NPP = 12.5 shrimp/pot, WPP = 0.21 kg/pot) in October 1999.

Between-study differences in pot configuration did not appear to significantly influence the catch of spot shrimp. The side-by-side comparison of rectangular pots and conical pots in the present study revealed that the rectangular pots that we used were much less effective than the conical pots at catching spot shrimp. Nevertheless, the catches of ADF&G were comparable to ours in

October 1999 (Table 4, Figures 9 and 10). Apparently, the somewhat larger rectangular pot with larger mesh enclosing the tunnels that ADF&G used accounted for the difference in effectiveness of their rectangular pots compared to ours. Although no consistent differences were observed in the catches of ADF&G's rectangular pots and our conical pots, ADF&G in Cordova should consider changing their pot design to the conical pot. The ADF&G in southeastern Alaska uses for their surveys a pot identical to the one that we used in PWS (G. Bishop, pers. comm.). For the sake of pot standardization within ADF&G and to facilitate more realistic comparisons of spot shrimp population structure in PWS where the population is depleted with southeastern Alaska where the population is apparently healthy and is currently commercially fished, the conical pot may be preferable to the rectangular pot currently in use by ADF&G in PWS.

Systematic annual resampling of the same index sites may provide a sensitive measure of temporal changes in spot shrimp abundance at those sites, but because of the lack of independence in the resulting data, statistical analysis of temporal trends in the data is rendered problematical. If ADF&G has time and resources to sample six sites in Prince William Sound during their annual survey, rather than resampling the same six sites it would be preferable to identify, say, 12 sites, and to choose randomly six sites among those 12 sites to sample annually. We found no significant differences in the site-group means between ADF&G's traditional six sites and our six new sites in October 1999 for several variables related to the spot shrimp populations at those sites including: mean number of spot shrimp per pot, mean weight of spot shrimp per pot, mean carapace length of males, transitional shrimp and females, and fecundity. With the exception, perhaps, of Eaglek Bay where our catch of spot shrimp was very low, the new sites that we sampled in October 1999 may be good candidates to be added to a larger group of sites from which ADF&G could randomly choose six sites to sample each year.

Our estimate of mean fecundity per site (by actual count of all eggs in each clutch) appeared to be uniformly higher than that of Trowbridge (1992), the only published estimates of which we are aware of spot shrimp fecundity in Prince William Sound. For this comparison we chose the largest estimate of mean fecundity at each site among three years (1989,1990 and 1991) from Trowbridge (1992; see Table 14 of Trowbridge). Although our fecundity estimate for Green Island was only 2.1% higher than that of Trowbridge, our estimates were often substantially higher for Unakwik Inlet (28.7% higher), Culross Passage (13.3%), Golden (41.7%), Herring Bay (36.7%), and North Chenega Island (52.8%). We were unable to test the difference between Trowbridge's estimates and ours because we lacked his raw data on fecundity, however the differences seem notable to us. If the differences are real, they may simply be ascribed to the different estimation techniques of Trowbridge and us or they may represent real interannual differences in the mean fecundity of the shrimp populations at these sites. The ADF&G does not routinely estimate spot shrimp fecundity in its annual survey. If real interannual differences occur in spot shrimp fecundity in Prince William Sound, and in view of the importance of fecundity estimates to our knowledge of the reproductive potential of a population, periodic monitoring of fecundity at ADF&G's sites may be warranted.

CONCLUSIONS

The slight apparent increase in the spot shrimp catch per unit effort (CPUE) that appeared in our data and that of the Alaska Department of Fish and Game (ADF&G) in October 1999 compared to ADF&G's CPUE estimate for 1998 proved to be statistically insignificant. Nevertheless, it marked the end of the decline in spot shrimp CPUE (weight of catch/pot) that occurred between 1995 and 1998. Another year of CPUE estimates by this study for comparison with the ADF&G survey in 2000 may resolve the question of whether the spot shrimp population in western Prince William Sound is starting to recover. Although our catches did not differ from those of ADF&G at the same sites in October 1999 despite the different pot configurations used by the two investigations, we recommend that ADF&G standardize the pots used in PWS with those used by the same agency elsewhere in Alaska, ie. change to the conical pot described in the methods section of this report. We also recommend that in future surveys ADF&G randomly select their sites from a larger group of potential sampling sites, the six additional sites that we sampled being good candidates for inclusion in the larger group of sites.

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Table 1 . Location, date set, depth and soak time of pot strings set to sample spot shrimp at 12 sites in Western Prince William Sound in October 1999.

Site	Station	Date set	Latitude	Longitude	Depth (m)		Soak time (h)
					Minimum	Maximum	
ADF&G Traditional Sites							
Unakwik Inlet	1	10/19/99	61°00' N	147°32' W	92	159	18
	2	10/19/99	61°00' N	147°33' W	43	72	19
Culross Passage	1	10/21/99	60°37' N	148°10' W	60	130	19
	2	10/21/99	60°36' N	148°10' W	94	102	19
Golden	1	10/22/99	60°58' N	148°01' W	69	170	18
	2	10/22/99	60°58' N	148°02' W	46	99	20
Herring Bay	1	10/25/99	60°29' N	147°46' W	55	133	19
	2	10/25/99	60°28' N	147°46' W	26	136	21
North Chenega Island	1	10/27/99	60°24' N	147°59' W	103	172	18
	2	10/27/99	60°24' N	148°00' W	70	148	19
Green Island	1	10/29/99	60°16' N	147°33' W	74	136	18
	2	10/29/99	60°17' N	147°32' W	115	159	19
New Sites							
Wells Bay	1	10/18/99	60°58' N	147°28' W	80	119	16
	2	10/18/99	60°59' N	147°28' W	65	184	19
Eaglek Bay	1	10/20/99	60°54' N	147°46' W	90	129	20
	2	10/20/99	60°53' N	147°46' W	158	166	20
McClure Bay	1	10/23/99	60°34' N	148°11' W	111	153	19
	2	10/23/99	60°33' N	148°10' W	72	175	20
Port Nellie Juan	1	10/24/99	60°31' N	148°20' W	54	132	18
	2	10/24/99	60°32' N	148°19' W	67	138	20
Perry Island	1	10/26/99	60°44' N	148°01' W	74	157	19
	2	10/26/99	60°43' N	148°02' W	147	176	21
Jackpot Bay	1	10/28/99	60°19' N	148°11' W	48	143	20
	2	10/28/99	60°19' N	148°13' W	40	158	22

Table 2 . Catches of spot shrimp in rectangular pots compared to those of adjacent conical pots nearest in depth at 12 sites in western Prince William Sound in October 1999.

		Conical pots					Rectangular pots				
Site	Station	No. pots	Mean no./pot	SE no./pot	Mean wt/pot (g)	SE wt/pot (g)	No. pots	Mean no./pot	SE no./pot	Mean wt/pot kg	SE wt/pot kg
ADF&G Traditional Sites											
Unakwik Inlet	1	2	3	3	99	99	2	0	0	0	0
	2	2	1.5	1.5	32.5	32.5	2	5	4	98	86
Culross Passage	1	2	9.5	9.5	169	169	2	7	7	154	154
	2	2	25.5	4.5	531	60	2	1.5	0.5	31	9
Golden	1	2	29	7	934	142	2	6	5	170	136
	2	2	4.5	3.5	71.5	49.5	2	4.5	2.5	192	182
Herring Bay	1	2	25.5	23.5	496	442	2	2	1	16.5	16.5
	2	2	1.5	1.5	33.5	33.5	2	1	1	28.5	28.5
North Chenega Island	1	2	0.5	0.5	2.5	2.5	2	0	0	0	0
	2	2	2.5	2.5	90	90	2	3	3	83	83
Green Island	1[a]	0	-	-	-	-	0	-	-	-	-
	2	2	0.5	0.5	0.5	0.5	2	0	0	0	0
New Sites											
Wells Bay	1	2	25	1	452	102	2	21.5	4.5	526	19.5
	2	3	41.7	19.8	1339	696	3	30	13.3	1184	452
Eaglek Bay	1	2	0.5	0.5	4.5	4.5	2	0	0	0	0
	2	2	0.5	0.5	4.5	4.5	2	0	0	0	0
McClure Bay	1	2	1.5	0.5	46.5	22.5	2	1	1	34	34
	2	2	16.5	14.5	520	428	2	8	8	226	226
Port Nellie Juan	1	2	5	0	13.5	6.5	2	0	0	0	0
	2	2	16.5	8.5	128	79	2	5	3	39.5	33.5
Perry Island	1	2	13.5	4.5	568	53.5	2	7	2	375	170
	2	2	6.5	3.5	210	86.5	2	4	1	130	58.5
Jackpot Bay	1	2	20.5	20.5	360	360	2	1	0	19.5	9.5
	2	2	19	7	560	113	2	0	0	0	0

a. No rectangular pots fished at this station.

Table 3 . Catch statistics of spot shrimp study at 12 sites in western Prince William Sound in October 1999. The number of pots fished at each site was 22. SE = one standard error of the mean.

							Males		Transitional		Ovigerous Females		Nonovigerous Females		All Females	
Site	No. Shrimp	Mean no./pot	SE no./pot	Catch weight [kg(lb)]	Mean wt/pot (g)	SE wt/pot (g)	Total No.	%	Total No.	%	Total No.	%	Total No.	%	Total No.	%
ADF&G Traditional Sites																
Unakwik Inlet	78	3	1.4	1.7 (3.8)	76	18.1	69	88	1	1.3	7	9.0	1	1.3	8	10
Culross Passage	893	40	27	16 (37)	765	494	797	93	16	1.9	45	5.0	0	0	45	5.0
Golden	300	13	5.3	8.3 (18)	377	169	228	76	6	2.0	66	22	1	0.3	67	22
Herring Bay	237	10	8.7	4.9 (11)	222	164	205	86	1	0.4	34	14	0	0	34	14
North Chenega Island	58	2.4	2.0	1.5 (3.3)	66	63	46	79	0	0	11	19	1	1.7	12	21
Green Island	59	2.6	0.8	1.0 (2.2)	44	14	52	88	3	5.1	3	5.1	1	1.7	4	6.8
New Sites																
Wells Bay	697	26	3.6	15 (33)	687	252	413	72	0	0	154	22	4	0.7	158	28
Eaglek Bay	4	0.2	0.09	0.06 (0.1)	2.9	2.0	4	100	0	0	0	0	0	0	0	0
McClure Bay	299	13	7.8	8.1 (18)	368	229	207	68	9	3.0	87	28	2	0.7	89	29
Port Nellie Juan	326	14	6.2	2.5 (5.5)	114	59	323	100	0	0	1	0.3	0	0	1	0.3
Perry Island	372	16	7.6	15 (33)	671	386	199	54	9	2.4	151	41	13	3.5	164	44
Jackpot Bay	513	23	16	8.9 (20)	403	189	465	91	19	3.7	23	4.5	3	0.6	26	5.1

Table 4. Spot Shrimp catch statistics from sites sampled traditionally by the Alaska Department of Fish and Game (ADF&G) during their Prince William Sound spot shrimp surveys from 1991 to 1999 (data courtesy of R. Berceli, ADF&G). Data collected at the same sites and at six new sites during the Auke Bay Lab/Valdez Native Tribe (ABL/VNT) cruise in 1999 added for comparison.

						Males			Females		
Year	No. pots	Catch weight kg (lbs)	Mean wt/pot kg (lbs)	No. shrimp	Mean no. shrimp/pot	No.	%	Mean carapace length (mm)	No.	%	Mean carapace length (mm)
1991	194	118 (260)	0.59 (1.3)	5964	31	5535	93	30.5	429	7	41.3
1992	281	91.6 (202)	0.36 (0.8)	3962	15	3480	88	31.7	482	12	41.9
1993	250	47.6 (105)	0.18 (0.4)	2075	8	1654	80	28.1	421	20	42.5
1994	264	40.4 (89)	0.14 (0.3)	2541	10	2416	95	27.5	123	5	43.5
1995	262	59.4 (131)	0.23 (0.5)	3418	13	3280	96	28.7	138	4	43.1
1996	263	63.5 (140)	0.09 (0.2)	3679	14	-[4]	-	-	-	-	-
1997	262	49.4 (109)	0.09 (0.2)	3031	11	2858	95	29	173	5	41.8
1998	219	29.5 (65.1)	0.04 (0.1)	2013	9.2	1913	95	28.3	100	5	44.1
1999A[1]	262	58.1 (128)	0.22 (0.5)	3525	13	-[5]	-	-	-	-	-
1999B[2]	132	34.1 (75.2)	0.27 (0.6)	1625	12	1397	86	30.6	170	10	43.7
1999C[3]	132	49.4 (109)	0.36 (0.8)	2211	15	1611	73	28.5	438	20	43.6

1. ADF&G traditional sites; data from ADF&G.
2. ADF&G traditional sites; data from present study.
3. New sites; data from present study.
4. Dashes in this row indicate data lost.
5. Dashes in this row indicate data not available from ADF&G at this time.

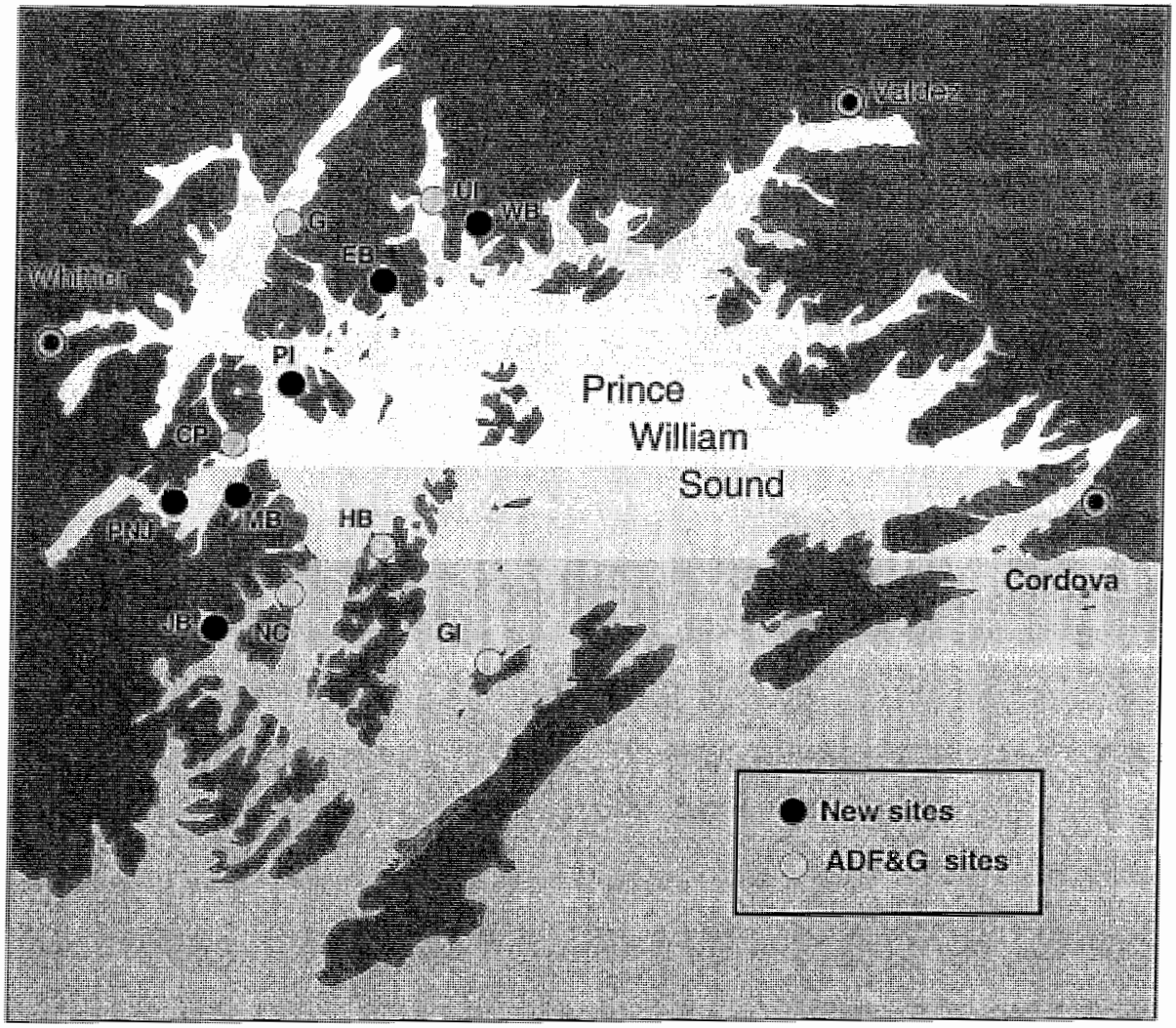

Figure 1. Location of spot shrimp study sites in Prince William Sound. The ADF&G sites are those traditionally sampled during the ADF&G annual survey.

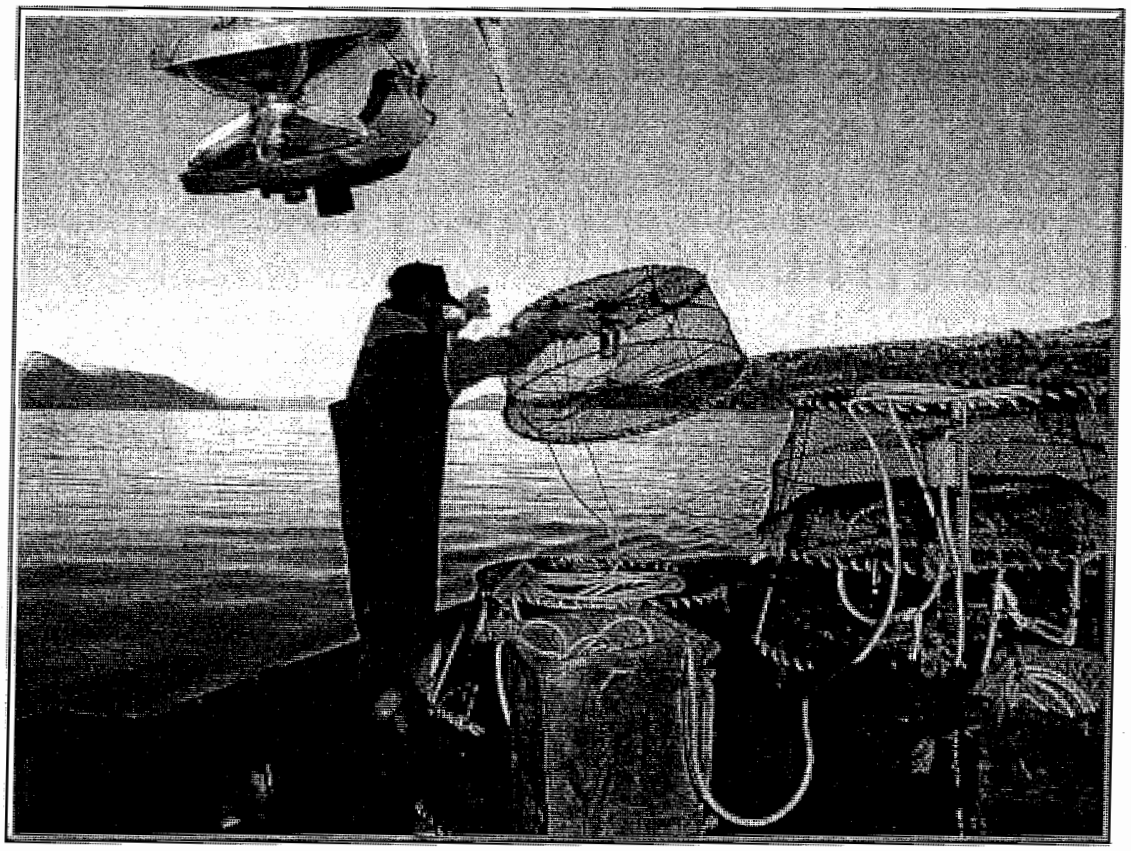

Figure 2. Setting shrimp pots at spot shrimp study sites in Prince William Sound.

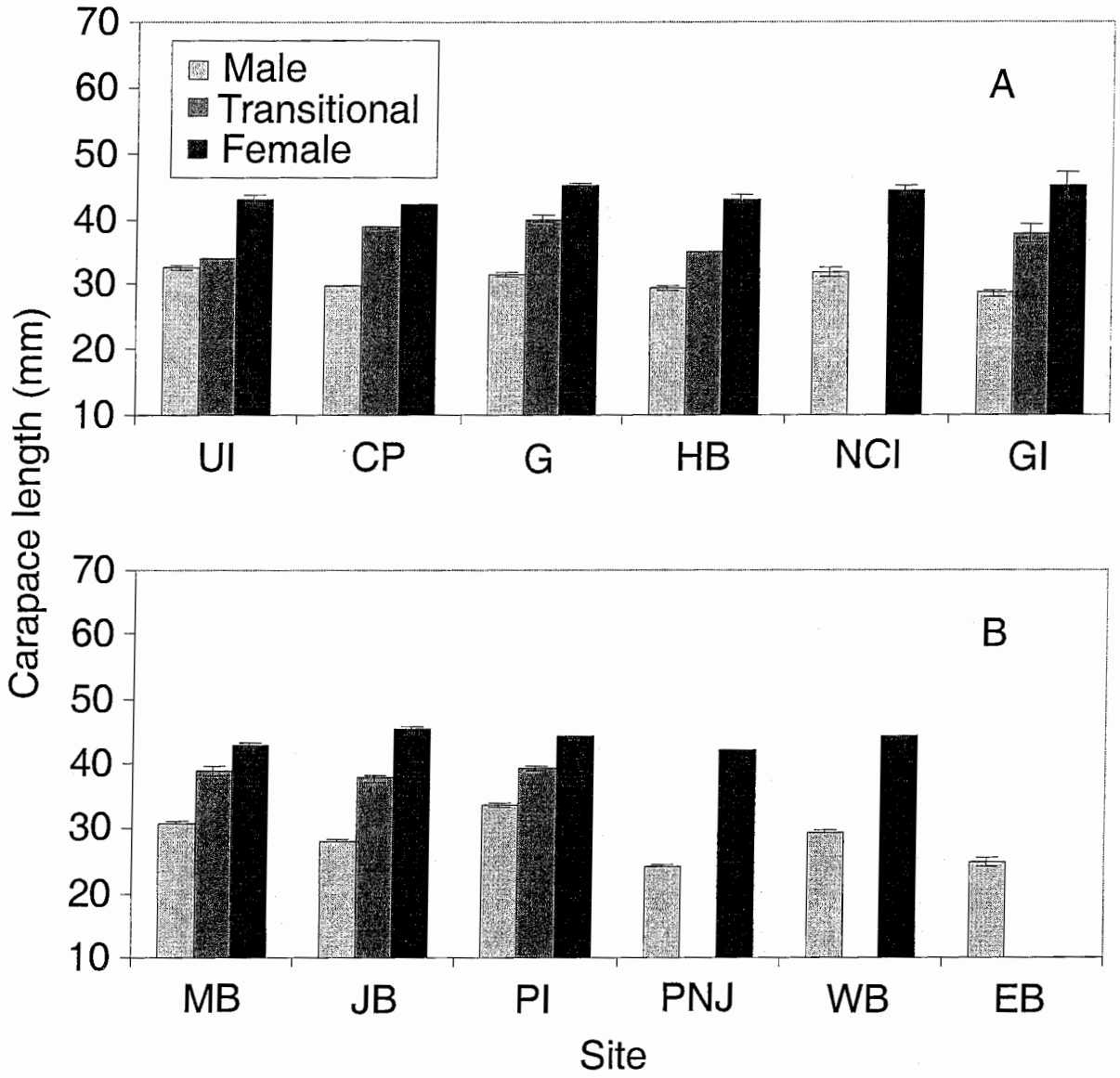

Figure 3. Mean carapace length of male, transitional and female spot shrimp at six traditional (A) and six new (B) sites in western Prince William Sound. No transitional or female shrimp were caught at EB. No transitional shrimp were caught at NCI, PNJ or WB. Error bars are one standard error of the mean. Site abbreviations are: UI, Unakwik Inlet; CP, Culross Passage; G, Golden; HB, Herring Bay; NCI, North Chenega Island; GI, Green Island; MB, McClure Bay; JB, Jackpot Bay; PI, Perry Island; PNJ, Port Nellie Juan; WB, Wells Bay; EB, Eaglek Bay.

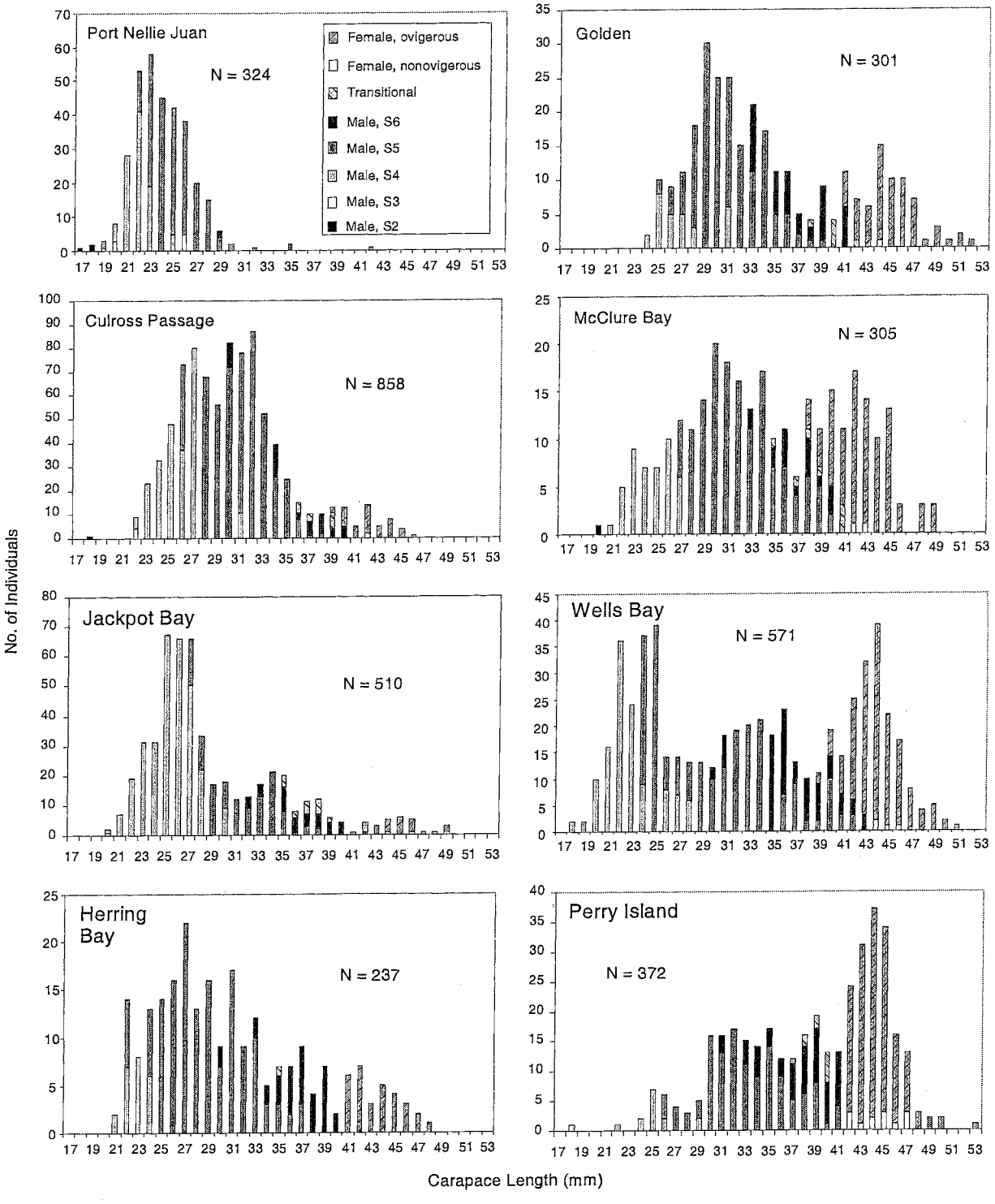

Figure 4. Length-frequency distributions of spot shrimp by sex, female reproductive condition and male stage from pot catches in western Prince William Sound in October 1999. Distributions on the left are from sites where few females were in the catch; those on the right from sites with relatively many females in the catch.

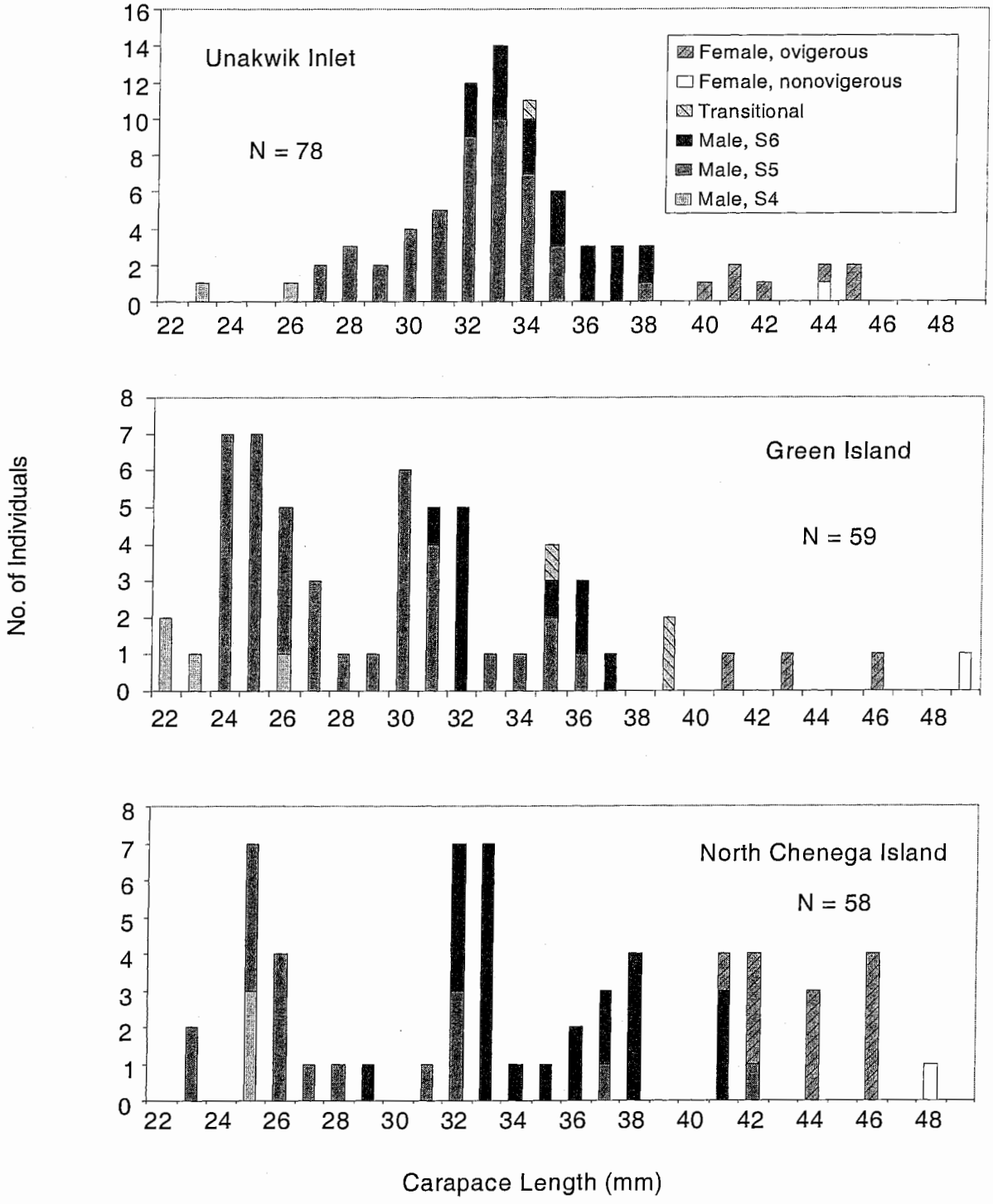

Figure 5. Length-frequency distributions of spot shrimp by sex, female reproductive condition and male stage from pot catches in western Prince William Sound in October 1999. Distributions are from sites where relatively few shrimp were caught in the pots.

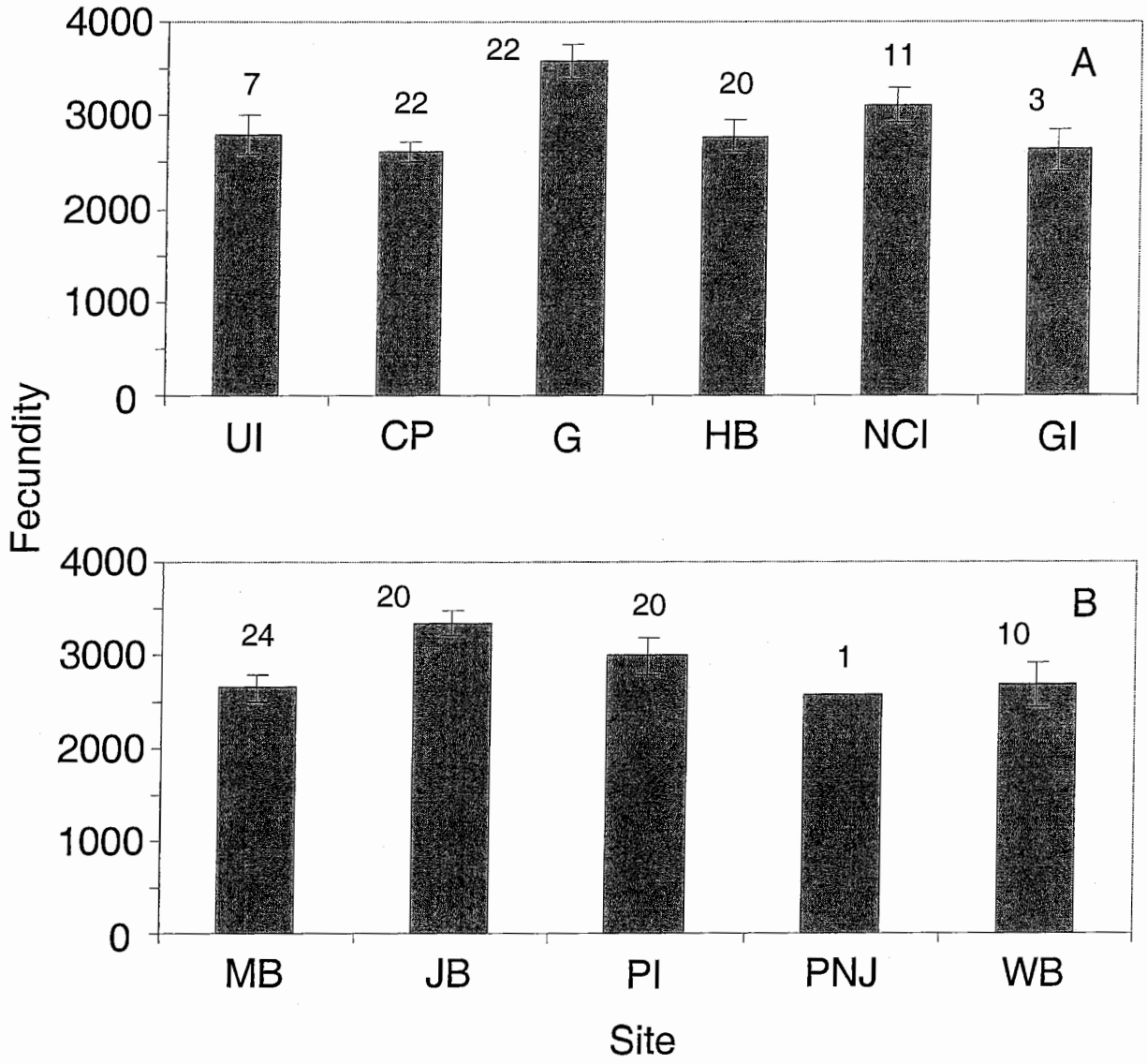

Figure 6. Fecundity of spot shrimp caught at six traditional (A) and five new (B) sites in Prince William Sound. Numbers above the bars are the number of egg clutches used to estimate fecundity. Error bars are one standard error of the mean. Site abbreviations are: UI, Unakwik Inlet; CP, Culross Passage; G, Golden; HB, Herring Bay; NCI, North Chenega Island; GI, Green Island; MB, McClure Bay; JB, Jackpot Bay; PI, Perry Island; PNJ, Port Nellie Juan; WB, Wells Bay.

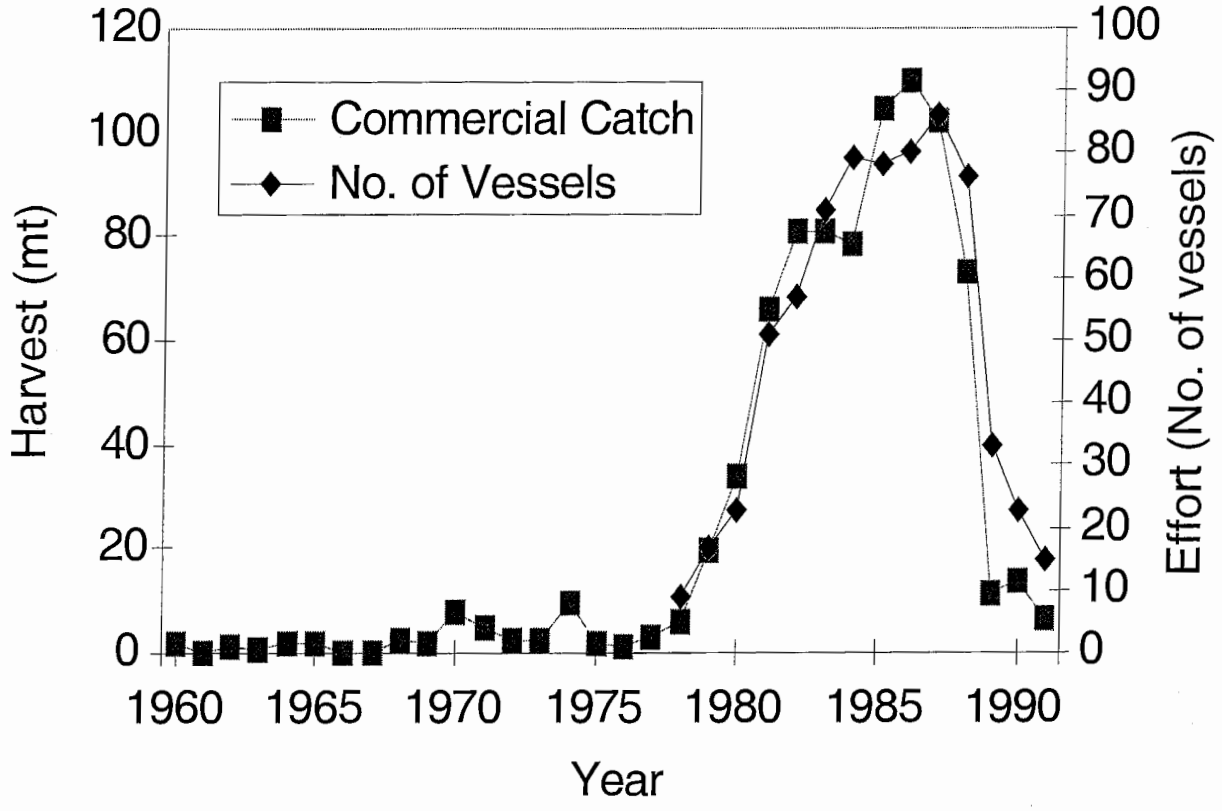

Figure 7. Commercial catch of spot shrimp and fishing effort in Prince William Sound from 1960 to 1991 [Data from Table 1 of Kimker et al. (1996)].

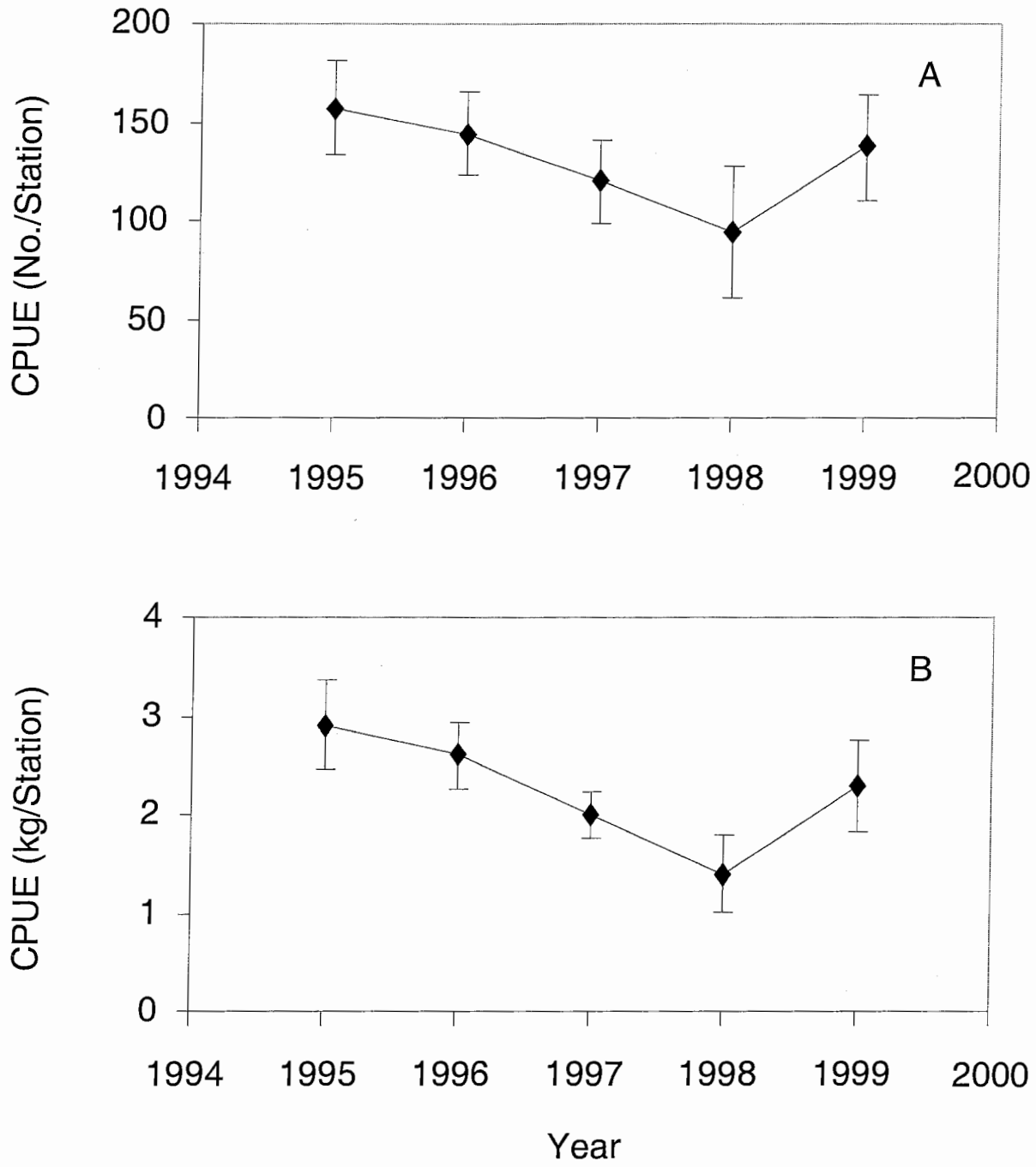

Figure 8. Catch per station (CPUE) of spot shrimp at Alaska Department of Fish and Game (ADF&G) traditional sites during ADF&G annual surveys in western Prince William Sound from 1995 to 1999. Error bars are one standard error of the mean. (Data provided by J. Brady, ADF&G).

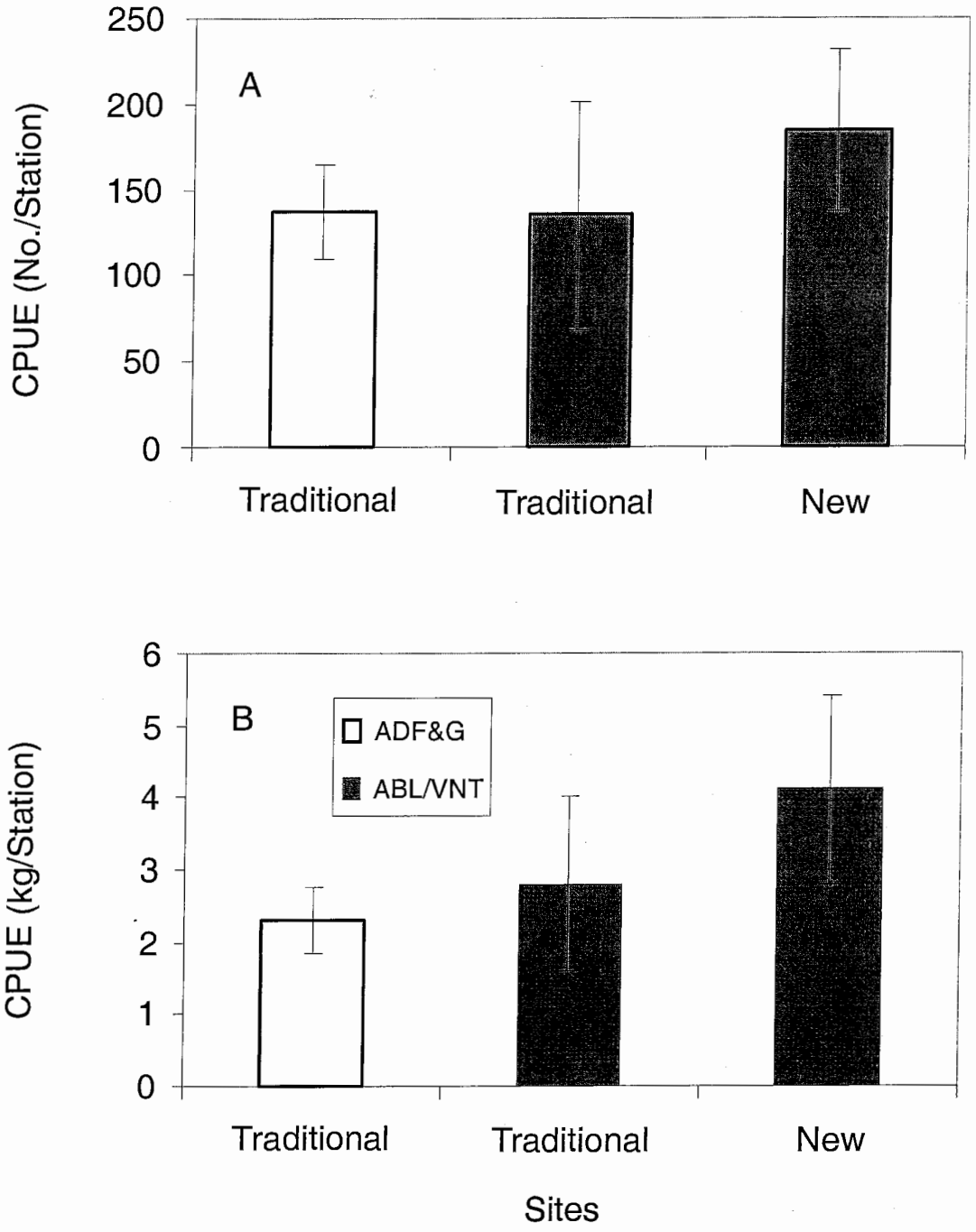

Figure 9. Catch (CPUE) expressed as No. per station (A) and as weight per station (B) of spot shrimp at Alaska Department of Fish and Game (ADF&G) traditional sites during the ADF&G annual survey in western Prince William Sound (WPWS) in October 1999 compared with the CPUE at ADF&G traditional sites and at six new sites in WPWS sampled jointly by the Auke Bay Lab and the Valdez Native Tribe (ABL/VNT) in October 1999. Error bars are one standard error of the mean. (ADF&G data provided by J. Brady).

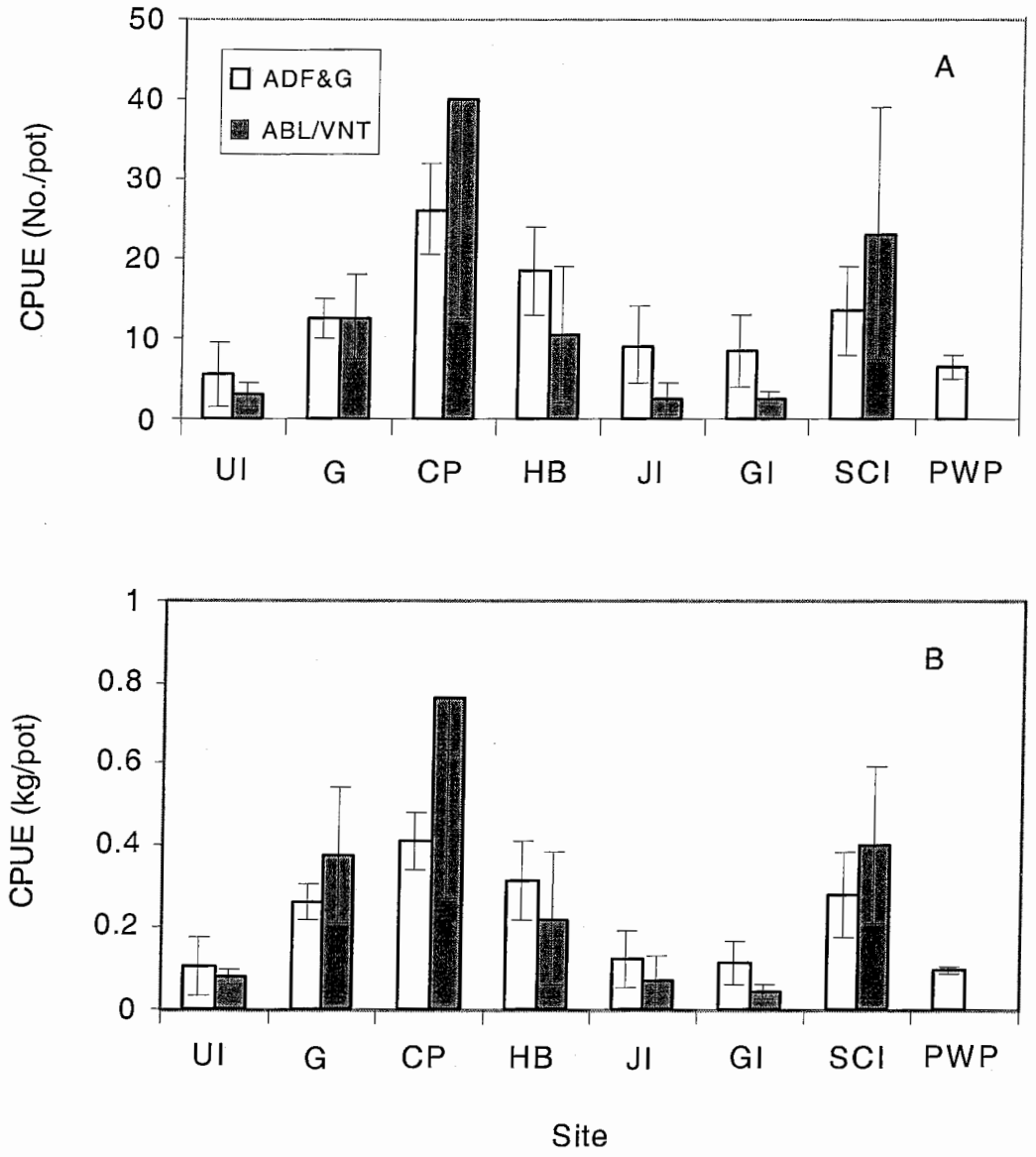

Figure 10. Catch (CPUE) expressed as No. per pot (A) and as weight per pot (B) of spot shrimp at sites sampled during the ADF&G annual survey in western Prince William Sound (WPWS) in October 1999 compared with the CPUE at the same or nearby sites sampled jointly by the Auke Bay Lab and the Valdez Native Tribe (ABL/VNT) in October 1999. Error bars are one standard error of the mean. (ADF&G data provided by J. Brady). Site abbreviations are: UI, Unakwik Inlet; G, Golden; CP, Culross Passage; HB, Herring Bay; JI, Junction Island; GI, Green Island; SCI, South Chenega Island; PWP, Prince of Wales Passage. Data from the ABL/VNT site at Jackpot Bay is compared with that from the ADF&G SCI site in the figure. No site was sampled by ABL/VNT near PWP.