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Assessment of northern shrimp (*Pandalus borealis*) off Baffin Island, Labrador and northeastern Newfoundland

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Abstract

Assessments of northern shrimp (*Pandalus borealis*) were performed for shrimp fishing areas 2, 4, 5 and 6, which correspond to Division 0B, Division 2G, Hopedale + Cartwright Channels and Hawke Channel + Division 3K, respectively. Within each area, status of the resource was inferred, in part, by examining trends in commercial catch, effort, catch per unit effort, fishing pattern and size/sex/age composition of the catches. Further, multispecies research trawl surveys conducted from 1995 to 1999, inclusive, provided information on distribution, abundance, biomass, size/sex composition and age structure of shrimp in Hawke Channel + Div. 3K for all five years, in Hopedale + Cartwright from 1996 to 1999 and in Div. 2G for 1996, 1997 and 1999.

Catch rates by offshore vessels in Hawke + 3K and Hopedale + Cartwright in recent years remained relatively stable at a high level. Research surveys showed that abundance/biomass indices in 1999 remained high relative to catch in both these areas but the survey estimates for Hopedale + Cartwright were imprecise. Within Div. 2G, catch rates fluctuated about a high level since 1991 with stability indicated since 1997. A healthy spawning stock has been maintained in recent years. Low survey coverage limits the usefulness of research vessel data. Status of the resource in Div. 0B remains uncertain in the absence of research trawl surveys.

The shrimp resource in Hawke Channel + Div. 3K is currently healthy with high abundance of males and females. Residual female biomass and stronger 1997 and 1998 year classes should buffer the effects of a weak 1996 year class for the next few years. Current status in Hopedale + Cartwright appears favourable from the fishery data and research surveys indicate a healthy female component. Prospects beyond 2000 are uncertain because the lack of a recruitment index does not allow projection. Current status in Div. 2G also is favourable. The fishery data indicate a high abundance of females and research data indicate a healthy spawning stock. Prospects beyond 2000 are uncertain in the absence of a recruitment index. Lack of data creates uncertainty in understanding the current state of stock distribution, delineation and exploitation level in Div. 0B and prospects beyond 2000 are unknown.

Résumé

Des évaluations de la crevette nordique (*Pandalus borealis*) ont été effectuées pour les zones de pêche à la crevette 2, 4, 5 et 6, qui correspondent, respectivement, à la division 0B, à la division 2G, à Hopedale Channel et Cartwright Channel ainsi qu'à Hawke Channel et à la division 3K. Dans chacune de ces zones, l'état de la ressource a été déduite, en partie, par l'examen des tendances des captures commerciales, de l'effort de pêche, des captures par unité d'effort, du patron d'exploitation et de la composition des prises selon la taille, le sexe et l'âge. En outre, des relevés de recherche plurispécifique au chalut réalisés de 1995 à 1999, inclusivement, ont fourni des renseignements sur la répartition, l'abondance, la biomasse, la composition selon la taille et le sexe et la structure par âge de la crevette dans Hawke Channel et la division 3K pendant ces cinq années, dans Hopedale Channel et Cartwright Channel de 1996 à 1999 et dans la division 2G en 1996, 1997 et 1999.

Les taux de capture par les bateaux hauturiers dans Hawke Channel et la division 3K ainsi que dans Hopedale Channel et Cartwright Channel ces dernières années sont demeurés relativement stables, à un niveau élevé. Les relevés de recherche ont montré que les indices d'abondance et de biomasse en 1999 sont demeurés élevés relativement aux captures dans ces deux zones, mais les estimations des relevés pour les Hopedale Channel et Cartwright Channel étaient imprécis. Dans la division 2G, les taux de capture, élevés, fluctuent depuis 1991 avec indication d'une stabilité depuis 1997. Un bon stock de géniteurs s'y maintient depuis quelques années. La faible couverture des relevés restreint cependant l'utilité des données du navire de recherche. L'état de la ressource dans la division 0B reste incertain en l'absence de relevés de recherche au chalut.

La ressource en crevettes de Hawke Channel et de la division 3K est actuellement bonne, l'abondance des mâles et des femelles est élevée. La biomasse résiduelle de femelles et la montée croissante des classes de 1997 et 1998 devraient atténuer les effets de la faible classe de 1996 au cours des prochaines années. D'après les données sur la pêche, l'état de la ressource de Hopedale Channel et Cartwright Channel semble favorable et les relevés de recherche indiquent un bon élément de femelles. Les perspectives au-delà de 2000 sont incertaines, car l'absence de tout indice de recrutement ne permet aucune projection. L'état de la ressource dans la division 2G est également favorable. Les données sur la pêche révèlent une grande abondance de femelles, et les données de recherche, un bon stock de géniteurs. Faute d'indices de recrutement, les perspectives au-delà de 2000 sont incertaines. Le manque de données empêche de comprendre avec certitude l'état actuel de la répartition du stock, la délimitation et le niveau d'exploitation dans la division 0B, et les perspectives au-delà de 2000 sont inconnues.

INTRODUCTION

The Canadian fishery for northern shrimp (*Pandalus borealis*) from southern Davis Strait (Division 0B) to the northeast Newfoundland Shelf (Division 3K) has been regulated within three-year, integrated management plans since 1991. The 1997 – 1999 Plan has expired and will be replaced in 2000 by another multi-year plan. A comprehensive Stock Status Report (SSR) is routinely produced at the beginning of each plan. The SSR is based on the results of scientific assessments that include detailed analyses of commercial fishery and research survey data. Interim reviews also are performed to monitor any changes in resource status within the multi-year term and, if necessary, to provide a basis for adjustments to the total allowable catches (TAC's) in the later years of the plan.

This research document provides the details considered in the scientific assessment of *Pandalus borealis* conducted in early 2000 for four shrimp fishing areas (SFA's): Hawke Channel + NAFO Division 3K (SFA 6), Hopedale + Cartwright Channels (SFA 5), Division 2G (SFA 4) and Division 0B (SFA 2). *Pandalus borealis* in Divisions 0A (SFA 1), 3L and 3M (SFA 7), assessed annually by Scientific Council of NAFO, were not included here. Also, *Pandalus montagui*, which are fished commercially in SFA's 2, 3 and 4, west of 63^0 W, were not considered because there was no new information on stock size or exploitation levels to use in assessing status of the resource. Therefore, there was no basis for revising the TAC for this species from its current level (3800 tons).

MATERIAL AND METHODS

Commercial fishery data

Catch (tons) and effort (hours fished) from vessel log records for all available areas and years (supplemented, as required, by observer data and vessel hails) were examined for trend. The data also were analyzed spatially to consider changes in fishing patterns and practices that might affect interpretations. Catch per unit effort (CPUE), expressed as an index, was calculated by year for each SFA and used as an indicator of change in the fishable stock over time. Records of double trawling (two complete trawls towed concurrently) by some vessels were omitted in the calculation of CPUE. The use of windows in trawls (escape openings) when shrimp density is high was not addressed. Raw catch/effort data for each SFA were standardized by multiple regression, weighted by effort, in an attempt to account for variation due to factors such as year, month, area and vessel. By including only vessels with several years' experience in the fishery, the number of parameters to be estimated was reduced thereby increasing confidence in the interpretation of results (Parsons et al., 1999). Final models included all significant class variables with the YEAR effect used to track the trend in stock size over time. The difference (or similarity) between the 1999 YEAR parameter estimate and those of previous years was inferred from the output statistics.

Sizes of male and female shrimp in the catches were obtained from samples taken by observers on offshore vessels. Samples were adjusted upward to set, month and year for each SFA to derive a series of annual catch-at-length compositions. Age structure was determined by identifying prominent year classes (modes) within the composite length distributions and tracking their developments over time. The samples are considered representative up to and including 1996. However, to date, there is no reliable sampling scheme for inshore vessels. Therefore, composite length distributions for 1997, 1998 and 1999 based on sampling from only offshore vessels might not reflect the actual catch at length and age, especially in SFA 6.

Research survey data

Multispecies research trawl surveys have been conducted annually in the Newfoundland-Labrador offshore area since 1995. These surveys employ a stratified-random sampling design that was developed primarily for groundfish but use a lined, Campelen 1800 shrimp trawl as the sampling gear. In Hawke Channel + Div. 3K (SFA 6), survey coverage has been extensive in areas where shrimp are abundant and reliable estimates of distribution as well as abundance/biomass indices have been obtained each year from 1995 to 1999. Farther north, survey coverage is not adequate to address the highly patchy distribution of shrimp seen in these areas. Therefore, the results (1996 to 1999 for Hopedale + Cartwright; 1996, 1997 and 1999 for Div. 2G) are less reliable for interpretation of trend in the resource. No surveys have been conducted in Div. 0B.

The non-parametric method of calculating abundance/biomass indices with Monte Carlo confidence intervals (Evans et al., 1999) was used exclusively in the current assessment. It also was applied to biological sampling data from survey catches, providing estimates of abundance at length and sex by area and year. The method uses the observed survey catches of northern shrimp in conjunction with latitude, longitude and depth data to estimate an abundance/biomass index. It relies on estimating the whole probability distribution for shrimp at any point within the survey area where depth is known. An estimate of the expected value of shrimp abundance/biomass is derived by integrating the estimates over a network of triangles covering the area. Monte Carlo resampling from the probability distribution at every survey point produces a set of simulations from which median estimates and confidence intervals are determined. An important advantage of the non-parametric method is that it does not assume observations have a Gaussian distribution and, therefore, negative confidence limits are avoided. The method is not tied to the survey stratification scheme and, therefore, expected concentrations in unsampled strata also are estimated.

Abundance-at-length estimates derived from the non-parametric method were compared with the previously used STRAP technique (Parsons et al., 1999). No

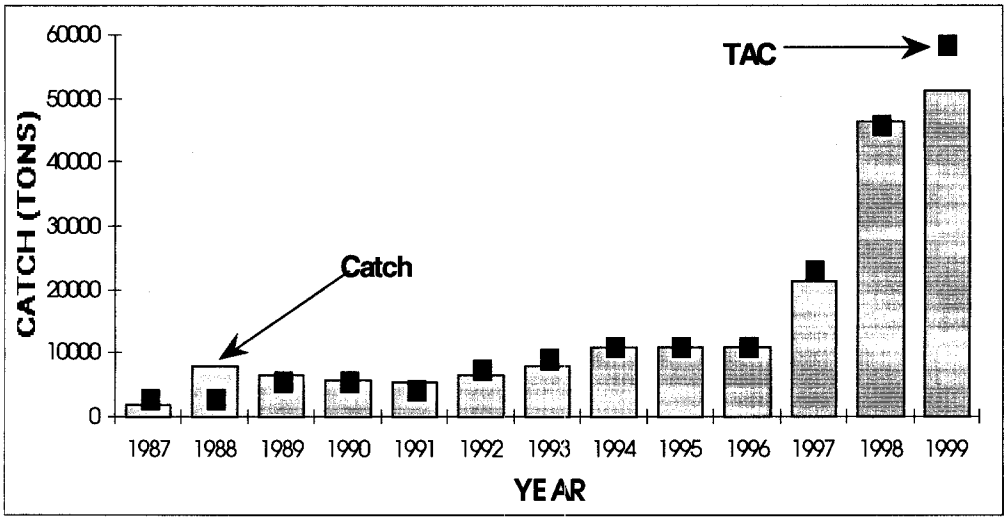
differences were detected. Age compositions from survey data were determined by identifying year classes within the composite distributions, estimating their abundances and tracking their developments over time.

ASSESSMENT OF SHRIMP IN HAWKE CHANNEL + DIV. 3K (SFA 6)

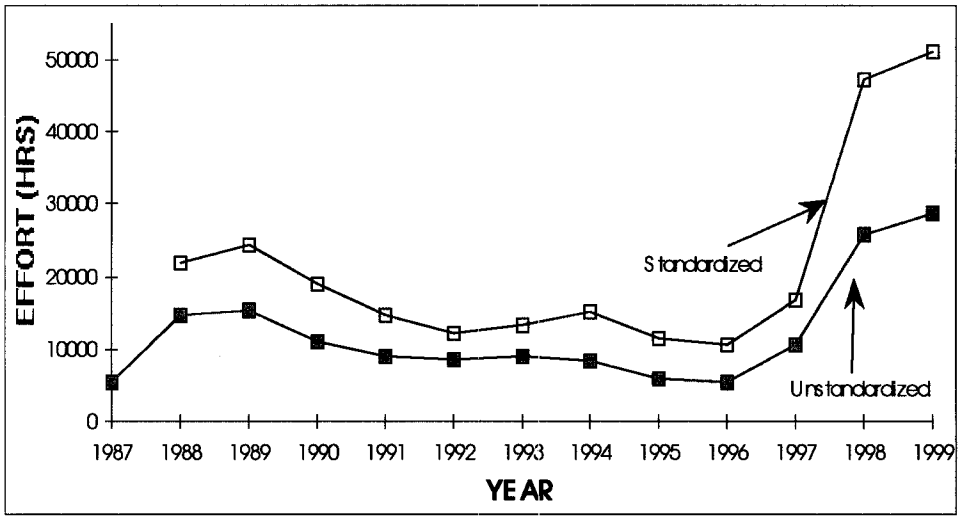
FISHERY DATA

Catch and effort

The shrimp fishery in Hawke Channel + Division 3K began in 1987 when about 1800 tons were caught. In previous years, only a few tons had been reported, primarily from Hawke Channel. Catches increased to more than 7800 tons in 1988 and ranged between 5500 and 8000 tons from 1989 to 1993, inclusive. The annual TAC for the 1994 - 1996 Management Plan was set at 11,050 tons to include Hawke Channel, St. Anthony Basin, east St. Anthony, Funk Island Deep as well as three exploratory areas on the seaward slope of the shelf. Catches increased to 11,000 tons in each of those three years. The assessment conducted in 1997 concluded that the resource was healthy and exploitation low (DFO, 1997). Consequently, the TAC for 1997, the first year of the 1997 - 1999 multi-year plan, was raised to 23,100 tons as a first step in increasing the exploitation. Most of the increase was reserved for the development of an "inshore" component. Catch in 1997 was estimated to be approximately 21,200 tons. Despite the large increase in catch, exploitation in 1997 remained low and the TAC for 1998 was increased again by 100% to 46, 200 tons and catches exceeded 46,300 tons. The 1999 TAC was increased further to 58,632 tons (27%) but, due to operational problems for the inshore sector, just over 51,000 tons were caught.



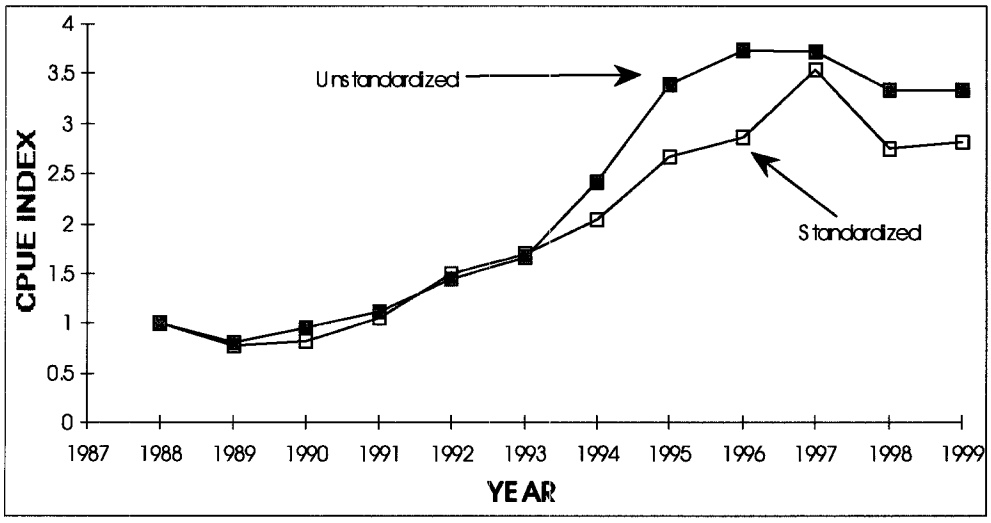
Fishing effort (expressed as hours fished for offshore vessels, i.e. total catch/offshore cpue) declined from 1989 to 1992, stabilized or increased slightly to 1994, declined again from 1994 to 1996 and increased in 1997, 1998 and 1999 with increases in TAC. The fishery by offshore vessels primarily occurs during the first five months of the year whereas inshore vessels fish in summer and fall.



An displacement of fishing effort towards the shelf edge occurred during the early 1990's due to: the establishment of exploratory areas on the shelf slope in 1992 and 1993, the discovery of dense concentrations of shrimp in these areas, the occurrence of ice throughout the area in winter and spring each year and the flexibility to fish TAC's anywhere within the large management area. The displacement was particularly evident in St. Anthony Basin and Funk Island Deep where both catch and effort declined markedly during the 1994 – 1996 period (Fig. 1). The "inshore" fishery concentrated in Hawke Channel, St. Anthony Basin and southern Div. 3K in 1997 and but less effort occurred in the Basin in 1998. Effort was widespread throughout the management area in 1999.

Catch per unit effort (CPUE)

Unstandardized, annual CPUE's for offshore vessels (single trawl data only) increased steadily from 1989 to 1995 and have since stabilized at a high level. The CPUE data were analyzed by multiple regression for year, month, vessel and area effects to standardize the catch rates (Table 1). The analysis, which incorporated effort weighting, showed that the 1999 CPUE index was similar to estimates for 1995, 1996 and 1998 ($P > 0.05$) but lower than the 1997 ($P < 0.05$).



The preliminary catch rates for January and February 2000 were reported to be as high as or higher than those for the same months in previous years.

Historical fishery data for this management-assessment area are summarized in Table 2.

Size composition

Catch-at-length, estimated from samples taken by observers on offshore vessels, showed dominance of the female component around 24 mm carapace length (CL) in most years (Fig. 2). The relatively strong 1991 year class, first appearing at approximately 16 mm in 1994 (age 3), dominated the male component at 18 mm in 1995 (age 4) and at 20 mm in 1996 (age 5). In 1997, at age 6, most were female. The 1993 and 1992 year classes also were well represented at 16 and 18 mm, respectively, in the 1996 samples and at 18 and 20 mm in the 1997 data but do not appear to be as strong as the 1991 year class. However, relative strength of recruiting year classes is difficult to evaluate from fishery data.

Mean size of females and the size at sex inversion have declined since 1996, indicating a possible change in growth within the area. Nevertheless, reproductive potential likely has been maintained in recent years by the high abundance of females.

RESEARCH SURVEY DATA

Stock size

Results of the 1995 - 1999 fall multispecies research surveys showed that shrimp were widely distributed and abundant throughout Hawke Channel + Div. 3K each year (Fig. 3a – 7a). The minimum trawlable biomass/abundance estimates,

obtained using the non-parametric method, and Monte Carlo confidence limits are shown in Figures 3b to 7b and compared in the following table.

Northern shrimp stock size estimates in Hawke Channel + Division 3K (SFA 6)[1] from fall research trawl surveys - offshore, 1995 - 1999.

	Biomass (tons)			Abundance (numbers x 10^{-6})			No. Sets
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	
1995	220,000	267,000	332,100	56,480	67,023	79,450	195
1996	420,600	501,300	589,100	100,000	115,400	133,900	238
1997	387,400	438,500	487,800	88,420	98,721	108,500	232
1998	424,400	468,400	517,600	96,730	107,422	118,600	234
1999	470,600	526,100	592,300	113,300	125,612	141,600	233

[1] **Area compared each year = 171,048.5 sq. km.**

Inshore strata along the northeast Newfoundland coast were not sampled in 1995 or 1999. The analyses were, therefore, confined to the offshore strata for comparative purposes. Inshore strata sampled during the 1996 – 1998 surveys generally produced low catches of shrimp.

Point estimates for biomass (abundance) increased from about 270,000 tons (67 billion) in 1995 to 500,000 tons (115 billion) in 1996 and remained fairly stable thereafter. The lower 95% confidence intervals for the biomass indices averaged 426,000 tons (about 100 billion animals) during the 1996 - 1999 period.

The ratios of nominal catch to the lower confidence intervals of the survey biomass indices were about 5% in 1995, 3% in 1996, 5% in 1997 and 11% in 1998 and 1999. Actual exploitation rates are unknown but are likely lower than indicated above because the biomass index is believed to underestimate the absolute biomass (i.e. catchability of the survey gear is believed to be < 1).

Biomass/abundance of males was relatively stable from 1996 to 1999, varying between 250,000 and 300,000 tons (75 billion to 90 billion animals). The female stock was stable from 1996 to 1998 and possibly increased in 1999. Any increase in 1999 would be due to the female portion of the 1994 year class and full recruitment of the 1993 year class as females.

Stock size estimates for male and female shrimp in Hawke Channel + Div. 3K (SFA 6) from fall research trawl surveys - offshore, 1995 - 1999.

	Biomass (tons)			Abundance (numbers x 10^{-6})		
	Males	Females	Total	Males	Females	Total
1995	129,700	137,300	267,000	49,954	17,068	67,023
1996	294,900	206,400	501,300	91,157	24,243	115,400
1997	254,200	184,200	438,500	76,462	22,259	98,721
1998	254,100	214,300	468,400	79,233	28,190	107,422
1999	266,600	259,500	526,100	90,576	35,036	125,612

Stock composition

Length distributions representing abundance-at-length in the 1995 survey showed the dominance of the 1993 year class (age 2) at approximately 14 mm CL and clear representation of the 1994 year class (age 1) at 10 mm (Fig. 3b, lower panel). Overlap of components to the right in the male distribution created difficulty in separating ages 3, 4 and 5. Females (primarily ages 6+) comprised 25% of the estimated abundance.

In the 1996 survey, the 1993 year class was evident at 17 mm (Fig. 4b, lower panel) and the 1994 year class at 14 - 15 mm. The 1995 year class was apparent at 9 - 10 mm. Females accounted for 16% of the estimated numbers.

Abundance estimated from the 1997 survey (Fig. 5b, lower panel) again was dominated by the 1993 and 1994 year classes occurring primarily within the 16 - 20 mm CL size range. The 1995 year class was evident at 14 mm and the 1996 year class in low numbers at 9 mm. Females comprised 23% of the estimated abundance.

The 1994 year class (about 19 mm CL) dominated in the 1998 survey (Fig. 6b, lower panel). The 1996 and 1995 year classes were evident at about 14 and 16 mm, respectively, and there was clear representation of the 1997 year class at 10 mm. Females (about 26% of estimated numbers) were smaller in 1998 than in previous years, possibly due to earlier sex change for part of the 1993 year class.

Abundance from the 1999 survey (Fig. 7b, lower panel) was dominated by a component of males larger than 17 mm CL (mostly the 1994 and 1995 year classes) and the 1997 year class (about 15 mm CL). Also, there was strong representation of the 1998 year class at 10 mm. Mean size of females, which comprised 28% of the estimated abundance, was slightly larger than that observed in 1998.

These data suggest that the 1995 year class, at age 4 in 1999, age 3 in 1998, age 2 in 1997 and age 1 in 1996, is weaker than both the 1994 or 1993 year classes. Further, the 1996 year class, at age 3 in 1999, age 2 in 1998 and age 1 in 1997, appears to have been the weakest observed in the short time series of research trawl surveys. Although comparison of year-class strengths at age 1 from survey data is questionable, the 1997 and 1998 year classes appear stronger than those of 1995 and 1996 (Fig. 8).

RESOURCE STATUS

Catch rates of offshore vessels in 1999 remained at the high level attained since 1995. The lower confidence intervals of the research survey biomass/abundance estimates from 1996 to 1999 also were relatively stable and averaged

approximately 426,000 tons/100 billion animals. Research data suggest that the 1995 and, especially, the 1996 year classes were weaker than those produced during the early 1990's. It is possible that biomass of males will decline in 2000/2001 but could increase, thereafter, with the stronger 1997 and 1998 year classes. The spawning stock (females) likely will be maintained in 2000 by the 1993 and 1994 year classes but could decline later with reduced recruitment from the weak 1996 year class. Nevertheless, it is anticipated that, over the next few years, the residual female stock and the stronger 1997 and 1998 year classes will buffer the negative effects of a weak 1996 year class.

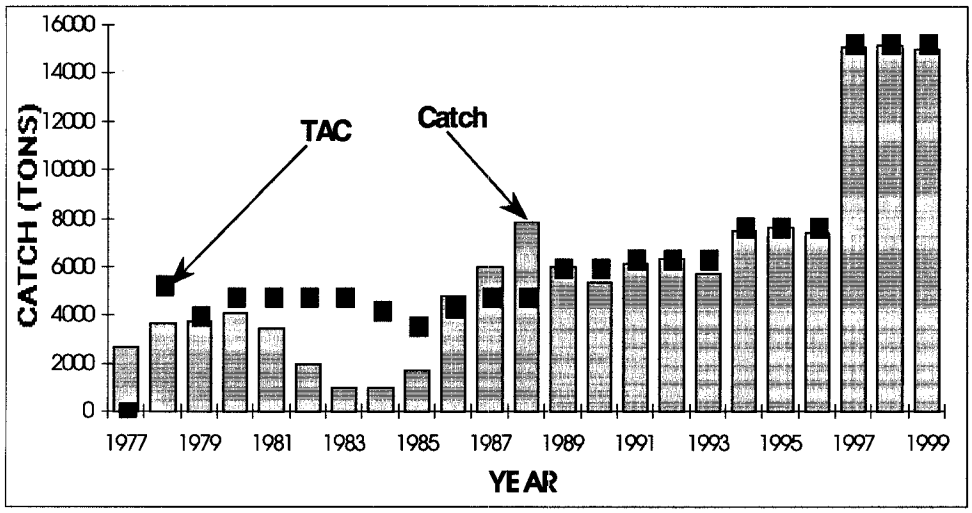
Given that commercial catch rates and research indices of stock size have been relatively stable in recent years, it is likely that abundance is no longer increasing. The resource in this area remains healthy with high biomass/abundance of male and female components. Further, exploitation likely has been low, possibly less than 11% (i.e. the ratio of nominal catch to the lower 95% confidence interval of the research trawl survey biomass index).

ASSESSMENT OF SHRIMP IN HOPEDALE & CARTWRIGHT CHANNELS (SFA 5)

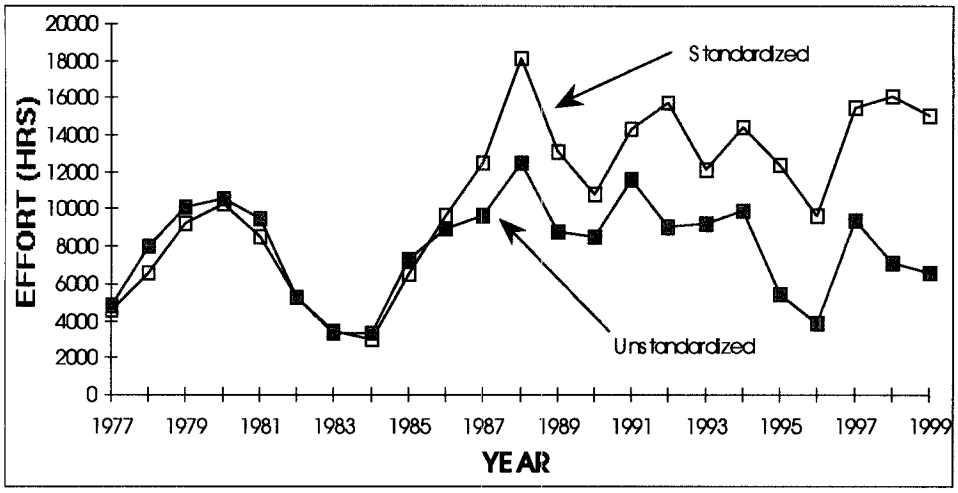
FISHERY DATA

Catch and effort

The northern shrimp fishery in Hopedale and Cartwright Channels began in 1977, following exploratory fishing in the previous two years. Catches increased from about 2700 tons in 1977 to 4100 tons in 1980, declined to 1000 tons in 1983 and 1984, increased again to 7800 tons in 1988 and then stabilized at roughly 6000 tons during the 1989 - 1993 period. The TAC's for the 1994 - 1996 management plan, which combined the two channels as a single management area, were increased to 7650 tons annually and catches subsequently increased, averaging 7500 tons during that period. Annual TAC's for the 1997 - 1999 plan were increased 100% to 15,300 tons and catches exceeded 15,000 tons each year.



Fishing effort (expressed as hours fished for offshore vessels, i.e. total catch/offshore cpue) showed approximately the same trends over time as catch. From 1994 to 1996, however, effort decreased while catches remained stable. Effort increased during the 1997 - 1999 period with the doubling of the TAC.



In the late 1970's and throughout the 1980's, the fishery concentrated in four main areas: northern, eastern and southern Hopedale Channel and Cartwright Channel. Fishing continued in the traditional areas during the 1990's, however, more effort was reported from the slopes of the shelf, north and east of Cartwright Channel (Fig. 9). From 1994 to 1999, substantial effort occurred on the eastern slope during winter and spring. Historically a summer - fall fishery, since 1995 it has become mainly a winter - spring operation.

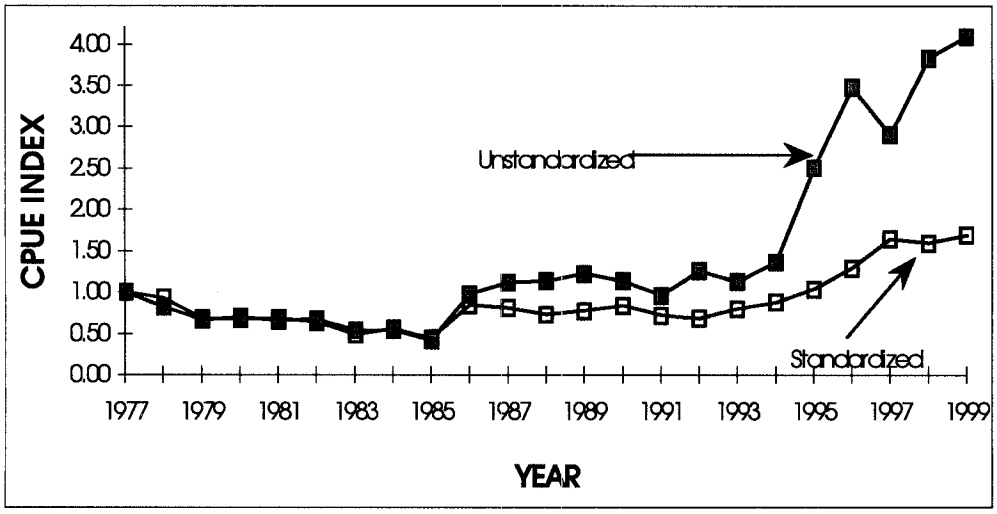
Catch per unit effort (CPUE)

Unstandardized, annual CPUE's (single trawl data for offshore vessels) declined from 1977 to 1985, increased substantially in 1986 and stabilized up to 1993.

Catch rates increased from 1993 to 1996, declined in 1997 and increased again in 1998 and 1999 to the highest level observed.

The CPUE data were further analyzed by multiple regression with effort weighting for year, month, vessel and area effects. The standardized 1999 catch rate index was the highest in the time series but was not significantly different ($P > 0.05$) from the 1997 and 1998 estimates (Table 3).

Both the unstandardized and standardized series show approximately the same trend: a decline to the mid 1980's, a substantial increase in 1986 followed by stability to the early 1990's and an increase since then. The last increase is more pronounced in the unstandardized data but stability in recent years is less obvious.



Preliminary catch rates for January and February 2000 were reported to be higher than those of the same months in previous years and persistent over a broad area.

Historical fishery data for this management-assessment area are summarized in Table 4.

Size composition

Catch-at-length data from 1990 to 1999 (Fig. 10) showed a modal group of females about 23-24 mm CL occurring each year. Recruitment of males between approximately 16 and 22 mm has been consistent from year to year and males have contributed substantially to the catch in numbers in all years. After 1994, both the male and female components of the catch increased substantially. Catch rates for females increased from about 1993 to 1997 and stabilized in 1998 and 1999. The mean size of females and the median size at sex change declined slightly since 1996.

The recruitment, growth and maturation of the assumed 1991 year class can be tracked from the 1995 - 1997 sampling data. It first appeared as male at 18 mm CL (age 4) in 1995, dominated the male component at roughly 20 mm (age 5) in 1996 and accounted for part of the females at 23 mm (age 6) in 1997. Similarly, the 1993 year class can be tracked as males at 18 mm (age 4) in 1997, at about 20 mm (age 5) in 1998 and as females (age 6) in 1999. The 1994 year class dominated the male component in 1999.

RESEARCH SURVEY DATA

Stock size

Results of the 1996 - 1999 fall multispecies research surveys showed that shrimp were widely distributed throughout the Hopedale + Cartwright Channel area each year but very high catches occur in some locations (Figs. 11a – 14a). The minimum trawlable biomass/abundance estimates, obtained using the non-parametric method, and Monte Carlo confidence limits are shown in Figures 11b to 14b and compared in the following table.

Northern shrimp stock size estimates in Hopedale + Cartwright Channels (SFA 5)[1] from fall research trawl surveys - offshore, 1996 - 1999.

	Biomass (tons)			Abundance (numbers x 10^{-6})			No. Sets
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	
1996	63,260	150,800	331,400	13,190	38,627	98,570	111
1997	95,590	135,800	179,300	20,590	29,885	40,700	112
1998	59,260	83,200	106,800	11,320	16,514	21,270	119
1999	67,400	103,400	136,200	13,060	20,346	27,110	117

[1] **Area compared each year = 60,578.6 sq. km.**

Two trawl stations in 1996 produced exceptionally large catches that were highly influential to the biomass/abundance estimate that year and resulted in wide confidence intervals. The Monte Carlo method avoids negative confidence intervals but the greater uncertainty in the 1996 estimates remains. Also, in 1997, depths less than 200 m were not sampled within Div. 2H and the method interpolated high shrimp densities in deeper water over a large area where densities are known to be less. Therefore, with low and incomplete survey coverage as well as patchy shrimp distribution, results must be interpreted cautiously. Considering the lower confidence intervals, no trend is evident in the time series.

The ratios of nominal catch to the lower confidence intervals of the survey biomass indices were about 12% in 1996, 16% in 1997, 26% in 1998 and 22% in 1999. Actual exploitation rates are unknown but are likely lower than indicated

above because the biomass index is believed to underestimate the absolute biomass (i.e. catchability of the survey gear is believed to be < 1).

Biomass/abundance of males declined from 1996 to 1998 and increased in 1999. The female stock varied without trend from 1996 to 1998 and also increased in 1999. However, as for the sex-aggregated data, the low, incomplete survey coverage and patchy distribution create much uncertainty in the estimates and trends are unknown.

Stock size estimates for male and female shrimp in Hopedale + Cartwright Channels (SFA 5) from fall research trawl surveys - offshore, 1996 - 1999.

	Biomass (tons)			Abundance (numbers x 10^{-6})		
	Males	Females	Total	Males	Females	Total
1996	115,800	34,900	150,800	34,445	4,143	38,627
1997	92,900	42,900	135,800	24,624	5,261	29,885
1998	43,400	39,700	83,200	11,621	4,892	16,514
1999	50,800	52,600	103,400	13,872	6,474	20,346

Stock composition

Length distributions from the 1996 survey, representing abundance at length (and age), showed a predominance of male shrimp about 16 - 17 mm CL within the survey area (Fig. 11b, lower panel). Assuming that growth and maturity schedules in recent years have been similar to those observed in Hawke Channel + Div. 3K (Parsons et al, 1999), most animals in the 1996 survey were thought to belong to the 1993 year class (age 3).

Males, which formed a mode at 18 – 19 mm, dominated in the 1997 survey (Fig. 12b, lower panel). Under the assumptions mentioned above, most of these male shrimp also represent the 1993 year class at age 4 in 1997. Although the 1994 year class at age 3 in 1997 appears weaker than the 1993 in 1996, it is noted that there is a high degree of overlap in the modal size/age groups and, therefore, the age composition is uncertain.

The prominent size group of males in the 1998 survey samples at 19 mm (Fig. 13b, lower panel) represents some combination of the 1993 and 1994 year classes. A part of the former changed sex between 1997 and 1998 and occurred as small females.

The male component in the 1999 survey was dominated by the 1994 and 1995 year classes and there was representation of the 1997 and 1998 year classes (Fig. 14b, lower panel). Females likely were dominated by the 1993 year class.

It appears that recruitment (e.g. small males, ages 1 – 3) is more difficult to measure in this area than in Hawke Channel + Div. 3K (Fig. 15). After four years of surveys, no recruitment index is available.

RESOURCE STATUS

The current status of the northern shrimp resource in the Hopedale and Cartwright Channels appears favourable from the fishery data and the survey data indicate a healthy spawning stock (females). Commercial catch rates, which were stable from the mid 1980's to the early 1990's, increased up to 1996 and have since stabilized at a high level. Good recruitment of year classes produced in the early 1990's has resulted in high catch rates of males over the past several years and the spawning component remains healthy. Data from the research surveys from 1996 to 1999, however, produced highly variable estimates of stock size and, within this uncertainty, must be interpreted cautiously.

Although female biomass/abundance should be maintained in 2000 by the 1993 and 1994 year classes, male abundance (recruitment to the fishery) could decline if the 1996 year class is weak as indicated in southern areas. Exploitation rate in recent years, as inferred but not quantified from catch-to-biomass ratios (lower 95% confidence interval), is thought to be low (< 26%).

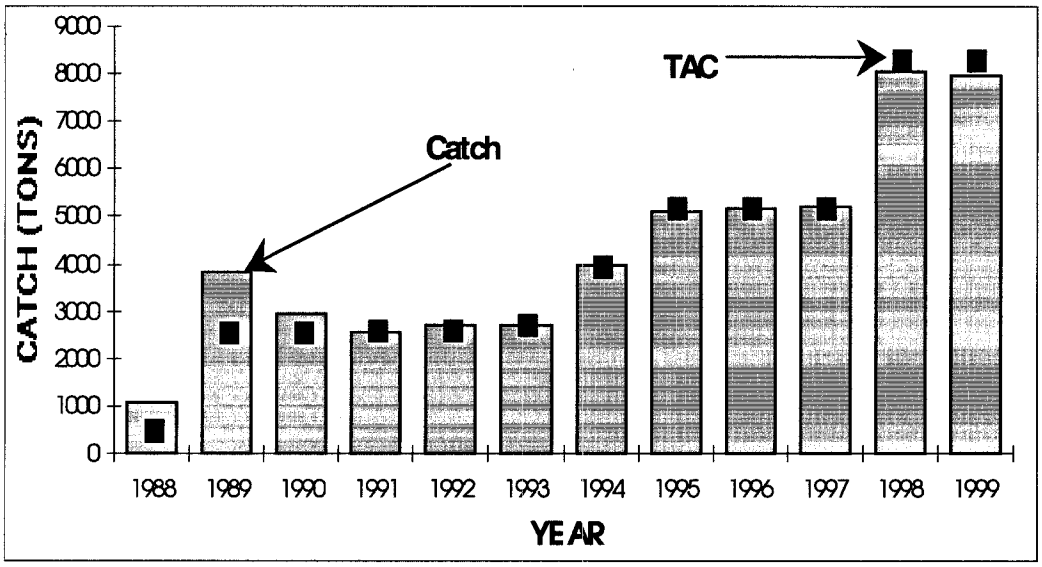
ASSESSMENT OF SHRIMP IN NAFO DIVISION 2G (SFA 4)

FISHERY DATA

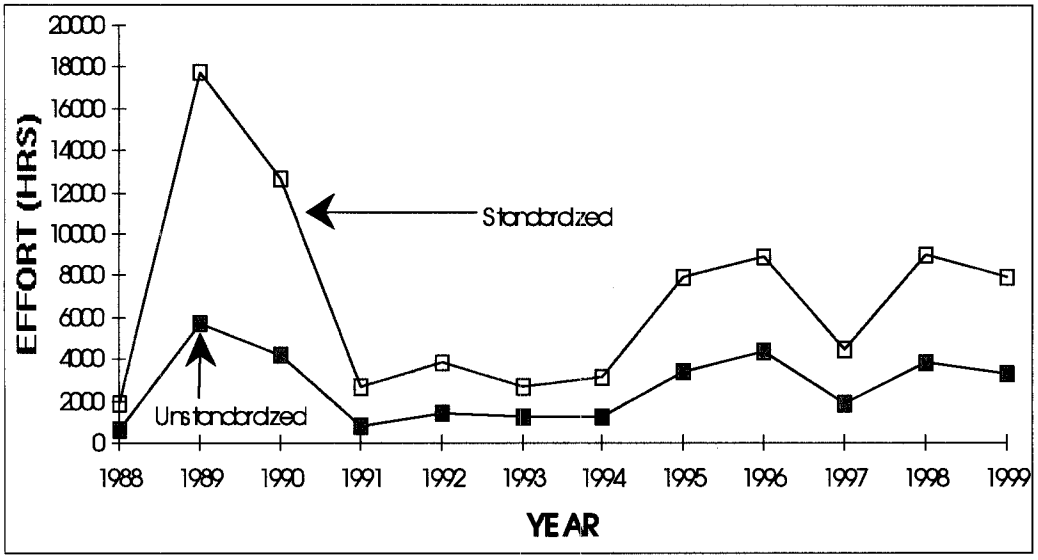
Catch and effort

The northern shrimp fishery in Div. 2G began in 1988, only incidental catch and effort having been reported from previous years. Catches increased from 1083 tons in 1988 to 3842 tons in 1989 and remained within the 2500 - 3000 ton range up to and including 1993. The 1994 catch increased to about 4000 tons with an increase in TAC to that level in the first year of the 1994 - 1996 Management Plan. A second increase to 5200 tons for 1995 and 1996 resulted in catches of about 5100 tons in both years. The TAC of 5200 tons was maintained for 1997 and catch was estimated at 5217 tons.

The interim review of stock status in the winter of 1998 indicated that an increase in TAC could be considered. Lacking the basis on which to advise an appropriate level of TAC, an increase of 60% (3120 tons) to 8320 tons was chosen in the management process. Furthermore, 70% of the increase (2184 tons) was applied to the area south of 60^0 N where very little fishing had occurred after 1990. Catches in 1998 and 1999 were estimated at approximately 8000 tons each year.



Fishing effort increased substantially from 1988 to 1989, decreased to 1991 and remained relatively stable at a low level up to 1994. Effort increased in 1995 and varied at a higher level, thereafter.

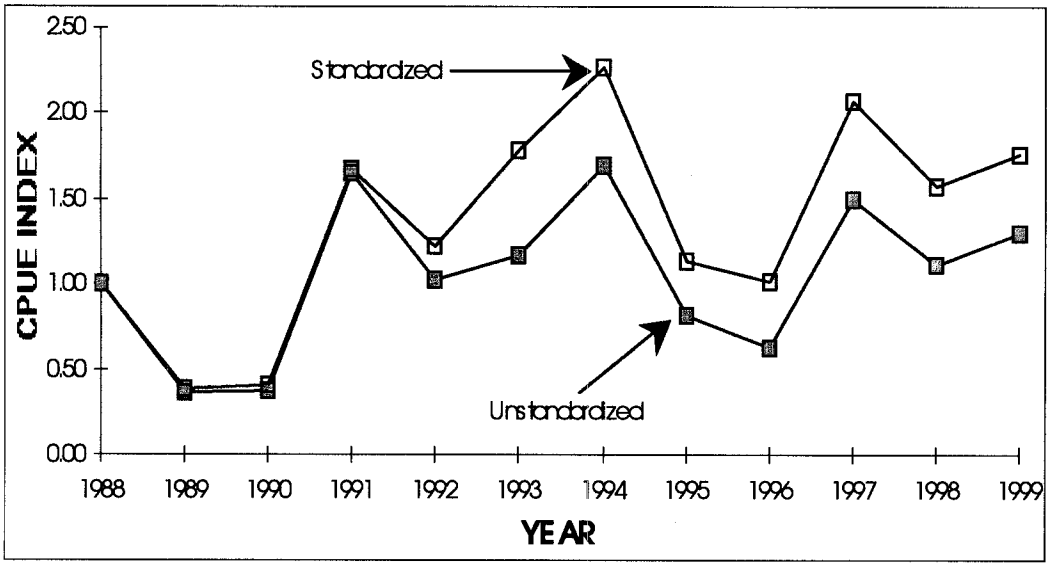


The fishery from 1988 to 1990 occurred throughout the Division, which, during that period, was split into two management zones, north and south of 60^0 N. The 1991 - 1993 Management Plan combined the two zones and, up to 1997, effort concentrated primarily in the north (Fig. 16). In 1998 and 1999, more effort was deployed south of 60^0 N because of the separate quota for that area. By-catches of *P. montagui* were reported at some northwestern locations during the 1995 - 1999 period.

Catch per unit effort (CPUE)

Unstandardized, annual CPUE's for the whole management area (single trawl data for offshore vessels) in 1989 and 1990 were lower than the 1988 estimate. In 1991, catch rate increased substantially as fishing effort concentrated in the northern grounds and high CPUE's were maintained up to 1994. The 1995 and 1996 catch rates declined but recovered again during the 1997 – 1999 period.

The CPUE data were analyzed by multiple regression, weighted by effort, for year, month and vessel effects. The model showed that the annual, standardized catch rates in 1997 and 1998 were similar ($P > 0.05$, Table 5) to the 1999 estimate. Both series showed that, since 1991, catch rates have fluctuated without any long-term trend.



Historical fishery data for this management-assessment area are summarized in Table 6.

Size composition

Catch-at-length data for the 1990 – 1999 period showed variable size distributions between years (Fig. 17). From 1991 to 1997, when effort concentrated in the north where males appeared to be less abundant, the female component dominated the catches by number and weight in all years except 1992. Since 1991, the mean length of females and median size at sex inversion has declined. The most recent decreases in 1998 and 1999 are thought to reflect increased fishing in southern 2G where growth rates and maturity schedules resemble those seen in the Hopedale + Cartwright area.

Given the recent high catch rates of primarily female shrimp in this area, it appears that a healthy spawning biomass is being maintained.

RESEARCH SURVEY DATA

Stock size

Results of fall multispecies research surveys for depths greater than 200 m in 1996, 1997 and 1999 (shallow depths not sampled in 1997) showed that shrimp were widely distributed throughout Division 2G area each year (Figs. 18a – 20a). The minimum trawlable biomass/abundance estimates, obtained using the non-parametric method, and Monte Carlo confidence limits are shown in Figures 18b to 20b and compared in the following table.

Northern shrimp stock size estimates in Division 2G (SFA 4)[1] from fall research trawl surveys > 200 m, 1996, 1997 and 1999.

	Biomass (tons)			Abundance (numbers x 10^{-6})			No. Sets
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	
1996	23,610	42,400	66,840	3,476	7,187	12,100	29
1997	30,670	64,100	110,800	5,670	10,943	18,410	69
1999	42,420	65,100	86,850	7,462	11,068	14,710	44

[1] **Area compared each year = 23,467.9 sq. km.**

Point estimates of minimum stock size (indices) in 1997 and 1999 were similar and higher than those obtained from the 1996 survey. Uncertainty in the estimates, as reflected in the 95% confidence intervals, was greatest in 1997 and least in 1999. Survey coverage in this area generally has been poor and, therefore, recent trend in the stock is uncertain.

Biomass/abundance indices for males increased from 1996 to 1997 and decreased in 1999 whereas the female stock showed an increase over the time period. However, as for the sex-aggregated data, the low, incomplete survey coverage and imprecision create much uncertainty in the estimates.

Stock size estimates for male and female shrimp in Division 2G (SFA 4) from fall research trawl surveys > 200m, 1996, 1997 and 1999.

	Biomass (tons)			Abundance (numbers x 10^{-6})		
	Males	Females	Total	Males	Females	Total
1996	23,600	18,700	42,400	5,225	1,955	7,187
1997	36,500	27,600	64,100	7,872	3,070	10,943
1999	32,600	32,500	65,100	7,197	3,871	11,068

The ratios of nominal catch to the lower confidence intervals of survey biomass indices, including depths less than 200 m in 1996 and 1999, were below 20 % in each year. Given that the survey coverage has been incomplete each year with respect to total shrimp habitat in the area and that the catchability of the survey

gear is thought to be less than 1, it can be concluded that recent exploitation rates, although not quantifiable, have been low.

Stock composition

Length distributions from the 1996 survey, adjusted to the estimated abundance, showed a predominance of male shrimp between 17 and 22 mm CL (Fig. 18b, lower panel). The prominent mode at 18.5 mm is though to be the 1992 year class and the component at 20.5 the 1991 year class. Several year classes (ages 6+) were represented in the female component.

The 1992 (about 20 mm) and 1993 (18 mm) year classes dominated in the 1997 survey (Fig. 19b, lower panel) and several size/age groups of females were present.

The male component in the 1999 survey was dominated by the 1994 and 1995 year classes and, for the first time, there was representation of age 1 males, the 1998 year classes (Fig. 20b, lower panel). The female component was well represented by year classes produced prior to 1994.

Based on the data from surveys in which coverage was incomplete, it appears that recruitment (e.g. small males, ages 1 – 3) is difficult to measure in this area (Fig. 21). After three years of surveys, no recruitment index is available. Also, age interpretation is confounded by the mixing of animals which, over a latitudinal scale, exhibit different growth rates and maturity schedules.

RESOURCE STATUS

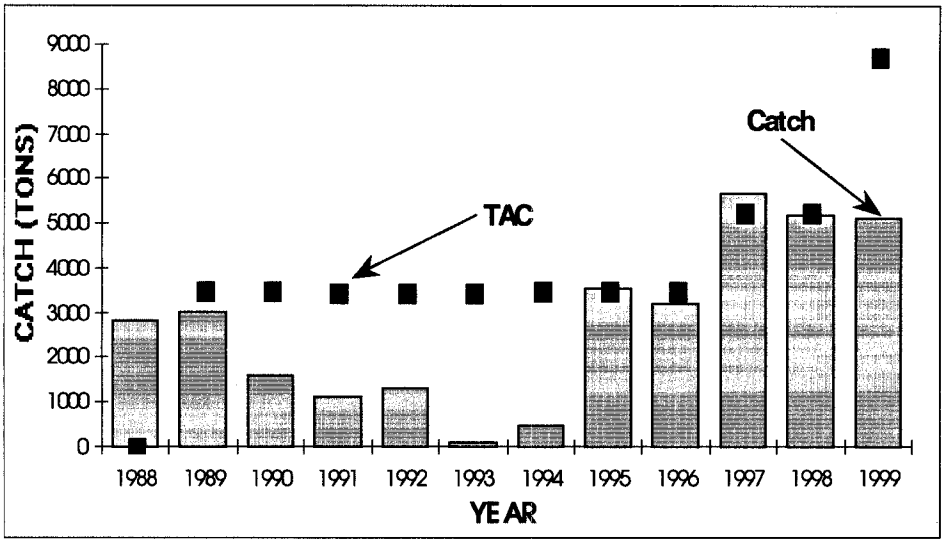
The spawning stock remains healthy, as evidenced in continued high catch rates of large female shrimp and stability in catch rates since 1997. Despite limitations, research surveys indicated an increase in abundance/biomass of females since 1996. Further, exploitation rate in recent years, as inferred but not quantified from catch-to-biomass ratios (lower 95% confidence interval), is thought to be low (<20%). However, prospects beyond 2000 are uncertain in the absence of data on relative strengths of recruiting year classes (males).

ASSESSMENT OF SHRIMP IN NAFO DIVISION 0B (SFA 2)

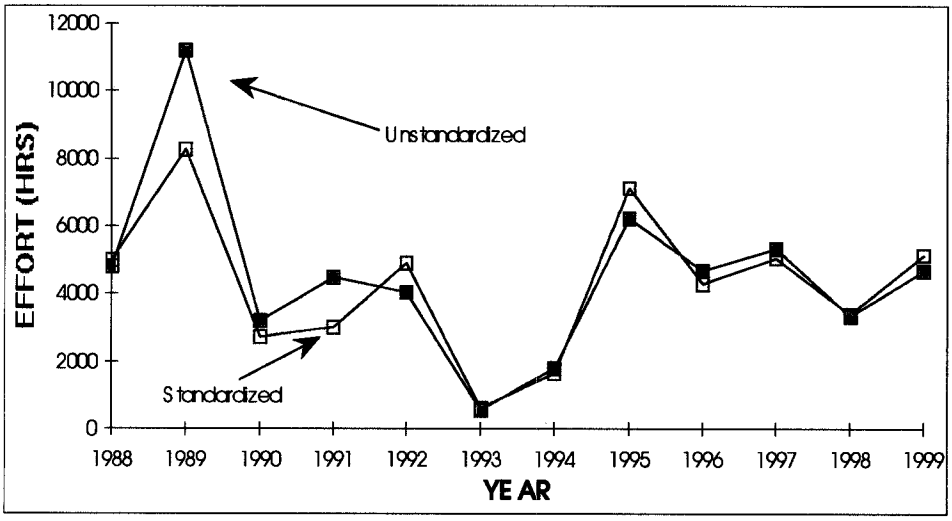
FISHERY DATA

Catch and effort

The fishery for *Pandalus borealis* in Div. 0B began in the fall of 1988. Catches increased from about 2800 tons that year to 3000 tons in 1989 but subsequently declined to 100 tons in 1993. In 1994, catch remained low at less than 500 tons but increased substantially to about 3600 and 3200 tons in 1995 and 1996, respectively, and to more than 5000 tons each year from 1997 to 1999. Recent catches for the species have been estimated from the mixed fishery data for *P. borealis/montagui* in the area east of Resolution Island but their accuracy is still questionable. *Pandalus borealis* taken in the immediately adjacent areas of SFA's 3 and 4 were included in the catches reported for SFA 2. TAC's remained at 3500 tons from 1989 to 1996 but were increased experimentally to 5250 tons for 1997 and 1998. In 1999, an additional 3500 tons were provided for the area north of 63^0 N as an incentive for the offshore fleet to return to grounds not fished extensively since 1995. However, preliminary year-end quota reports showed that just over 100 tons were taken within this area in 1999.



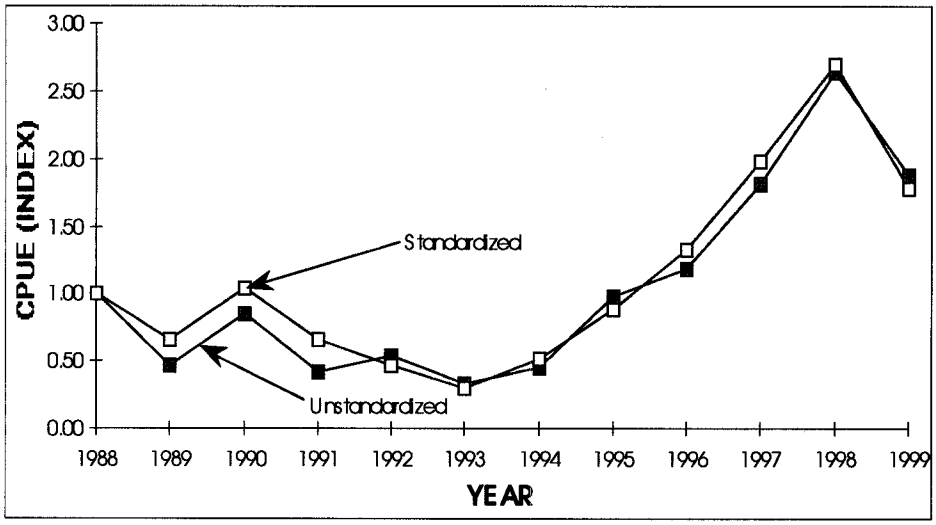
Fishing effort about doubled from 1988 to 1989, decreased sharply in 1990 and remained near the 1990 level for the next two years. Effort increased from 1993 to 1995 and has since remained relatively stable.



In the late 1980's, fishing effort was primarily concentrated between 64^0 and 65^0 N whereas, during the 1990 - 1994 period, proportionately more was distributed south of 64^0 N. The areas fished extensively in the southwest from 1995 to 1999 reflect the targeting of *Pandalus borealis* and *P. montagui* concentrations east of Resolution Island. Most effort since 1996 occurred south of 63^0 N (Fig. 22).

Catch per unit effort (CPUE)

Both the unstandardized and standardized annual CPUE's showed an overall decline from 1988 to 1993. Catch rates increased sharply from 1993 to 1998 but decreased in 1999 to the level observed in 1997. The standardized model for year, month and vessel effects with effort weighting showed that the 1999 catch rate was significantly higher ($P < 0.05$) than estimates for all years prior to 1997, similar to the 1997 ($P > 0.05$) and lower than the 1998 estimate (Table 7). The pronounced increase in CPUE after 1994 is associated with the shift of fishing effort to the southwest.



Historical fishery data for this management-assessment area are summarized in Table 8.

Size composition

Catches in most years were composed primarily of large, female shrimp (Fig. 23) with a modal length of about 27 mm CL. However, the mean size of females and the median size at sex change declined after 1996. The occurrence of males <22 mm in the catches, as well as the overall catch rates of male and female components, increased with the southward shift in fishing effort.

RESOURCE STATUS

Although shrimp concentrations in northeast are elusive, as evidenced by the low catch in 1999 from the area north of 63^0 N, those adjacent to eastern Resolution Island have persisted since first fished in 1995. However, the population structure is uncertain throughout Div. 0B and distribution is unknown for much of the year. Therefore, the current status of this resource remains uncertain.

The fishery shifted to the southwest, east of Resolution Island, after 1994 and the CPUE and sampling data are not considered to be representative of stock conditions. The mixed fishery for *Pandalus borealis/montagui* confounds the assessment and the lack of knowledge on the distribution and abundance/biomass of both species (i.e. the boundary question) will persist in the absence of a time series of research trawl surveys. Future prospects are unknown.

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Evans, G.T., D.C. Orr, D.G. Parsons, and P.J. Veitch. 1999. A Non-parametric methods of estimating biomass from trawl surveys with Monte Carlo confidence intervals. NAFO SCR Doc. 99/72, Serial No. N4143: 8 p.

Parsons, D.G., P.J. Veitch, and G.T. Evans. 1999. Resource status of northern shrimp (Pandalus borealis) off Baffin Island, Labrador and northeastern Newfoundland – second interim review. CSAS Res. Doc. 99/112: 53 p.

TABLE 1. MULTIPLICATIVE, YEAR MONTH VESSEL AREA MODEL FOR CPUE IN HAWKE CHANNEL + DIV. 3K,1988 - 1999, WEIGHTED BY EFFORT.

General Linear Models Procedure
Class Level Information

Class	Levels	Values
YEAR	12	88 89 90 91 92 93 94 95 96 97 98 99
MONTH	5	2 3 4 5 99
VESSEL	20	5 12 13 21 30 32 38 39 40 41 42 43 44 47 58 67 69 70 71 99
AREA	7	67 68 69 90 91 92 99

Number of observations in data set = 1134

Dependent Variable: LNCPUE
Weight: WFACTOR

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	40	43187.59422487	1079.68985562	85.75	0.0001
Error	1093	13762.23869011	12.59125223		
Corrected Total	1133	56949.83291498			

R-Square	C.V.	Root MSE	LNCPUE Mean
0.758345	52.41453	3.54841545	6.76990739

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	11	37366.85335195	3396.98666836	269.79	0.0001
MONTH	4	409.56968260	102.39242065	8.13	0.0001
VESSEL	19	2369.81812770	124.72726988	9.91	0.0001
AREA	6	3041.35306262	506.89217710	40.26	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	11	6888.75915057	626.25083187	49.74	0.0001
MONTH	4	521.39334017	130.34833504	10.35	0.0001
VESSEL	19	2215.92312533	116.62753291	9.26	0.0001
AREA	6	3041.35306262	506.89217710	40.26	0.0001

Parameter		Estimate	T for HO: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		7.674012081 B	108.56	0.0001	0.07069063
YEAR	88	-1.032265845 B	-13.97	0.0001	0.07390449
	89	-1.298854159 B	-18.74	0.0001	0.06932345
	90	-1.217874469 B	-15.23	0.0001	0.07996310
	91	-0.981658198 B	-13.05	0.0001	0.07521954
	92	-0.623745984 B	-8.79	0.0001	0.07097548
	93	-0.501593423 B	-6.96	0.0001	0.07210634
	94	-0.317253377 B	-4.83	0.0001	0.06569956
	95	-0.052337852 B	-0.76	0.4456	0.06859783
	96	0.017126513 B	0.25	0.8006	0.06779940
	97	0.231430126 B	3.34	0.0009	0.06927443
	98	-0.020127810 B	-0.33	0.7428	0.06132524
	99	0.000000000 B	.	.	.

TABLE 2. NORTHERN SHRIMP FISHERY DATA FOR HAWKE CHANNEL + DIVISION 3K (SFA 6), 1977 - 1999.

			UNSTANDARDIZED			STANDARDIZED		
YEAR	TAC [1] (t)	CATCH [2] (t)	CPUE (KG/HR)	CPUE INDEX	EFFORT [3] (HR)	RELATIVE CPUE	CPUE INDEX	EFFORT [3] INDEX
1977		1	117		6			
1978	1300							
1979	2250	5	189		29			
1980	1350							
1981	1350	135	207		652			
1982	1350	1	151		3			
1983	1350							
1984	1350							
1985	1350							
1986	2050							
1987	3000	1845	333		5544			
1988	3000	7849	536	1.00	14637	0.36	1.00	22035
1989	5600	6662	433	0.81	15403	0.27	0.77	24421
1990	5600	5598	508	0.95	11027	0.30	0.83	18919
1991	4301	5500	603	1.12	9120	0.37	1.05	14678
1992	7565	6609	774	1.44	8534	0.54	1.50	12333
1993	9180	8035	892	1.66	9012	0.61	1.70	13268
1994	11050	10978	1295	2.41	8477	0.73	2.04	15078
1995	11050	10914	1821	3.40	5992	0.95	2.66	11501
1996	11050	10923	2008	3.74	5440	1.02	2.86	10737
1997	23100	21246	1998	3.72	10636	1.26	3.54	16857
1998	46200	46337	1795	3.35	25818	0.98	2.75	47278
1999	58632	51255	1790	3.34	28640	1.00	2.81	51255

1 HISTORICAL TAC'S APPLIED AS FOLLOWS:

1978 TO 1985 - INCLUDES 500 TON EXPLORATORY TAC FOR DIVISION 3K;

1986 TO 1988 - HAWKE CHANNEL + ST. ANTHONY BASIN;

1989 TO 1991 - HAWKE CHANNEL, ST. ANTHONY BASIN, EAST ST. ANTHONY AND FUNK ISLAND DEEP;

1992 - INCLUDES 1700 TONS EXPLORATORY;

1993 - INCLUDES 3400 TONS EXPLORATORY;

1994 to 1999 - ALL AREAS COMBINED.

TAC'S FROM 1987 TO 1990, INCLUSIVE, ARE FOR THE FISHING SEASON MAY 1 TO APRIL 30, MAKING 1986 A 16 MONTH YEAR (JAN.1, 1986 - APRIL 30, 1987) AND 1991 AN 8 MONTH YEAR (MAY 1 - DEC. 31).

2 CATCH (TONS) IN CALENDAR YEAR AS REPORTED IN: LOG BOOKS FOR 1977, ECONOMIC ASSESSMENT OF THE NORTHERN SHRIMP FISHERY FROM 1978 TO 1989 AND YEAR-END QUOTA REPORTS, THEREAFTER.

3 EFFORT CALCULATED FROM CATCH/CPUE. CPUE CALCULATED FROM OFFSHORE VESSEL LOG DATA, SINGLE TRAWL.

TABLE 3. MULTIPLICATIVE, YEAR MONTH VESSEL AREA MODEL FOR CPUE IN HOPEDALE + CARTWRIGHT CHANNELS, 1977 - 1999, WEIGHTED BY EFFORT.

General Linear Models Procedure
Class Level Information

Class	Levels	Values
YEAR	23	77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99
MONTH	12	1 2 3 4 5 6 8 9 10 11 12 99
VESSEL	25	1 4 5 7 13 15 21 29 30 33 39 40 41 43 44 45 46 47 49 53 58 67 69 70 99
AREA	4	52 53 54 99

Number of observations in data set = 1452

Dependent Variable: LNCPUE
Weight: WFACTOR

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	60	53414.94243962	890.24904066	80.48	0.0001
Error	1391	15386.14266703	11.06120968		
Corrected Total	1451	68801.08510665			

R-Square	C.V.	Root MSE	LNCPUE Mean
0.776368	52.19416	3.32583970	6.37205367

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	22	44064.99422796	2002.95428309	181.08	0.0001
MONTH	11	6209.69690366	564.51790033	51.04	0.0001
VESSEL	24	3034.69429322	126.44559555	11.43	0.0001
AREA	3	105.55701478	35.18567159	3.18	0.0232

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	22	8101.80640836	368.26392765	33.29	0.0001
MONTH	11	5287.11501545	480.64681959	43.45	0.0001
VESSEL	24	3035.08902796	126.46204283	11.43	0.0001
AREA	3	105.55701478	35.18567159	3.18	0.0232

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		7.083940286 B	101.22	0.0001	0.06998826
YEAR	77	-0.525445923 B	-4.66	0.0001	0.11271832
	78	-0.601274057 B	-5.55	0.0001	0.10826932
	79	-0.908033979 B	-9.64	0.0001	0.09417751
	80	-0.916206507 B	-11.42	0.0001	0.08024180
	81	-0.909528091 B	-11.60	0.0001	0.07842574
	82	-0.981648384 B	-11.70	0.0001	0.08393447
	83	-1.242243214 B	-14.05	0.0001	0.08844483
	84	-1.104467315 B	-12.46	0.0001	0.08861241
	85	-1.346422379 B	-17.72	0.0001	0.07598746
	86	-0.693836723 B	-8.79	0.0001	0.07896074
	87	-0.742003151 B	-9.56	0.0001	0.07761897
	88	-0.839761193 B	-11.34	0.0001	0.07407789
	89	-0.786365827 B	-10.73	0.0001	0.07331074
	90	-0.707733505 B	-9.69	0.0001	0.07302945
	91	-0.854559692 B	-12.18	0.0001	0.07015660
	92	-0.912963997 B	-13.86	0.0001	0.06588720
	93	-0.756379867 B	-11.48	0.0001	0.06585851
	94	-0.654287831 B	-10.54	0.0001	0.06207794
	95	-0.490619928 B	-7.07	0.0001	0.06940127
	96	-0.269516684 B	-3.58	0.0004	0.07527565
	97	-0.027720440 B	-0.45	0.6534	0.06172125
	98	-0.061387514 B	-0.96	0.3387	0.06414621
	99	0.000000000 B	.	.	.

TABLE 4. NORTHERN SHRIMP FISHERY DATA FOR HOPEDALE + CARTWRIGHT CHANNELS (SFA 5), 1977 - 1999.

			UNSTANDARDIZED			STANDARDIZED		
YEAR	TAC [1] (t)	CATCH [2] (t)	CPUE (KG/HR)	CPUE INDEX	EFFORT [3] (HR)	RELATIVE CPUE	CPUE INDEX	EFFORT [3] INDEX
1977	.	2686	552	1.00	4865	0.59	1.00	4543
1978	5300	3630	453	0.82	8011	0.55	0.93	6623
1979	4000	3727	368	0.67	10136	0.40	0.68	9241
1980	4800	4108	388	0.70	10594	0.40	0.68	10270
1981	4800	3449	364	0.66	9485	0.40	0.68	8565
1982	4800	1983	372	0.67	5329	0.37	0.63	5292
1983	4800	1000	297	0.54	3368	0.29	0.49	3464
1984	4200	1002	297	0.54	3373	0.33	0.56	3024
1985	3570	1689	230	0.42	7350	0.26	0.44	6491
1986	4400	4826	538	0.97	8970	0.50	0.85	9658
1987	4800	5956	615	1.11	9685	0.48	0.81	12507
1988	4800	7838	626	1.13	12530	0.43	0.73	18152
1989	6000	5985	677	1.23	8847	0.46	0.77	13139
1990	6000	5360	627	1.13	8555	0.49	0.83	10877
1991	6375	6118	528	0.96	11589	0.43	0.72	14378
1992	6375	6315	694	1.26	9093	0.40	0.68	15736
1993	6375	5719	620	1.12	9228	0.47	0.79	12184
1994	7650	7499	754	1.37	9944	0.52	0.88	14427
1995	7650	7616	1386	2.51	5496	0.61	1.04	12440
1996	7650	7383	1921	3.48	3842	0.76	1.29	9667
1997	15300	15103	1603	2.90	9422	0.97	1.65	15527
1998	15300	15170	2117	3.83	7165	0.94	1.59	16130
1999	15300	15028	2262	4.10	6645	1.00	1.69	15028

1 TAC'S FROM 1987 TO 1990, INCLUSIVE ARE FOR THE FISHING SEASON MAY 1 TO APRIL 30, MAKING 1986 A 16 MONTH YEAR (JAN.1, 1986 - APRIL 30, 1987) AND 1991 AN 8 MONTH YEAR (MAY 1 - DEC. 31).

2 CATCH (TONS) IN CALENDAR YEAR AS REPORTED IN : LOG BOOKS FOR 1977, ECONOMIC ASSESSMENT OF THE NORTHERN SHRIMP FISHERY FROM 1978 TO 1989 AND YEAR-END QUOTA REPORTS, THEREAFTER.

3 EFFORT CALCULATED FROM CATCH/CPUE. CPUE CALCULATED FROM OFFSHORE VESSEL LOG DATA FOR SINGLE TRAWLS.

TABLE 5. MULTIPLICATIVE, YEAR MONTH VESSEL MODEL FOR CPUE IN DIV. 2G , 1988 - 1999, WEIGHTED BY EFFORT.

General Linear Models Procedure

Class Level Information

Class	Levels	Values
YEAR	12	88 89 90 91 92 93 94 95 96 97 98 99
MONTH	8	5 7 8 9 10 11 12 99
VESSEL	18	5 12 21 29 33 34 37 40 42 43 44 47 58 67 69 70 71 99

Number of observations in data set = 314

Dependent Variable: LNCPUE
Weight: WFACTOR

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	35	8328.47921537	237.95654901	22.14	0.0001
Error	278	2987.76356421	10.74735095		
Corrected Total	313	11316.24277958			

R-Square	C.V.	Root MSE	LNCPUE Mean
0.735976	45.06830	3.27831526	7.27410389

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	11	7217.16956942	656.10632449	61.05	0.0001
MONTH	7	362.82725481	51.83246497	4.82	0.0001
VESSEL	17	748.48239113	44.02837595	4.10	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	11	3734.34138098	339.48558009	31.59	0.0001
MONTH	7	245.46136084	35.06590869	3.26	0.0024
VESSEL	17	748.48239113	44.02837595	4.10	0.0001

Parameter		Estimate	T for HO: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		7.660633320 B	60.09	0.0001	0.12748659
YEAR	88	-0.565680348 B	-2.21	0.0277	0.25566160
	89	-1.529582031 B	-11.23	0.0001	0.13624546
	90	-1.461081635 B	-12.81	0.0001	0.11401892
	91	-0.051963934 B	-0.28	0.7793	0.18521737
	92	-0.360688967 B	-2.81	0.0054	0.12858510
	93	0.013647917 B	0.11	0.9148	0.12740286
	94	0.253463291 B	2.14	0.0329	0.11825119
	95	-0.437552698 B	-4.71	0.0001	0.09281611
	96	-0.550925446 B	-5.14	0.0001	0.10719495
	97	0.163223359 B	1.62	0.1059	0.10060675
	98	-0.114014687 B	-1.41	0.1610	0.08113171
	99	0.000000000 B	.	.	.

TABLE 6. NORTHERN SHRIMP FISHERY DATA FOR DIV. 2G (SFA 4), 1979 - 1999.

			UNSTANDARDIZED			STANDARDIZED		
YEAR	TAC [1] (t)	CATCH [2] (t)	CPUE (KG/HR)	INDEX	EFFORT [3] (HR)	RELATIVE CPUE	CPUE INDEX	EFFORT [3] INDEX
1979	500	3	823		4			
1980	500	<1	6		8			
1981	500	2	381		5			
1982	500	5	252		20			
1983	500	30	441		68			
1986	500	2	450		4			
1987	500	7	660		11			
1988	500	1083	1856	1.00	584	0.57	1.00	1907
1989	2580	3842	673	0.36	5709	0.22	0.38	17738
1990	2580	2945	703	0.38	4190	0.23	0.41	12694
1991	2635	2561	3071	1.66	834	0.95	1.67	2697
1992	2635	2706	1901	1.02	1423	0.70	1.23	3881
1993	2735	2723	2160	1.16	1261	1.01	1.78	2686
1994	4000	3982	3142	1.69	1267	1.29	2.27	3090
1995	5200	5104	1503	0.81	3397	0.65	1.14	7906
1996	5200	5160	1173	0.63	4399	0.58	1.01	8952
1997	5200	5217	2779	1.50	1877	1.18	2.07	4431
1998	8320	8051	2074	1.12	3882	0.89	1.57	9024
1999	8320	7961	2410	1.30	3303	1.00	1.76	7961

[1] TAC'S FROM 1987 TO 1990, INCLUSIVE ARE FOR THE FISHING SEASON MAY 1 TO APRIL 30, MAKING 1986 A 16 MONTH YEAR (JAN.1, 1986 - APRIL 30, 1987) AND 1991 AN 8 MONTH YEAR (MAY 1 - DEC. 31).

[2] CATCH (TONS) AS REPORTED IN: LOGBOOKS FOR 1979, ECONOMIC ASSESSMENT OF THE NORTHERN SHRIMP FISHERY FROM 1980 TO 1989 AND FROM YEAR-END QUOTA REPORTS AND/OR LOGBOOKS, THEREAFTER.

[3] EFFORT CALCULATED FROM CATCH/CPUE. CPUE CALCULATED FROM OFFSHORE VESSEL LOGS FOR SINGLE TRAWLS.

TABLE 7. MULTIPLICATIVE, YEAR VESSEL MODEL - DIVISION 0B - SINGLE TRAWL, 1988 - 1999

General Linear Models Procedure

Class Level Information

Class	Levels	Values
YEAR	12	88 89 90 91 92 93 94 95 96 97 98 99
MONTH	7	6 7 8 9 10 12 99
VESSEL	18	5 12 21 29 30 32 39 40 41 42 44 47 58 67 69 70 71 99

Number of observations in data set = 376

Dependent Variable: LNCPUE
Weight: WFACTOR

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	34	19790.92520706	582.08603550	15.84	0.0001
Error	341	12533.04419327	36.75379529		
Corrected Total	375	32323.96940033			

R-Square	C.V.	Root MSE	LNCPUE Mean
0.612268	98.17908	6.06249085	6.17493132

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	11	17041.95053471	1549.26823043	42.15	0.0001
MONTH	6	575.34014393	95.89002399	2.61	0.0174
VESSEL	17	2173.63452841	127.86085461	3.48	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	11	6200.41210325	563.67382757	15.34	0.0001
MONTH	6	541.89737467	90.31622911	2.46	0.0244
VESSEL	17	2173.63452841	127.86085461	3.48	0.0001

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		6.351891015 B	33.73	0.0001	0.18833238
YEAR	88	-0.575118039 B	-2.77	0.0058	0.20729340
	89	-1.002414636 B	-5.63	0.0001	0.17795033
	90	-0.534990558 B	-2.61	0.0095	0.20522039
	91	-0.999772217 B	-4.91	0.0001	0.20380590
	92	-1.338232788 B	-7.50	0.0001	0.17833880
	93	-1.789762907 B	-4.96	0.0001	0.36053714
	94	-1.237213260 B	-6.72	0.0001	0.18421647
	95	-0.694219733 B	-5.53	0.0001	0.12550461
	96	-0.291667809 B	-2.02	0.0444	0.14454633
	97	0.112805257 B	0.89	0.3754	0.12710570
	98	0.420672464 B	2.99	0.0030	0.14074357
	99	0.000000000 B	.	.	.

TABLE 8. NORTHERN SHRIMP FISHERY DATA FOR DIV. 0B (SFA 2), 1988 - 1999.

			UNSTANDARDIZED			STANDARDIZED		
YEAR	TAC[1] (t)	CATCH[2] (t)	CPUE (KG/HR)	CPUE INDEX	EFFORT[3] (HR)	RELATIVE CPUE	CPUE INDEX	EFFORT[3] INDEX
1988	.	2826	586	1.00	4824	0.56	1.00	5023
1989	3500	3039	271	0.46	11214	0.37	0.65	8281
1990	3500	1609	498	0.85	3230	0.59	1.04	2747
1991	3485	1107	248	0.42	4469	0.37	0.65	3008
1992	3485	1291	317	0.54	4070	0.26	0.47	4922
1993	3485	106	194	0.33	545	0.17	0.30	635
1994	3500	476	266	0.45	1790	0.29	0.52	1640
1995	3500	3564	573	0.98	6222	0.50	0.89	7135
1996	3500	3220	690	1.18	4665	0.75	1.33	4311
1997	5250	5670	1064	1.82	5331	1.12	1.99	5065
1998	5250	5204	1546	2.64	3367	1.52	2.71	3417
1999	8750	5132	1101	1.88	4662	1.00	1.78	5132

1 TAC'S FOR 1989 AND 1990 ARE FOR THE FISHING SEASON MAY 1 TO APRIL 30 AND FOR THE CALENDAR YEAR, THEREAFTER, MAKING 1991 AN 8 MONTH YEAR (MAY 1 - DEC. 31)

2 CATCH (TONS) FOR 1988 AND 1989 AS REPORTED IN ECONOMIC ASSESSMENT OF THE NORTHERN SHRIMP FISHERY AND FROM YEAR-END QUOTA REPORTS AND/OR LOGBOOK RECORDS, THEREAFTER.

3 EFFORT CALCULATED FROM CATCH/CPUE. CPUE CALCULATED FROM OFFSHORE VESSEL LOGS FOR SINGLE TRAWL.

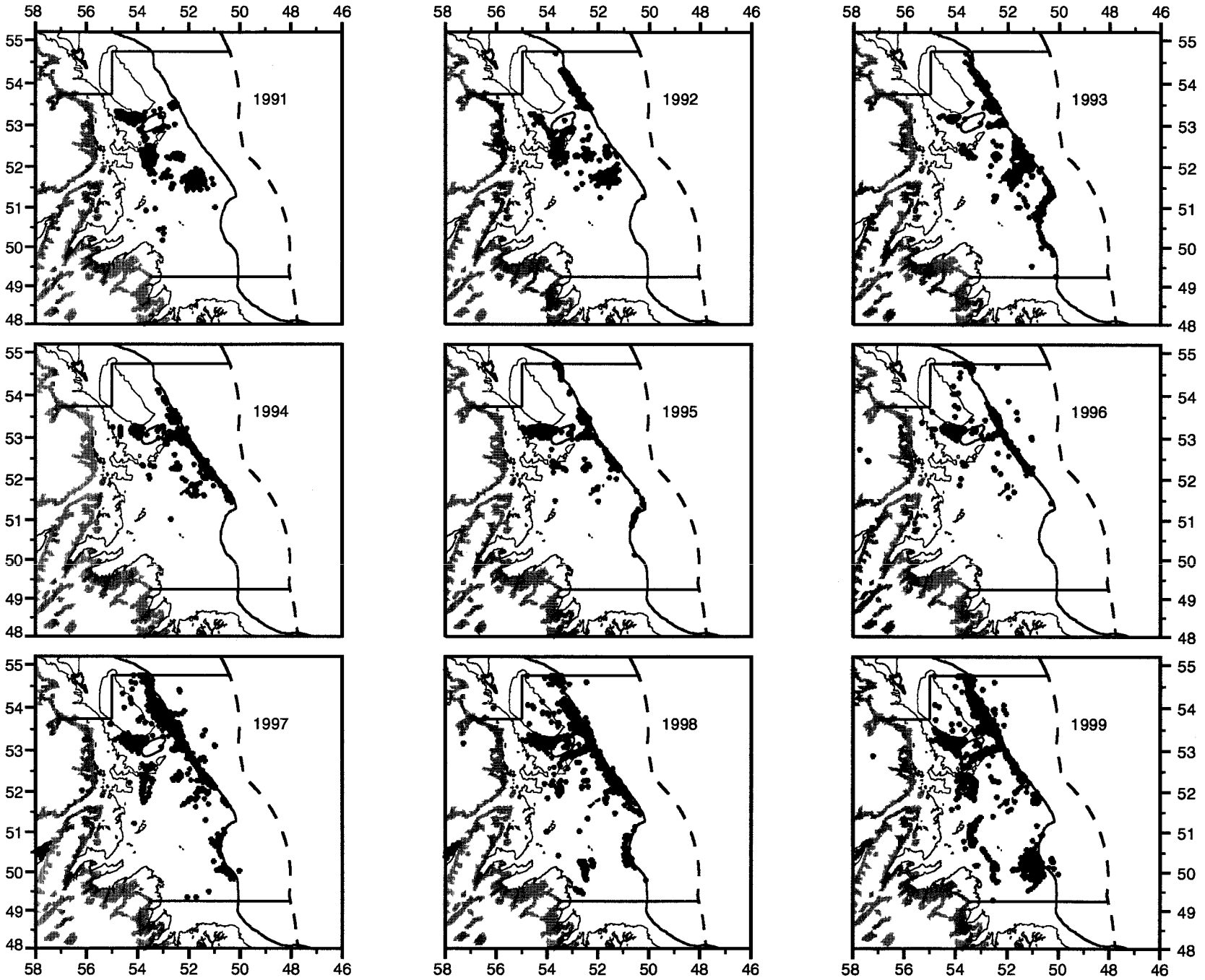


Figure 1. Distribution of commercial fishing effort in Hawke Channel + Division 3K (SFA 6), 1991 – 1999.

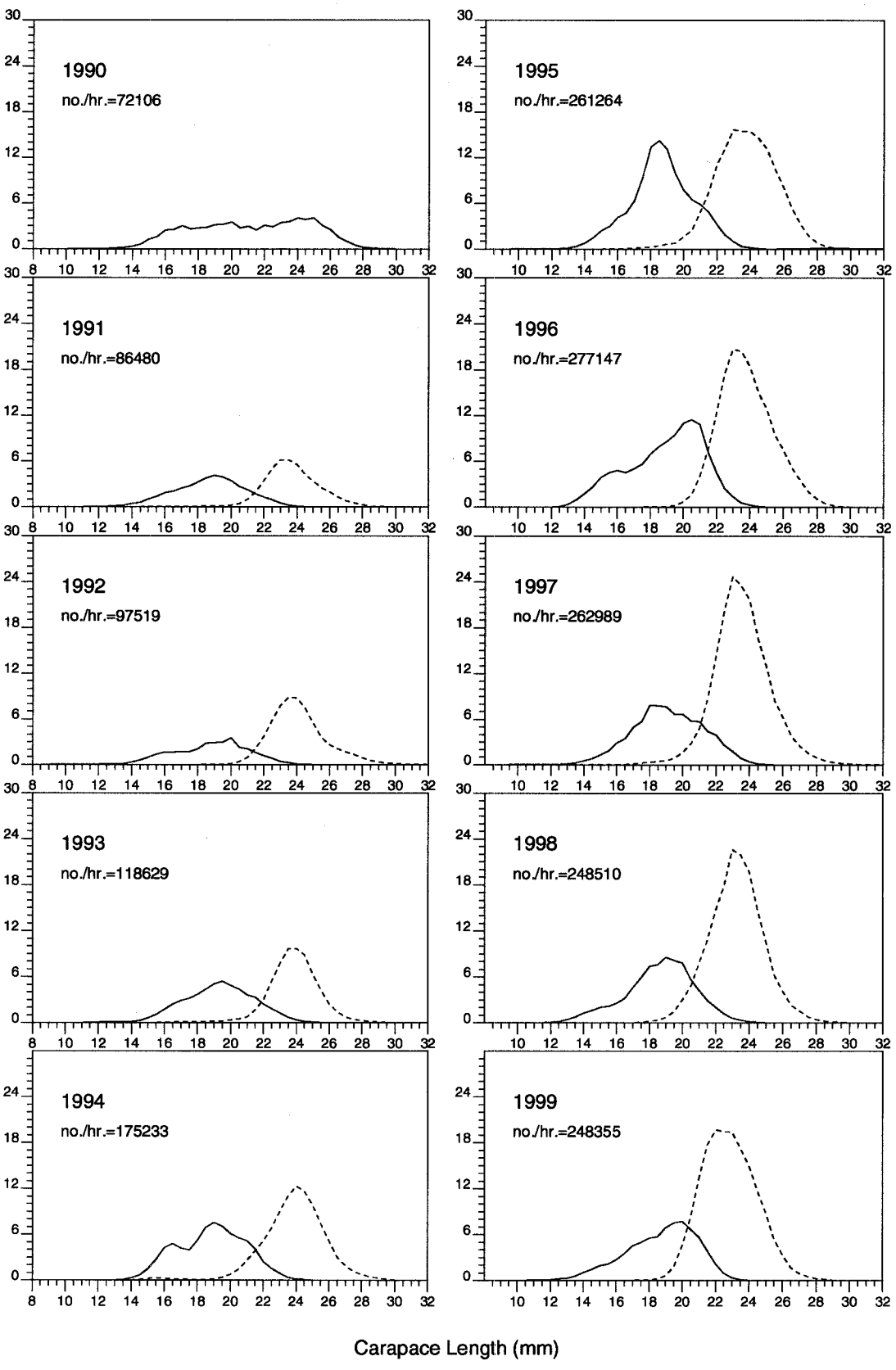


Figure 2. Number (x 10^{-3}) caught per hour at length in Hawke Channel + Division 3K, 1990 – 1999. Solid line = male, broken line = female.

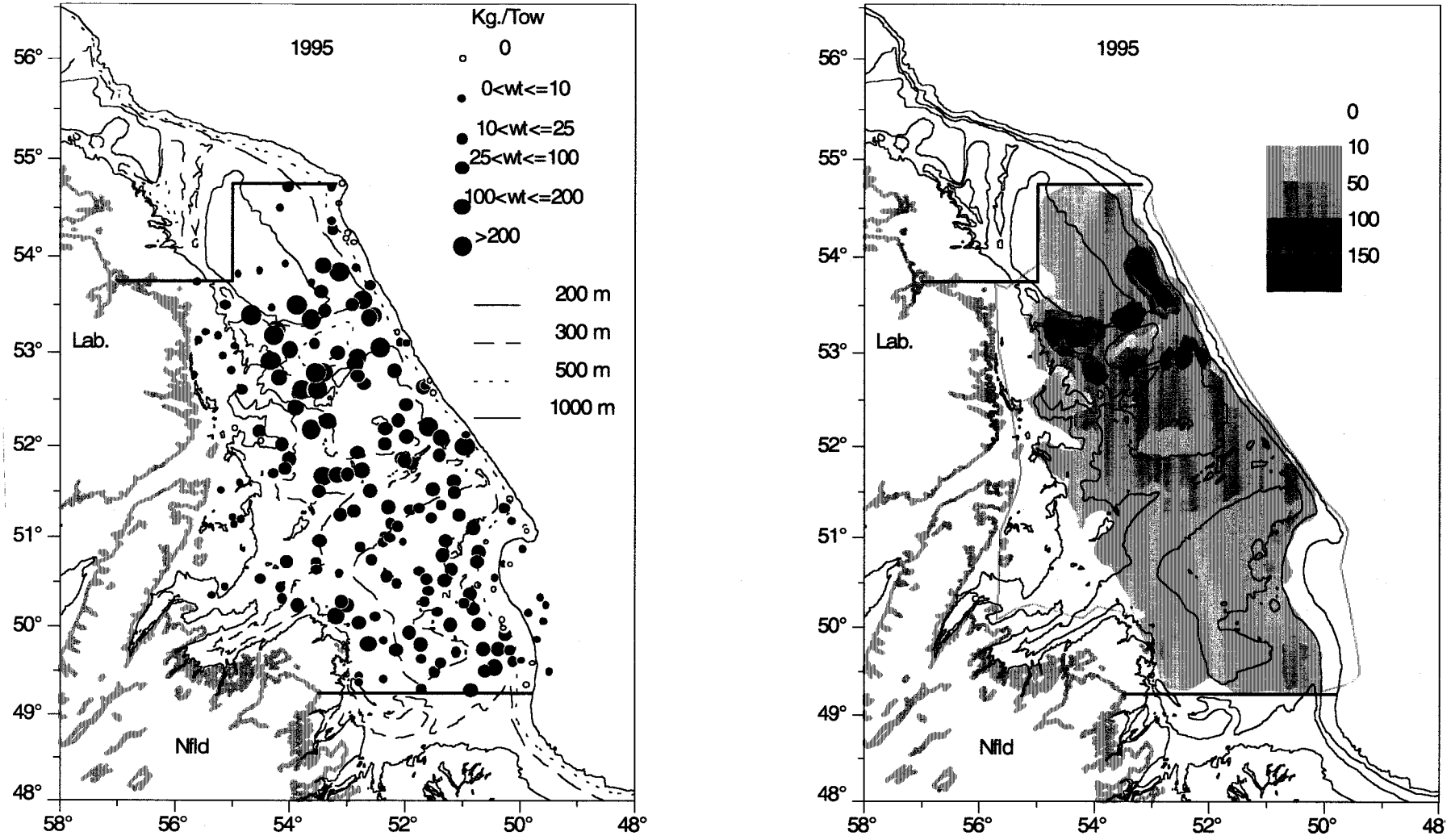
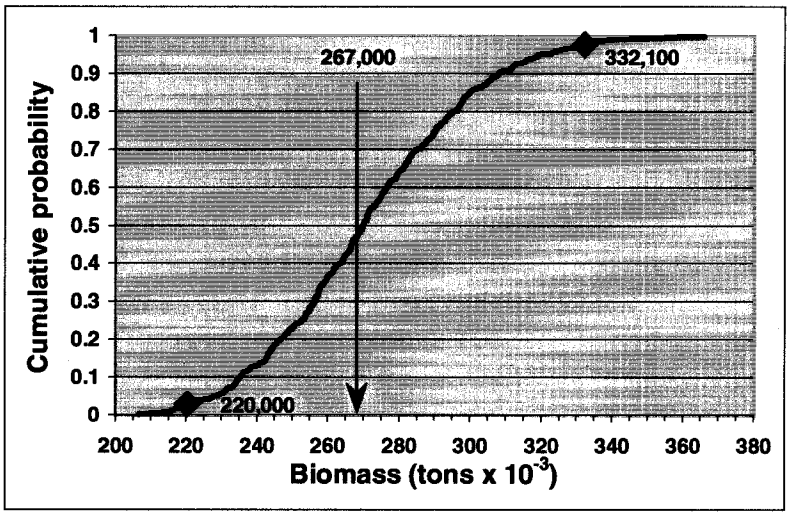
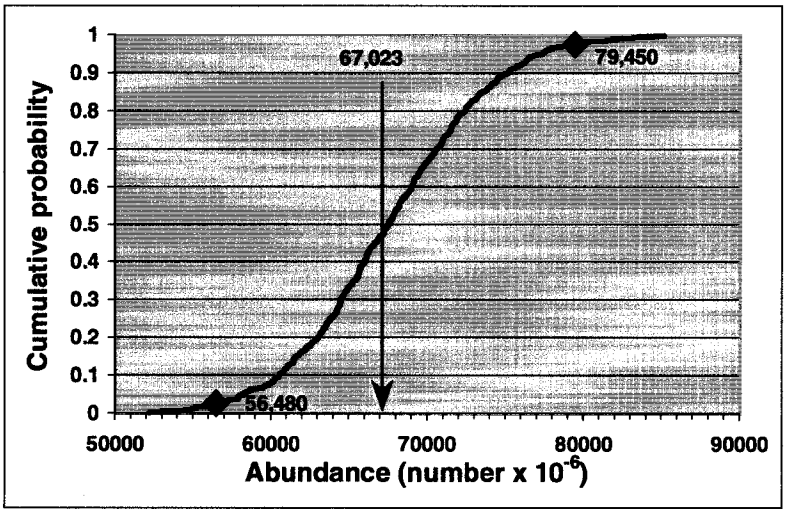
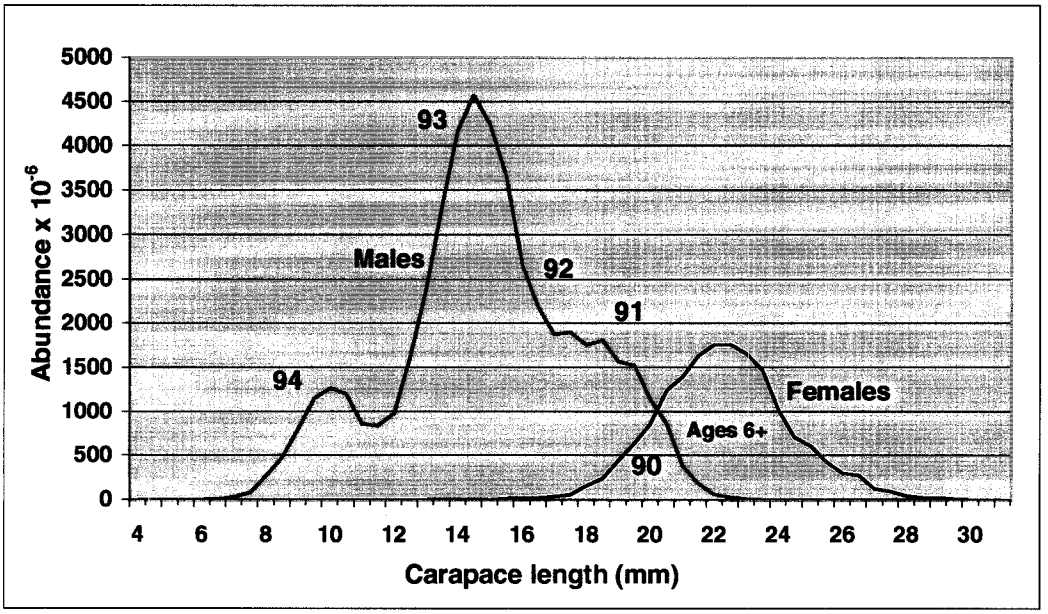


Figure 3a. Shrimp catch weight per standard 15 minute tow (left panel) from the 1995 research trawl survey in Hawke Channel + Div. 3K (SFA 6) and shrimp biomass per area^2 (right panel) estimated by ogive mapping (ogmap).

Figure 3b. Biomass, abundance and abundance-at-length for shrimp in Hawke Channel + Div. 3K (SFA 6) estimated by ogive mapping (ogmap) of research survey data, 1995.







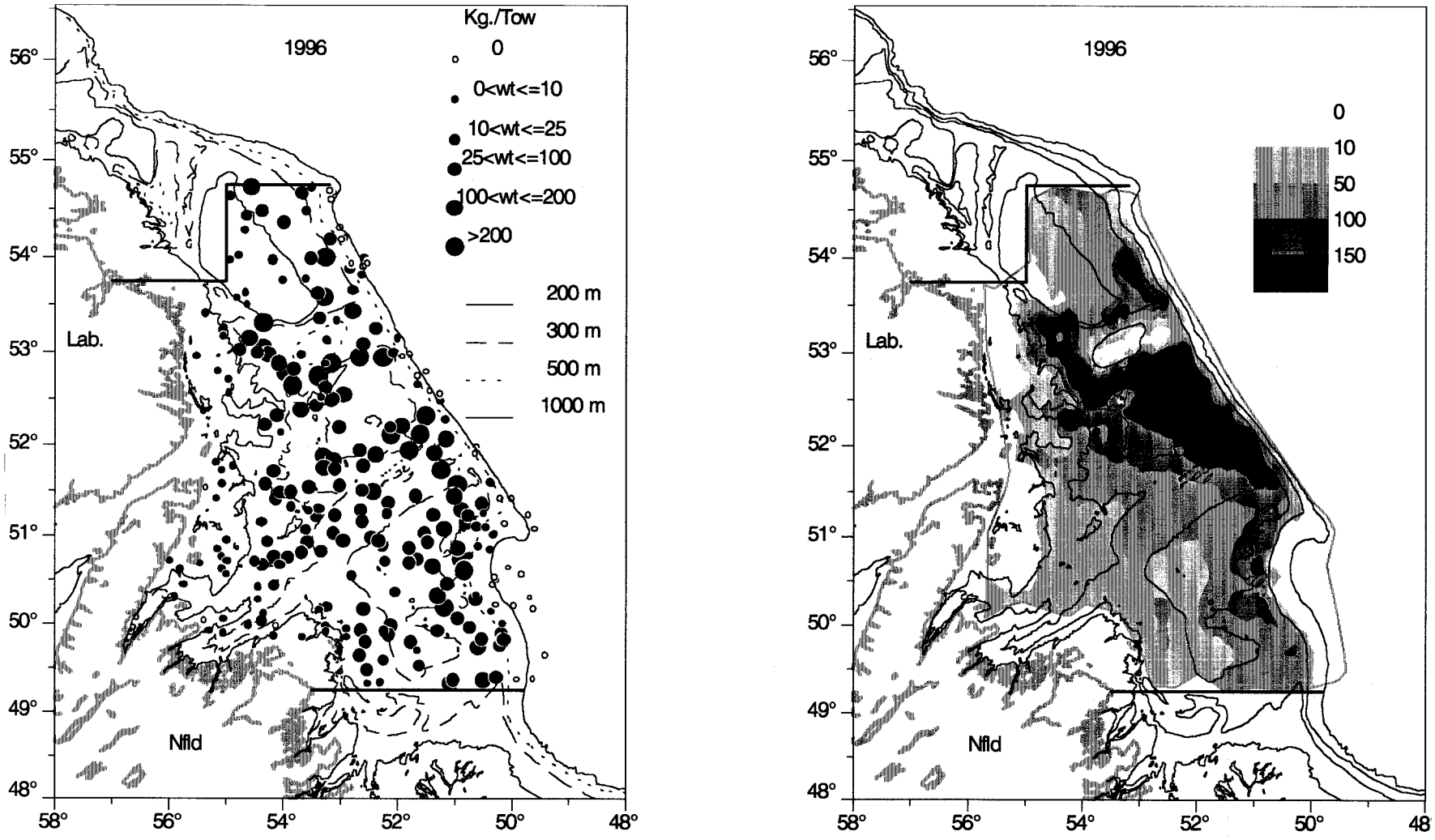
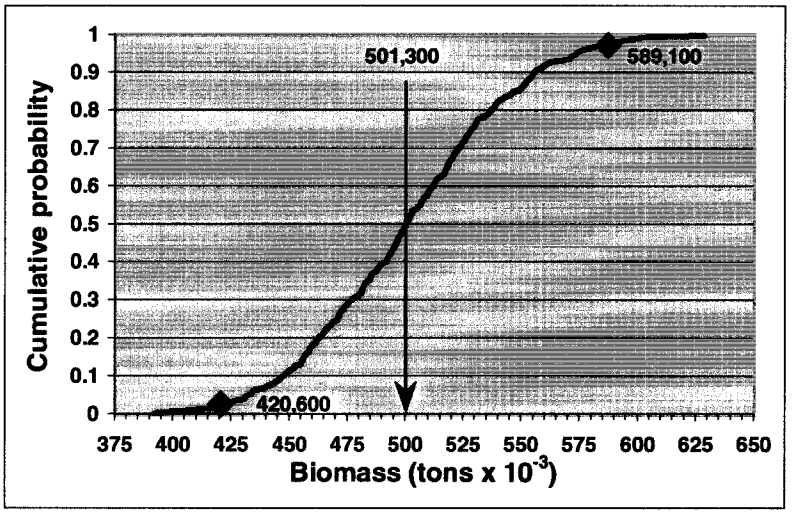
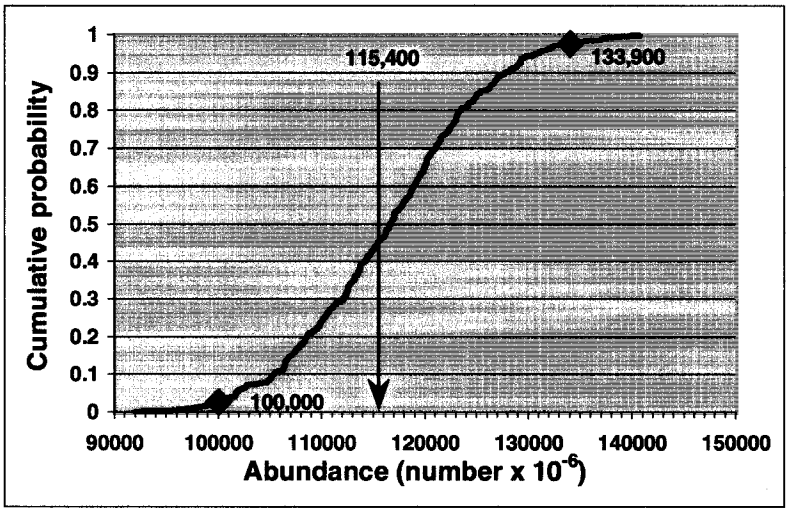
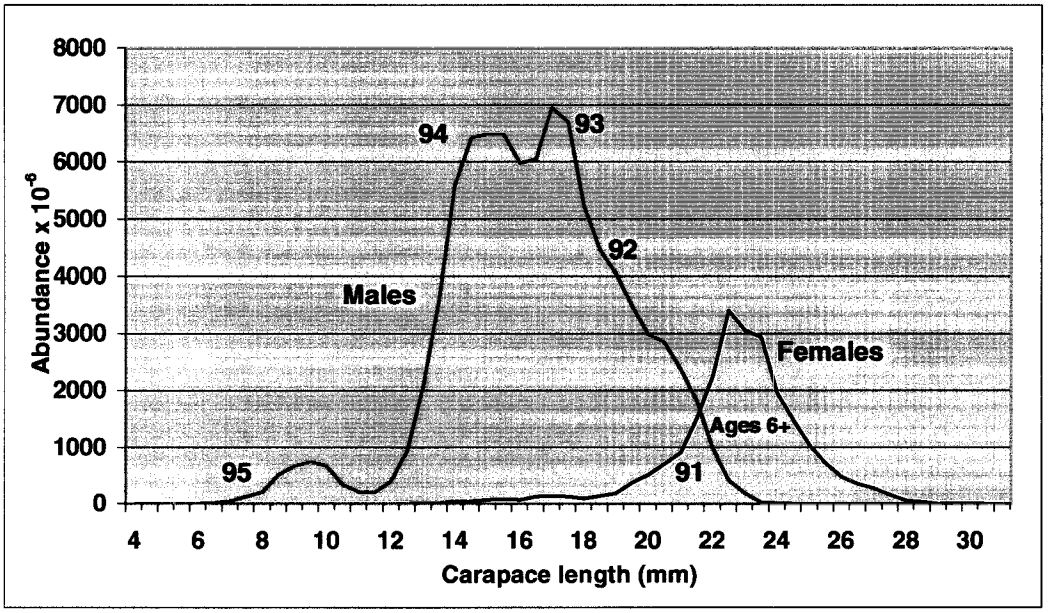


Figure 4a. Shrimp catch weight per standard 15 minute tow (left panel) from the 1996 research trawl survey in Hawke Channel + Div. 3K (SFA 6) and shrimp biomass per area^2 (right panel) estimated by ogive mapping (ogmap).

Figure 4b. Biomass, abundance and abundance-at-length for shrimp in Hawke Channel + Div. 3K (SFA 6) estimated by ogive mapping (ogmap) of research survey data, 1996.







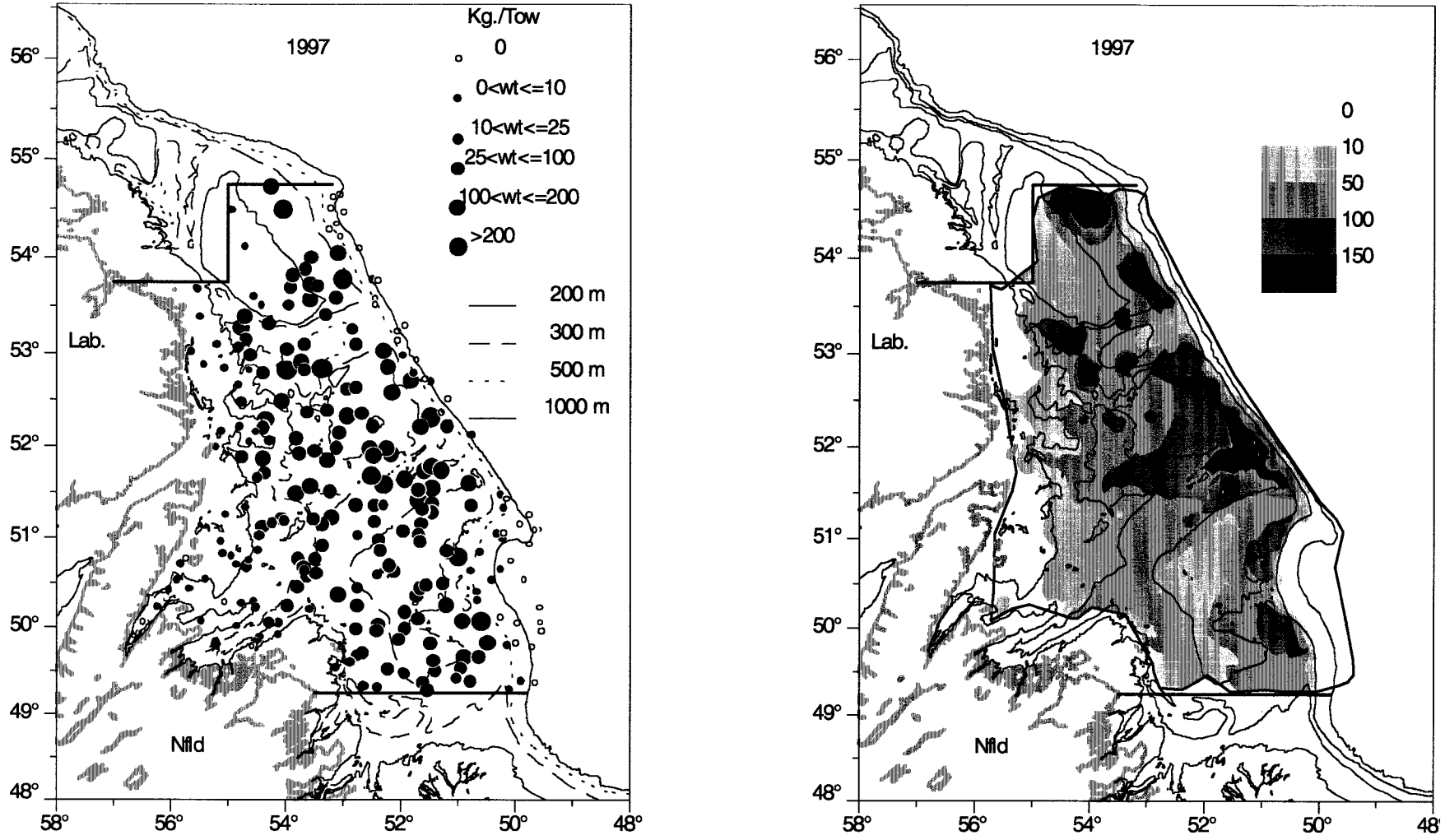
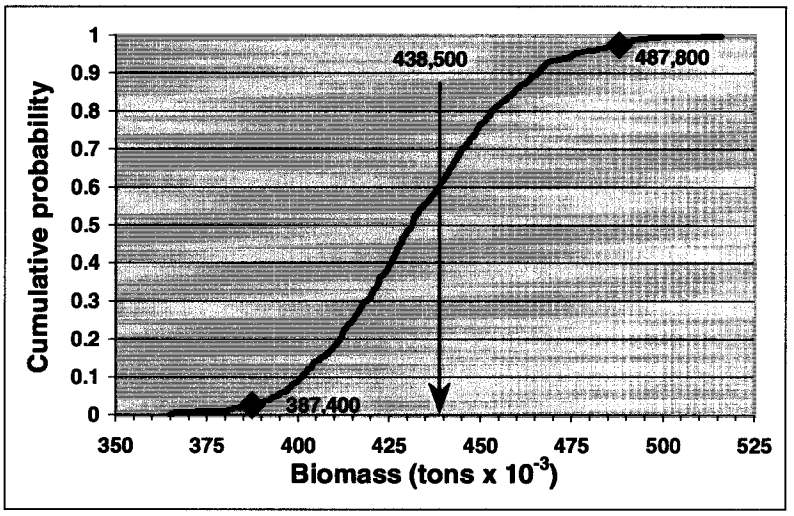
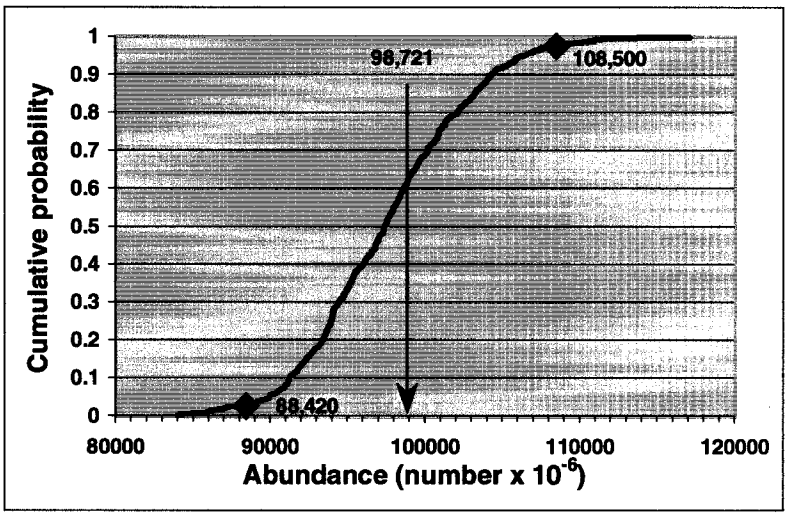
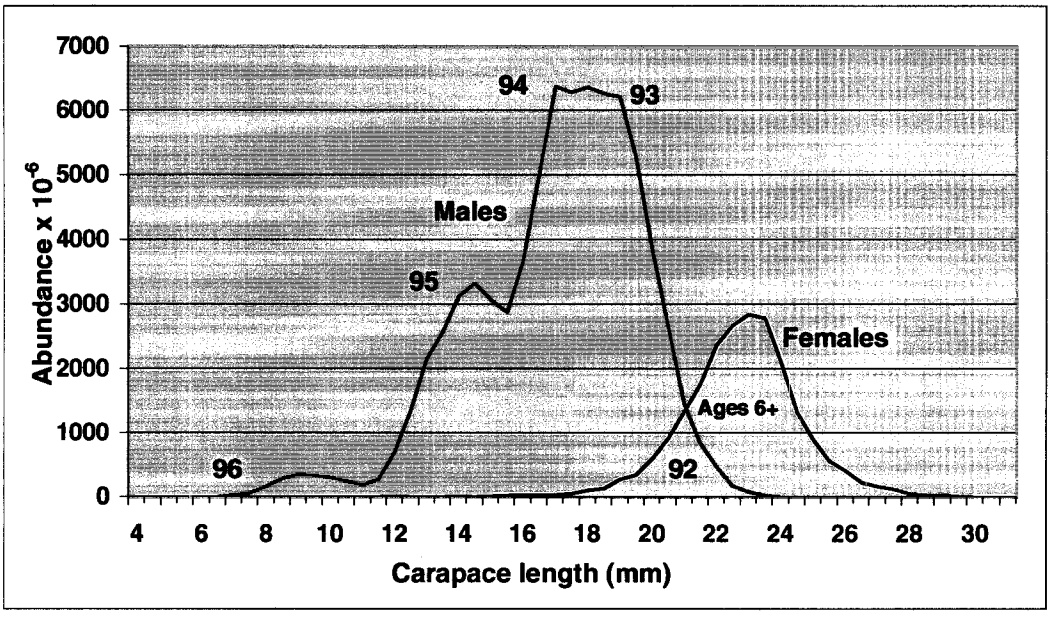


Figure 5a. Shrimp catch weight per standard 15 minute tow (left panel) from the 1997 research trawl survey in Hawke Channel + Div. 3K (SFA 6) and shrimp biomass per area^2 (right panel) estimated by ogive mapping (ogmap).

Figure 5b. Biomass, abundance and abundance-at-length for shrimp in Hawke Channel + Div. 3K (SFA 6) estimated by ogive mapping (ogmap) of research survey data, 1997.







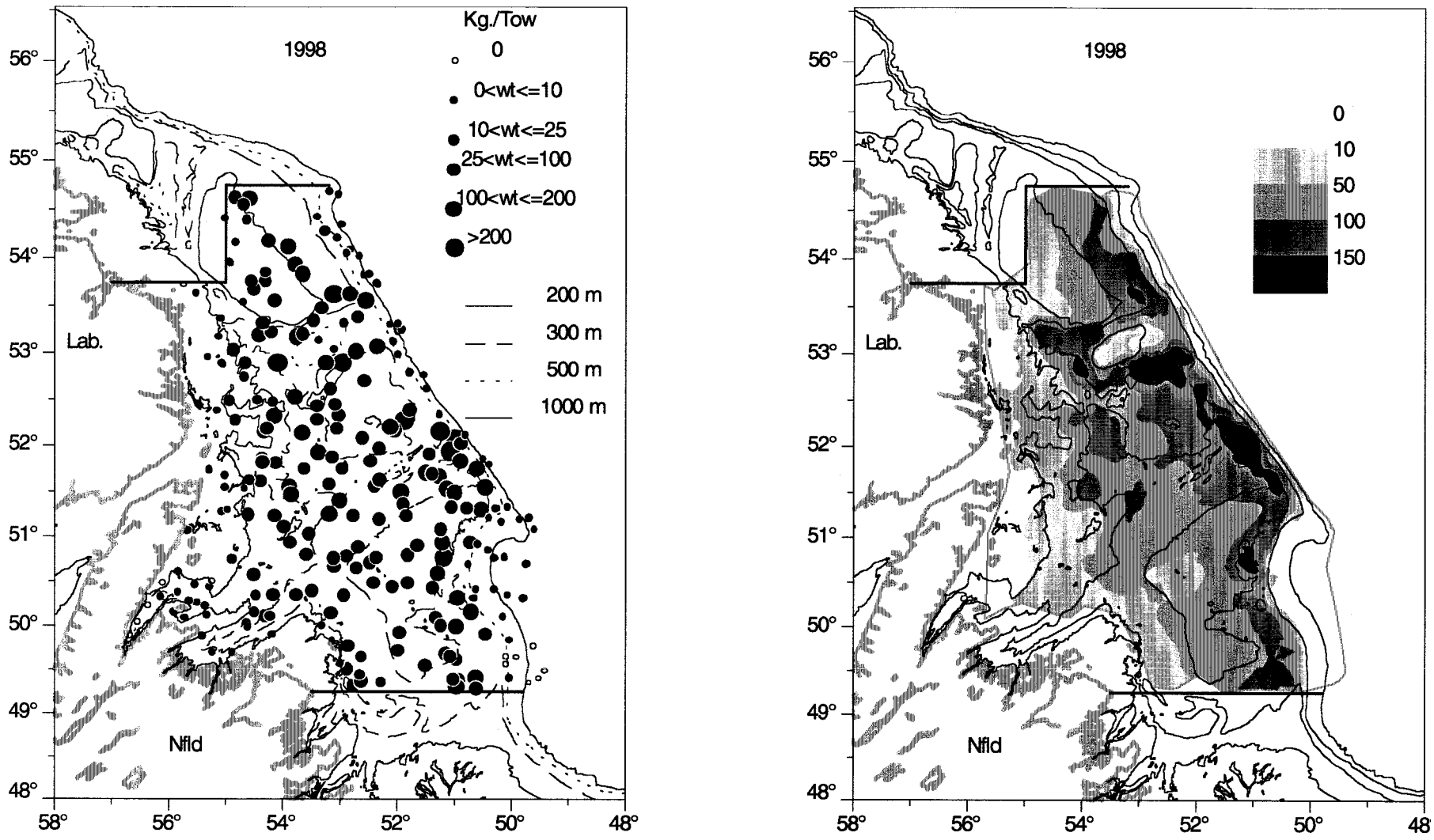
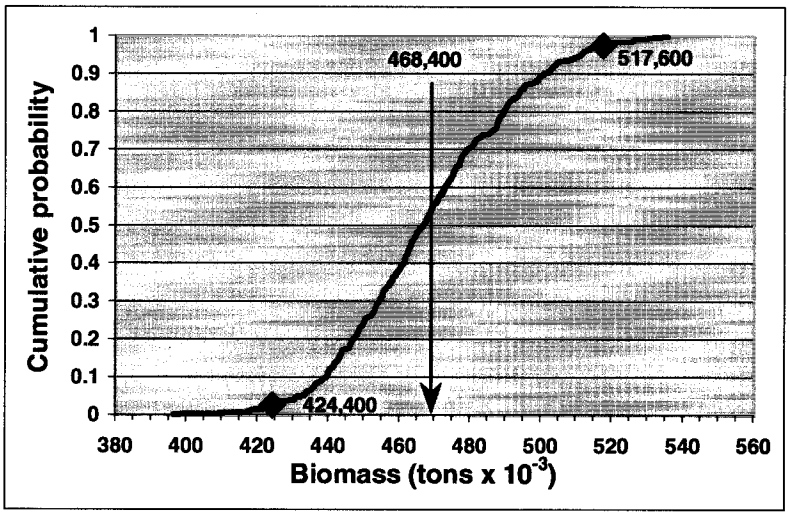
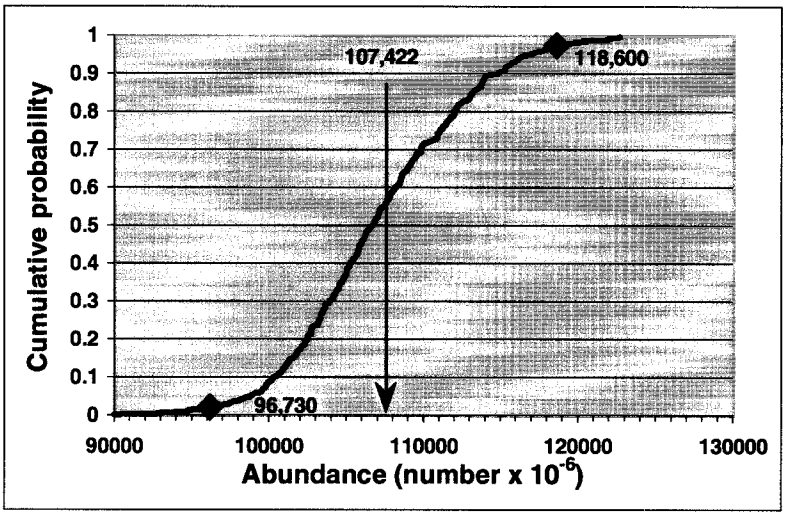
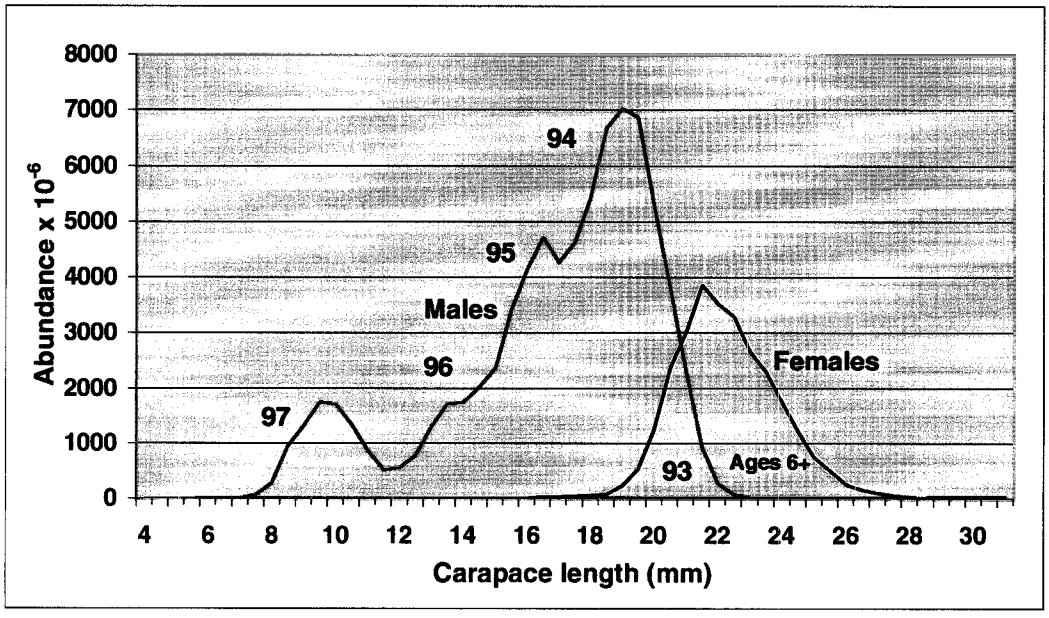


Figure 6a. Shrimp catch weight per standard 15 minute tow (left panel) from the 1998 research trawl survey in Hawke Channel + Div. 3K (SFA 6) and shrimp biomass per area^2 (right panel) estimated by ogive mapping (ogmap).

Figure 6b. Biomass, abundance and abundance-at-age for shrimp in Hawke Channel + Div. 3K (SFA 6) estimated by ogive mapping (ogmap) of research survey data, 1998.







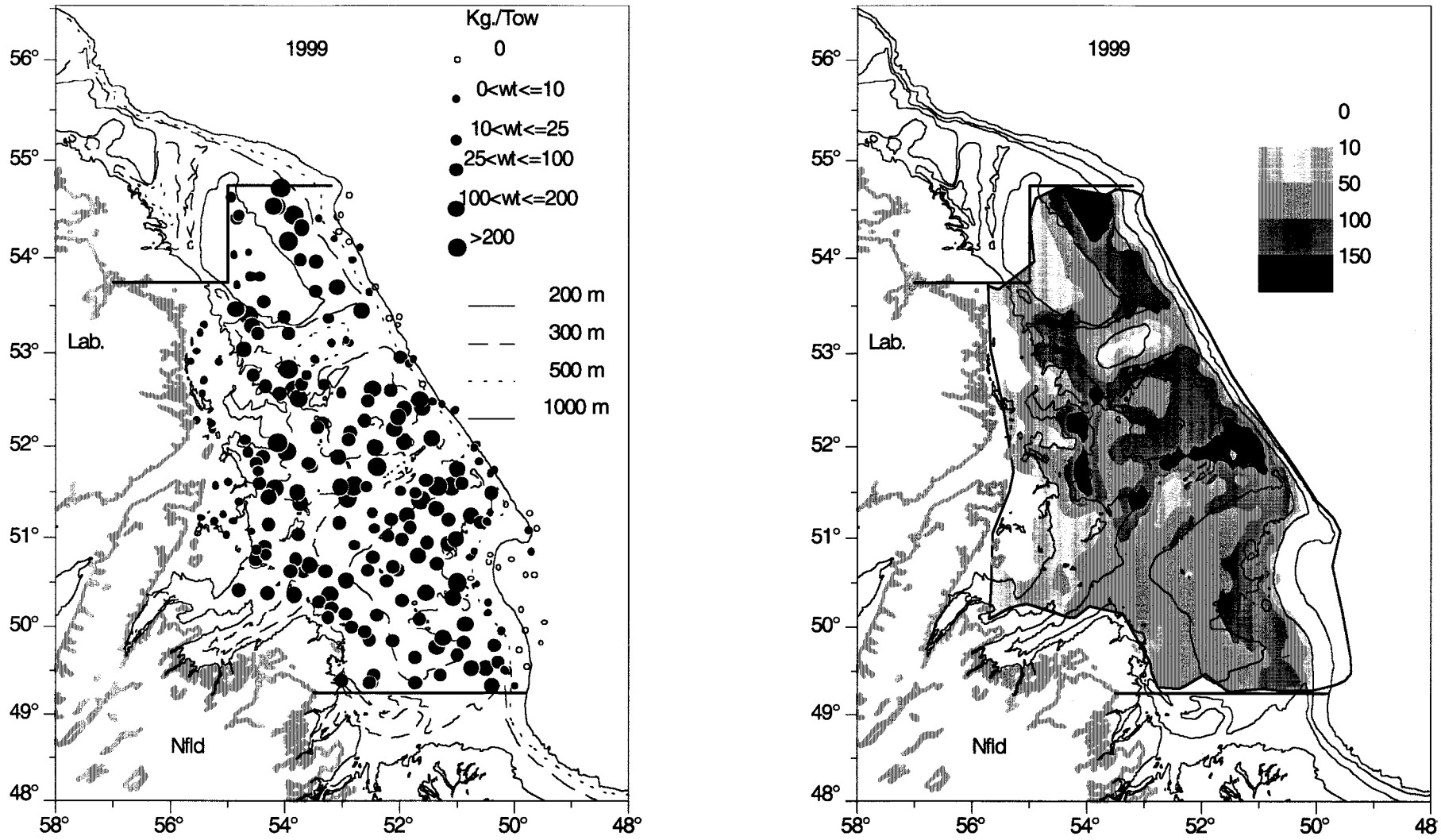
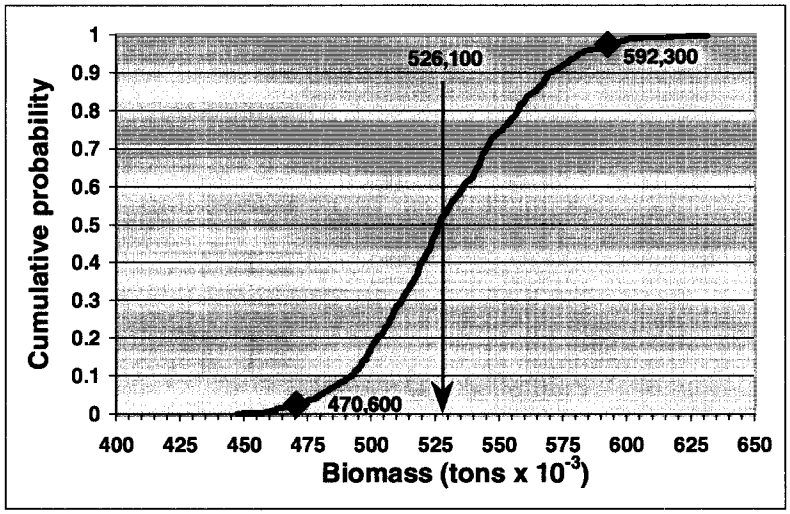
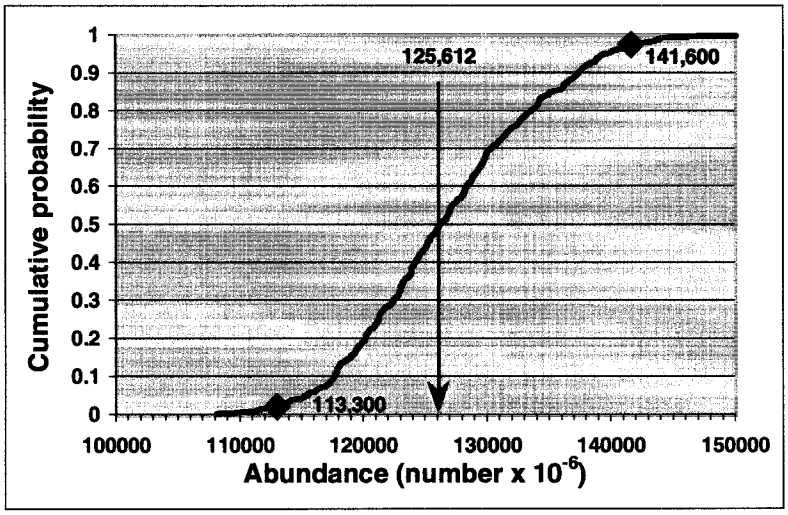


Figure 7a. Shrimp catch weight per standard 15 minute tow (left panel) from the 1999 research trawl survey in Hawke Channel + Div. 3K (SFA 6) and shrimp biomass per area^2 (right panel) estimated by ogive mapping (ogmap).

Figure 7b. Biomass, abundance and abundance-at-length for shrimp in Hawke Channel + Div. 3K (SFA 6) estimated by ogive mapping (ogmap) of research survey data, 1999.





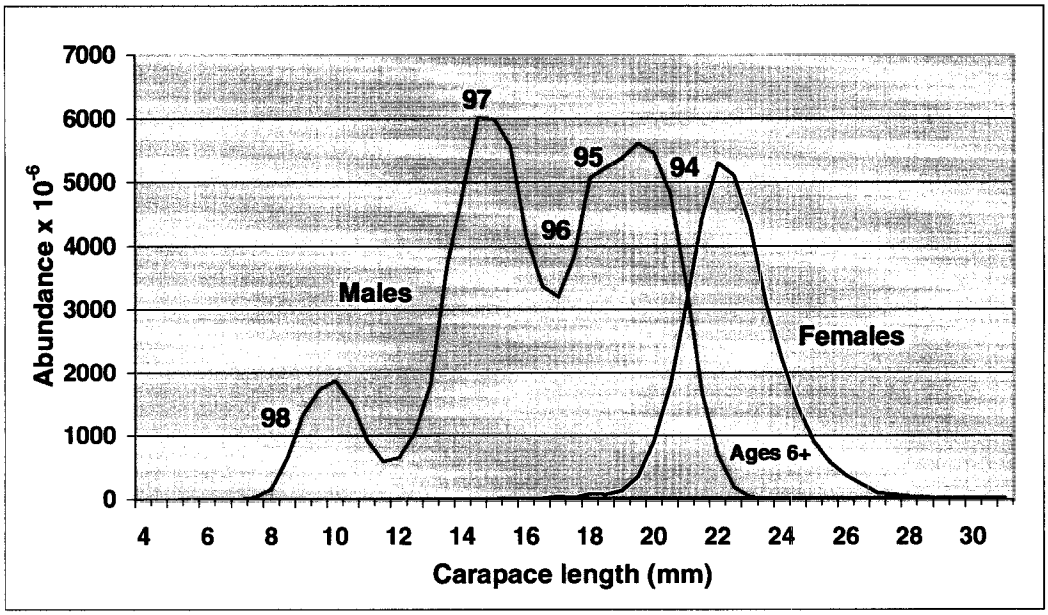
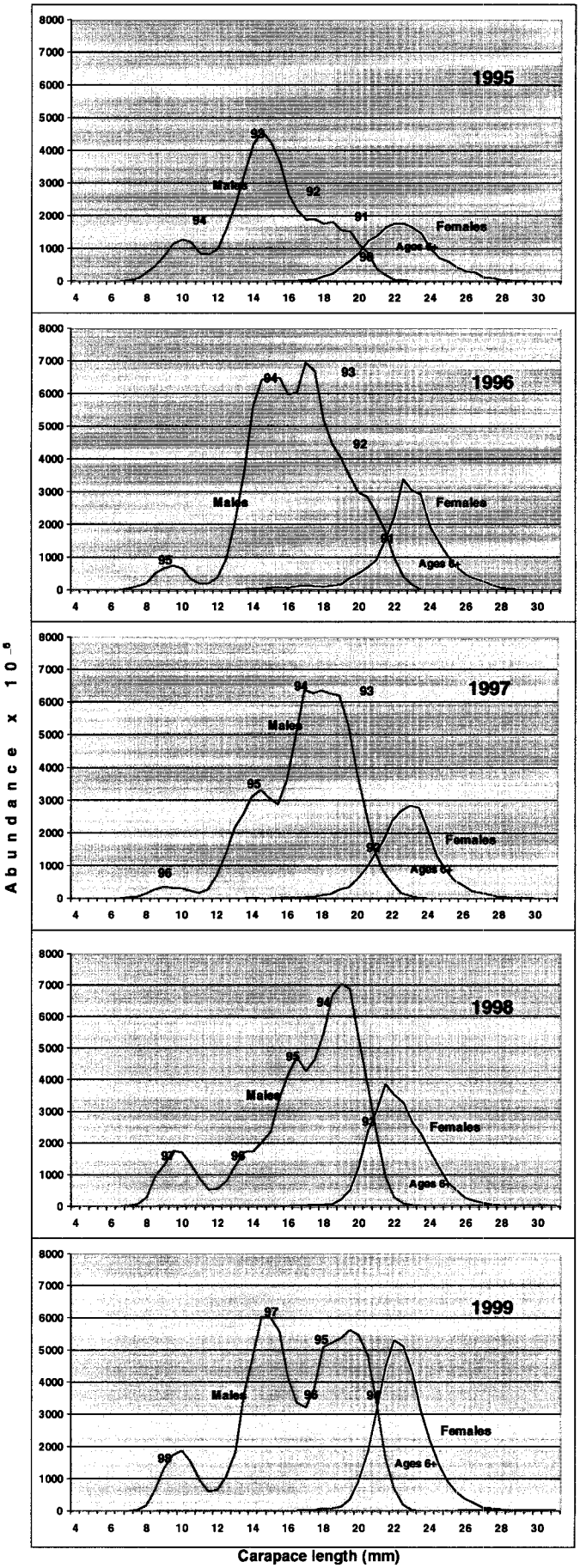


Figure 8. Abundance-at-length for shrimp in Hawke Channel + Div. 3K (SFA 6) estimated by ogive mapping (ogmap) of research survey data, 1995 - 1999.



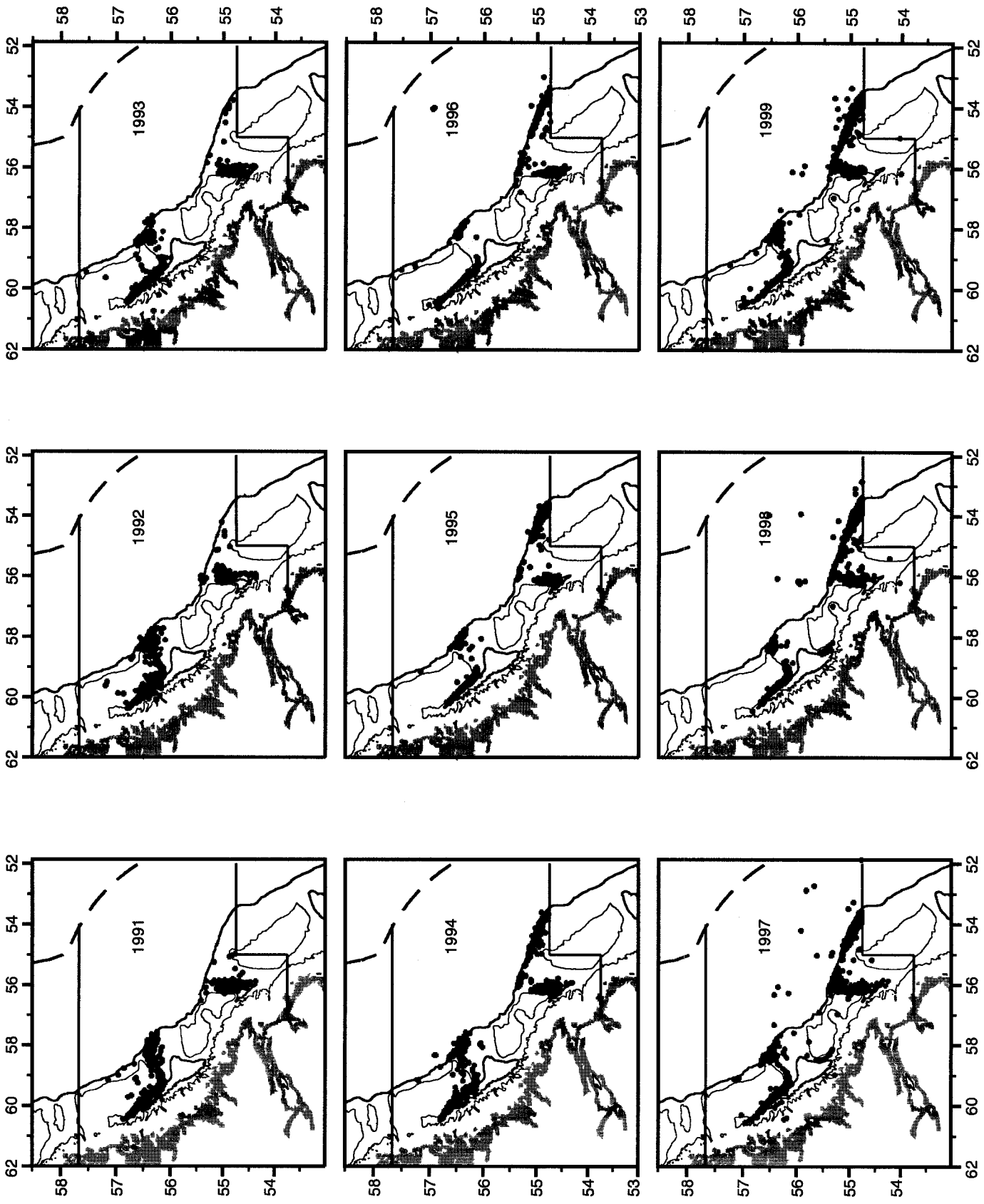


Figure 9. Distribution of commercial fishing effort in Hopedale + Cartwright Channels (SFA 5), 1991 – 1999.

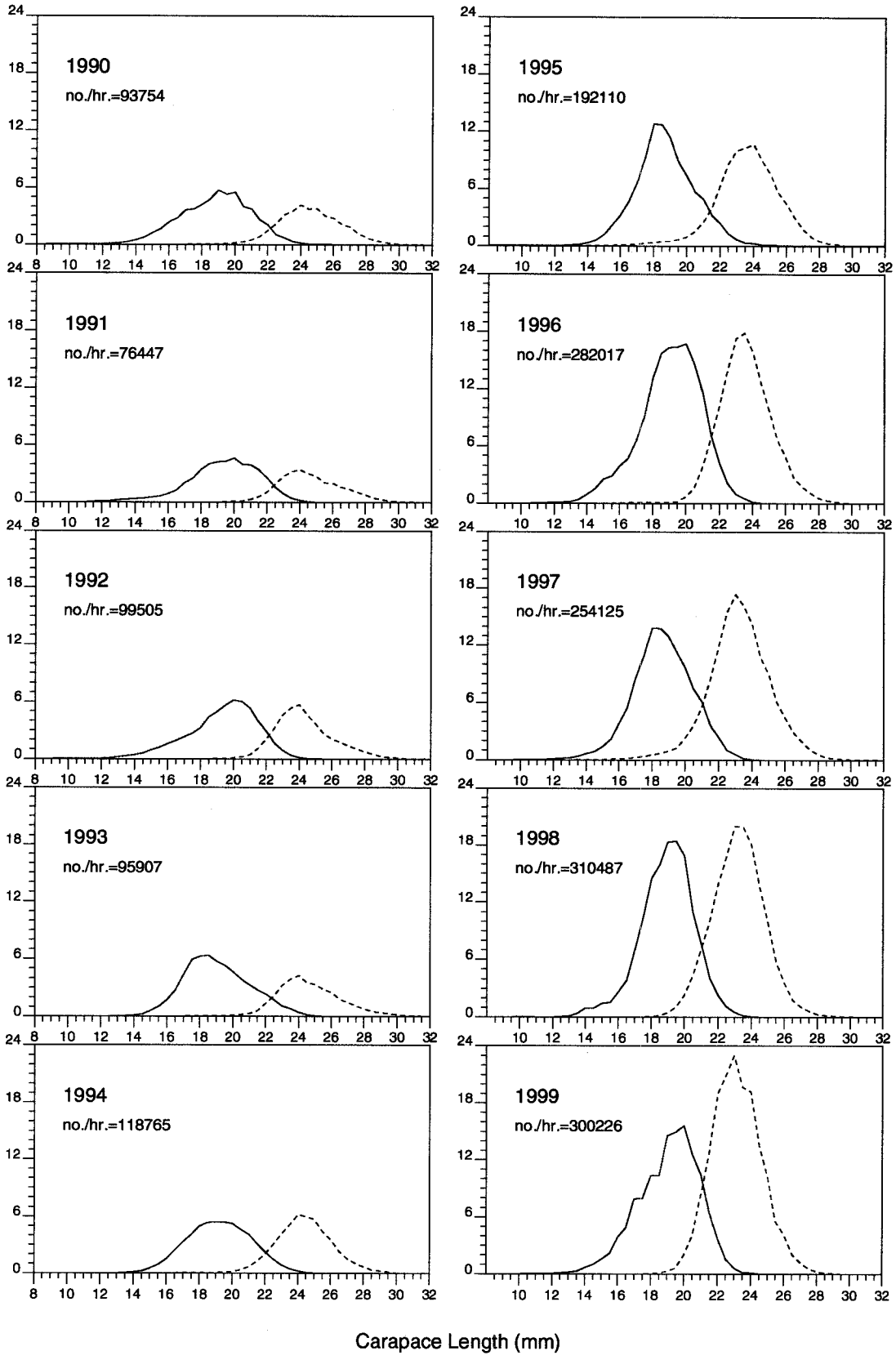


Figure 10. Number (x 10^{-3}) caught per hour at length in Hopedale + Cartwright Channels, 1990 – 1999. Solid line = male, broken line = female.

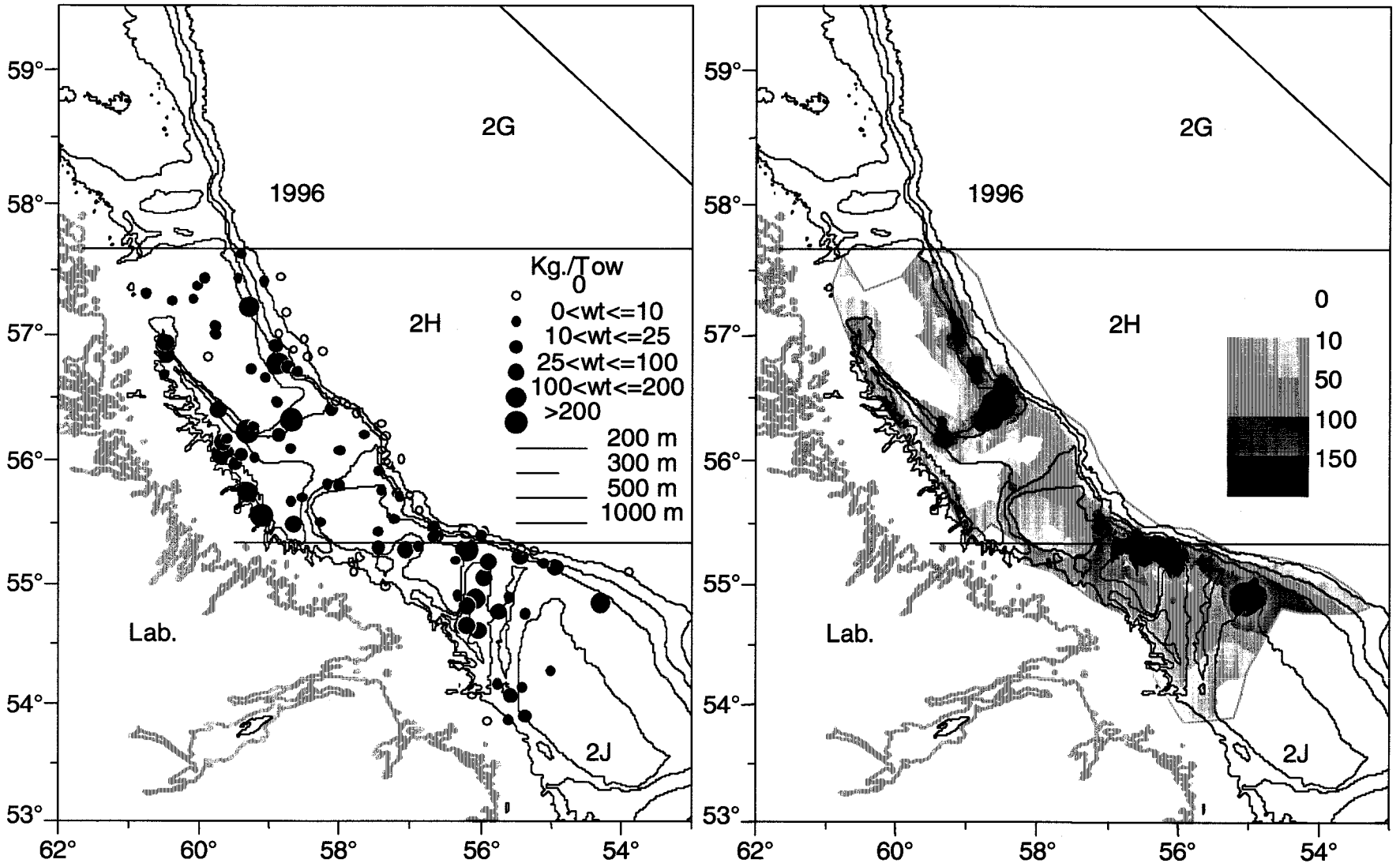
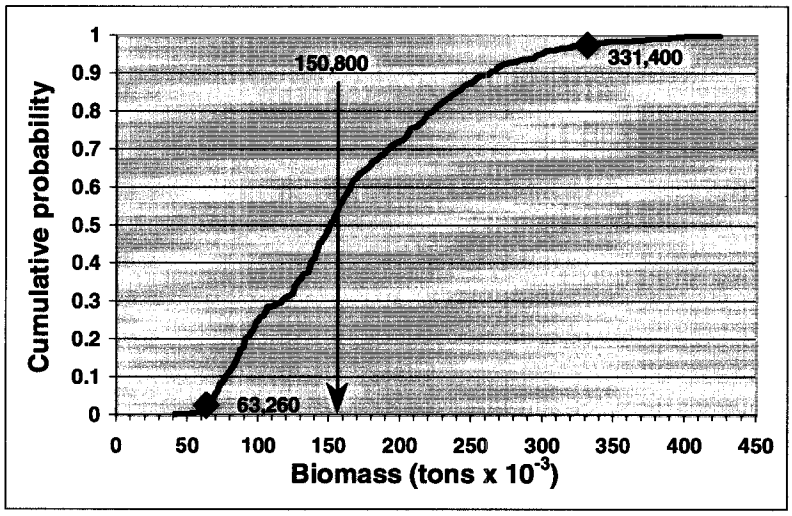
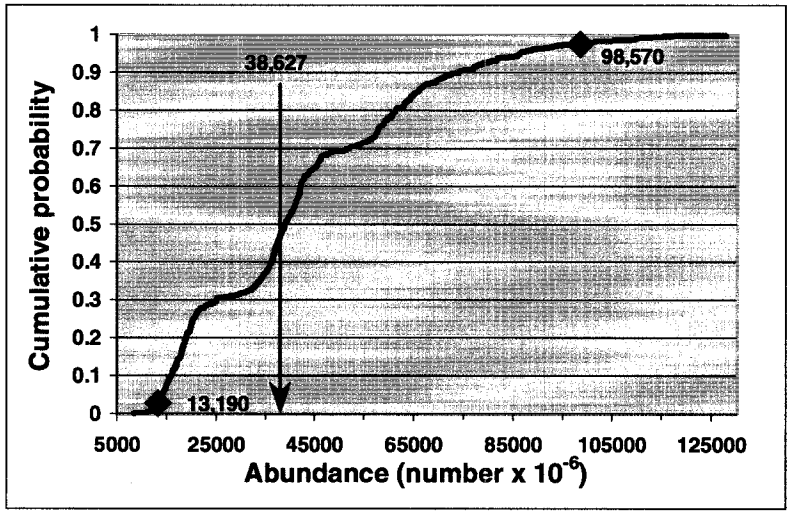
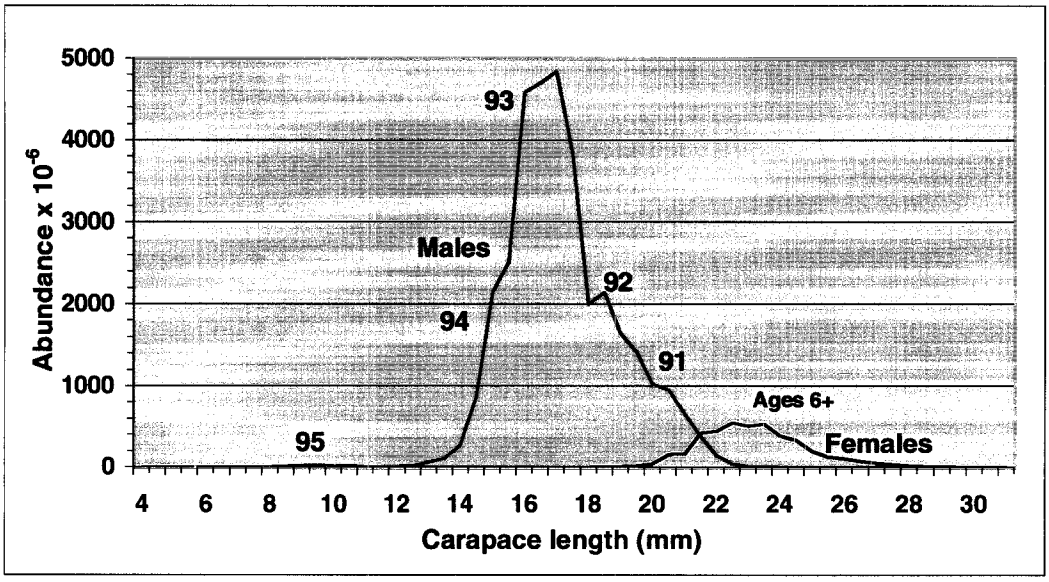


Figure 11a. Shrimp catch weight per standard 15 minute tow (left panel) from the 1996 research trawl survey in Hopedale + Cartwright Channels (SFA 5) and shrimp biomass per area^2 (right panel) estimated by ogive mapping (ogmap).

Figure 11b. Biomass, abundance and abundance-at-length for shrimp in Hopedale + Cartwright Channels (SFA 5) estimated by ogive mapping (ogmap) of research survey data, 1996.







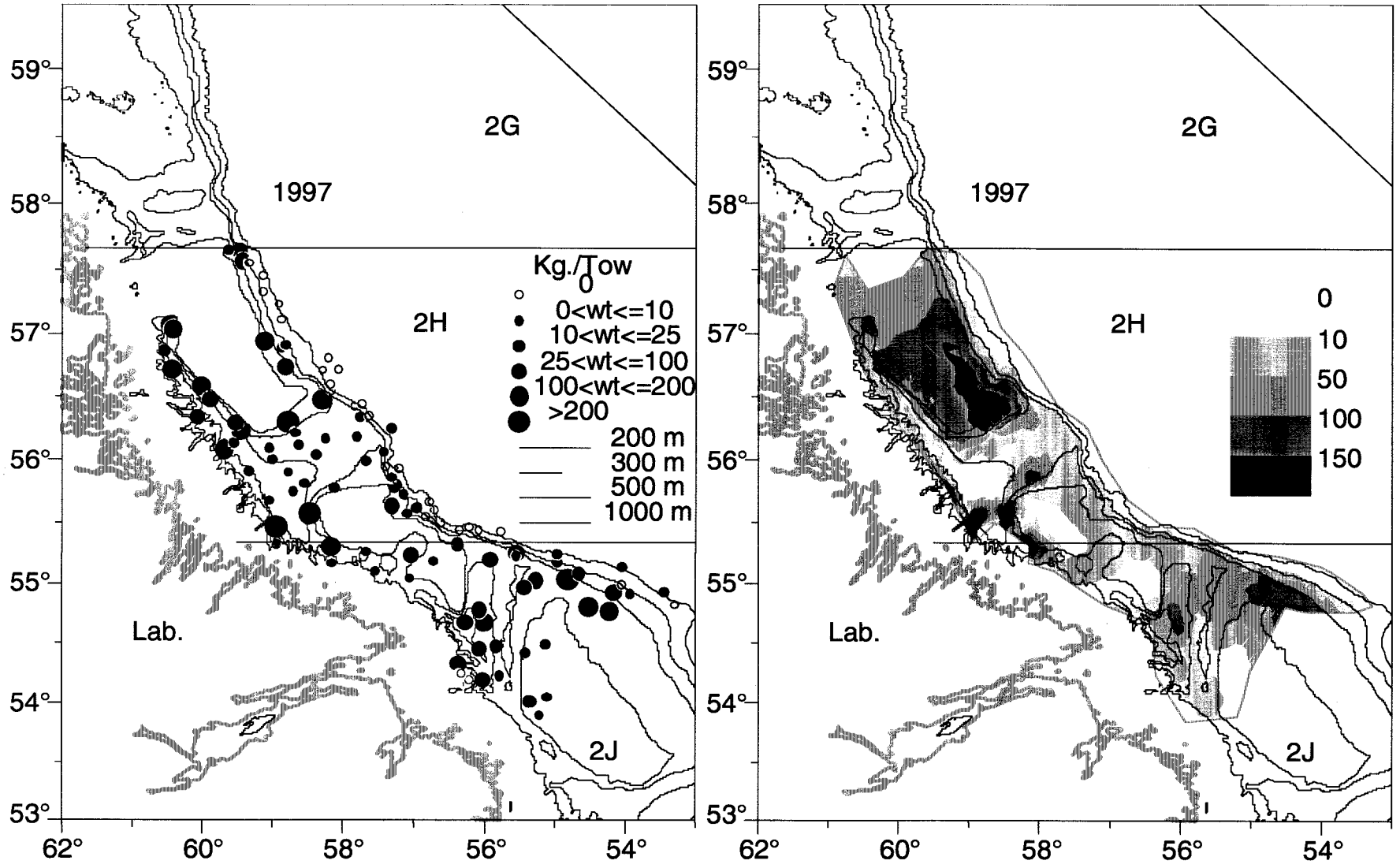
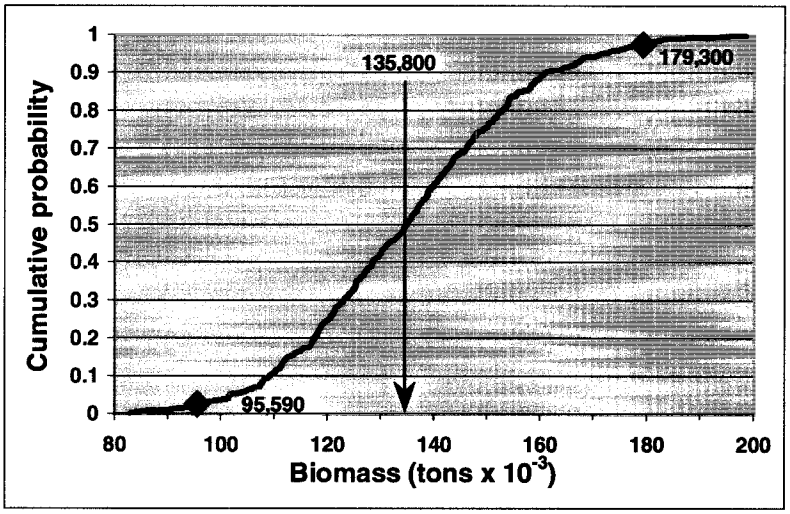
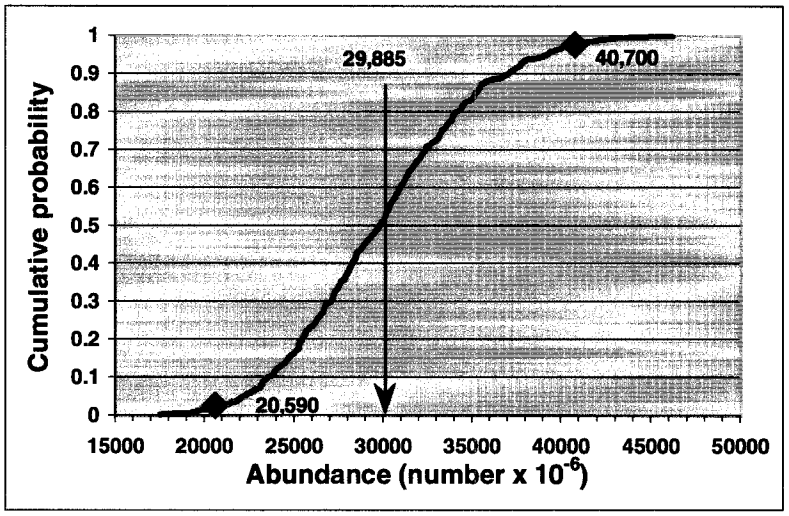
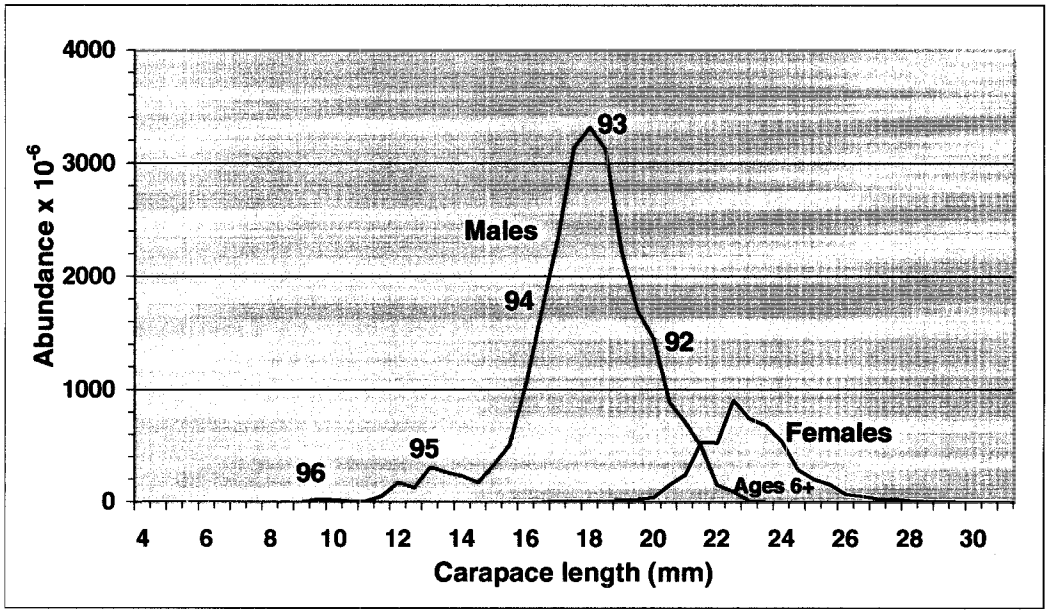


Figure 12a. Shrimp catch weight per standard 15 minute tow (left panel) from the 1997 research trawl survey in Hopedale + Cartwright Channels (SFA 5) and shrimp biomass per area^2 (right panel) estimated by ogive mapping (ogmap).

Figure 12b. Biomass, abundance and abundance-at-length for shrimp in Hopedale + Cartwright Channels (SFA 5) estimated by ogive mapping (ogmap) of research survey data, 1997.







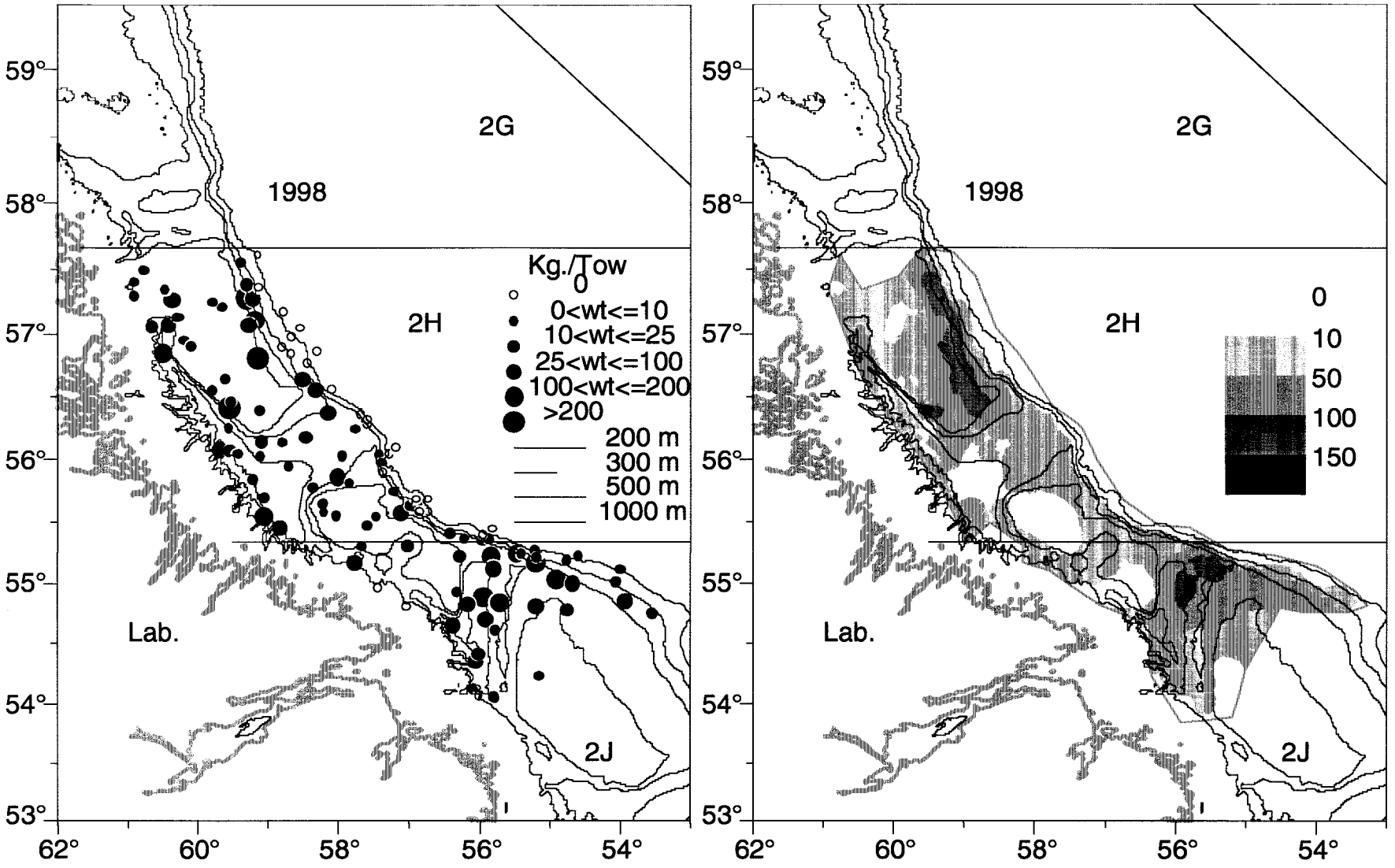
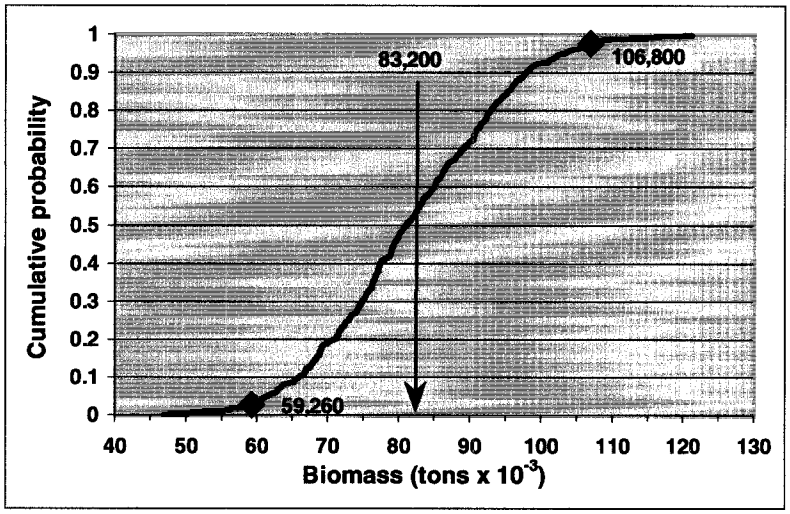
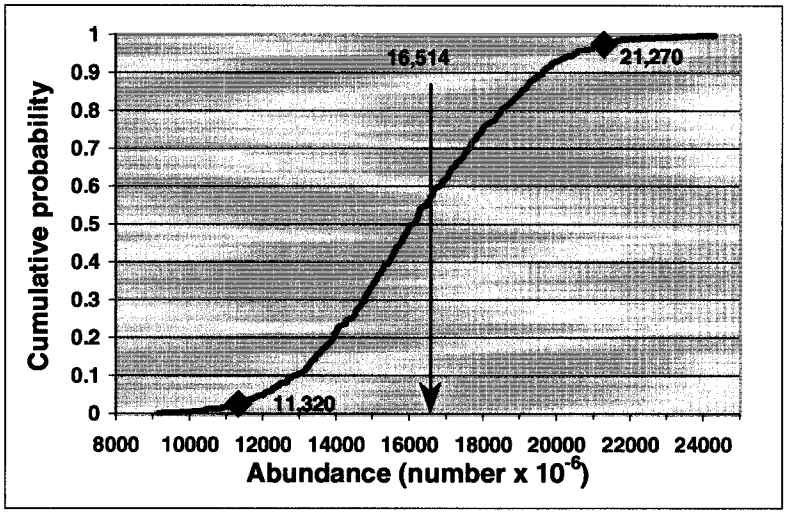
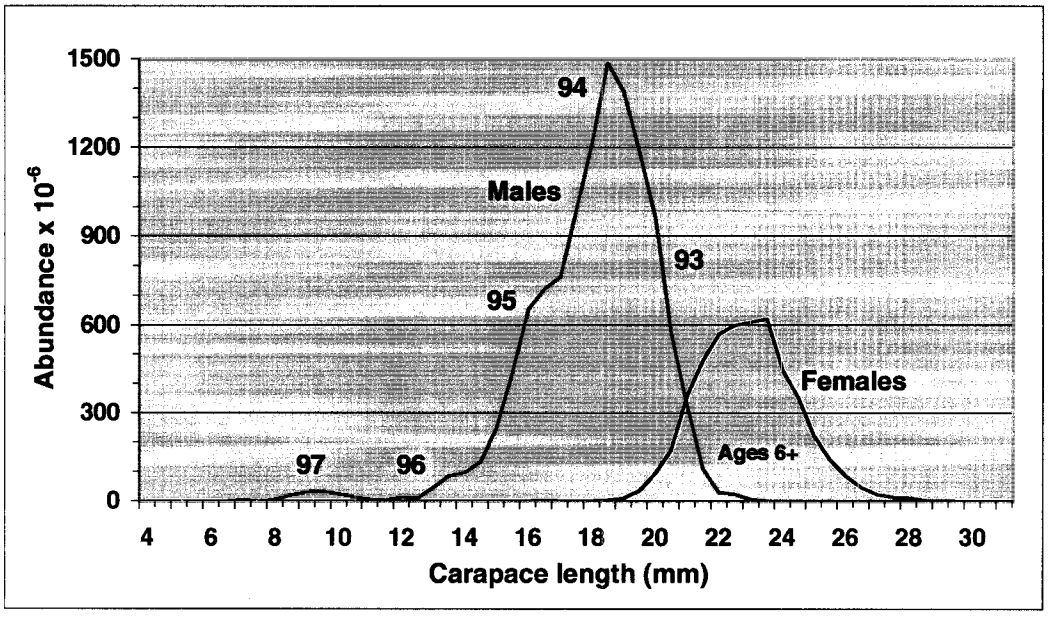


Figure 13a. Shrimp catch weight per standard 15 minute tow (left panel) from the 1998 research trawl survey in Hopedale + Cartwright Channels (SFA 5) and shrimp biomass per area^2 (right panel) estimated by ogive mapping (ogmap).

Figure 13b. Biomass, abundance and abundance-at-length for shrimp in Hopedale + Cartwright Channels (SFA 5) estimated by ogive mapping (ogmap) of research survey data, 1998.







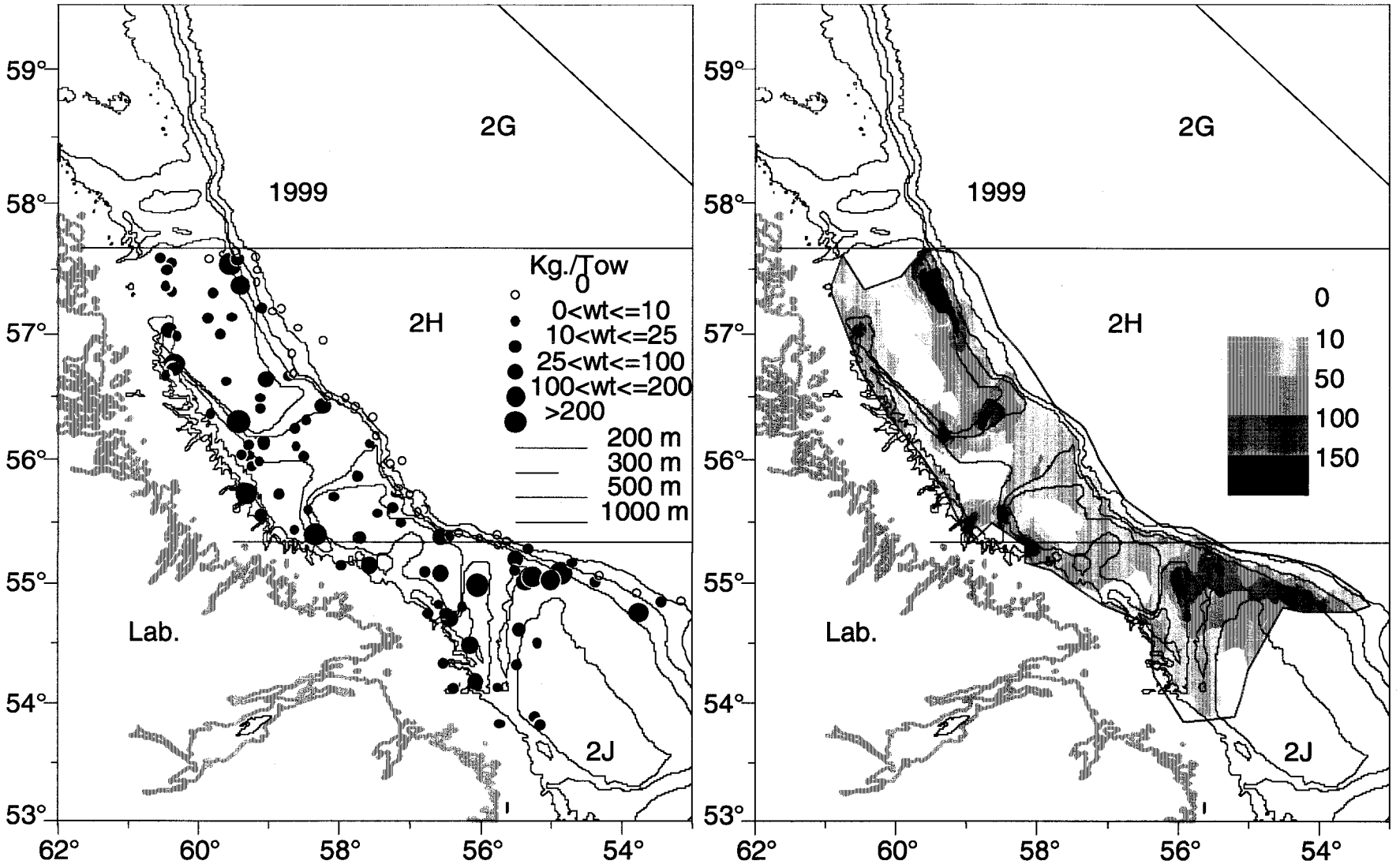
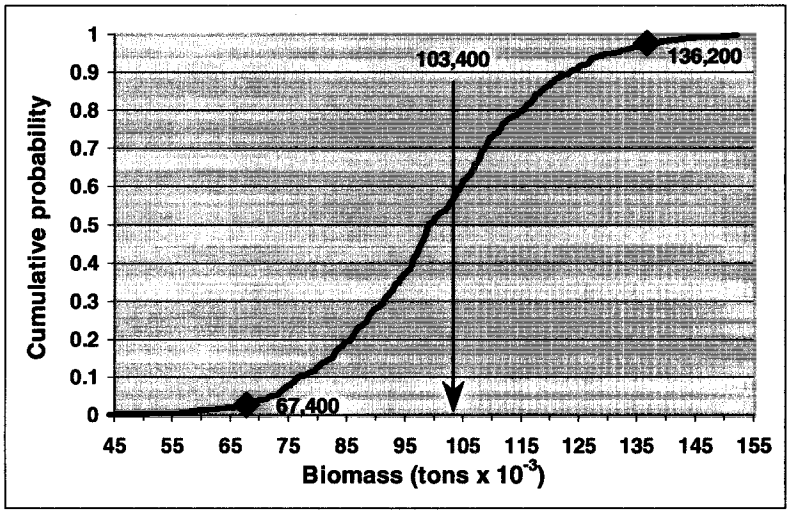
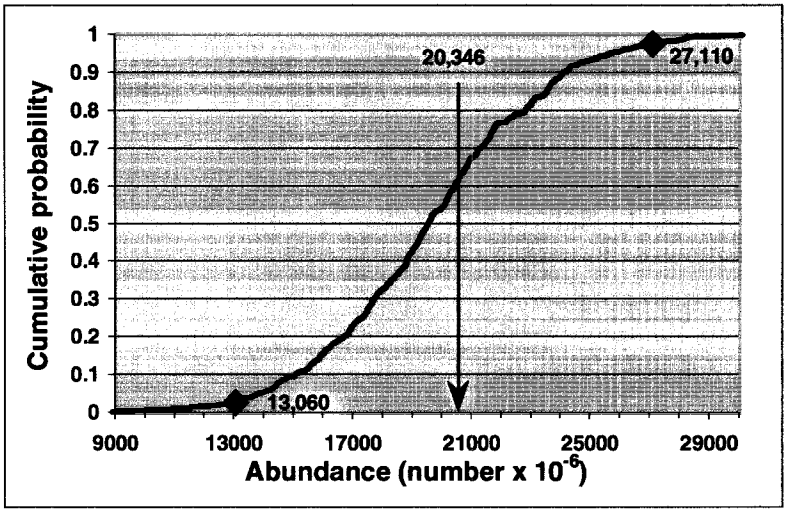


Figure 14a. Shrimp catch weight per standard 15 minute tow (left panel) from the 1999 research trawl survey in Hopedale + Cartwright Channels (SFA 5) and shrimp biomass per area^2 (right panel) estimated by ogive mapping (ogmap).

Figure 14b. Biomass, abundance and abundance-at-length for shrimp in Hopedale + Cartwright Channels (SFA 5) estimated by ogive mapping (ogmap) of research surveys data, 1999.





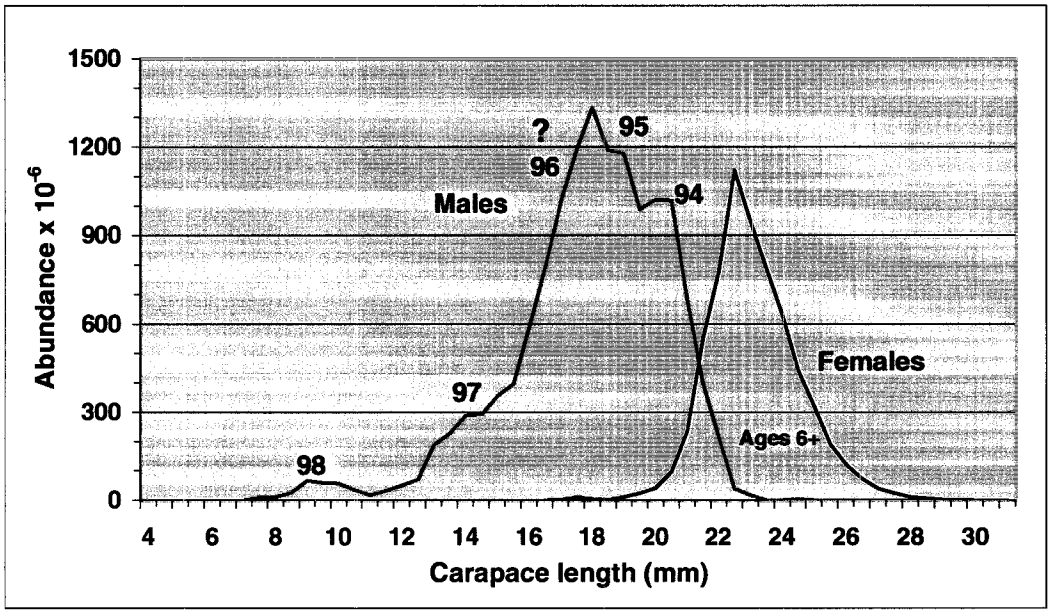
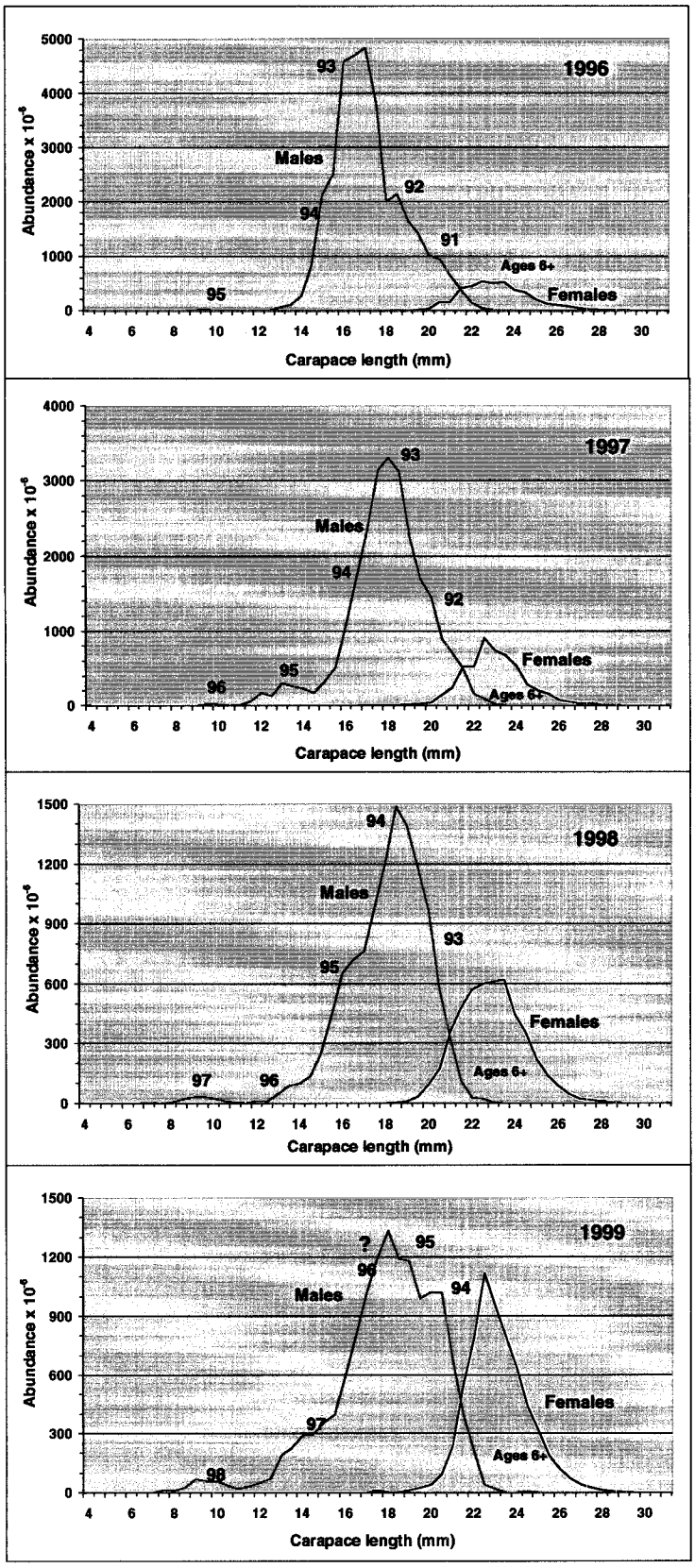


Figure 15. Abundance-at-length for shrimp in Hopedale + Cartwright Channels (SFA 5) estimated by ogive mapping (ogmap) of research survey data, 1996 - 1999.



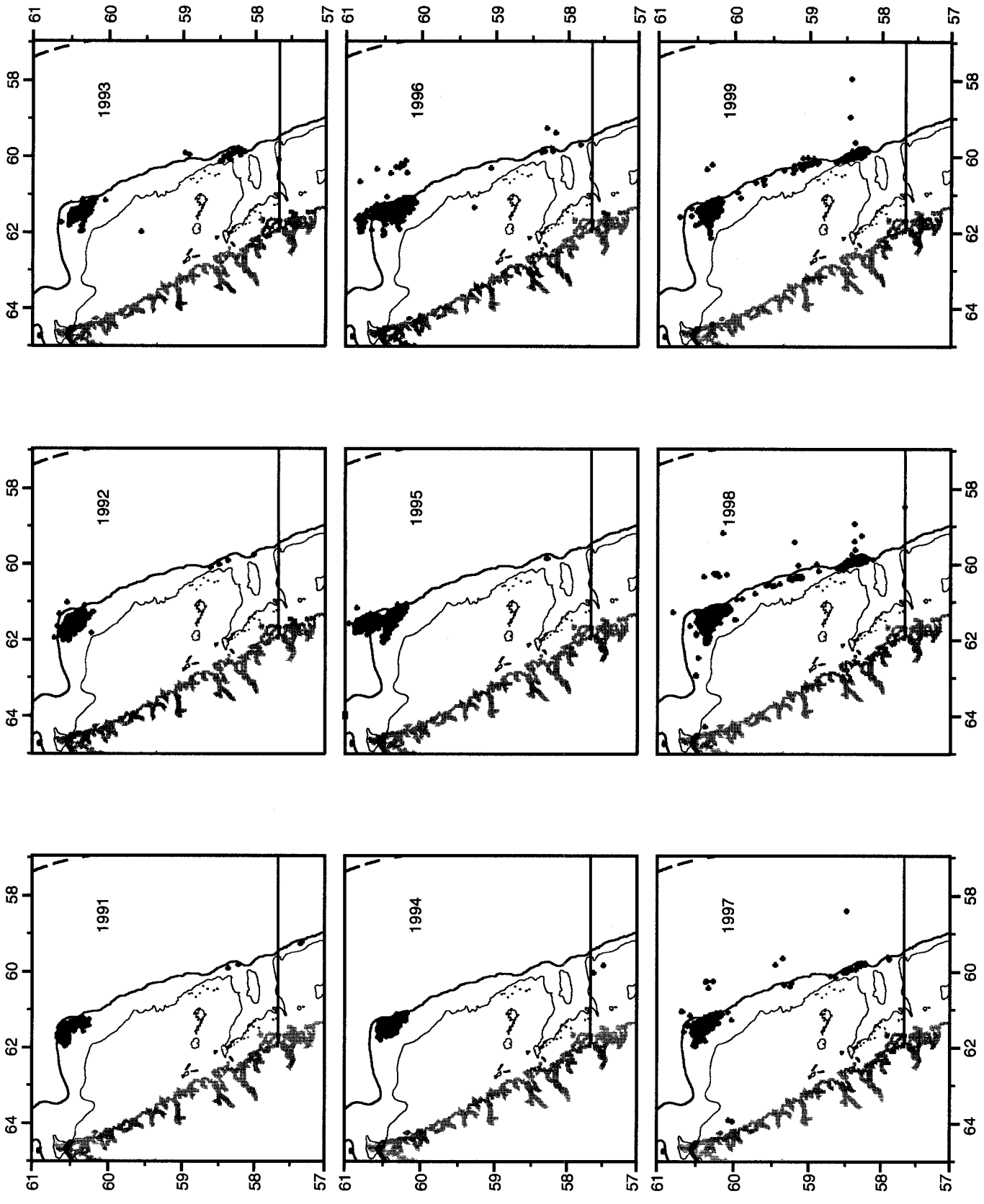


Figure 16. Distribution of commercial fishing effort in Division 2G (SFA 4), 1991 – 1999.

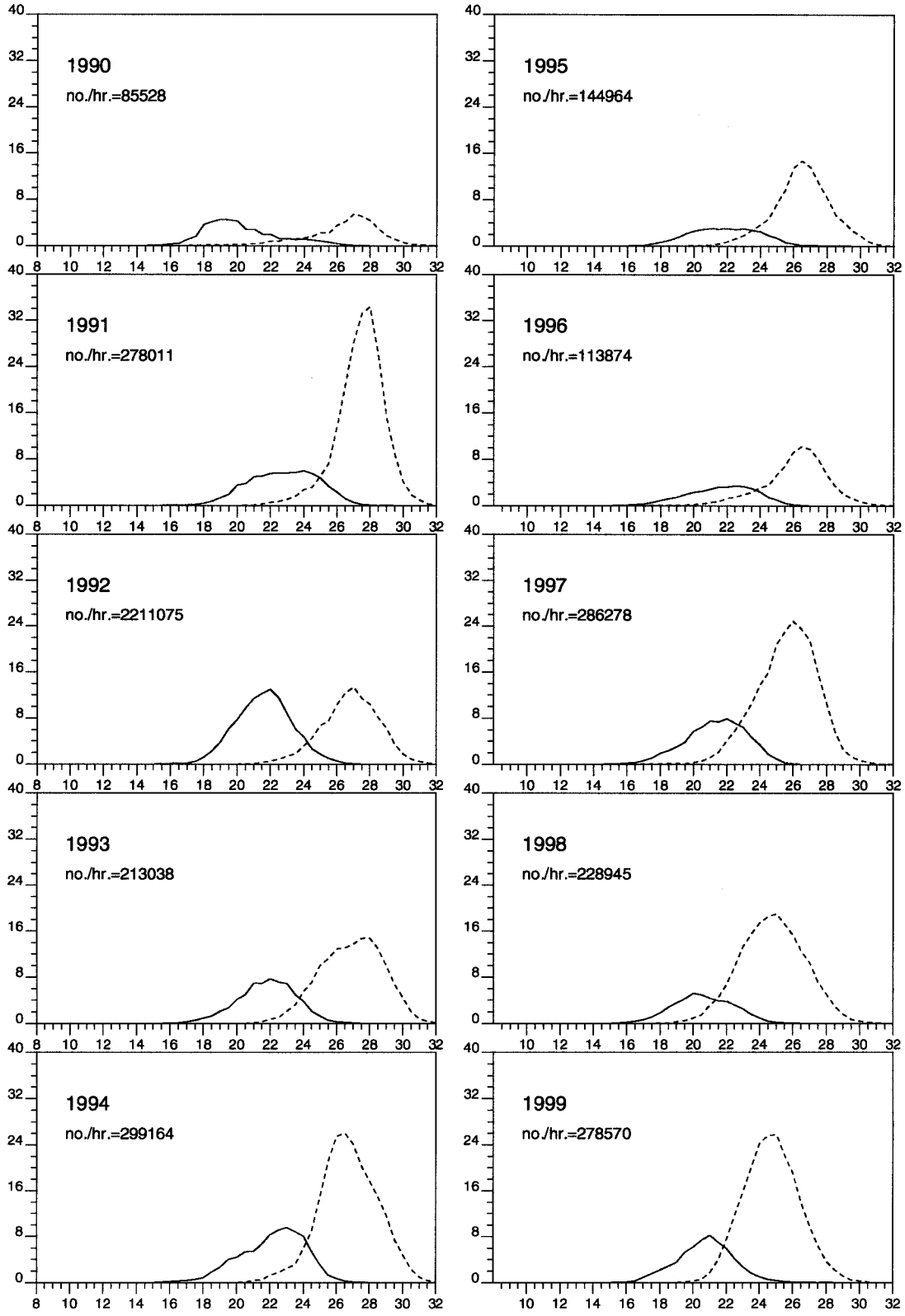


Figure 17. Number (x 10^{-3}) caught per hour at length in Division 2G, 1990 – 1999. Solid line = male, broken line = female.

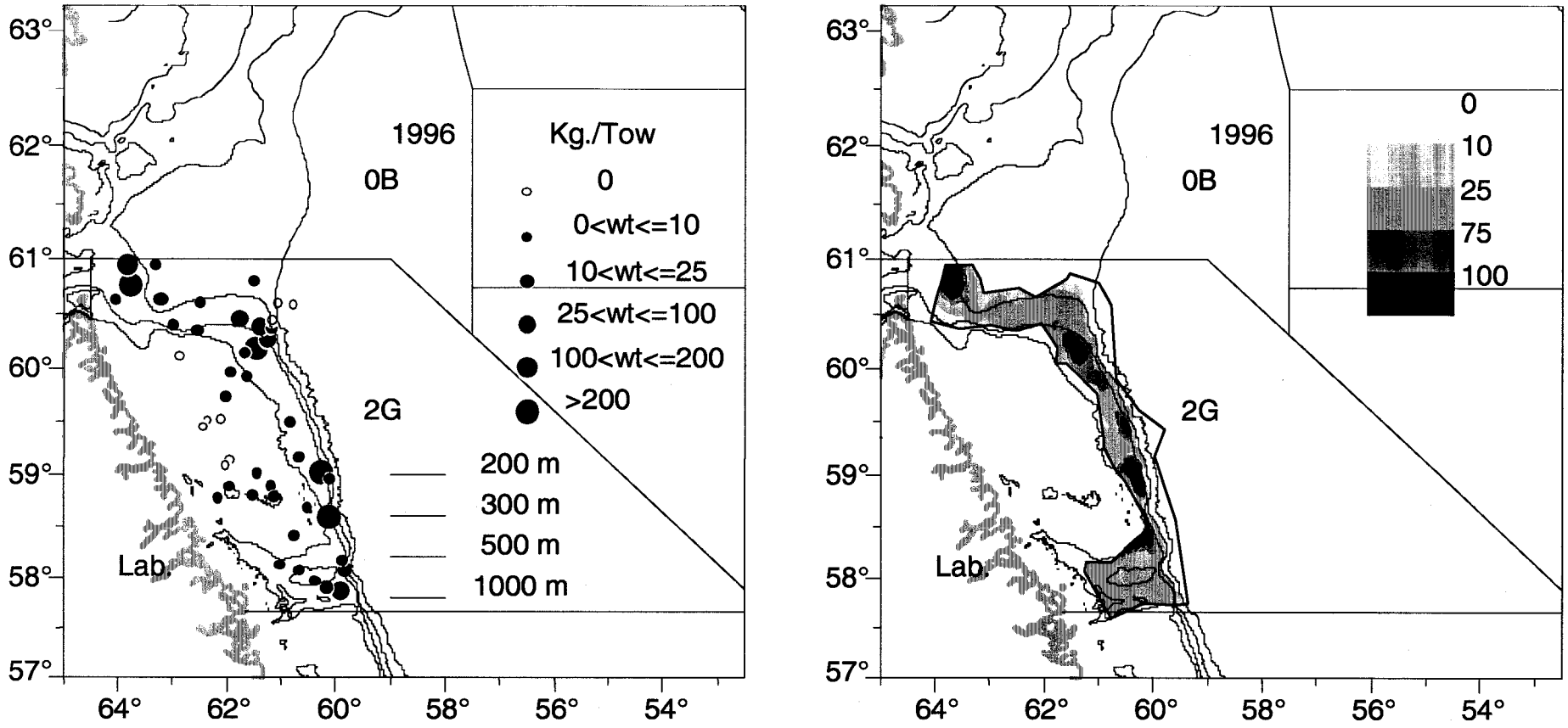
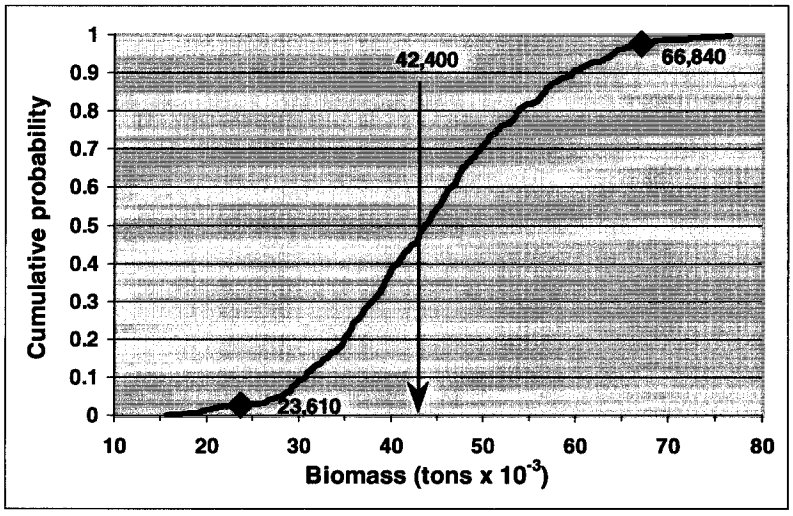
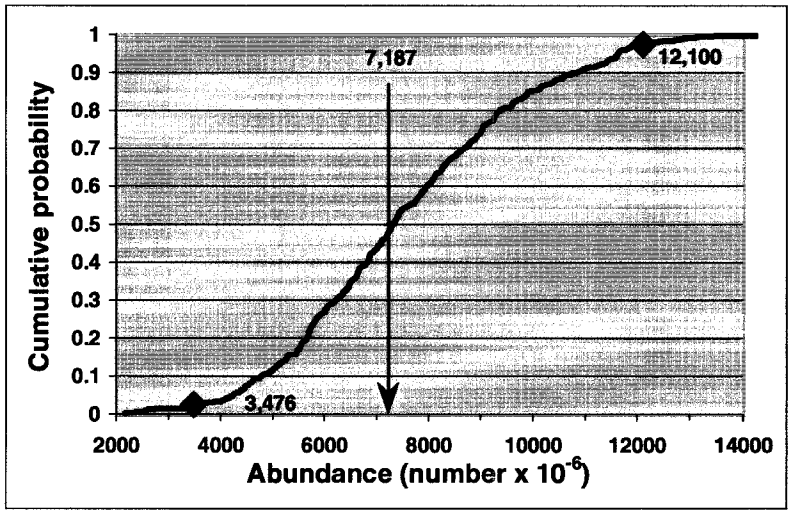
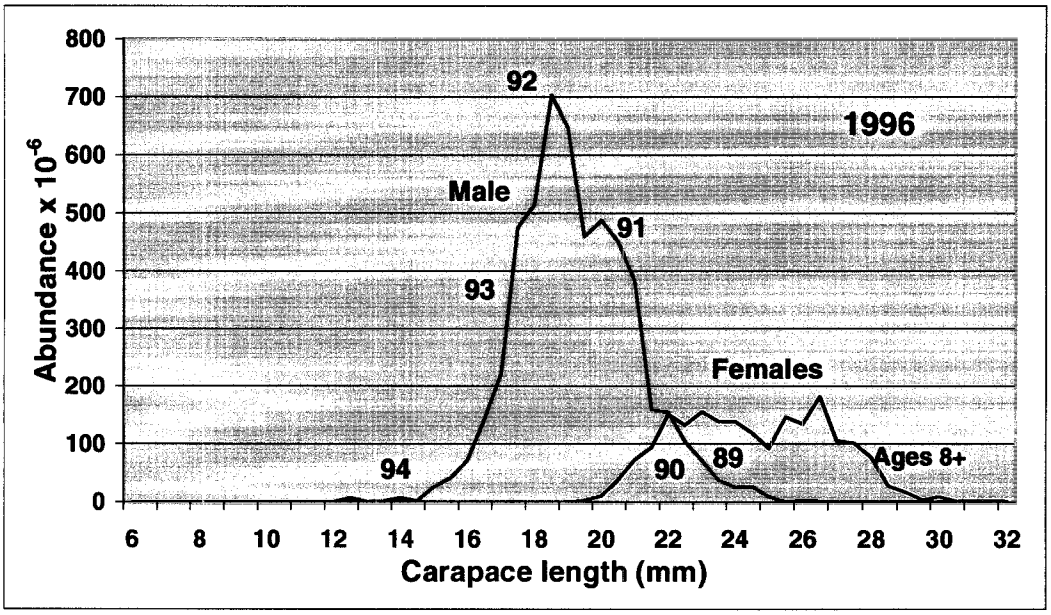


Figure 18a. Shrimp catch weight per standard 15 minute tow (left panel) from the 1996 research trawl survey in Div. 2G (SFA 4) and shrimp biomass per area^2 (right panel) for depths greater than 200 m estimated by ogive mapping (ogmap).

Figure 18b. Biomass, abundance and abundance-at-length for shrimp in Division 2G (SFA 4) estimated by ogive mapping (ogmap) of research survey data, 1996.







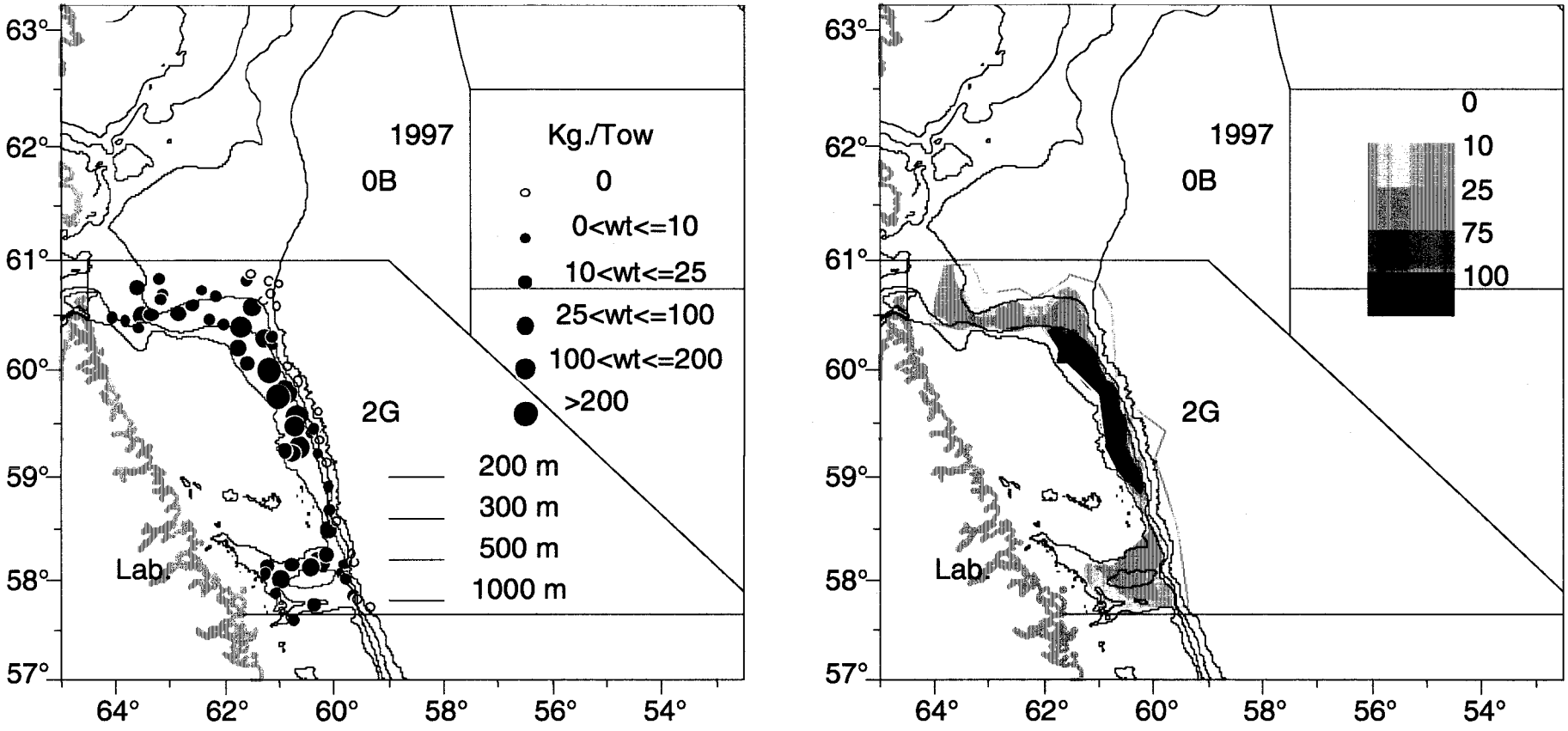
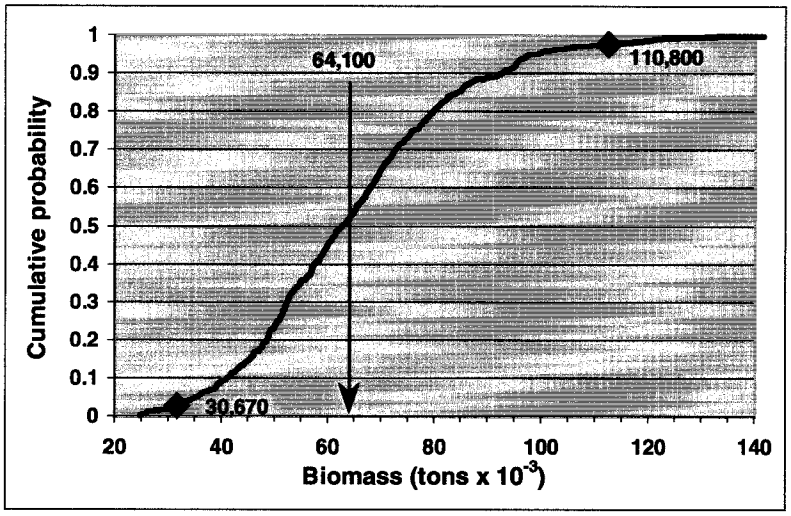
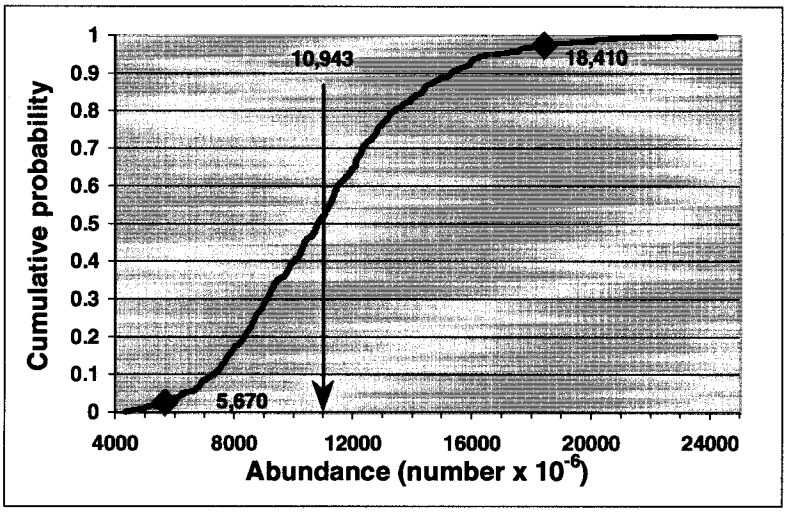
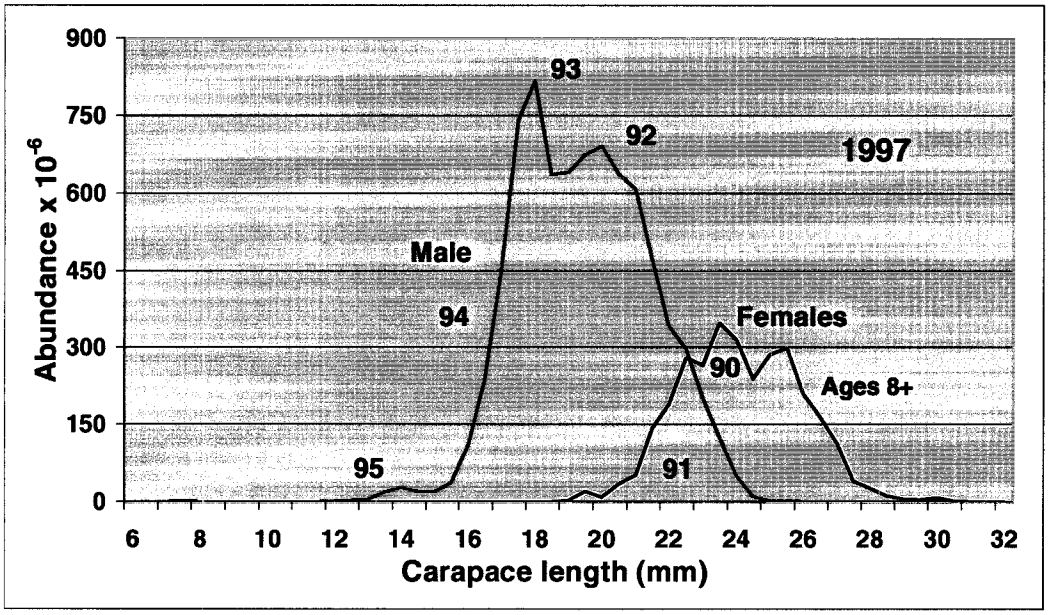


Figure 19a. Shrimp catch weight per standard 15 minute tow (left panel) from the 1997 research trawl survey in Div. 2G (SFA 4) and shrimp biomass per area^2 (right panel) for depths greater than 200 m estimated by ogive mapping (ogmap).

Figure 19b. Biomass, abundance and abundance-at-length for shrimp in Division 2G (SFA 4) estimated by ogive mapping (ogmap) of research survey data, 1997.







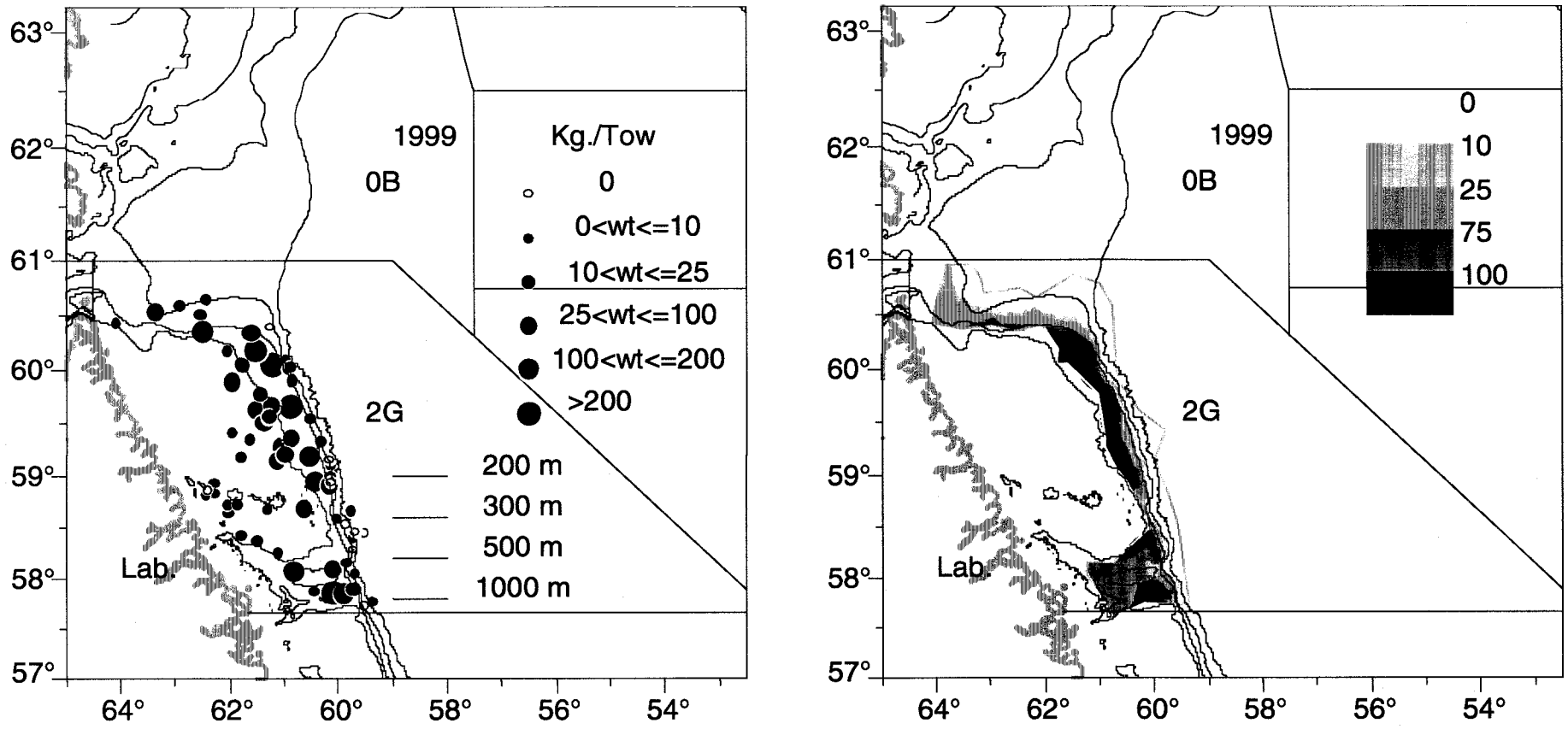
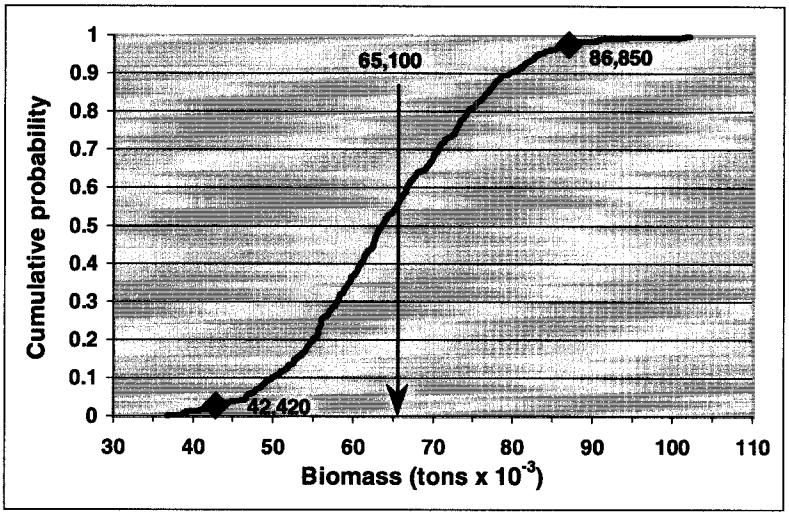
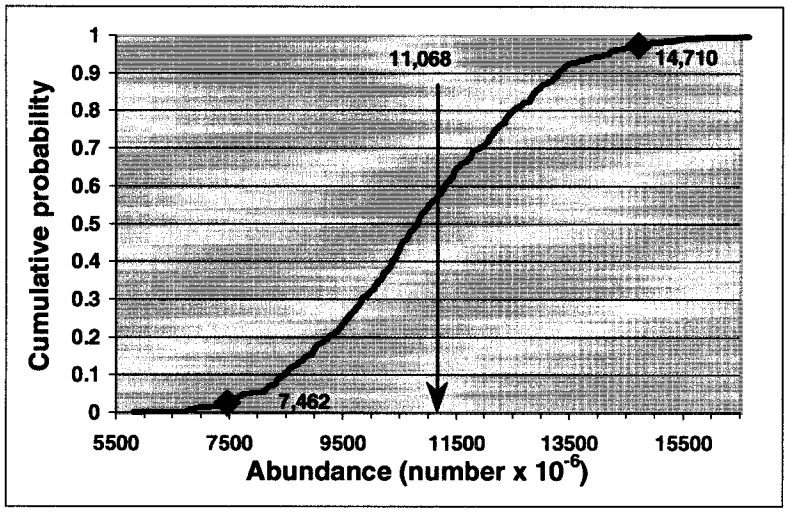


Figure 20a. Shrimp catch weight per standard 15 minute tow (left panel) from the 1999 research trawl survey in Div. 2G (SFA 4) and shrimp biomass per area^2 (right panel) for depths greater than 200 m estimated by ogive mapping (ogmap).

Figure 20b. Biomass, abundance and abundance-at-length for shrimp in Division 2G (SFA 4) estimated by ogive mapping (ogmap) of research survey data, 1999.





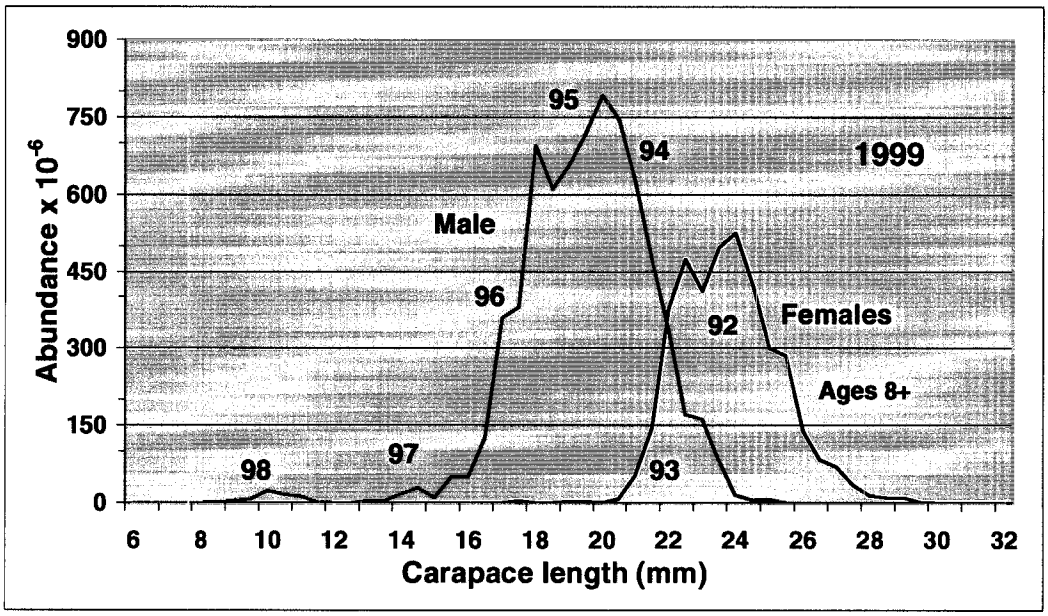
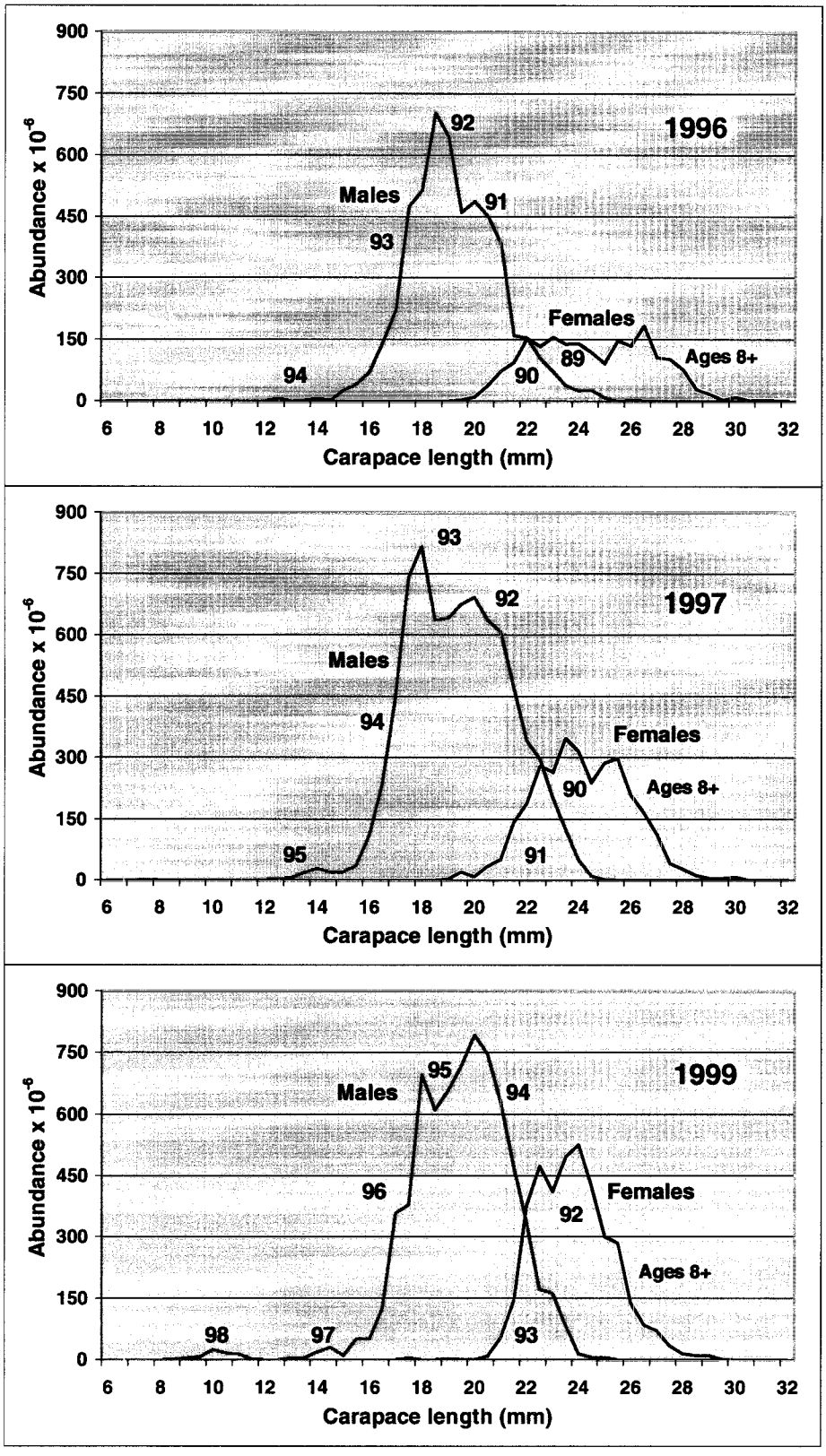


Figure 21. Abundance-at-length for shrimp in Division 2G (SFA 4) estimated by ogive mapping (ogmap) of research survey data, 1996, 1997 and 1999.



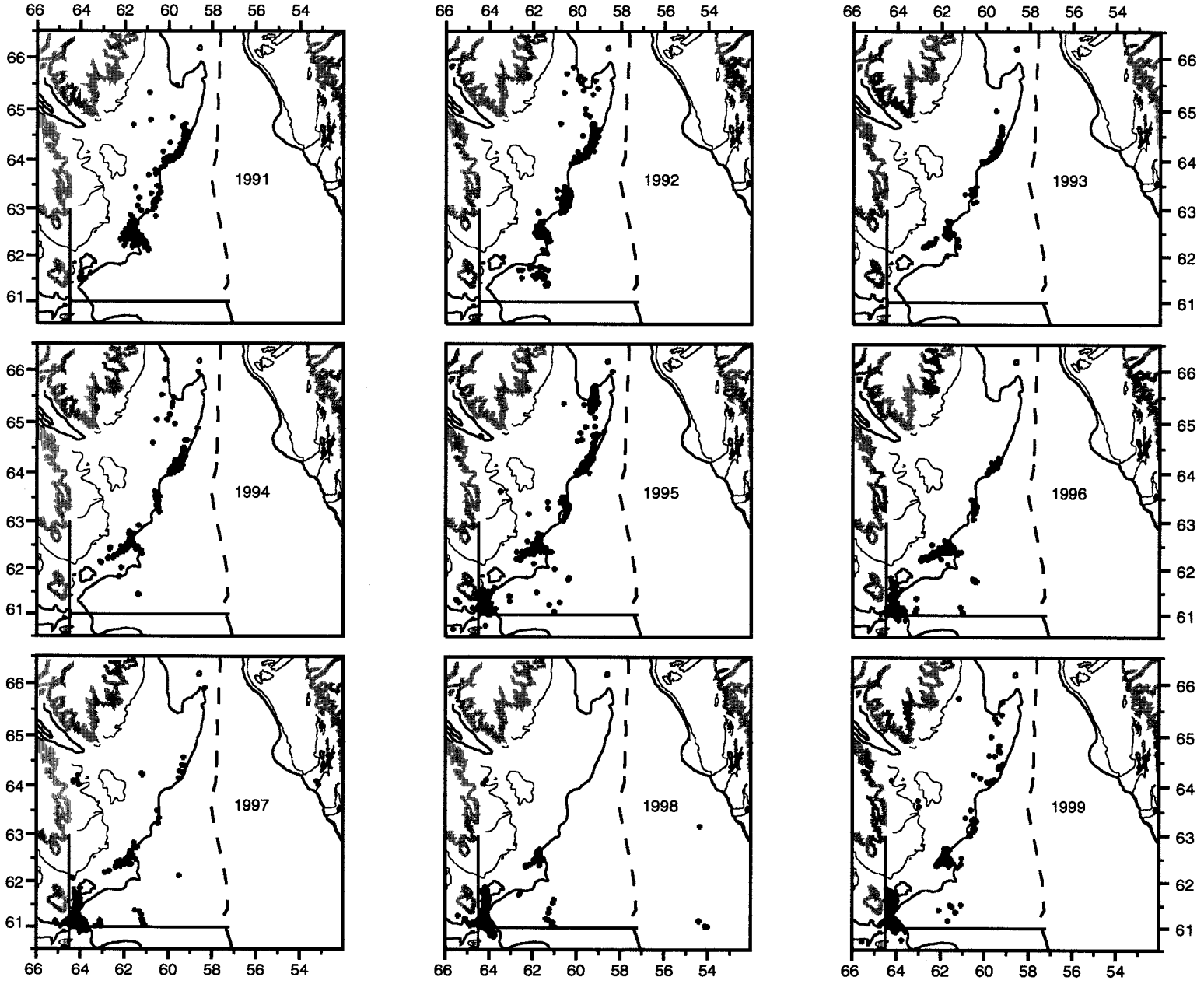


Figure 22. Distribution of commercial fishing effort in Division 0B (SFA 2), 1991 – 1999.

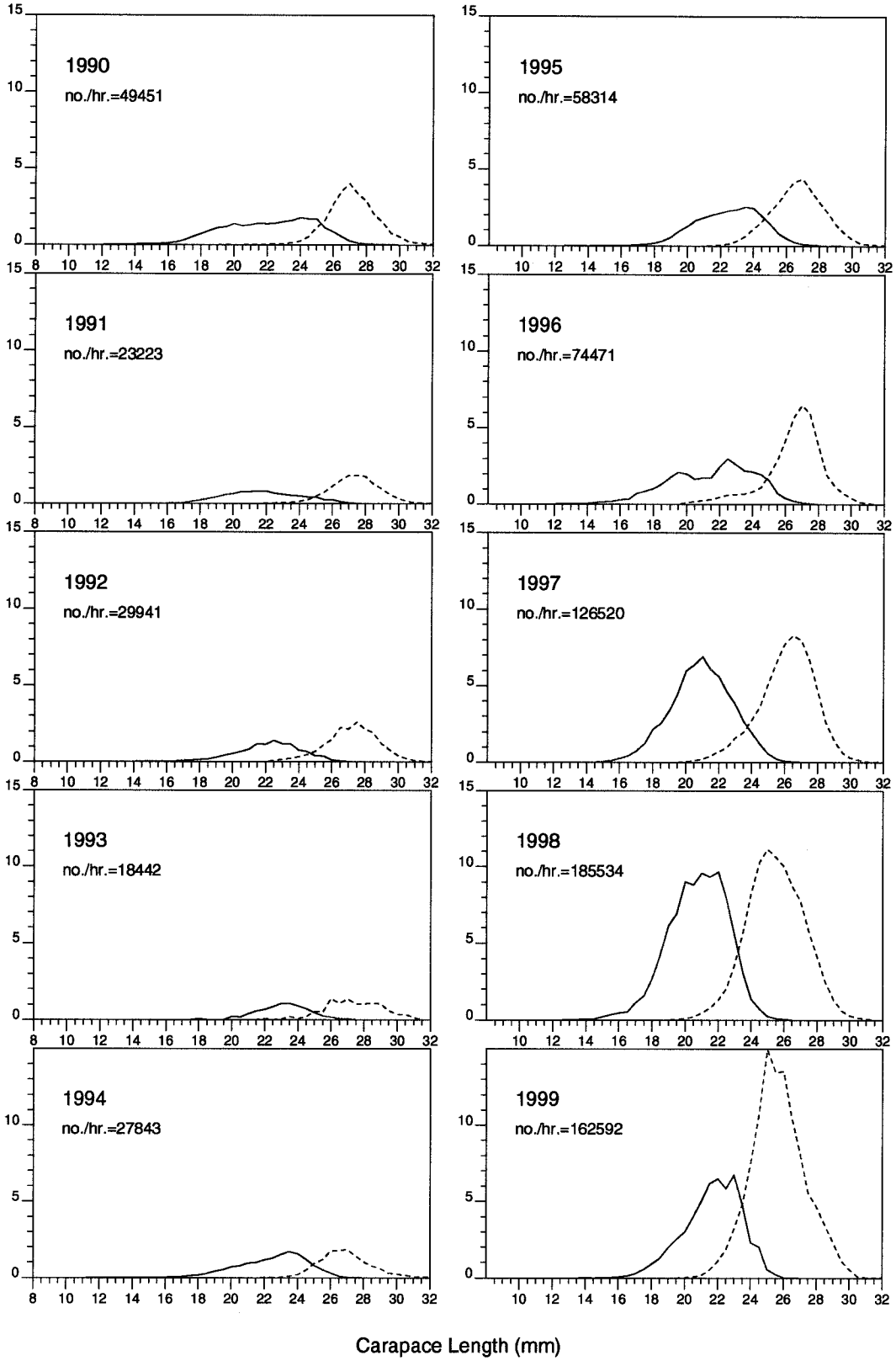


Figure 23. Number (x 10^{-3}) caught per hour at length in Division 0B, 1990 – 1999. Solid line = male, broken line = female.