

Southern Gulf Snow Crab

Background

Snow crab (*Chionoecetes opilio*) is a crustacean like lobster and shrimp, with a flat almost circular body and five pairs of spider-like legs. The hard outer shell is periodically shed in a process called molting. After molting, crab have a soft shell for a period of time and are called white crab. Unlike lobster, snow crab do not continue to molt throughout their lives. Females stop growing after the molt in which they acquire a wider abdomen for carrying eggs; which occurs at shell widths less than 95 mm, the minimum legal size. Male snow crab stop growing after the molt in which they acquire large claws on the first pair of legs, which can occur at shell widths as small as 40 mm. Female crab produce eggs that are carried beneath the abdomen for approximately 2 years. The eggs hatch in late spring or early summer and the tiny newly-hatched crab larvae spend 12-15 weeks floating freely in the water column. At the end of this period they settle on the bottom. It takes at least 8-9 years for snow crab males to reach legal size.

The snow crab fishery in the southern Gulf began in the mid-1960s. There are four fishing Zones: 12, 18, 19, and 25/26, and two exploratory zones (E and F) each with separate management schemes. There is no biological basis for these areas, and for assessment purposes the southern Gulf is considered as one stock.

Female crab is not kept by industry. Baited traps, constructed of wire or tubular steel, are used to catch crab, mainly on mud or sand-mud bottoms at temperatures ranging from -0.5 to 4.5 °C and depths ranging from 50 to 280 m. The fishery takes place in spring and early summer in Zones 12 and 25/26 and in early fall in Zones 18 and 19.



Neither soft-shelled crab or white crab are harvested. Soft-shelled crab is defined by shell hardness (<68 durometer units). The term white crab describes both new-soft and clean crab (categories 1 and 2).

Management of these fisheries is based strictly on quotas and effort controls (number of licenses, trap limits and seasons). There were about 260 crab licenses until 1995 when about 400 temporary (one year) permits were added to the fishery. In 1996, 159 temporary permits were issued to Zone 12 and exploratory Zones E and F. Although the number of participants in Zone 12 increased in 1995-96, the increase in total effort or trap hauls over previous years was < 10%.

The Fishery

The southern Gulf stock is exploited by two spring fisheries, Zones 12 and 25/26, and two summer fisheries, Zones 18 and 19. The largest fishery takes place in Zone 12; in 1996, there was considerable delay in the opening of this fishery because of uncertainties in the management plan.

Zone 12, Southern Gulf of St. Lawrence- Zone 12 is fished by 130 fishermen from New Brunswick, Quebec and Nova Scotia, with a trap limit of 150 per license. The

fishery expanded rapidly, and landings peaked in 1982 at 31,500 t. Landings then fluctuated around 25,000 t until 1986, falling to 11,700 t in 1987. Even lower catches were recorded in 1989 (7,882 t) when the fishery was closed due to a high incidence of soft crab. The quota was set at 7,000 t in 1990. In 1995, landings were 19,944 t (quota of 20,000 t). A total of 4,500 t was allocated for the first time to 320 temporary permit holders. In 1996, the quota was set at 16,100 t of which 3,508 t was allocated to 137 temporary permit holders.

Quota (t) and landings in Zone 12

	1992	1993	1994	1995	1996
Quota (t)	11,200	14,500	20,000	20,000	16,100
Landings (t)	11,235	14,336	19,995	19,944	15,978
CPUE	31.0	41.6	51.2	47.8	50.1
Soft crab(%)	8.6	6.1	5.6	2.5	5.1

In 1995, exploratory fisheries were officially conducted for the first time in Zone E (4 vessels and a quota of 217 t) and Zone F (7 vessels and a quota of 317 t). Parts of these areas had been fished in the past by the traditional fleet. These Zones were maintained in 1996 with lower quotas of 163.8 t and 238 t shared with 8 and 14 permits respectively.

Zone 25/26, Prince Edward Island - The Prince Edward Island snow crab fishery began as an exploratory fishery in 1985 with 16 permits. In 1986, the number of permits issued was increased to 30. Since 1989, this fishery has been open only in the spring. In 1990, the two areas in question were reserved exclusively for fishers from Prince Edward Island. Each of the 30 fishers could use 50 traps. The largest total catch recorded to date was 1,239 t in 1986. Since 1990, this fishery has been subject to a

quota, which was increased to 1,000 t in 1994. The quotas have not been reached since 1994, when the fishery was closed early due to a high incidence of soft-shelled crabs in the catches. Early closure was not necessary in 1995. An additional 22 temporary permits with a total quota of 200 t were issued for the 1995 fishery. A total quota of 750 t was established for 1996, of which 600 t was reserved for the traditional fleet and the remaining 150 t was to be allocated to the temporary permit holders. As a result of poor catch rates and catch composition only the 600 t allocation was harvested.

Quota (t) and landings (t) in Zone 25/26

	1992	1993	1994	1995	1996
Quota (t)	800	800	1,000	1,000	750
Landings (t)	783	800	923	981	598
CPUE	44.4	63.0	31.5	23.9	18.8
Soft crab(%)	10.1	n/a	12.4	8.7	14.3

Zones 18 and 19, Cape Breton Island -

The fishing grounds along the west coast of Cape Breton Island were initially fished by a group of fishers based in Cheticamp. Subsequently, fishermen from Quebec and New Brunswick sporadically fished in the area. With the increase in the commercial value of snow crabs in the late 1970s, the fishery gradually expanded to cover all fishing grounds along the west coast of Cape Breton Island.

Zone 18 was fished for the first time in 1979 by 14 inshore vessels with exploratory licenses and a trap limit of 30 traps per license. The following year, the licenses were converted into permanent fishing licenses and nine supplementary licenses were issued to explore fishing grounds further offshore. Midshore vessels fished these same grounds

until 1982. In 1984, Zone 18 was reserved exclusively for inshore fishermen. The overall quota, which had initially been set at 835 t in 1981, was reduced to 626 t in 1986 and then increased to 674 t in 1988, where it remained for the 1990 season. In the spring of 1991, a quota of 200 t was set to promote a spring fishery in the area. Later that year, a quota of 674 t was set for the 1991 fall fishery and 1992 spring fishery. The quota was raised to 749 t for 1992-93, and remained at that level for 1993-94 and 1994-95. Since 1992-93, 30 fishers have participated in this fishery. In 1995, temporary permits were given to 30 fishers with a total quota of 109 t. The spring fishery was abolished after the 1995 season. In 1996, no temporary permits were issued and a quota of 340 t was allocated to 30 fishers. The season was closed early due to a high incidence of soft-shelled crab and because of low catch rates.

Quota (t), and landings (t) in Zone 18

	1992	1993	1994	1995	1996
Quota (t)	749	749	749	749	340
Landings (t)	741	748	734	693	306
CPUE	50.0	55.5	59.4	33.5	21.2
Soft crab(%)	5.6	10.4	7.2	8.2	20.5

In 1978, Zone 19 was established as an inshore area reserved exclusively for inshore fishers using vessels under 13.7 m (45 feet) in length. During 1992-94, quotas were set at 1,686 t. Landings, regulated by quotas, fluctuated between 900 t and 1,390 t from 1979 to 1991. In 1995, 74 fishermen participated in this fishery, with a trap limit of 20 per license. The quota of 134 t was allocated to 37 temporary permit holders. In 1996, a 5-year co-management agreement was signed between DFO and Zone 19 snow

crab fishermen's association and a quota of 1,343 t was allocated to 111 licenses holders.

Quota (t) and landings (t) in Zone 19

	1992	1993	1994	1995	1996
Quota (t)	1,686	1,686	1,686	1,575	1,343
Landings (t)	1,678	1,678	1,672	1,575	1,343
CPUE	97.9	92.2	68.3	63.4	54.6
Soft crab(%)	6.6	1.9	5.5	3.5	10.8

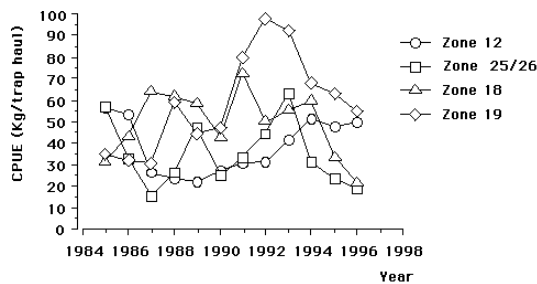
Resource Status

The assessment is normally based on a trawl survey which provides estimates of uncaught, exploitable biomass (large-clawed, hard-shelled males of legal size) immediately following the fishery plus estimates of large-clawed, soft-shelled males larger than 95mm that will be part of the exploitable biomass in the following year as new recruits. The method assumes that there is no natural mortality between the time of the survey and the start of the fishery nine months later. Abundance is also estimated for smaller size crab or pre-recruits. Density contour maps are provided for the different types of crab. In previous years, a generalized variogram was used for all calculations. More accurate estimates of density are achieved when separate variograms are calculated for each area or patch. This year's estimates of recruitment were made using the new method. Abundance estimates are standardized to an area of 0.8 km². The survey should be viewed as an estimate of the population at the time of the sampling.

The stock assessment in Zones 18 and 19 was based on a 1996 trawl survey. In Zones 12 and 25/26 there was no survey in 1996 and instead the 1995 survey was used to estimate the harvestable biomass and new recruitment that would be available for the

1997 fishery. The 1996 landings and an estimate of 100% natural mortality for very old crab (category 5) were subtracted from this value. The biomass of these old crab remaining after the 1995 fishery was estimated to be 4,400 t for Zone 12 and 170 t in Zones 25/26.

Catch rates are available from logbooks but are generally viewed with caution because fishers are provided with maps of crab concentrations before the opening of their fishery. Also catch rates are affected by socio-economic factors. Historically, there has been a good relationship between catch rates and the biomass survey but in 1996 industry noted that there was a large increase in the soak time of traps in most areas and catch rates were considered to be inflated and not comparable to previous years, particularly in Zone 12. Consequently, 1996 biomass could not be estimated using catch rate data. Nominal catch rates declined in all Zones except in Zone 12 where they have not changed for the past three years. In Zone 12, catch rates were similar

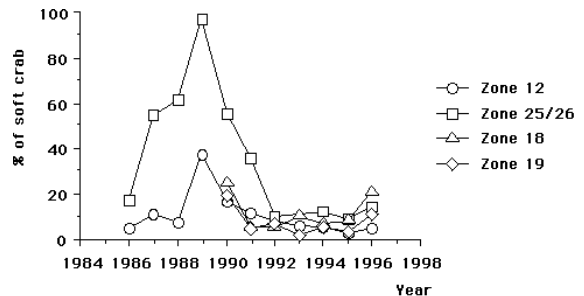


CPUE (kg/trap haul) in the southern Gulf since 1985.

for traditional fishermen (51.1 kg/trap haul) and temporary permits holders (46.8 kg/trap haul). Logbook data were also used to describe the general distribution of fishing effort per section (10 by 10 minutes). In the exploratory Zones, 1996 catches were located only at the boundaries and catch rates would not reflect abundance

throughout the Zone. By contrast in 1995, fishers were deployed throughout the exploratory Zones and their catch rates, although lower than in 1996, were considered to be more representative of abundance.

Soft-shelled crab was observed with increased incidence in all Zones in 1996 compared to the previous season. In Zone 12, the seasonal percentage of soft-shelled crab doubled (5.1 %) compared to the previous season (2.5 %). In Zone 25/26, an increase of the percentage of soft crab (14.3 %) from the previous season (8.7%) and a high incidence of skip molters (20.4%) were observed. In Zone 18, the percentage of soft-shelled crab was so high (average of 20.5 %) that the fishery was closed on July 29, before the quota was caught. In Zone 19, the percentage of soft-shelled crab increased by threefold compared to the 1995 season.



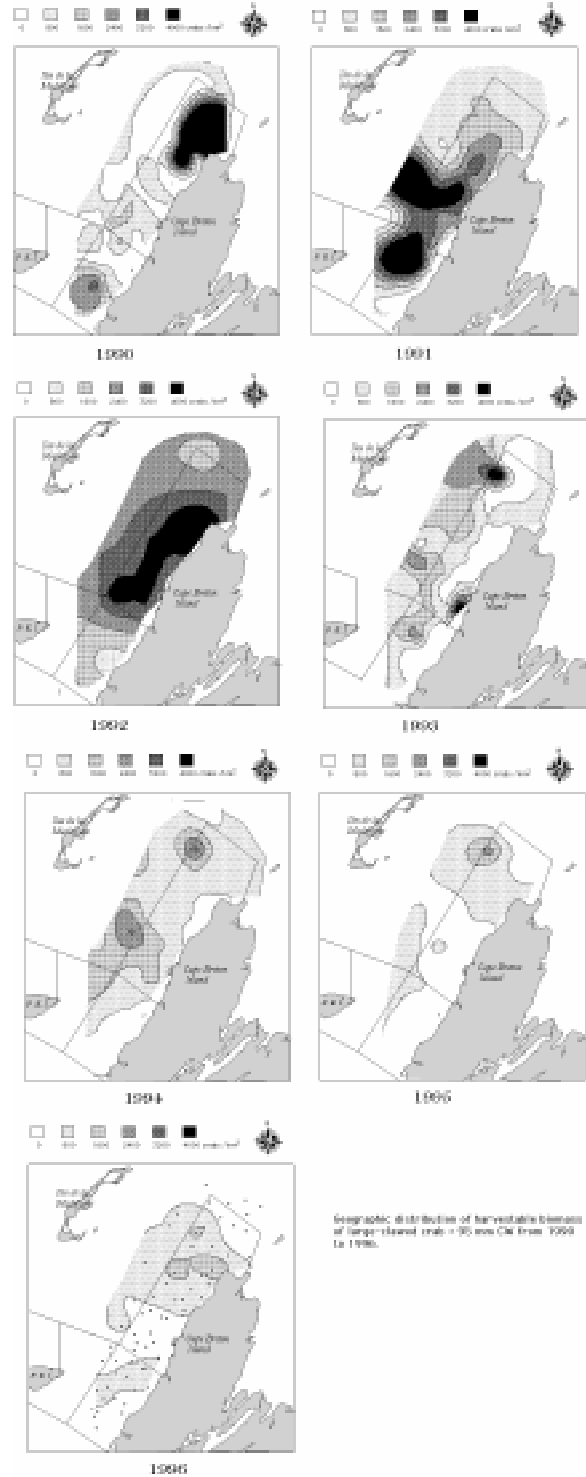
Percentage of soft crab in the southern Gulf since 1986.

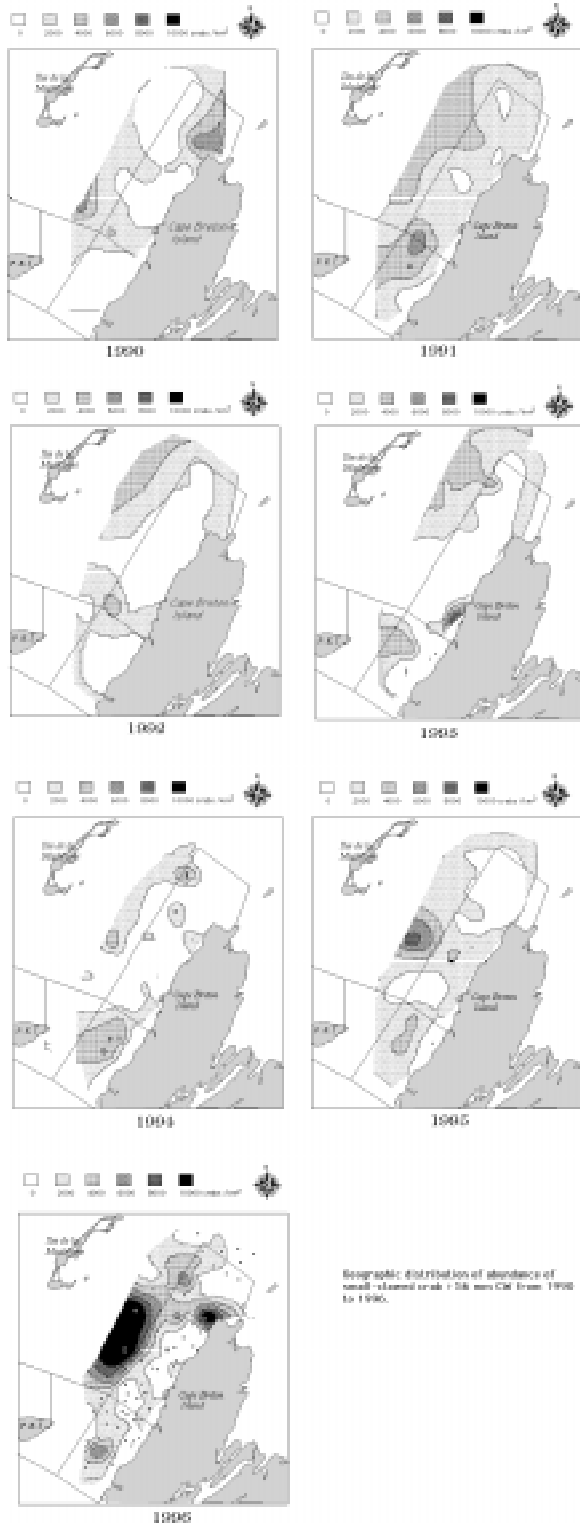
Carapace condition was estimated from sea samples taken from the 1996 fishery. It is clear that older crab (categories 3-5) comprised the bulk of the fishery and will continue to dominate the fishery in 1997.

Carapace condition of large-clawed commercial-sized crab in the catch

Category	Zone 12	Zone 18	Zone 19	Zones 25/26
1	3.6	7.6	6.1	1.7
2	8.6	2.2	7.7	3.9
3	45.5	54.2	42.4	63.9
4	35.6	30.0	38.4	19.4
5	6.7	6.0	5.4	11.1

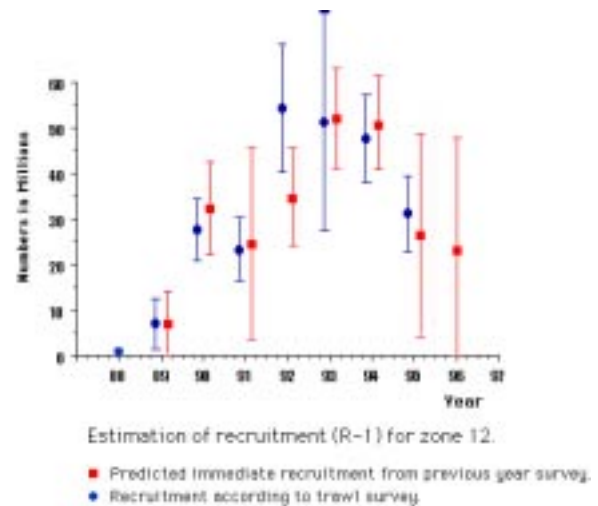
Population abundance of fishable snow crab declined in the southern Gulf from 1993 to 1995. In Zones 18 and 19 there was no change in the biomass of uncaught fishable crab between 1995 and 1996. In Zone 18, however, there was an increase in available biomass because of a large increase in recruitment.





Recruitment from the 1996 survey in Zones 18 and 19 indicated that the biomass of recruits or large-clawed, soft-shell males ≥ 95 mm (R-1) had increased from the low values seen in 1995.

Recruitment for Zones 12, and 25/26 was estimated from the abundance of three categories of immature crab found in earlier surveys: small-clawed males, 75 to 94mm, (R-2); small-clawed, recently-molted males, ≥ 95 mm (R'-2); and small-clawed males with old shells, ≥ 95 mm that did not molt in the current year, skip molters (R'_{sk}-2). A multiple-regression between the three categories of R-2 and R-1 was used to predict numbers of recruits in 1996. The predicted value of R-1 in numbers in 1996 derived from this relationship was multiplied by a mean weight of 0.584 kg (which was the mean weight of all commercial-sized new recruits from the biomass survey, 1988-1995) to obtain an estimate of the biomass recruiting to the fishable stock in 1997. Because the factors that determine molt to maturity and skip molting are poorly understood and because there is uncertainty in annual survey estimates of the different categories of crab, there is considerable uncertainty in the estimate of recruiting biomass for 1997. The value 13,400 t represents the best available estimate; however, the 95% confidence intervals indicate that the true value lies within a very wide range ($\pm 107\%$).



Abundance estimates (x 10⁶) of R-2 and R-1 categories in Zone 12 from trawl survey

Year	R-2 juvenile 75≥CW <95	R'-2 juvenile 95≥CW	R' _{SK-2} skip molters 95≥CW	R-1 new recruits
1988	5.6	5.3	3.4	0.8
1989	55.5	14.3	7.5	7.3
1990	96.3	22.6	5.1	27.8
1991	76.6	19.0	7.6	22.8
1992	96.2	28.8	13.7	54.4
1993	107.3	35.9	14.9	51.4
1994	55.0	30.1	12.3	47.9
1995	36.3	26.6	12.1	31.4

Exploitation rate for the combined southern Gulf of St. Lawrence fisheries was estimated at 35%. However, the rate varied from Zone to Zone (32 % for Zone 12, 75 % for Zone 25/26, 53% for Zone 18 and 74% for Zone 19). Historically, the exploitation rate has been higher in inshore Zones than in Zone 12.

Exploitation rates (%) in Zones 12, 25/26, 18 and 19

	Southern Gulf	Zone 12	Zone 25/26	Zone 18	Zone 19
1990	-	32	41	-	-
1991	-	43	46	-	-
1992	-	38	29	-	-
1993	38	38	36	58	32
1994	34	32	-	58	73
1995	35	34	45	58	61
1996	35	32	75	53	74

Cold water temperatures are preferred by snow crab. Bottom water temperatures in the southern Gulf have been colder than the

long-term average since the late 1980s. During the years 1995 and 1996 subzero bottom water was seen to be at its greatest extent since these measurements began in 1971. The warm winters in 1995-96 and 1996-97 suggest that temperatures will start to warm, which could have an influence on the distribution of crab.

Outlook

The general picture of declining catch rates in peripheral areas (Zones 18, 19, 25/26) and of stable or declining catch rates in the central area (Zone 12) is consistent with a contraction of commercial concentrations and a decrease in stock abundance. Overall, the assessment indicates somewhat lower biomass in 1997 than in 1996. The estimate of 1997 recruitment to Zone 12 suggests that there will be a further decline in recruitment compared to 1996, but there is considerable uncertainty around this estimate. In peripheral Zones there are indications of possible increase in recruitment.

Estimates of the biomass of commercial-sized male crab that will be available for the 1997 fishery are provided in the table below.

Harvestable biomass estimates in the southern Gulf of St. Lawrence

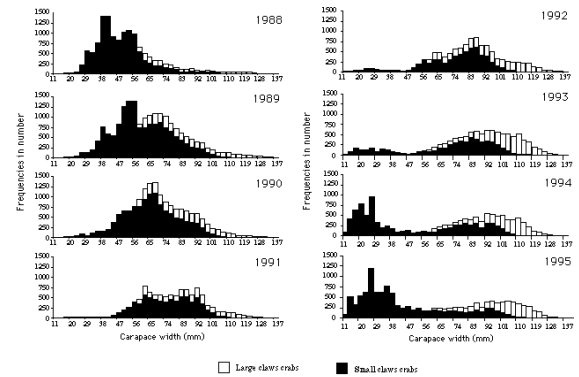
Zone	Southern Gulf	12
1989	-	8,700 (±42%)
1990	-	21,700 (±53%)
1991	-	23,400 (±53%)
1992	-	29,400 (±50%)
1993	46,500 (±42%)	37,800 (±38%)
1994	68,800 (±16%)	61,900 (±13%)
1995	66,100 (±14%)	58,700 (±12%)
1996	52,700 (±17%)	49,500 (±16%)
1997	47,200 (±33%)	43,600 (±54%)

Zone	25/26	18	19
1989	500 (±121%)	-	-
1990	1,300 (±98%)	-	-
1991	1,300 (±72%)	-	-
1992	2,700 (±62%)	-	5,500 (±36%)
1993	2,200 (±81%)	1,300 (±92%)	5,200 (±42%)
1994	n/a	1,300 (±83%)	2,300 (±27%)
1995	2,200 (±81%)	1,200 (±89%)	2,600 (±40%)
1996	800 (±46%)	600 (±39%)	1,800 (±21%)
1997	400 (±1700%)	1000 (±54%)	2,200 (±27%)

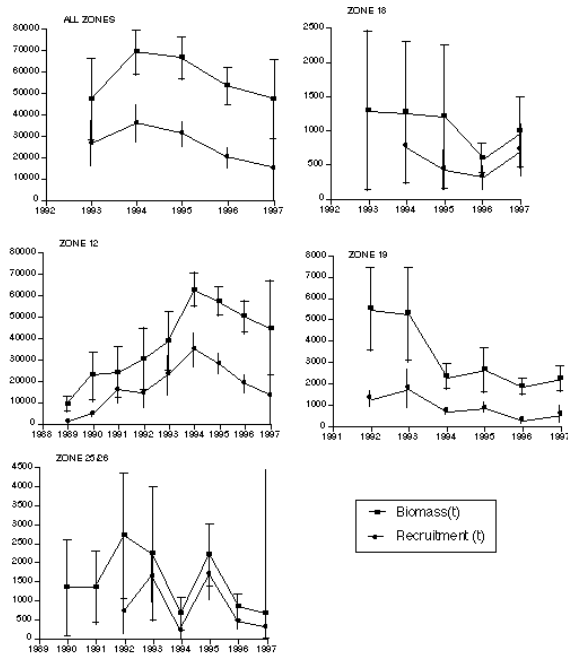
It can be noted that the harvestable biomass of crab in the southern Gulf has declined since 1994. The distribution of biomass in Zones 12 and 25/26 is expected to be in similar, but less extensive, locations as described last year (DFO Atlantic Fisheries SSR 96/1E). In Zones 18 and 19, harvestable biomass in 1997 is expected to increase because of the new recruitment.

There is evidence from the 1995 survey throughout the southern Gulf and from the 1996 survey in Zones 18 and 19 of numerous smaller-sized crab (20-50mm). Because of uncertainty about growth patterns,

particularly as abundance changes, it is not known when these small crab would be expected to recruit into the fishery. The likelihood of encountering soft-shelled crab is expected to increase in 1997.



Size frequency distribution for male crabs taken during the research surveys in zone 12 after the fishing season from 1988 to 1995.



Estimated biomass and standard deviation of harvestable biomass (t) and recruits (t) to the following year in the southern Gulf.

Uncertainties in this assessment relate to the lack of a 1996 survey in much of the stock area and to incomplete knowledge of growth patterns of pre-recruits. For example, the proportion of the different groups of R-2 crab that will molt to recruitment is not well

known. Lack of a survey means that recruitment must be projected two years forward. The projection also assumes that the molting rate of immature crab into new recruits is constant and this is unlikely to be true, especially for a stock with changing abundance. Nevertheless, surveys were conducted in some peripheral areas and observations from these surveys corroborated the results of the statistical model.

Sources of uncertainty related to abundance estimates from the trawl survey include assumptions about the surface trawled by the gear being constant and that all sizes of crab >75mm are equally catchable. In addition crab concentrations are sometimes situated at the boundaries of the area sampled as noted in the 1993 and 1994 surveys, and there is the possibility of dispersion of the crabs between the time the survey is conducted and the start of the following fishing season. There are also regional variations in the distribution of crab that may not be accounted for in the analysis and there is error in converting carapace size to biomass.

Uncertainty is particularly evident in Zones 25/26, where almost 90% of the estimated 1997 fishable biomass is new recruitment based on the abundance of R-2 stages in the 1995 survey and it is known that the survey is less predictable in areas that are peripheral to the main concentrations of crab.

Other sources of uncertainty include error in the classification of old or mossy crab and assuming that natural mortality equals zero for all crab except those at category 5. Finally, there are assumptions that the illegal or unreported landings and discard mortality of white crab are negligible. All of these

assumptions and uncertainties must be considered.

Management Considerations

The southern Gulf stock has been managed with a target exploitation rate around 35%. This value was initially proposed by industry and it is an average value that applies to the whole stock area. Given the large number of uncertainties in stock status, the target exploitation rate in the 1997 fishery should not be higher than 35%, possibly lower. An exploitation rate at or below this level will help to protect any new recruitment and will also help to stabilize long-term yield. It should also be noted that the percent removals has been very high in the peripheral areas of the stock distribution but it does not appear to present any problems with regard to stock conservation.

It is critical that the industry does not target only the best crab (carapace stage 3) in the upcoming fishing seasons. If all old crab (carapace stages 4 and 5) is discarded, an increase in mortality and a reduction in catchability can be expected. It is important to adjust the management strategy in relation to the timing and strength of recruitment to the fishery for each Zone, because its pattern seems to be different among the four Zones.

Although the crab population is aging, there is a possibility of an increased incidence of soft-shelled crab in the fishery for 1997-1998, particularly if the residual biomass is low. Soft-shelled crab is the future recruitment to the fishery. These crabs should be avoided or returned carefully to the sea if captured. Trends in the southern Gulf are consistent with the northern Gulf where the incidence of soft-shelled crab is expected to increase in 1997-1998.

Inshore Zones:

Caution must be exercised in interpreting annual variations in biomass in Zones 18 and 19. These variations are highly affected by the fact that the current management areas do not correspond to biological units. Crab concentrations straddle the boundaries between the areas. Some small concentrations of crab observed in Zone 12 may have contributed to the biomass in Zone 19. An increased biomass together with a high incidence of soft-shelled crab indicated the arrival of new recruitment to the fishery in 1997. If this recruitment remains within Zone 18, a continuous increase of biomass may be anticipated. In Zone 25/26 it is very difficult to suggest any sound management strategy because of the migratory behaviour of crab in this area.

Exploratory fisheries:

Biologically Zones E and F are part of the southern Gulf stock. The lower incidence of soft-shelled crab and the higher CPUE in 1996 compared to the previous year indicated that recruitment has ended in this Zone. This fishery should not be considered as an exploratory fishery unless the exploratory licenses are deployed throughout the entire Zone.

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