



# ASSESSMENT OF NEWFOUNDLAND AND LABRADOR SNOW CRAB

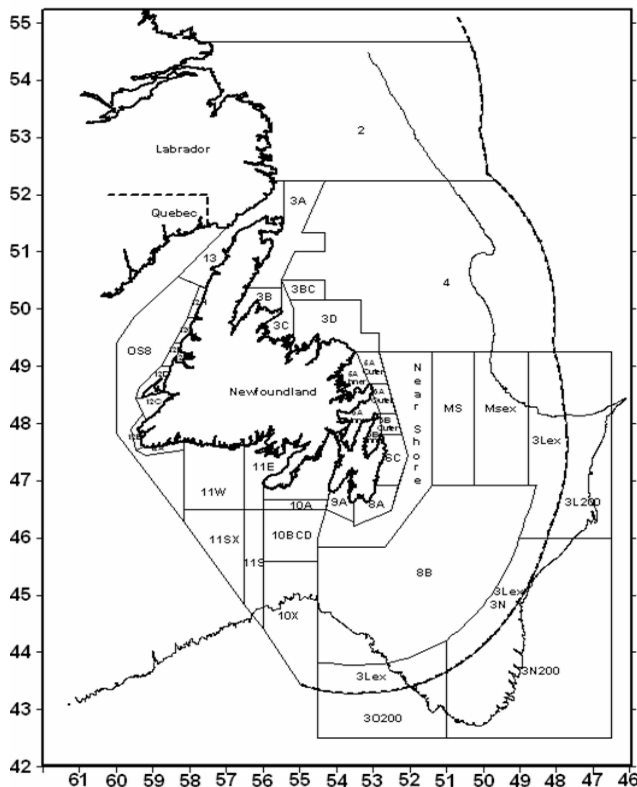
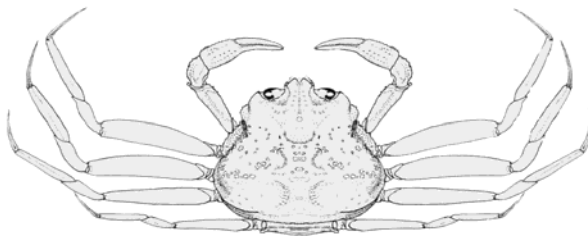


Figure 1: Newfoundland and Labrador Snow Crab Management Areas.

## Context

Snow crab (*Chionoecetes opilio*) occur over a broad depth range in the Northwest Atlantic from Greenland to the Gulf of Maine. Distribution in waters off Newfoundland and southern Labrador is widespread and continuous.

Crab harvesters use fleets of conical baited traps. The minimum legal size is 95 mm carapace width (CW). This regulation excludes females from the fishery while ensuring that a portion of the adult males in the population remains available for reproduction.

Total Allowable Catch (TAC) management was initiated in the late 1980's. This led to the development of multiple TAC-controlled management areas (Fig. 1) with over 3300 licence holders across several vessel fleets under enterprise allocation in 2007. All fleets have designated trap limits, quotas, trip limits, fishing areas within divisions, and differing seasons.

Stock status is assessed annually for inshore and offshore areas (where applicable) within each NAFO Division. A vessel monitoring system (VMS) was fully implemented in the offshore fleets in 2004.

Resource status is evaluated based on trends in fishery catch per unit of effort (CPUE), exploitable biomass indices, recruitment prospects, and mortality indices. Data are derived from multi-species bottom trawl surveys in Div. 2J3KLNOP, inshore trap surveys in Div. 3KL, fishery data from logbooks, observer catch-effort data, industry-DFO collaborative trap survey data, VMS and dockside monitoring data, as well as biological sampling data from multiple sources.

A meeting of the Regional Advisory Process was held Mar. 3-5 and Mar. 10-11, 2008 in St. John's, NL to assess the status of the snow crab resource. Participants included DFO scientists, French scientists (IFREMER), fisheries managers, and representatives from industry, the provincial government and Memorial University.

## SUMMARY

- The multi-species surveys in Div. 2J3KLNO during fall and in Div. 3LNOPs during spring indicate a decline in **exploitable biomass** from 1998-2003 and 1999-2004 respectively. However survey indices and commercial **CPUE** agree that the exploitable biomass has increased in the north (Div. 2J3K) in 2006 and 2007.
- **Recruitment** has increased overall since 2005 due to increases in the north, while prospects have improved in the south.
- Longer-term recruitment prospects are uncertain but the persistence of a warm oceanographic regime implies poor prospects relative to the strong recruitment of the late 1990's.

### Division 2J

- **Landings** declined from 2002-2005 and then increased by 53% to 2330 t in 2007. **Effort** declined by more than half from 2004-2006 before increasing by 12% in 2007.
- The exploitable **biomass** has increased in recent years. The fall survey **exploitable biomass index** has increased over the past five years but remains below levels observed prior to 2002. Commercial **CPUE** has increased from its lowest level in 2004 to about the long-term average in 2007.
- **Recruitment** has increased from 2004 but is expected to decrease in the next several years.
- The **exploitation rate index** and the **pre-recruit fishing mortality index** both declined sharply from 2003-2005 and have changed little since.
- Maintaining the current level of fishery removals would not likely result in any increase in the exploitation rate in 2008. An increase in fishery removals would likely accelerate an expected decline in the exploitable biomass in the near future.

### Division 3K Offshore

- **Landings** decreased sharply in 2005 and then increased by 55% to 9450 t in 2007 while **effort** declined by 28%.
- The exploitable **biomass** has increased substantially over the past two years. The fall survey exploitable biomass index has increased steadily since 2003 to its highest level since 1998. CPUE increased sharply from 2005-2007 to approach the highest level previously observed.
- **Recruitment** remains promising for the next several years although it may decrease slightly in the next 1-2 years.
- The **exploitation rate index** has changed little in the past 3 years at about the long-term average whereas the **pre-recruit fishing mortality index** declined sharply to its lowest level in 2007.

- Fishery removals could likely be increased in 2008 without increasing the exploitation rate.

### Division 3K Inshore

- **Landings** decreased by 21% in 2005 and then increased by 9% to 2820 t in 2007 while **effort** declined by 47%.
- The exploitable **biomass** has recently increased. CPUE increased sharply from 2005-2007 to approach the highest level previously observed. Post-season trap survey catch rates increased from 2004-2006 and were unchanged in 2007.
- **Recruitment** remains promising for the next several years although it may decrease slightly in the next 1-2 years.
- Data are insufficient to estimate fishery-induced **mortality** indices.
- Maintaining the current level of fishery removals would not likely result in an increase in the exploitation rate.

### Division 3L Offshore

- **Landings** have increased since 2001 and reached their highest level in 2007 at 21,000 t - a 17% increase. **Effort** increased steadily since 2000 to its highest level in 2007.
- The **exploitable biomass** has declined in recent years. The fall survey **exploitable biomass index** increased from 2006-2007 but remained low relative to previous years. Commercial **CPUE** declined steadily since 2000 to the lowest level since 1991. The post-season trap survey catch-rates also declined over 2004-2007.
- **Recruitment** is expected to increase over the next several years.
- Both the **exploitation rate index** and the **pre-recruit fishing mortality rate index** increased to very high levels in 2007.
- Increased removals, under the present scenario of reduced biomass and imminent recruitment increase, could result in increased mortality on soft-shelled immediate pre-recruits.

### Division 3L Inshore

- **Landings** changed little between 2004 and 2007 (6490 t), while effort declined by 27%.
- The exploitable **biomass** has recently increased. **CPUE** increased by 39% from 2004 to 2007. Post-season trap survey catch rates increased from 2004-2006 and were unchanged in 2007.
- **Recruitment** prospects are uncertain.
- Data are insufficient to estimate fishery-induced **mortality** indices.

- Maintaining the current level of fishery removals would not likely result in an appreciable change in the exploitation rate in 2008.

### Division 3NO

- The fishery has been concentrated along the shelf edge. **Landings**, totaling 3380 t in 2007, declined by about 28% since 2004. **Effort** declined by 23% from 2004-2006 and increased by 16% in 2007.
- Trends in **biomass** are uncertain. Survey indices are unreliable. **CPUE** changed little during 2004-2006 before decreasing in 2007.
- Recent **recruitment** and future prospects are uncertain.
- The effects of maintaining the current catch level on the fishery-induced mortality rate are unknown.

### Subdivision 3Ps Offshore

- **Landings** increased by 21% to 2800 t in 2007, following a 47% decline from 2002-2006.
- **Effort** increased by 16% in 2007, following a 32% decrease from 2003-2006.
- The exploitable **biomass** remains at a very low level. **CPUE** decreased steadily from 1999-2003 and has since remained at a low level. The spring survey **exploitable biomass index** declined from 1999-2001, and has since remained unchanged. However the post-season trap survey catch rates increased from 2004-2006 and were unchanged in 2007.
- **Recruitment** is expected to increase in the next several years.
- Increased removals, under the present scenario of very low biomass and imminent recruitment increase, could result in increased mortality on soft-shelled immediate pre-recruits.

### Subdivision 3Ps Inshore

- **Landings** declined by 79% to their lowest level from 2002-2005 and have since increased by 63% to 1150 t in 2007. **Effort** decreased by about half from 2003-2005 and changed little since.
- The exploitable **biomass** remains low. **CPUE** declined from 2001 to its record low level in 2004-2005 before increasing slightly in 2006 and 2007. The post-season trap survey catch rates increased slightly from 2004-2007.
- **Recruitment** increased slightly in 2007 and prospects remain positive in the short term.
- Increased removals, while the exploitable biomass remains low and recruitment is increasing, could result in increased mortality on soft-shelled immediate pre-recruits.

### **Division 4R3Pn Offshore**

- **Landings** decreased from 750 t in 2001 to 80 t in 2006 before increasing to 190 t in 2007. **Effort** declined by 87% during 2005-2006 and increased in 2007.
- There are insufficient data to assess resource status.

### **Division 4R3Pn Inshore**

- **Landings** declined by 65% since 2002 to a record low of 370 t in 2007. **Effort** decreased sharply in 2005 and changed little since.
- **Biomass** has recently declined. Both CPUE and post-season trap survey catch rates have declined sharply since 2005.
- **Recruitment** prospects are unknown.
- Maintaining the current level of fishery removals would likely result in an increase in the exploitation rate in 2008.

## **BACKGROUND**

### **Species Biology**

The snow crab life cycle features a planktonic larval period, following spring hatching, involving several stages before settlement. Benthic juveniles of both sexes molt frequently, and at about 40 mm CW (~ 4 years of age) they may become sexually mature.

Crabs grow by molting, in spring. Females cease molting after sexual maturity is achieved at about 40-75 mm CW and so do not contribute to the exploitable biomass. However sexually mature (adolescent) males may continue to molt annually until their terminal molt, when they develop enlarged claws (adults), which enhances their mating ability. Males may molt to adulthood within a size range of about 40-115 mm CW, and so only a portion of any cohort will recruit to the fishery at 95 mm CW (~ 8 years of age).

Adult legal-sized males remain new-shelled with low meat yield throughout the remainder of the year of their terminal molt. They are considered to be pre-recruits until the following year when they begin to contribute to the exploitable biomass as older-shelled adults. Males may live about 6-8 years as adults after the terminal molt.

Large males are most common on mud or mud/sand, while smaller crabs are common on harder substrates. Snow crab diet includes fish, clams, polychaete worms, brittle stars, shrimp, snow crab, and other crustaceans. Predators include various groundfish, other snow crabs, and seals.

Effects of temperature differ throughout the life cycle. Cold conditions in early life favour survival while in later life they promote early terminal molt, thereby reducing the proportion that will recruit to the fishery. Negative relationships between bottom temperature and snow crab CPUE

have been demonstrated at lags of 6-10 years suggesting that the positive effects on recruitment of cold conditions early in the life history are stronger than the negative effects in later life. A warm oceanographic regime has persisted over the past decade implying poor long-term recruitment prospects relative to the strong recruitment of the late 1990's.

## **The Fishery**

The fishery began in Trinity Bay (Management area 6A, Fig. 1) in 1967. Initially, crabs were taken as gillnet by-catch but within several years a directed trap fishery developed in inshore areas along the northeast coast of Div. 3KL. The minimum legal mesh size of traps is 135 mm, to allow small crabs to escape. Under-sized and new-shelled males that are retained in the traps are returned to the sea and an unknown proportion dies.

Until the early 1980's, the fishery was prosecuted by approximately 50 vessels limited to 800 traps each. In 1981 fishing was restricted to the NAFO Division where the licence holder resided. During 1982-1987 there were major declines in the resource in traditional areas in Div. 3K and 3L while new fisheries started in Div. 2J, Subdiv. 3Ps and offshore Div. 3K. A snow crab fishery began in Div. 4R in 1993.

Licences supplemental to groundfishing were issued in Div. 3K and Subdiv. 3Ps in 1985, in Div. 3L in 1987, and in Div. 2J in the early 1990's. Since 1989 there has been a further expansion in the offshore. Temporary permits for inshore vessels <35 ft, introduced in 1995, were converted to licences in 2003. There are now several fleet sectors and about 3300 licence holders.

In the late 1980's quota control was initiated in all management areas of each division. All fleets have designated trap limits, quotas, trip limits, fishing areas within divisions, and differing seasons. Fishing seasons have become progressively earlier and have recently been prosecuted predominately in spring, resulting in reduced incidence of soft-shelled crabs in the fishery. A protocol was initiated in 2004 that results in closure of localized areas when the percent soft-shelled crabs within the legal-sized catch exceeds 20%.

Mandatory use of the electronic vessel monitoring system (VMS) was fully implemented in all offshore fleets in 2004, to ensure compliance with regulations regarding area fished.

**Landings** for Div. 2J3KLNOP4R (Fig. 2) increased steadily from 1989 to peak at 69,000 t in 1999, largely due to expansion of the fishery to offshore areas. They decreased by 20% to 55,400 t in 2000 and changed little until they decreased to 43,900 t in 2005, primarily due to a sharp decrease in Div. 3K where the TAC was not taken. Landings increased by 14% since 2005 to 50,000 t in 2007, due primarily to increases in Div. 3K. Historically, most of the landings have been from Div. 3KL.

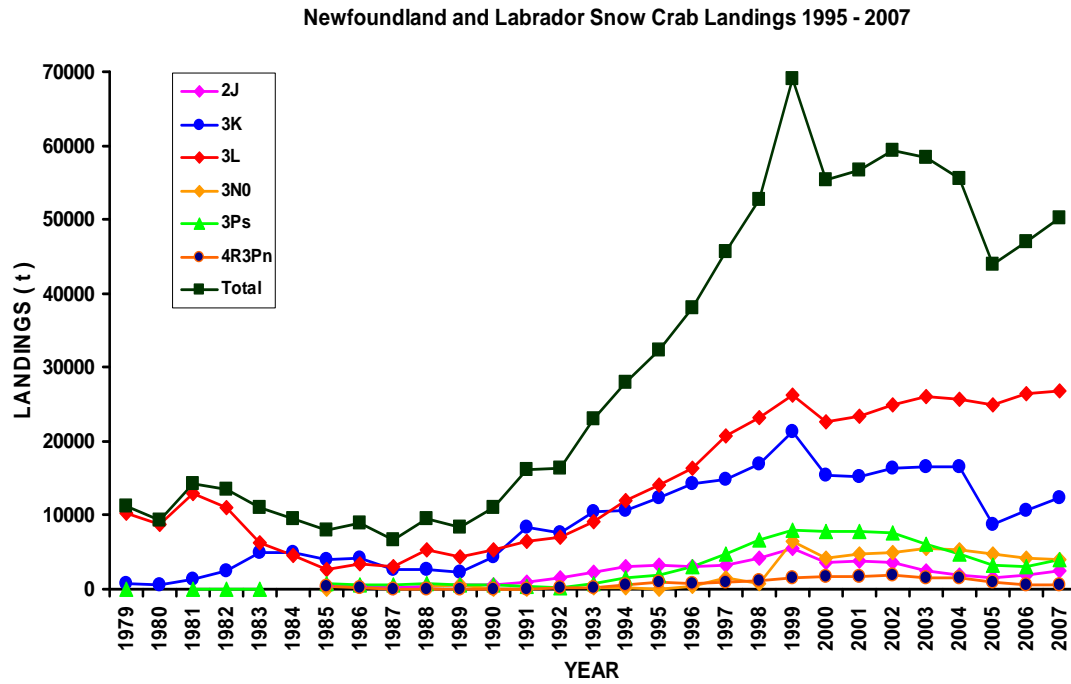


Figure 2: Trends in landings by NAFO Division and in total.

Effort has increased since the 1980's and has been broadly distributed in recent years (Fig. 3).

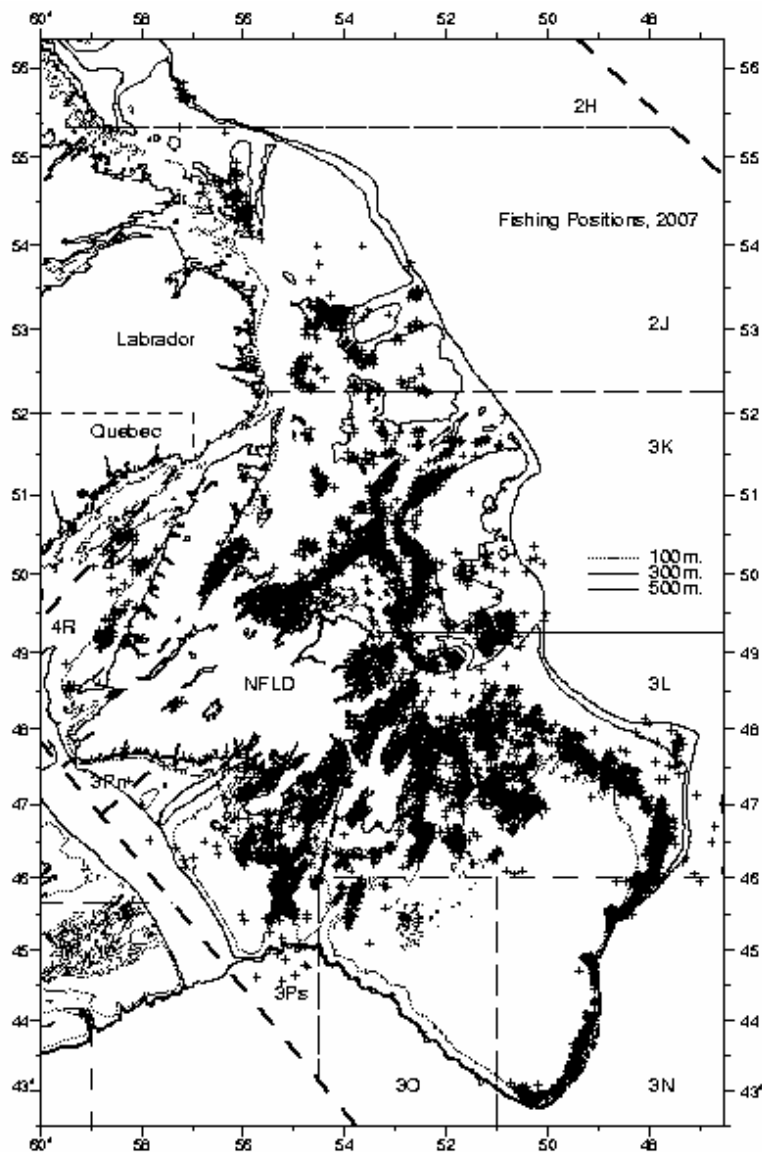


Figure 3: Spatial distribution of commercial fishing effort during 2007.

## ASSESSMENT

Resource status was evaluated based on trends in fishery **CPUE**, **exploitable biomass indices**, **recruitment** prospects and **mortality indices**. Information was derived from multi-species bottom trawl surveys conducted during fall in Div. 2J3KLNO and during spring in Subdiv. 3Ps. The trawl used in these multi-species surveys was changed to a Campelen shrimp trawl in the fall of 1995, and this trawl proved to be more efficient in sampling crabs than the previously used groundfish trawl. Snow crab sampling during spring Subdiv. 3Ps surveys did not begin until 1999. Data from Subdiv. 3Ps spring surveys had previously been considered unreliable, but a recent analysis on a more extended time series has shown that they provide useful assessment indices (Mullowney *et al.*, 2008). Information is also utilized from DFO inshore trap surveys in Div. 3KL, fishery data from logbooks, observer catch-effort data, data



from industry-DFO collaborative post-season trap surveys, VMS and dockside monitoring data, as well as biological sampling data from multiple sources.

The resource is assessed separately for offshore and inshore areas of each division, where appropriate (Div. 3KLPs4R3Pn). Div. 3NO represents a fully offshore area, and there is no distinction between inshore and offshore areas in Div. 2J (Fig. 1 and 3). More data are available in most divisions for offshore than for inshore areas. Trawl survey data are used only for offshore areas because these surveys have not consistently extended into inshore areas. Observer coverage and sampling has also been more extensive in offshore than inshore areas. Also, vessel monitoring devices are used only on offshore vessels.

Fall trawl surveys (post-fishery surveys with respect to snow crab) provide an index of the exploitable biomass (older-shelled adults of legal size) that is expected to be available for the fishery in the following year for Div. 2J3KLNO. This index, based on offshore survey strata, is used together with offshore commercial CPUE to evaluate trends in the exploitable biomass.

Inshore commercial CPUE is compared with catch rates from inshore DFO trap surveys, where available. These indices are also compared with inshore and offshore biomass indices (catch rate of legal-sized crabs) from a limited (4-year) time series of industry-DFO collaborative post-season trap surveys.

Fall trawl surveys also provide data on adolescents larger than 75 mm that are used to calculate an index of pre-recruit males that would begin to recruit to the fishery 2 years later, as older-shelled adults. This index has previously been compared to observer-based catch rates (kg/trap haul) of total crabs caught and released (discarded) as soft-shelled or sub-legal sized ('undersized') crabs. However, this observer-based index has been discontinued because recent changes to earlier fishing seasons have resulted in reduced catches of soft-shelled crabs. Recruitment is also inferred from collaborative trap survey catch rates of new-shelled legal-sized crabs as well as undersized crabs.

Exploitable biomass and pre-recruit indices were calculated for offshore Subdiv. 3Ps based on spring trawl surveys. The spring survey is conducted in April and so is considered a pre-season survey.

Fishery-induced mortality is a function of the proportion of the exploitable population that is harvested and the proportion of the pre-recruit population that dies as a result of being caught and released. Trends in exploitation rate are inferred from changes in the ratio of landings to the exploitable biomass index from the previous year's fall trawl survey. Trends in pre-recruit mortality are inferred from changes in the ratio of the estimated total catch of pre-recruits to the trawl survey pre-recruit biomass index of the previous fall. The total catch of pre-recruits is estimated as the ratio of observed discards to observed landings scaled to total landings.

The pre-recruit fishing mortality index reflects an unknown (but likely high) mortality on released pre-recruits. Pre-recruit mortality is reduced by increasing trap mesh size and soak time, as well as by careful handling and quick release of pre-recruits.

The percentage discarded by weight of the total catch, as estimated from observer data, is interpreted as an index of wastage of pre-recruits. Mortalities on pre-recruits, including wastage, will impact short-term (about 1-3 years) recruitment. Also, mortality on small (<95 mm CW) males may adversely affect insemination of females, especially when abundance of larger males is low.

## Overall Resource Status, Divisions 2J3KLNO

The fall trawl surveys in Div. 2J3KLNO indicate a decline in **exploitable biomass** from 1998-2003 (Fig. 4). The fall survey indices and commercial **CPUE** agree that the exploitable biomass has recently increased in the north (Div. 2J3K) but continued to decline in the south. The more limited time series from spring trawl surveys in Div. 3LNOPs also indicated an early decline in exploitable biomass, from 1999-2004 (Fig. 4). This survey also showed an increase in exploitable biomass and abundance indices in 2007. However these recent increases in 2007 spring indices were limited to Div. 3L and were not supported by subsequent changes in commercial CPUE or fall trawl survey indices for that division.

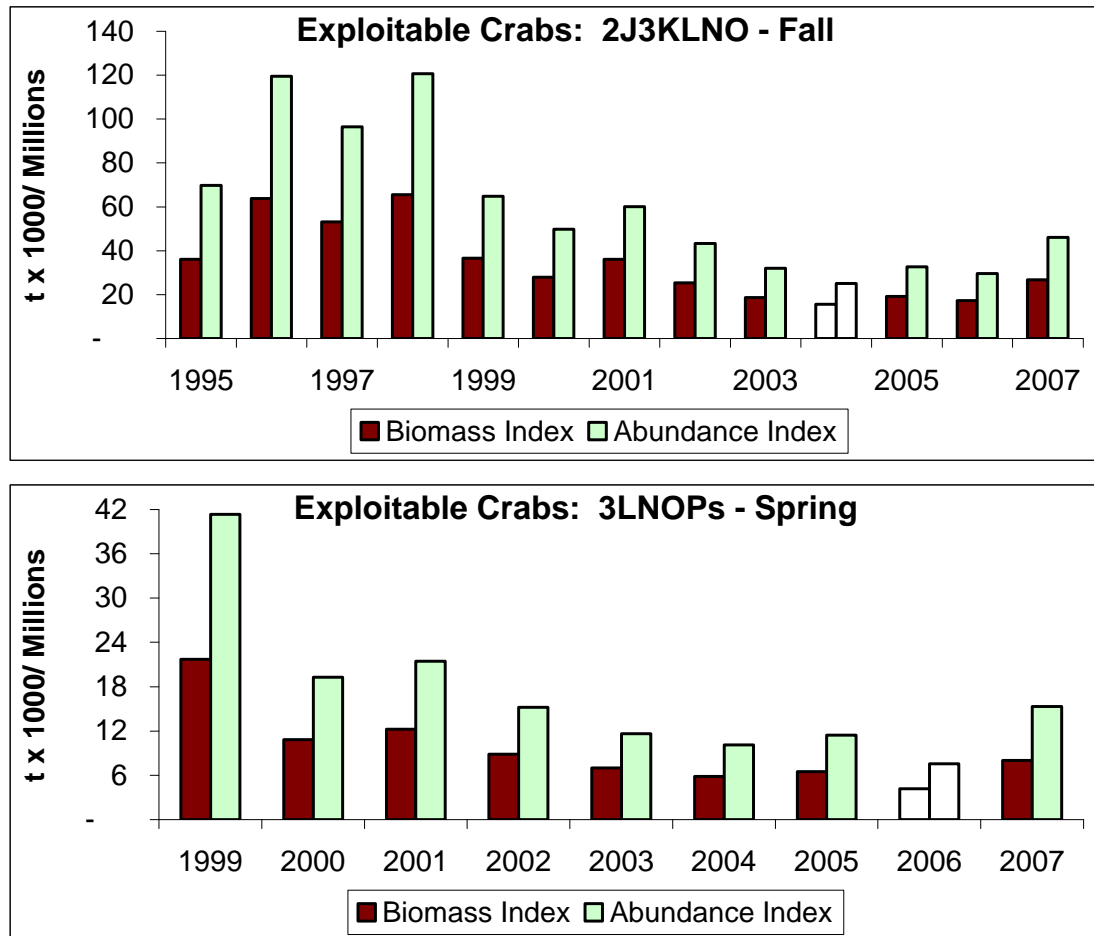


Figure 4: Trends in the trawl survey exploitable biomass and abundance indices, for Div. 2J3KLNO during fall (above) and for Div. 3LNOPs during spring (below). Surveys were incomplete in fall 2004 and spring 2006.

**Recruitment** has increased overall since 2005 due to increases in the north. Prospects remain promising overall (Fig. 5) and have improved in the south.

Longer-term recruitment prospects are uncertain but the spring and fall surveys indicate that there has been a decline in abundance indices of smallest males across all areas in recent years that may indicate reduced biomass in the long term. The persistence of a warm oceanographic regime (Colbourne *et al.*, 2008) implies poor prospects relative to the strong recruitment of the late 1990's (Dawe *et al.*, 2005).

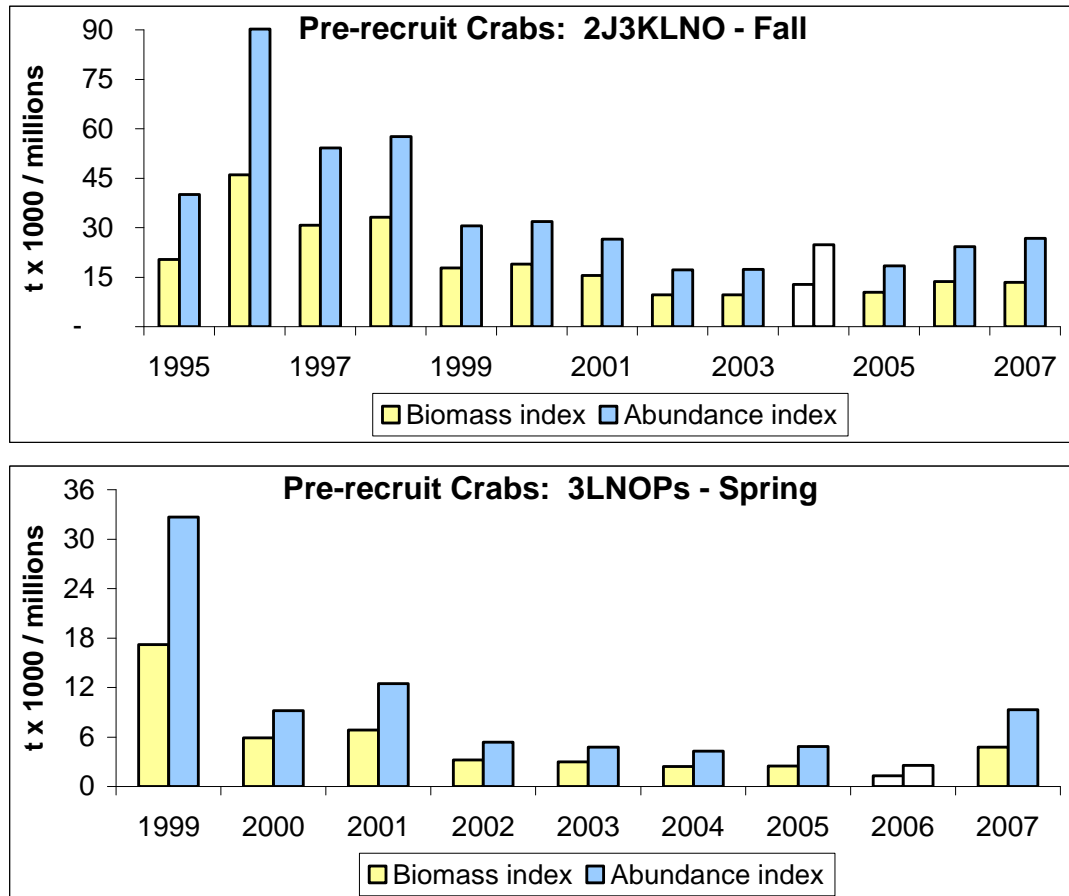


Figure 5: Trends in the trawl survey pre-recruit biomass and abundance indices for Div. 2J3KLNO during fall (above) and for Div. 3LNOPs during spring (below). Surveys were incomplete in fall 2004 and spring 2006.

## Resource Status, Division 2J

### Commercial Fishery

**Landings** (Fig. 6) peaked in 1999 at 5400 t, decreased sharply to 3700 t in 2000 and changed little to 2002. They declined from 2002-2005 and then increased by 53% to 2330 t in 2007. **Effort** increased to a record high level in 2002-2004. It declined by more than half from 2004-2006 before increasing by 12% in 2007.

The 2007 fishery was concentrated in Hawke and Cartwright channels, similar to 2006. In 2006-2007 there was no fishery on the slope as there was in 2002-2005.

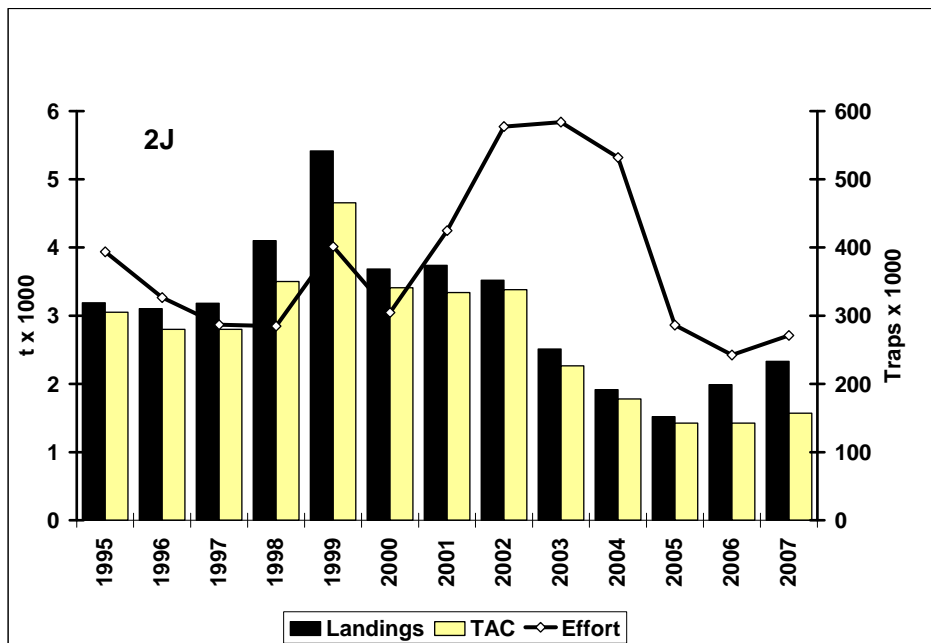


Figure 6: Trends in TAC, landings, and fishing effort in Div. 2J.

Commercial CPUE (Fig. 7) indicates that fishery performance has improved since 2004. The fishing season has occurred relatively early in recent years, especially in 2005 and 2006. It began later in 2007 due to unfavorable ice conditions.

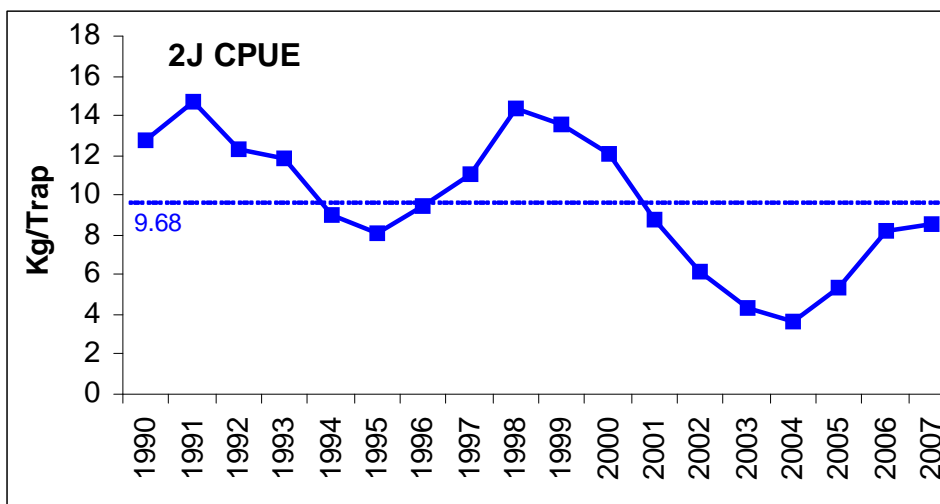


Figure 7: Trends in Div. 2J commercial CPUE in relation to the long-term average (dotted line).

**Biomass**

The exploitable biomass has increased in recent years. The fall survey **exploitable biomass index** (Fig. 8) has increased over the past five years but remains below levels observed prior to 2002. It had previously decreased steadily, by 94%, from 1998-2002. Commercial catch rate (**CPUE**) has oscillated over the time series (Fig. 7), initially decreasing from 1991-1995, and increasing to peak in 1998. It declined steadily by 76% from 1998 to a record low level in 2004 before increasing to about the long-term average in 2007.

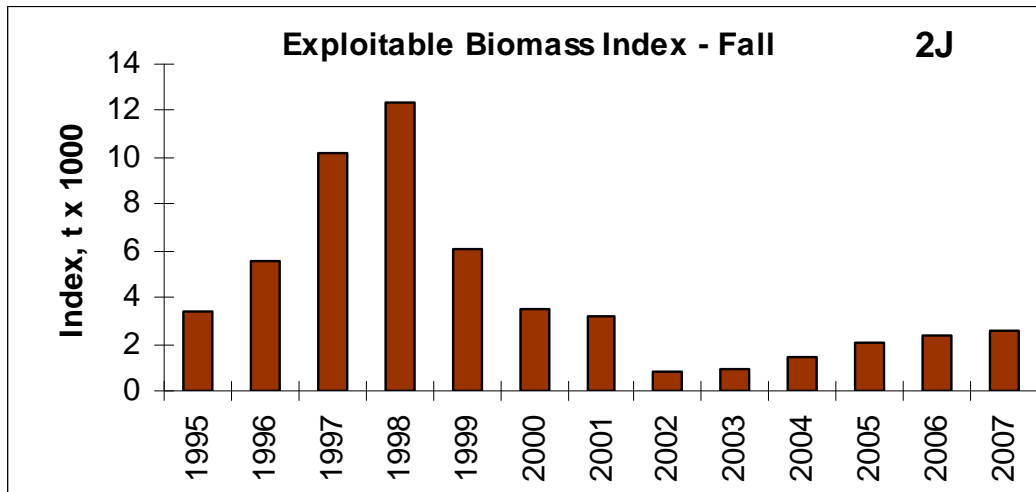


Figure 8: Trends in the Div. 2J fall trawl survey exploitable biomass index.

### Recruitment

**Recruitment** has increased recently, as reflected by the increase in exploitable biomass while landings increased (Fig. 6). Also, the fall trawl survey biomass index of new-shelled legal-sized crab (i.e. recruitment) has increased since 2002.

The fall survey **pre-recruit index** decreased from 1998 to a lower level during 1999-2003 (Fig. 9) before increasing sharply to peak in 2004. It then decreased in 2005, was unchanged in 2006 and decreased further in 2007. Therefore, **recruitment** is expected to decrease in the next several years.

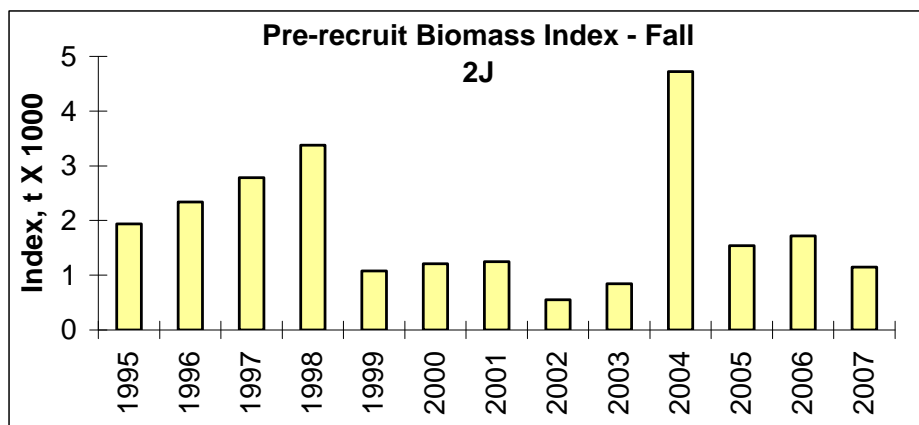


Figure 9: Trends in the Div. 2J fall trawl survey pre-recruit biomass index.

### Mortality

The percentage of the total catch discarded (Fig. 10) increased sharply in 2002, was unchanged in 2003, and further increased to a record high level in 2004. It declined sharply over the next two years to the pre-2002 level, and changed little in 2007, implying reduced wastage of under-sized and new-shelled pre-recruits in the fishery.

The **pre-recruit fishing mortality index** (Fig. 10) increased sharply from 2001 to 2003,

decreased sharply from 2003-2005, and has changed little since to remain at a very low level in 2007.

The **exploitation rate index** (Fig. 10) increased sharply from 2000 to 2003, decreased sharply from 2003-2005, and has changed little since.

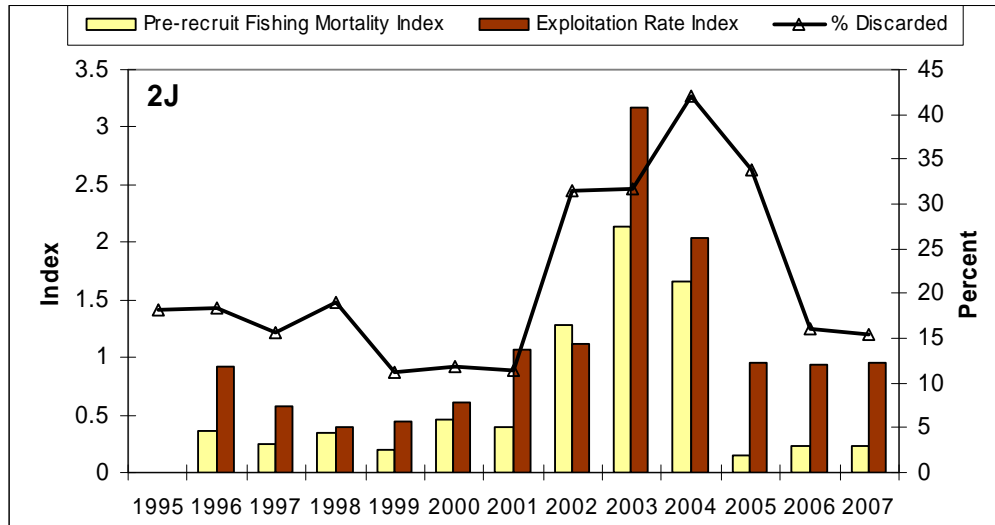


Figure 10: Trends in two Div. 2J mortality indices (the exploitation rate index and the pre-recruit fishing mortality index) and in the percentage of the catch discarded in the fishery.

Fishery and trawl survey data suggest that the **exploitable biomass** remains highly dependent upon immediate recruitment. Maintaining the current level of fishery removals would not likely result in any increase in the exploitation rate in 2008. An increase in fishery removals would likely accelerate an expected decline in the exploitable biomass in the near future.

## Resource Status, Division 3K

### Commercial Fishery

Offshore **landings** have generally been higher than inshore landings by a factor of 3-5 (Fig. 11). **Offshore landings** peaked in 1999 at 17,900 t. They decreased to about 13,000 t in 2000-2004, due to reduction in TAC. **Landings** decreased sharply in 2005 when the TAC was not fully subscribed because the fishery was closed prematurely due to high levels of soft-shelled crabs in the catch. Landings then increased by 55% to 9450 t in 2007. **Effort** increased sharply in 2004, decreased sharply in 2005, and further declined by 28% to 2007. The spatial distribution of fishing effort has changed in recent years. For example there was a decline in effort in the St. Anthony Basin since 2004.

**Inshore landings** (Fig. 11) peaked in 1999 at 3460 t and decreased sharply in 2000 due to TAC reduction. They increased to 3340 t in 2003 and changed little in 2004. **Landings** decreased by 21% in 2005 and then increased by 9% to 2820 t in 2007 while **effort** declined by 47%. There has been no clear change in spatial distribution of inshore fishing effort in recent years.

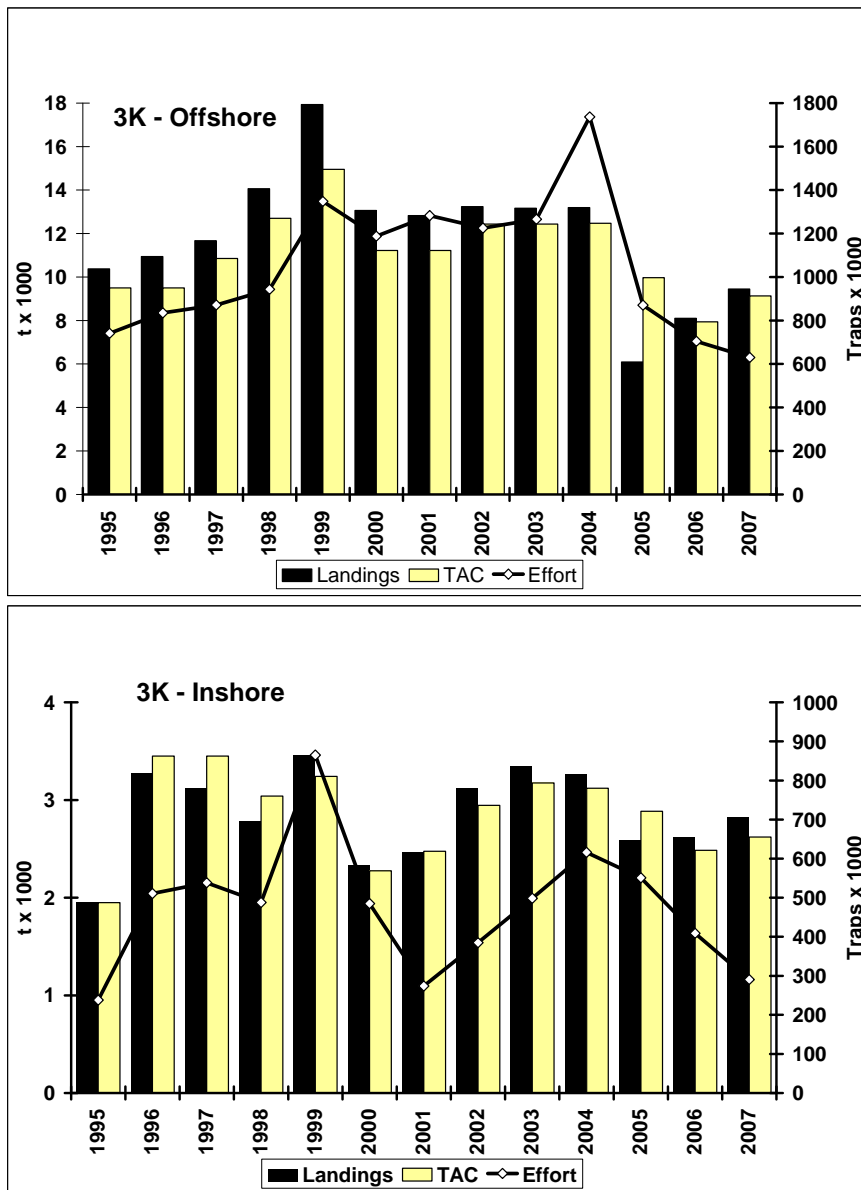


Figure 11: Trends in TAC, landings, and fishing effort in Div. 3K offshore (above) and inshore (below).

**Commercial CPUE** (Fig. 12) indicates that fishery performance has improved substantially in both inshore and offshore areas since 2004. Inshore CPUE has been consistently lower than offshore CPUE.

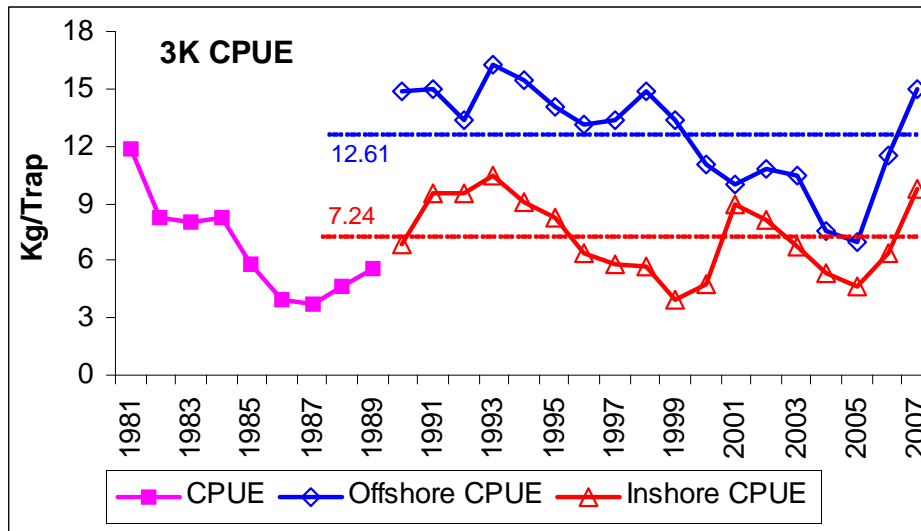


Figure 12: Trends in Div. 3K inshore and offshore commercial CPUE in relation to their long-term averages (dotted lines).

Division 3K Offshore

Biomass

The exploitable **biomass** has increased substantially over the past two years. The fall survey **exploitable biomass index** (Fig. 13) has increased steadily since 2003 to its highest level since 1998. It had previously decreased from its highest level by almost half in 1999 and changed little until it decreased again from 2001 to its lowest level in 2003. **CPUE** increased sharply from 2005-2007 to approach the highest level previously observed (Fig. 12), following a decline to its lowest level in 2005. Collaborative trap survey catch rates varied without trend during 2004-2007.

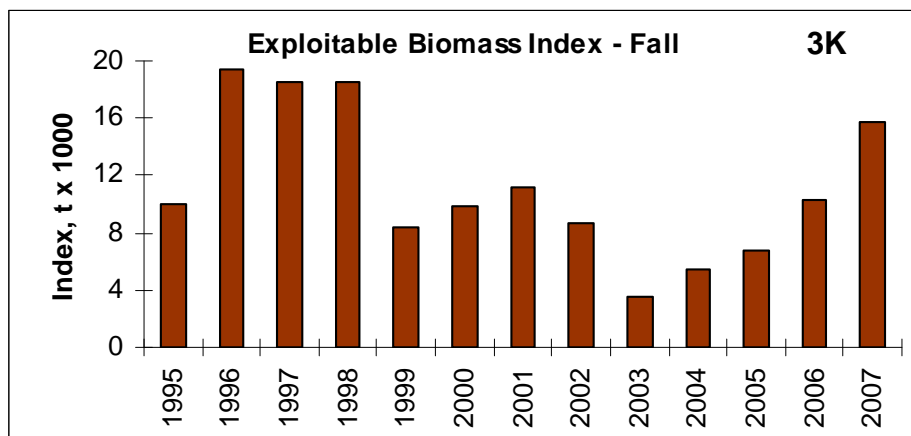


Figure 13: Trends in the offshore Div. 3K fall trawl survey exploitable biomass index.



## Recruitment

**Recruitment** has increased in recent years, as reflected by the substantial increase in exploitable biomass while landings increased. The fall trawl survey biomass index of new-shelled legal-sized crab had increased sharply during 2005-2006 and remained high in 2007.

The fall survey **pre-recruit index** declined from 1997 to a lower level during 1999-2002 (Fig. 14). It then increased to peak in 2006 and decreased sharply in 2007.

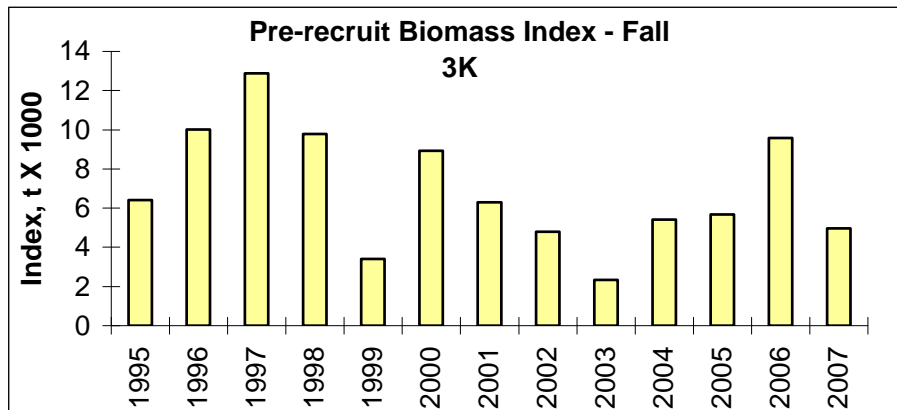


Figure 14: Trends in the offshore Div. 3K fall trawl survey pre-recruit biomass index.

**Recruitment** remains promising for the next several years although it may decrease slightly in the next 1-2 years. A group of small adolescents has been apparent in the fall trawl survey size distributions during the past two years that achieved a modal size of about 65 mm CW in 2007. These adolescents are expected to begin to recruit to the exploitable biomass in about three years.

## Mortality

The percentage of the total catch discarded in the fishery (Fig. 15) increased from 2002 to about 40% in 2005, reflecting increased wastage of under-sized and new-shelled pre-recruits. The high wastage in 2005 is consistent with a high incidence of soft-shelled pre-recruits in the catch, which resulted in a premature closure of the fishery and failure to achieve the TAC. The percentage discarded decreased sharply in 2006 to its lowest level and was unchanged in 2007 (Fig. 15). This implies greatly reduced wastage of pre-recruits in the fishery during 2006 and 2007.

The **pre-recruit fishing mortality index** (Fig. 15) declined sharply in 2006 and was at its lowest level in 2007.

The **exploitation rate index** (Fig. 15) has changed little in the past 3 years at about the long-term average.

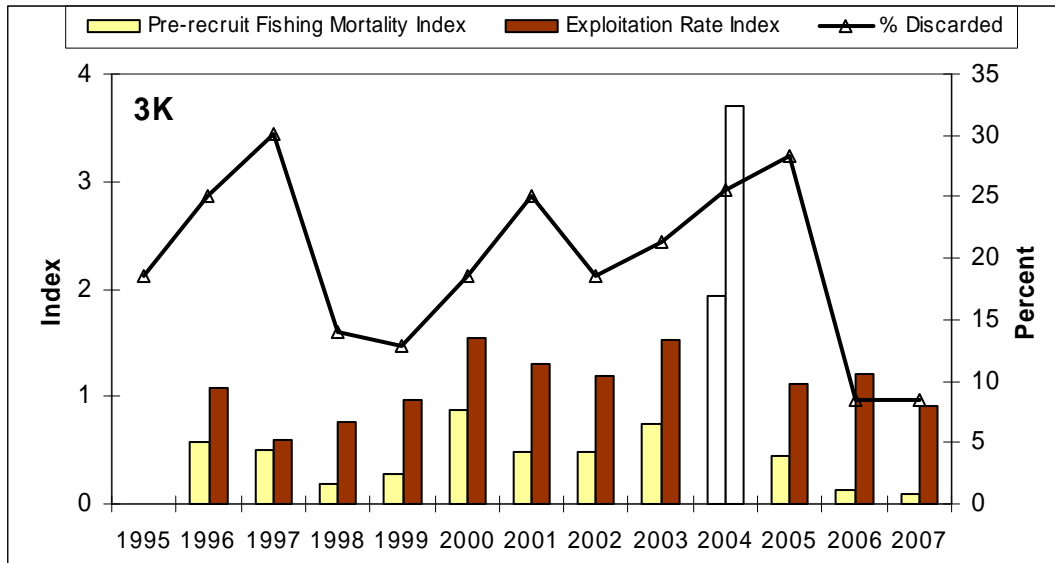


Figure 15: Trends in two offshore Div. 3K mortality indices (the exploitation rate index and the pre-recruit fishing mortality index) and in the percentage of the catch discarded in the fishery. High mortality indices in 2004 are due to low catchability in 2003 that resulted in low biomass indices.

The catch rate of older-shelled crabs increased sharply in 2007, indicating that the **exploitable biomass** has become less dependent upon immediate recruitment. Fishery removals could likely be increased in 2008 without increasing the exploitation rate.

Division 3K Inshore

Biomass

The exploitable **biomass** has recently increased. **CPUE** increased sharply from 2005-2007 to approach the highest level previously observed (Fig. 12), following a decline during 2002-2005. Collaborative trap survey catch rates increased slightly from 2004-2006 and were unchanged in 2007 (Fig. 16).

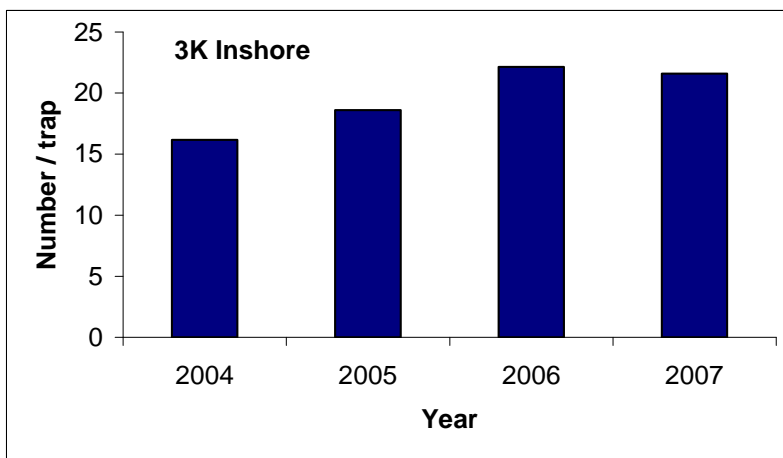


Figure 16: Catch rates of legal-sized crabs from the industry-DFO collaborative post-season trap survey in inshore Div. 3K.

Post-season trap surveys (collaborative and DFO) show that catch rates of older-shelled legal-sized crabs have increased since 2004.

### Recruitment

**Recruitment** has increased in recent years, as reflected by the recent increase in exploitable biomass while landings increased slightly. Collaborative trap survey catch rates of new-shelled legal-sized crab have increased in the past two years.

Recruitment remains promising for the next several years although it may decrease slightly in the next 1-2 years. A group of small adolescents has been apparent in localized DFO inshore trap survey size distributions, from small-meshed traps, during the past three years that achieved a modal size of about 60 mm CW during 2007. These adolescents are expected to begin to recruit to the exploitable biomass in about 3-4 years.

### Mortality

The percentage of the catch discarded declined sharply in 2006 and 2007 to its lowest level (Fig. 17) implying a low level of wastage in the fishery in 2007.

Data are insufficient to estimate fishery-induced **mortality** indices because the fall trawl survey is not consistently conducted in inshore areas and so an exploitable biomass index is not calculated. However it has been concluded that the exploitable biomass has recently increased based on trends in CPUE in relation to landings and trap survey catch rates.

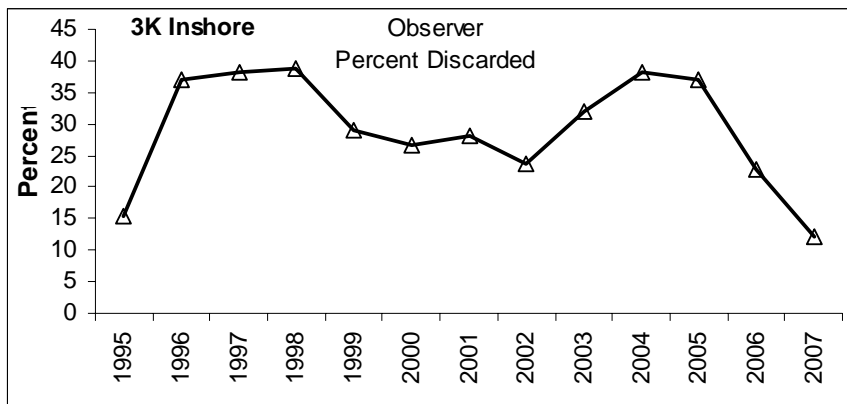


Figure 17: Percentage of the catch discarded in the inshore Div. 3K fishery from observer data.

Therefore, maintaining the current level of fishery removals would not likely result in an increase in the exploitation rate.

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## **Resource Status, Division 3L**

### Commercial Fishery

Offshore **landings** have generally been higher than inshore landings by about a factor of 3 in recent years (Fig. 18). **Offshore landings** (Fig. 18) peaked at 20,800 t in 1999 and decreased to about 17,900 t in 2000 and 2001 due to a reduction in TAC. **Landings** have increased since 2001 and reached their highest level in 2007 at 21,000 t - a 17% increase since 2001. **Effort** increased steadily since 2000 to its highest level in 2007. The spatial distribution of fishing effort has changed in recent years. For example there has been a decrease in effort within the Bonavista Corridor since 2004.

**Inshore landings** (Fig. 18) peaked in 1996 at 7900 t. They declined to 4700 t in 2000, increased to 6800 t in 2003, and decreased slightly to 6400 t in 2004 due to changes in TAC. **Landings** changed little between 2004 and 2007 (6490 t), while effort declined by 27%. There has been no change in spatial distribution of inshore fishing effort in recent years.

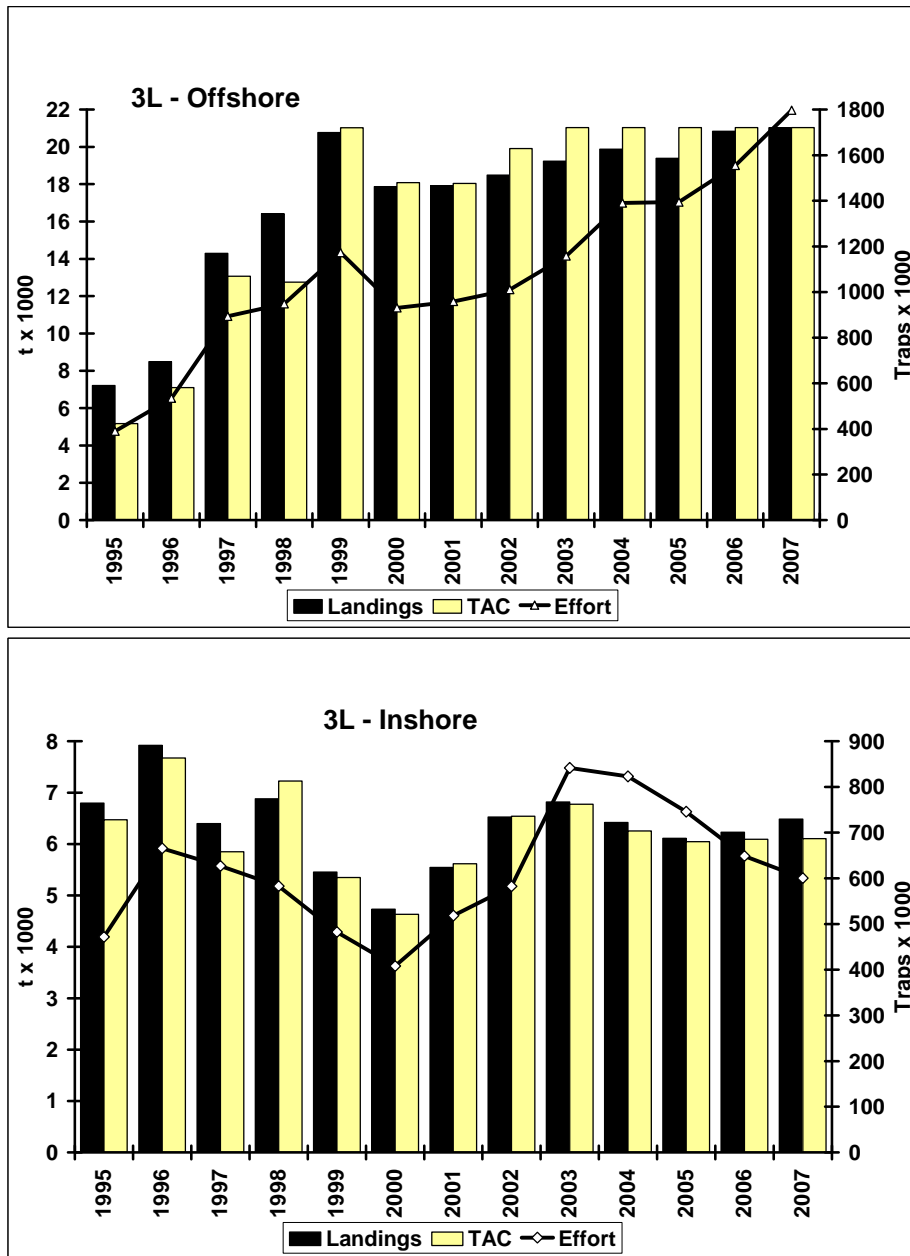


Figure 18: Trends in TAC, landings, and fishing effort in Div. 3L offshore (above) and inshore (below).

**Commercial CPUE** (Fig. 19) indicates that fishery performance has deteriorated offshore but improved inshore over recent years. Inshore CPUE has historically been lower than offshore CPUE, but there was little difference in 2007.

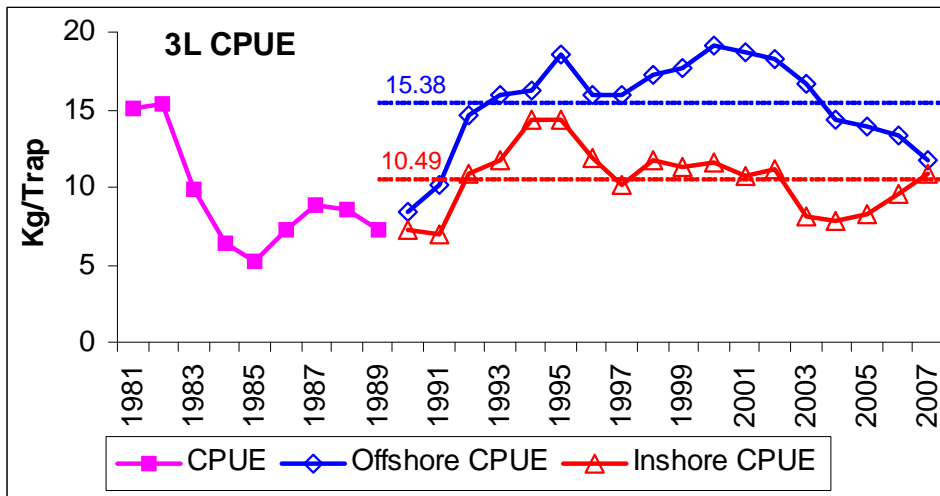


Figure 19: Trends in Div. 3L inshore and offshore commercial CPUE in relation to their long-term averages (dotted lines).

Division 3L Offshore

Biomass

The **exploitable biomass** has declined in recent years. The fall survey **exploitable biomass index** (Fig. 20) declined from 1996-2000 and remained at that lower level until it further decreased to its lowest level in 2006. It increased from 2006-2007 but remained low relative to previous years.

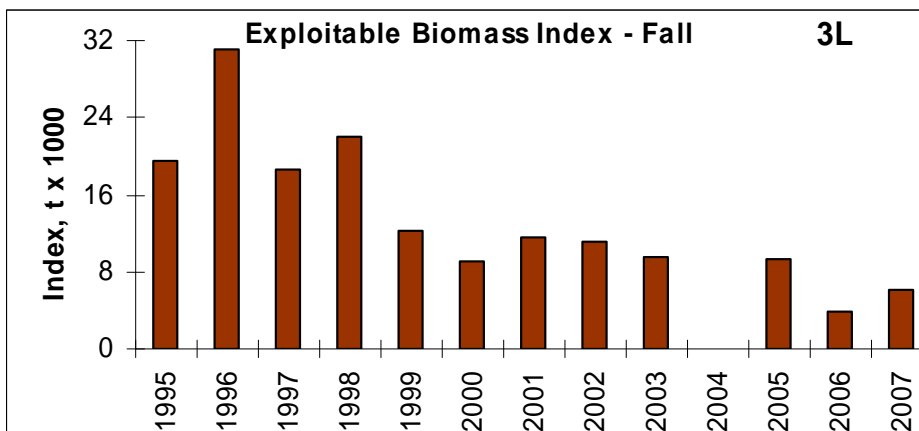


Figure 20: Trends in the offshore Div. 3L fall trawl survey exploitable biomass index; the survey was incomplete in 2004.

Commercial **CPUE** (Fig. 19) declined steadily since 2000 to the lowest level since 1991. The collaborative trap survey catch rates also declined over 2004-2007 (Fig. 21).

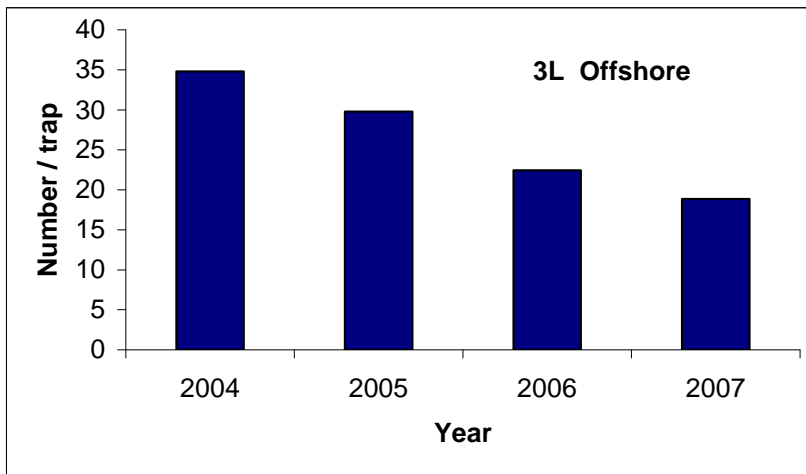


Figure 21: Catch rates of legal-sized crabs from the industry-DFO collaborative post-season trap survey in offshore Div. 3L.

Recruitment

**Recruitment** has remained relatively low in recent years, as reflected by the decline in exploitable biomass while landings increased slightly (Fig. 18). The fall survey biomass index of new-shelled legal-sized crabs has remained low following a decline during 1996-1999. The survey pre-recruit index had declined from 1996-2002 and remained low to 2006 (Fig. 22).

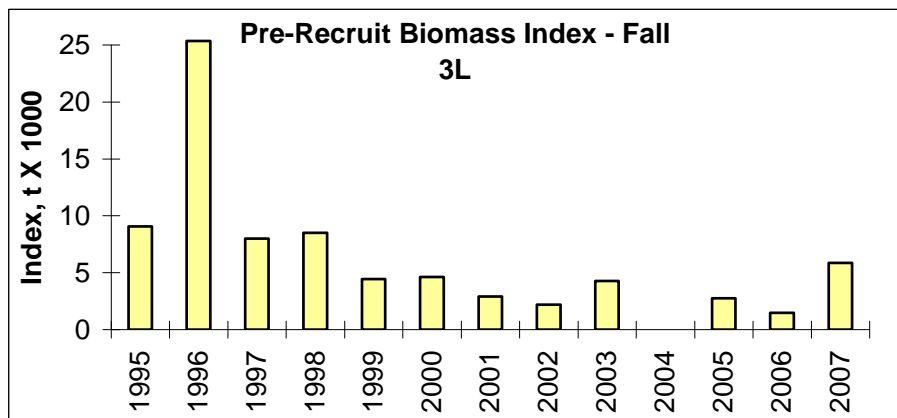


Figure 22: Trends in the offshore Div. 3L fall trawl survey pre-recruit biomass index.

**Recruitment** is expected to increase over the next several years. The fall trawl survey pre-recruit index increased in 2007 to its highest level since 1998 (Fig. 22). This reflects the presence of a group of small adolescents in the trawl survey size distributions in recent years that achieved a modal size of about 80 mm CW in 2007. These adolescents are expected to begin to recruit to the exploitable biomass in the immediate future.

Mortality

The percentage of the total catch discarded in the fishery (Fig. 23) increased from 1995-1997 and decreased sharply in 1998. It then declined gradually until 2002, and changed little since, implying relatively little wastage of under-sized and new-shelled pre-recruits in the fishery in recent years.

The **pre-recruit fishing mortality index** (Fig. 23) increased gradually to 2001, doubled to 2003, and was lower in 2004 and 2006. The **exploitation rate index** (Fig. 23) increased from 1996 to 2001 and changed little to 2006. Both indices increased to very high levels in 2007. These sharp increases in 2007 were due to decreases in the survey exploitable biomass index (Fig. 20) and pre-recruit biomass index (Fig. 22) in 2006.

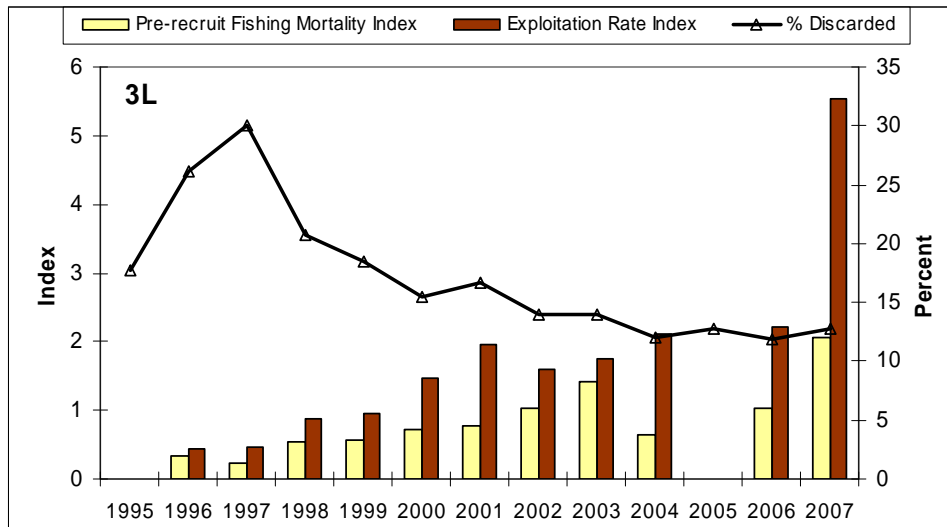


Figure 23: Trends in two offshore Div. 3L mortality indices (the exploitation rate index and the pre-recruit fishing mortality index) and in the percentage of the catch discarded in the fishery. Mortality indices were not calculated for 2005 because the survey was incomplete in 2004.

Increased removals, under the present scenario of reduced biomass and imminent recruitment increase, could result in increased mortality on soft-shelled immediate pre-recruits.

### Div. 3L Inshore

#### Biomass

The exploitable **biomass** has recently increased. **CPUE** increased by 39% from 2004 to 2007 (Fig. 19), after decreasing from 2002-2004. Collaborative trap survey catch rates increased slightly from 2004-2006 and were unchanged in 2007 (Fig. 24).



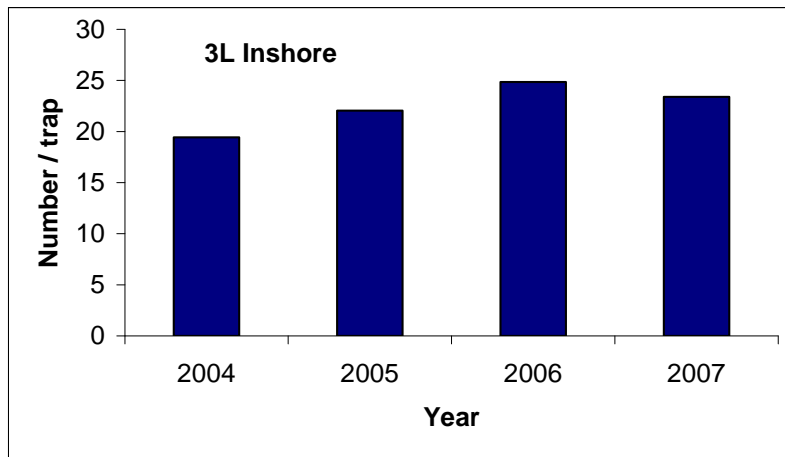


Figure 24: Catch rates of legal-sized crabs from the industry-DFO collaborative post-season trap survey in inshore Div. 3L.

Recruitment

**Recruitment** has increased in recent years, as reflected by the increase in exploitable biomass while landings changed little. Localized DFO trap surveys in two bays indicate that catch rates of new-shelled legal-sized crabs have increased since 2004 and remain high, whereas collaborative trap survey catch rates show no trend since 2004.

Recruitment prospects are uncertain. The trap survey data show no recent change in catch rates of sub-legal sized crabs.

Mortality

The percentage of the total catch discarded in the fishery (Fig. 25) increased from 1995-1997 and decreased sharply in 1998. It remained unchanged until it increased in 2005, and then declined to 16% in 2007, the lowest level since 1995. This implies relatively little wastage of under-sized and new-shelled pre-recruits in the 2007 fishery.

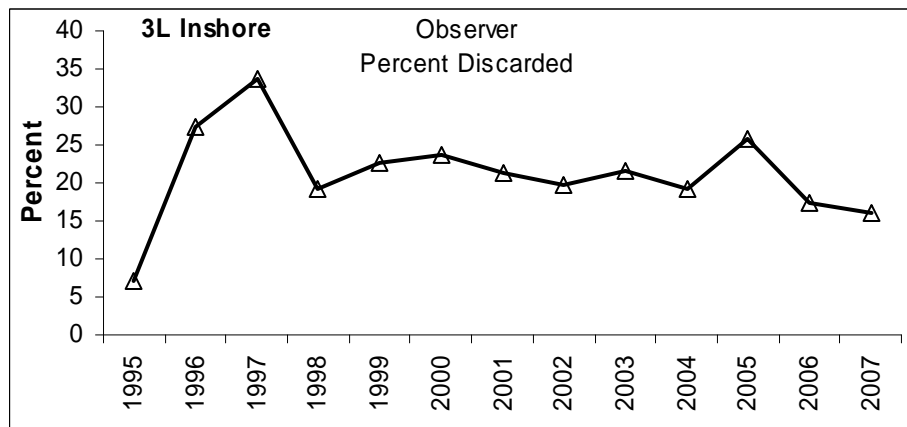


Figure 25: Percentage of the catch discarded in the inshore Div. 3L fishery from observer data.

Data are insufficient to estimate fishery-induced **mortality** indices because no fall trawl survey exploitable biomass index is available. However it has been concluded that the exploitable biomass has recently increased. Trap survey catch rates of older-shelled crabs

have generally increased since 2004, indicating that the fishery has recently become less dependent upon immediate recruitment.

Maintaining the current level of fishery removals would not likely result in an appreciable change in the exploitation rate in 2008.

## Resource Status, Divisions 3NO

### Commercial Fishery

The fishery has been concentrated along the shelf edge, mostly in Div. 3N. Landings do not reflect (and have consistently exceeded) TACs because not all fishing has been regulated by TAC. **Landings** declined by about 28% since 2004 to 3380 t in 2007 (Fig. 26). **Effort** declined by 23% from 2004-2006 and increased by 16% in 2007.

The spatial distribution of fishing effort has changed in recent years. For example there has been a reduction of effort in Div. 3O since 2004 and an increase in effort along the southern 3N slope in 2007.

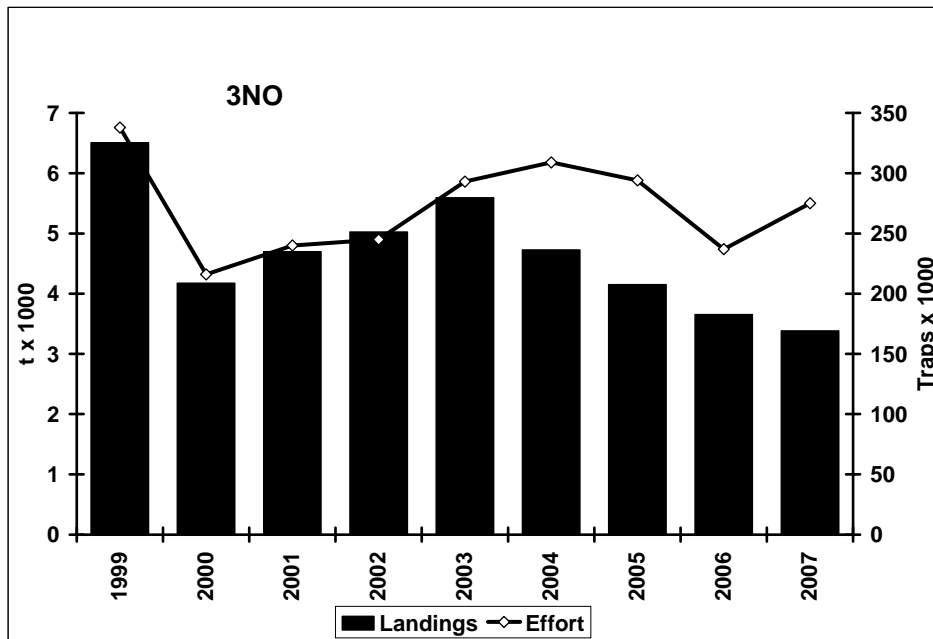


Figure 26: Trends in landings, and fishing effort in Div. 3NO.

Commercial CPUE (Fig. 27) indicates that fishery performance deteriorated in 2007.

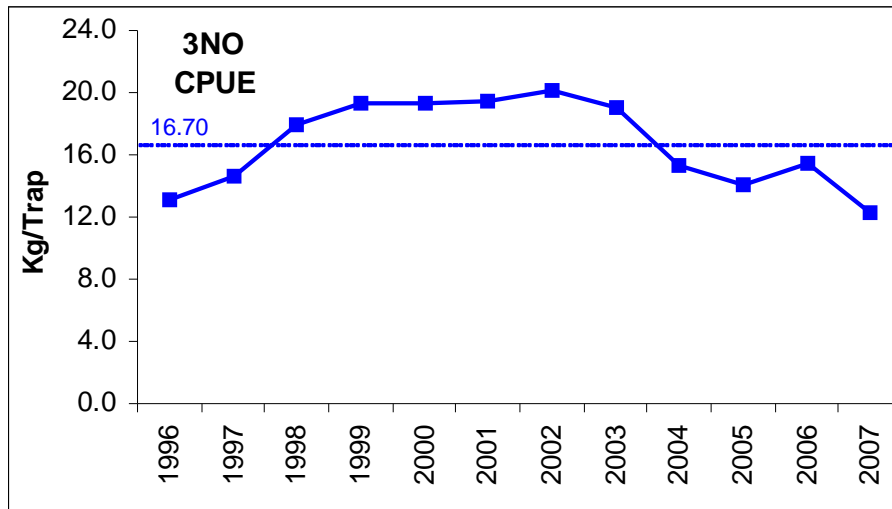


Figure 27: Trends in Div. 3NO commercial CPUE in relation to its long-term average (dotted line).

### Biomass

Trends in **biomass** are uncertain. Survey indices are unreliable because of a limited spatial distribution of the resource within these divisions that is poorly sampled by the multi-species survey. **CPUE** (Fig. 27) changed little during 2004-2006 before decreasing in 2007.

### Recruitment

Recent **recruitment** and future prospects are uncertain.

### Mortality

The percentage of the total catch discarded in the fishery (Fig. 28) declined by more than half from 1999-2002. It has remained steady during the last 6 years at a low level, implying little wastage of pre-recruits in the fishery in recent years.

The **exploitation rate index** and **pre-recruit fishing mortality index** are not informative because of uncertainties associated with the survey biomass indices. Trends in fishery-induced mortality are unknown.

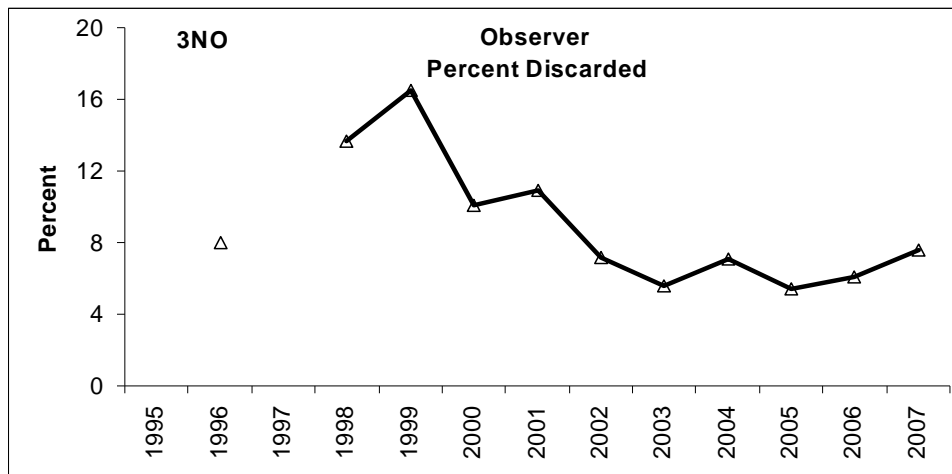


Figure 28: Trends in the percentage of the catch discarded in the Div. 3NO fishery.

The effects of maintaining the current catch level on the fishery-induced **mortality** rate are unknown.

## Resource Status, Subdivision 3Ps

### Commercial Fishery

**Landings** (Fig. 29) from offshore areas have been about twice as high as those from inshore areas in recent years. Landings from both inshore and offshore were at their highest level during 1999-2002. **Offshore landings** increased by 21% to 2800 t in 2007, following a 47% decline from 2002-2006. **Effort** increased by 16% in 2007, following a 32% decrease from 2003-2006. The spatial distribution of fishing effort changed little in recent years but there was virtually no fishery on the south-west slope of St. Pierre bank during 2005-2007 as there was in 2002-2004.

**Inshore landings** (Fig. 29) declined by 79% to their lowest level from 2002-2005 and have since increased by 63% to 1150 t in 2007. **Effort** decreased by about half from 2003-2005 and changed little since. The distribution of fishing effort between Fortune and Placentia Bays varied among years.

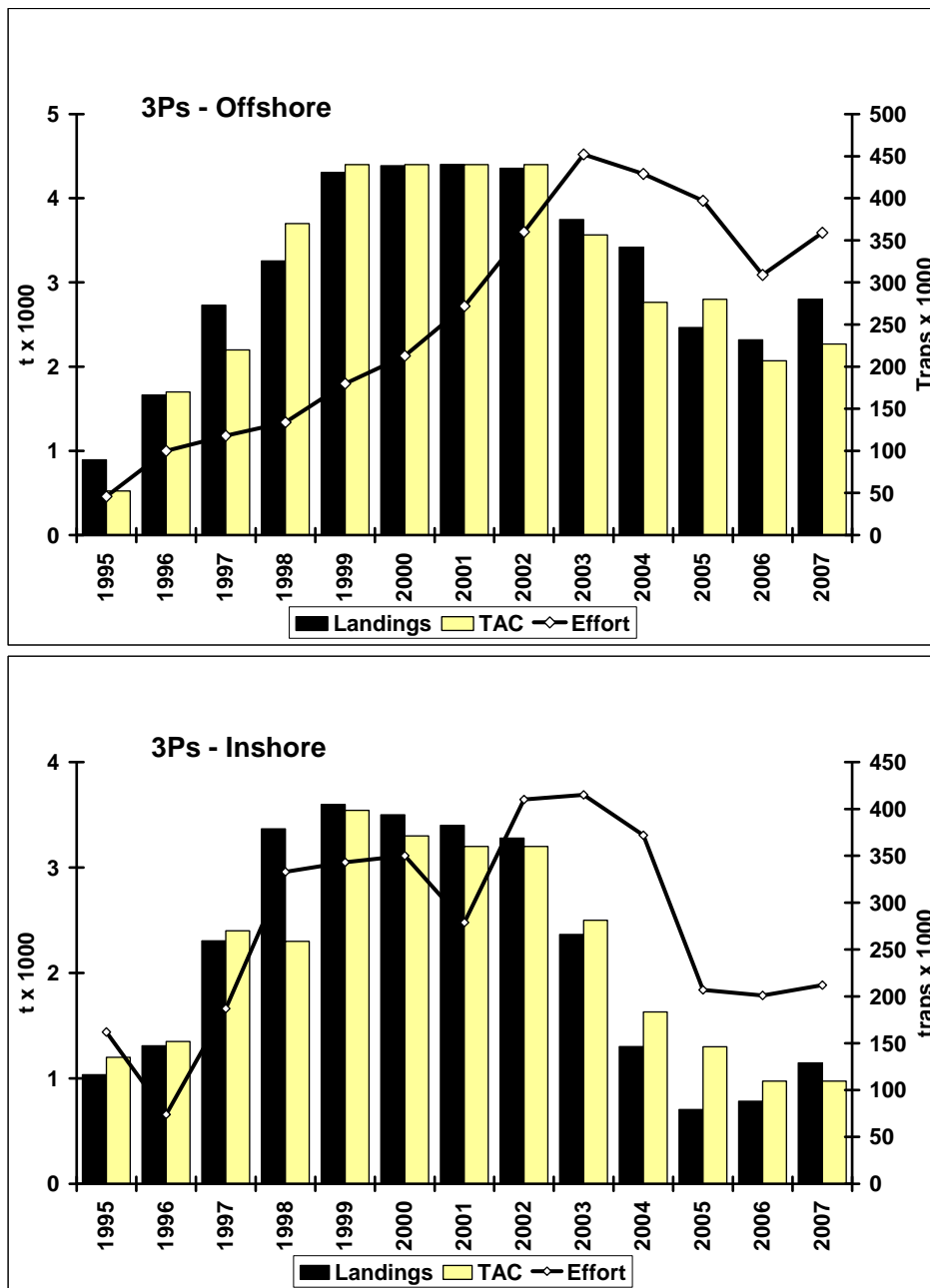


Figure 29: Trends in TAC, landings, and fishing effort in Subdiv. 3Ps offshore (above) and inshore (below).

CPUE trends (Fig. 30) indicate that fishery performance has changed little over the past four years offshore whereas it has improved slightly inshore in the past two years. CPUE has consistently been higher offshore than inshore.

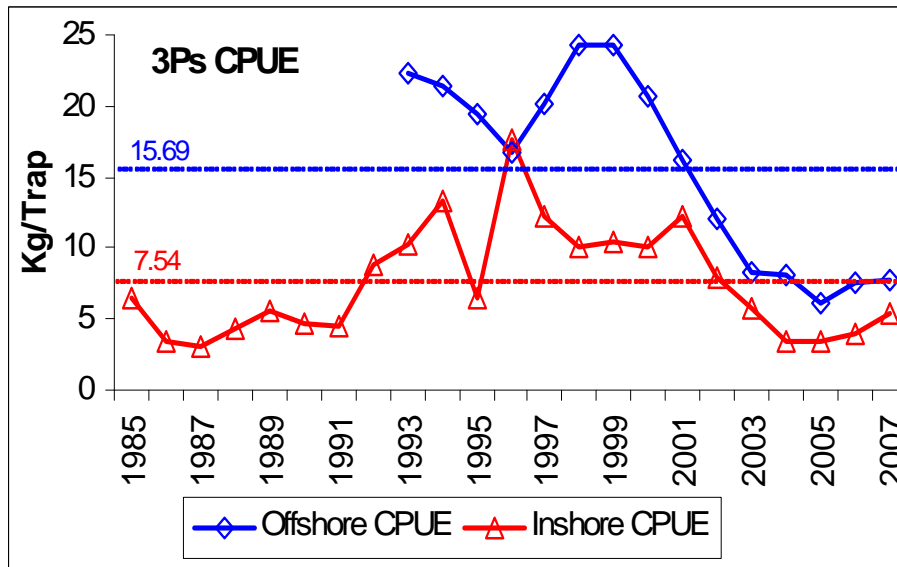


Figure 30: Trends in Subdiv. 3Ps inshore and offshore commercial CPUE in relation to their long-term averages (dotted lines).

Subdiv. 3Ps Offshore

Biomass

The exploitable **biomass** remains at a very low level. The spring survey **exploitable biomass index** declined from 1999-2001, and has since remained unchanged (Fig. 31). **CPUE** decreased steadily from 1999-2003 and has since remained at a low level (Fig. 30).

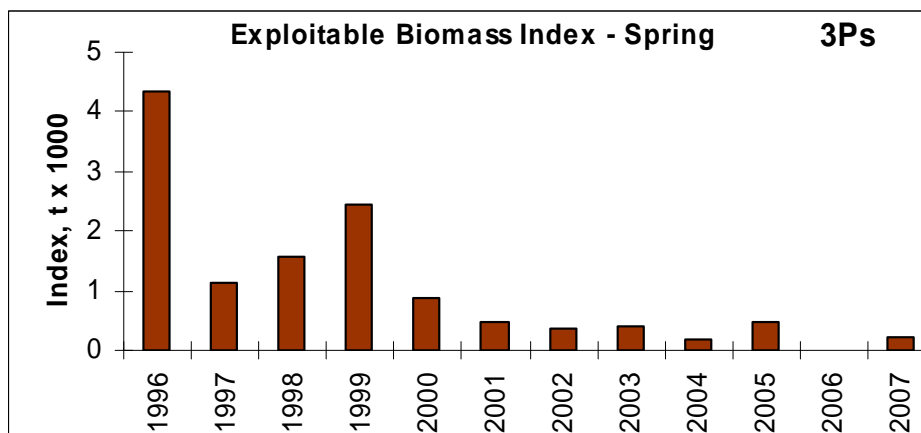


Figure 31: Trends in the offshore Subdiv. 3Ps spring trawl survey exploitable biomass index.

However the collaborative trap survey catch rates increased from 2004-2006 and were unchanged in 2007 (Fig. 32).

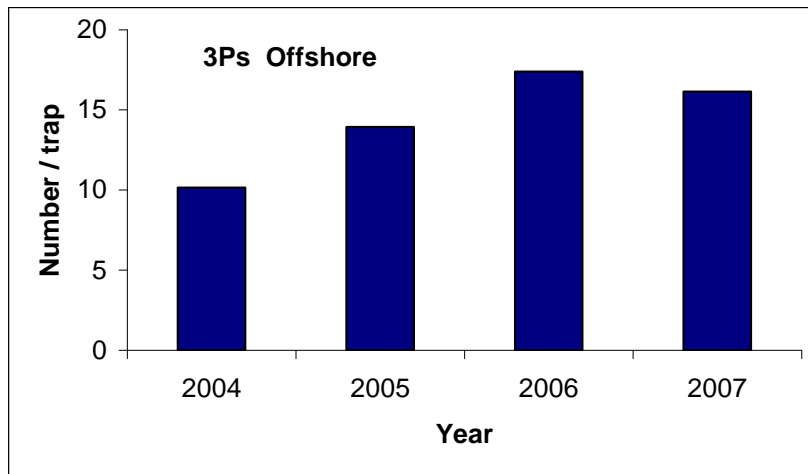


Figure 32: Catch rates of legal-sized crabs from the industry-DFO collaborative post-season trap survey in offshore Subdiv. 3Ps.

### Recruitment

**Recruitment** has been low in recent years, as reflected by the low exploitable biomass while landings remained relatively low following a decline (Fig. 29). The spring survey biomass index of new-shelled legal-sized crabs has remained low following a decline during 1996-2001.

**Recruitment** is expected to increase in the next several years. The spring multi-species survey pre-recruit index increased in 2007 to its highest level since 1996 (Fig. 33). This increase is related to a modal group of adolescents first observed in the spring trawl survey size distributions in 2005, which achieved a modal size of about 80 mm CW in 2007.

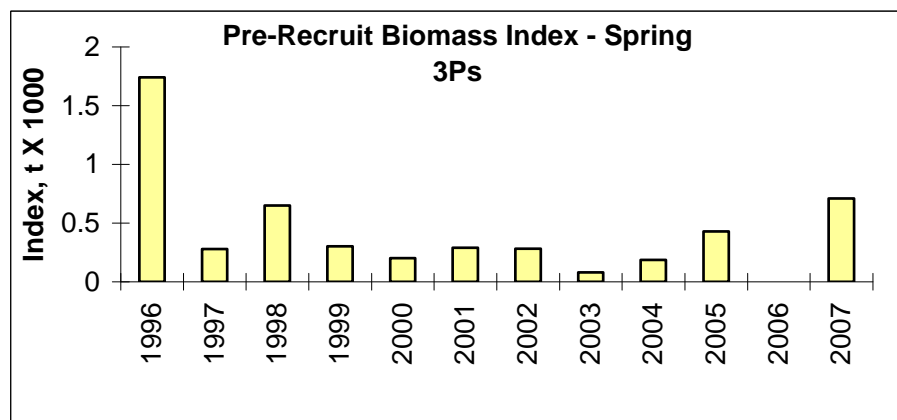


Figure 33: Trends in the offshore Subdiv. 3Ps spring trawl survey pre-recruit biomass index.

### Mortality

The percentage of the total catch discarded in the fishery (Fig. 34) almost doubled to about 45% in 2005 and declined but remained high in 2006 and 2007. This implies a high level of wastage of pre-recruits in recent years.

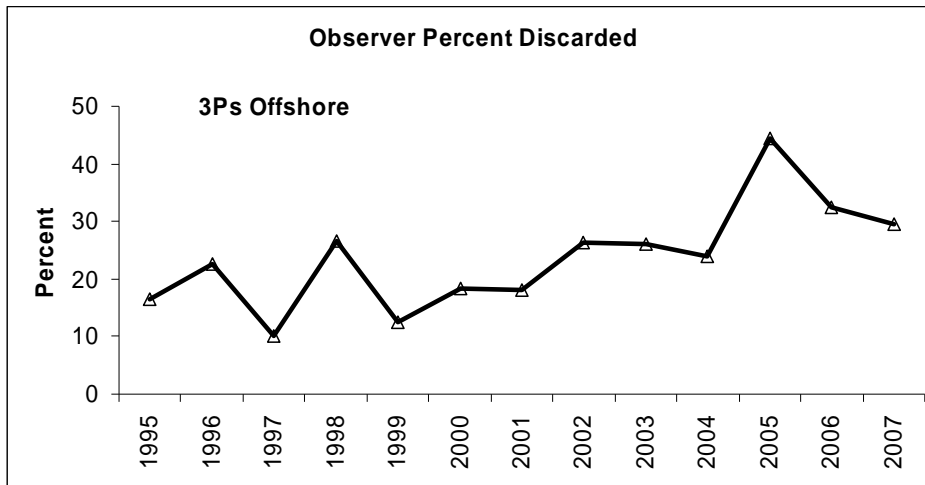


Figure 34: Trend in the percentage of the catch discarded in the offshore Subdiv. 3Ps fishery.

No **exploitation rate index** or **pre-recruit fishing mortality index** have been developed using spring trawl survey data.

Increased removals, under the present scenario of very low biomass and imminent recruitment increase, could result in increased mortality on soft-shelled immediate pre-recruits.

Subdiv. 3Ps Inshore

Biomass

The exploitable **biomass** remains low. **CPUE** declined from 2001 to its record low level in 2004-2005 before increasing slightly in 2006 and 2007 (Fig. 30). The collaborative trap survey catch rates increased slightly from 2004-2007 (Fig. 35).

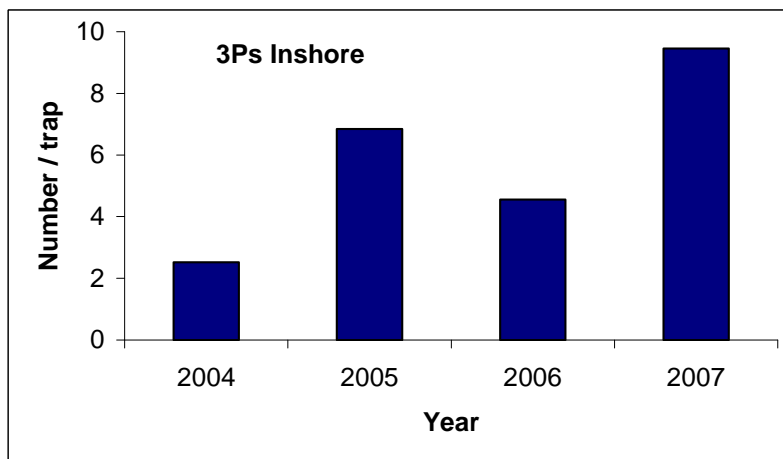


Figure 35: Catch rates of legal-sized crabs from the industry-DFO collaborative post-season trap survey in inshore Subdiv. 3Ps.



## Recruitment

**Recruitment** increased slightly in 2007, as reflected by the slight increase in CPUE (Fig. 30) while landings increased (Fig. 29), and by the slight increase in the collaborative trap survey catch rate of legal-sized crabs (Fig. 35).

**Recruitment** prospects remain positive in the short term. The trap survey catch rate of legal-sized new-shelled crabs and sub-legal-sized crabs has increased since 2004.

## Mortality

The percentage of the total catch discarded in the fishery (Fig. 36) was at its highest, about 60%, in 2005 and 2006. It decreased to remain high, at 47%, in 2007. This implies a high level of wastage of pre-recruits in recent years.

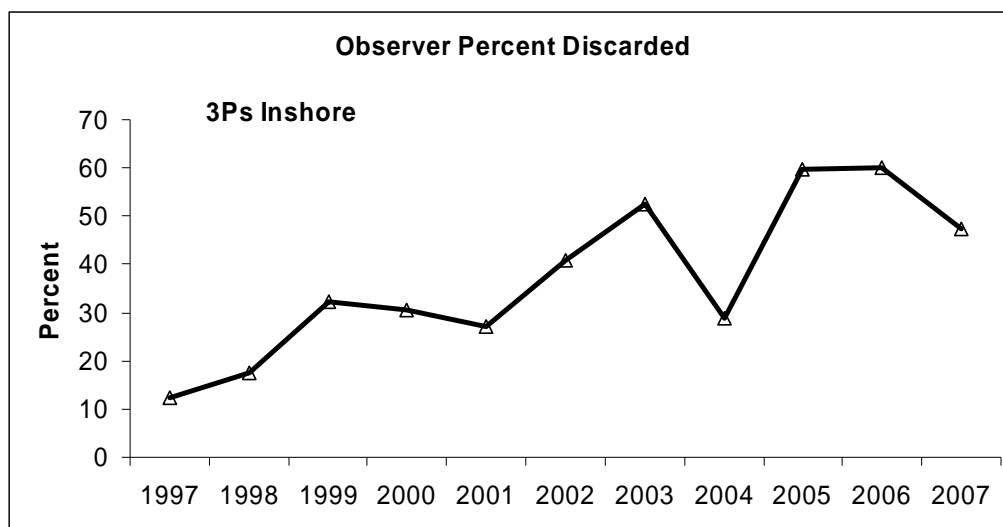


Figure 36: Trends in the percentage of the catch discarded in the inshore Subdiv. 3Ps fishery.

Increased removals, while the exploitable biomass remains low and recruitment is increasing, could result in increased mortality on soft-shelled immediate pre-recruits.

## Resource Status, Division 4R3Pn

### Commercial Fishery

**Landings** (Fig. 37) have generally been comparable between inshore and offshore areas. TACs have not been taken since 2002. **Offshore landings** decreased from 750 t in 2001 to 80 t in 2006 before increasing to 190 t in 2007. **Effort** declined by 86% during 2005-2006 and increased in 2007.

**Inshore landings** declined by 65% since 2002 to a record low of 370 t in 2007. **Effort** decreased sharply in 2005 and changed little since.

The spatial distribution of fishing effort has changed substantially since 2002. Effort has become highly aggregated, both offshore and inshore, within a few localized areas.

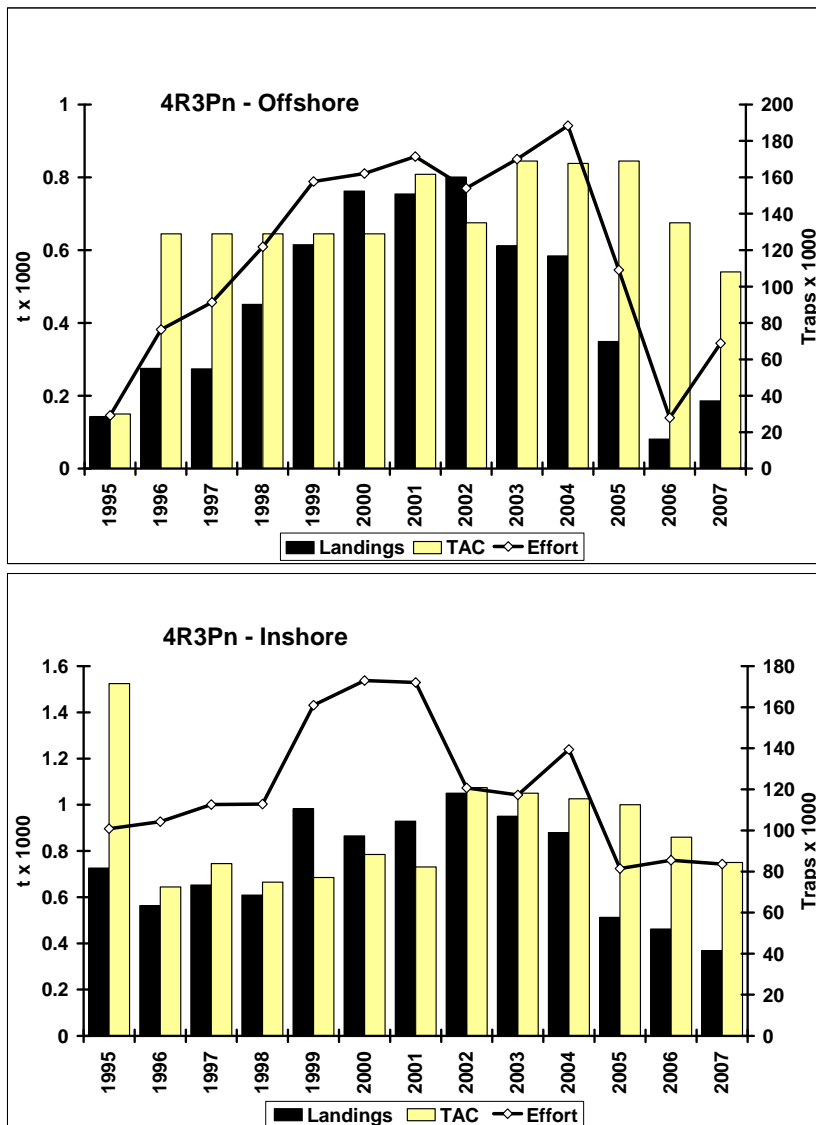


Figure 37: Trends in TAC, landings, and fishing effort in Div. 4R offshore (above) and inshore (below).

CPUE (Fig. 38) is higher in inshore than in offshore areas but is low relative to other divisions.

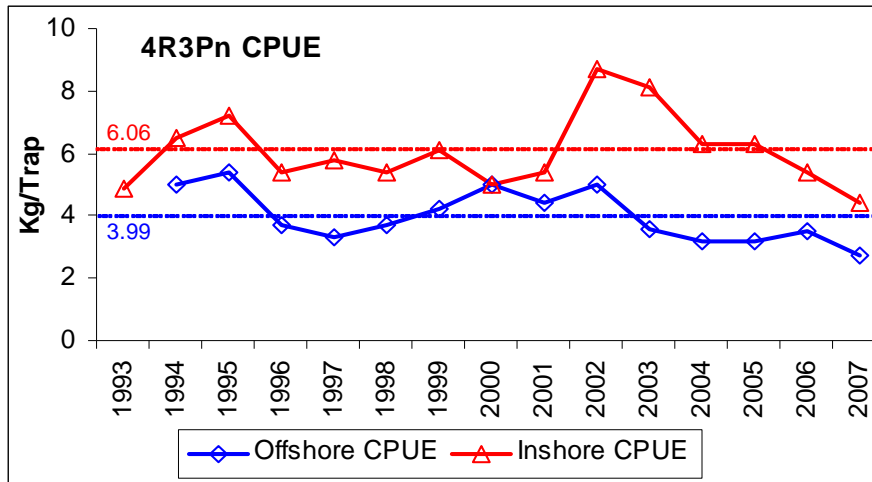


Figure 38: Trends in Div. 4R3Pn inshore and offshore commercial CPUE in relation to their long-term averages (dotted lines).

### Div. 4R Offshore

#### Biomass

It is not possible to infer trends in **exploitable biomass** from commercial CPUE data because of recent changes in the spatial distribution (steady contraction) of fishing effort.

#### Recruitment

There are no data available that could be used to infer recruitment.

Therefore, short-term recruitment prospects are unknown.

#### Mortality

The observer data are insufficient to estimate the percentage of the catch discarded in the fishery or to infer wastage of pre-recruits.

Trends in fishing mortality on either the exploitable or pre-recruit population are unknown.

There are **insufficient data** to assess resource status.

### Div. 4R and Subdiv. 3Pn Inshore

#### Biomass

**Biomass** has recently declined. Both CPUE (Fig. 38) and post-season trap survey catch rates (Fig. 39) have declined sharply since 2005.

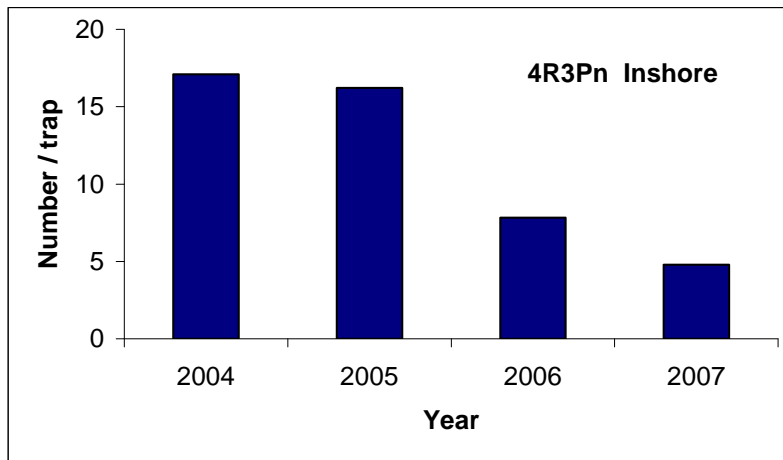


Figure 39: Catch rates of legal-sized crabs from the industry-DFO collaborative post-season trap survey in inshore Div. 4R3Pn.

### Recruitment

**Recruitment** has declined in 2006 and 2007, as reflected by the decline in the exploitable biomass while landings declined. Collaborative trap survey catch rates of new-shelled legal-sized crabs have decreased since 2005.

Recruitment prospects are unknown.

### Mortality

Maintaining the current level of fishery removals would likely result in an increase in the exploitation rate in 2008.

## Sources of Uncertainty

A major source of uncertainty is a lack of reliable fishery-independent indices, or limited time series, in some divisions, particularly Div. 3NO and offshore Div. 4R.

The CPUE series are not standardized. There is uncertainty regarding the effects of changes in some fishing practices (e.g. location, seasonality, soak time, trap mesh size, and high-grading) on catch rates and their interpretation as indicators of resource status. The reliability of the logbook data is uncertain with respect to reported effort and areas fished.

Pre-recruit fishing mortality indices based on observer data are uncertain due to low observer coverage and, more importantly, seasonal variation in the distribution of observer coverage.

Exploitable biomass and recruitment indices from multi-species trawl surveys may be affected by variation in catchability of crabs by the survey trawl. Furthermore, important strata in Div. 3L were not surveyed in 2004 and most of Subdiv. 3Ps was not surveyed in 2006.

There is uncertainty in interpreting trends in exploitable biomass and recruitment from the industry-DFO collaborative trap survey data because the time series is short. There is additional uncertainty related to inconsistent spatial coverage, especially in Div. 2J and 4R.

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## ADDITIONAL STAKEHOLDER PERSPECTIVES

### Division 2J

CPUE improved for the third consecutive year in 2J. Harvesters feel that these positive signs can be attributed to measures they have taken in recent years, including, but not exclusive to reductions in TAC. Harvesters see the stock as improving based on positive recruitment indicators.

### Division 3K

2007 CPUE improved significantly in the offshore and most inshore areas. Again in 2007, there were no significant occurrences of soft-shelled animals. According to harvester observations, overall abundance is increasing.

### Division 3LNO

The TAC was reached in 2007 and CPUEs remain high relative to other areas. Inshore CPUEs improved for the third consecutive year based on increases in most CMAs. There were no significant occurrences of soft-shelled animals.

2007 CPUEs are particularly sensitive to economic factors in many offshore areas. Often only small portions of the fishable area are targeted as harvesters concentrate effort on CMA boundaries. Even though CPUEs drop in a localized area it is still more economical to fish these areas than it is to travel greater distances. Thus, in these areas, CPUE is not an accurate indicator of exploitable biomass.

### Subdivision 3Ps

Landings increased significantly in 2007, with CPUEs increasing as well. Harvesters feel the early start to the fishery was positive again, as very few soft-shelled animals were encountered. Recruitment is still seen to be exceptional as harvesters are seeing large numbers of undersized animals. This coupled with the recruitment seen in the 2007 fishery, have harvesters very optimistic about the fishery in the near future.

### Division 4R and Subdivision 3Pn

Landings have declined in recent years, however, the fishery still remains strong in 12E and F (Bay of Islands).

## CONCLUSIONS AND ADVICE

### Division 2J

**Recruitment** and the **exploitable biomass** have recently increased. The fishery-induced **mortality** rate has decreased. Recruitment is expected to decrease in the next several years.

The fishery remains highly dependent upon immediate recruitment.

Maintaining the current level of fishery removals would not likely result in any increase in the exploitation rate in 2008 because the exploitable biomass, projected from the 2007 fall survey, has increased marginally. An increase in fishery removals would likely accelerate an expected decline in the exploitable biomass in the near future.

### **Division 3K**

#### Offshore

**Recruitment** and the **exploitable biomass** have recently increased. The fishery-induced **mortality** rate has decreased. Recruitment remains promising for the next several years.

The fishery has become less dependent upon immediate recruitment.

The exploitable biomass for 2008, projected from the 2007 fall survey, has increased. Fishery removals could likely be increased in 2008 without increasing the exploitation rate.

#### Inshore

**Recruitment** and the **exploitable biomass** have recently increased. Recruitment remains promising for the next several years.

CPUE and post-season trap survey catch rates indicate that the exploitable biomass will remain high for 2008. Maintaining the current level of fishery removals would not likely result in an increase in the exploitation rate.

### **Division 3L**

#### Offshore

**Recruitment** and the **exploitable biomass** have declined in recent years. **Recruitment** is expected to increase over the next several years.

Both the **exploitation rate index** and the **pre-recruit fishing mortality rate index** increased to very high levels in 2007. These sharp increases in 2007 were due to decreases in the survey exploitable biomass index and pre-recruit biomass index in 2006, while fishery removals and total discards changed little in 2007.

A group of small adolescents apparent in the fall multi-species size distributions in recent years will begin to achieve legal size in 2008. This could result in an increase in the percentage of soft-shelled immediate pre-recruits beginning in 2008. Increased removals, under the present scenario of reduced biomass and imminent recruitment increase, could result in increased mortality on soft-shelled immediate pre-recruits.

Inshore

**Recruitment** and the **exploitable biomass** have recently increased. **Recruitment** prospects are uncertain.

The fishery has become less dependent upon immediate recruitment.

CPUE and post-season trap survey catch rates indicate that the exploitable biomass will remain high for 2008. Maintaining the current level of fishery removals would not likely result in an appreciable change in the exploitation rate in 2008.

**Divisions 3NO**

Survey indices are unreliable. Commercial **CPUE** changed little during 2004-2006 before decreasing in 2007. Recent **recruitment** and future prospects are uncertain.

The effects of maintaining the current catch level on the fishery-induced **mortality** rate are unknown.

**Subdivision 3Ps**Offshore

The exploitable **biomass** remains at a very low level. **Recruitment** is expected to increase in the next several years.

A group of small adolescents apparent in the spring multi-species size distributions in recent years will begin to achieve legal size in 2008. This could result in an increase in the percentage of soft-shelled immediate pre-recruits beginning in 2008. Increased removals, under the present scenario of very low biomass and imminent recruitment increase, could result in increased mortality on soft-shelled immediate pre-recruits.

Inshore

The exploitable **biomass** remains low. **Recruitment** increased slightly in 2007 and prospects remain positive in the short term.

The trap survey catch rate of sub-legal-sized crabs has increased since 2004. This could result in an increase in the percentage of soft-shelled immediate pre-recruits beginning in 2008, similar to that expected in the offshore. Increased removals, while the exploitable biomass remains low and recruitment is increasing, could result in increased mortality on soft-shelled immediate pre-recruits.

**Division 4R and Subdivision 3Pn**Offshore

There are **insufficient data** to assess resource status.

Inshore

The fishery has become concentrated in localized areas. **Biomass** has recently declined and **recruitment** prospects are unknown.

Maintaining the current level of fishery removals would likely result in an increase in the exploitation rate in 2008.

**OTHER CONSIDERATIONS****Reproductive Biology**

The percentage of mature females carrying full clutches of viable eggs has remained high throughout the time series.

Fishery-induced mortality on undersized males may adversely affect insemination of females, especially when abundance of larger adults is low.

**Bitter Crab Disease (BCD)**

There had been a broadly-distributed incidence of **bitter crab disease** during 1996-2006, but the distribution has contracted primarily to Div. 3K in 2007. This disease, which is fatal to crabs, occurs in new-shelled crab of both sexes and appears to be acquired during molting. Prevalence has decreased in 2007.

**Management Considerations**

Reproductive potential is largely protected by conservation measures that exclude females and males smaller than 95 mm CW, including a portion of the adult (large-clawed) males, from the fishery. Therefore exploitation has been considered to have minimal impact on reproductive potential. However fishery-induced mortality on small (< 95 mm CW) males may adversely affect insemination of females, especially when abundance of larger adults is low.

Fishery-induced mortality on pre-recruits can impair future recruitment. Options for reducing this mortality include early fishing seasons, increasing mesh size and soak time, improving handling practices, and reducing high-grading, as well as trap modifications such as escape mechanisms and biodegradable panels.

Wastage of pre-recruits in the fishery would increase sharply as a recruitment pulse begins to enter the legal size range as new-shelled immediate pre-recruits, especially when the exploitable biomass is low. This wastage negatively affects recruitment and future yield. It increases as the exploitable biomass declines due to an increase in both the relative abundance of pre-recruits and their catchability by traps. Recruitment could be promoted by not allowing the exploitable biomass to become critically low.



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