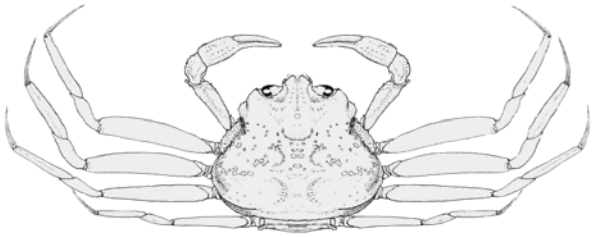
Fisheries and Oceans Canada | Pêches et Océans Canada
Science | Sciences
Newfoundland and Labrador Region
Canadian Science Advisory Secretariat
Science Advisory Report 2011/011

ASSESSMENT OF NEWFOUNDLAND AND LABRADOR SNOW CRAB



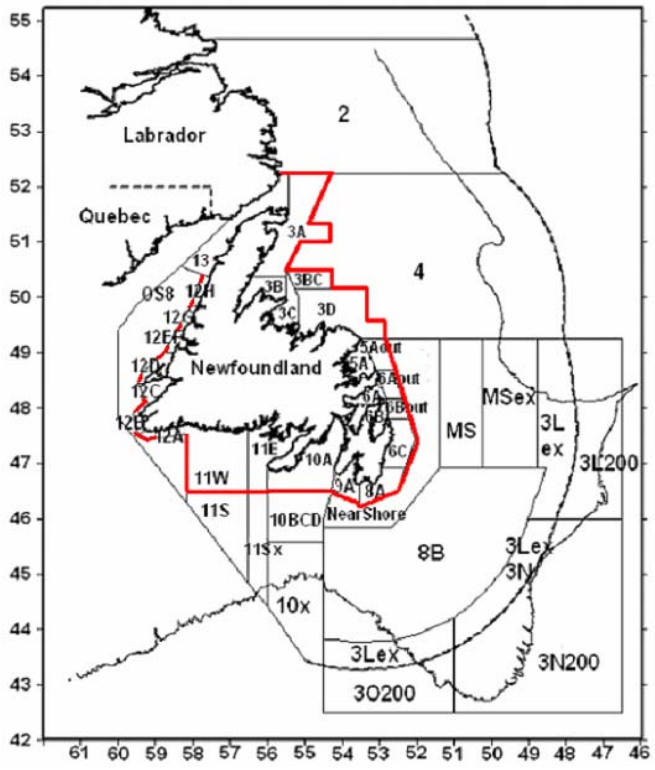


Figure 1: Newfoundland and Labrador Snow Crab Management Areas (CMAs). Red line segregates inshore from offshore CMAs.

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 about 3200 licence holders across several vessel fleets under enterprise allocation in 2010. 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. 2HJ3KLNOP4R, DFO inshore trap surveys in Div. 3KLPs, fishery data from logbooks, observer catch-effort data, industry-DFO collaborative trap survey data, as well as biological sampling data from multiple sources.

A meeting of the Regional Advisory Process (RAP) was held Feb. 28-Mar.4 and Mar. 7-11, 2011 in St. John's, NL to assess the status of the snow crab resource. Participants included DFO scientists, fisheries managers, and representatives from industry, and the Provincial and Nunatsiavut governments.

SUMMARY

- Total **landings** increased by 22% from 44,000 t in 2005 to 53,500 t in 2009, but then decreased to 52,200 t in 2010, primarily due to a decrease in Div. 3K.
- The multi-species trawl surveys indicate that the **exploitable biomass** increased from 2003-2007 due to recovery in the south (Div. 3LNOPs) while the north had decreased (Div. 2HJ3K). There has since been little change.
- **Recruitment** increased from 2003-2008 and has since changed little.
- Longer-term recruitment prospects are uncertain.

Division 2H

- **Landings** declined by 63% from 190 t in 2007 to 70 t in 2010.
- **CPUE** decreased from 2006-2009 and was unchanged in 2010.
- The **exploitable biomass** changed little from 2008-2010. The post-season trawl survey exploitable biomass index peaked in 2006, decreased by 68% to 2008, and remained unchanged in 2010.
- **Recruitment** has decreased since 2004 and is expected to be low over the next several years. There were no pre-recruit males captured in the 2010 post-season trawl survey.
- Maintaining the current level of fishery removals would likely result in little change to the exploitation rate in 2011, but would increase the exploitation rate in future years.

Division 2J

- **Landings** increased by 60% from 1,500 t in 2005 to 2,400 t in 2008. They decreased by 14% to 2,100 t in 2010. **Effort** increased by 27% in 2009 and changed little in 2010.
- **CPUE** increased from 2004-2007 and changed little until it decreased sharply in 2010.
- The **exploitable biomass** has decreased in recent years. The post-season trawl survey exploitable biomass index peaked in 2006, declined to 2009, and changed little in 2010.
- **Recruitment** has recently declined and is expected to remain low in the short term. The post-season trawl survey pre-recruit index was exceptionally high in 2004 and has otherwise fluctuated without trend since 1999.
- The **exploitation rate index** declined between 2003 and 2007 but has since gradually increased. The **pre-recruit fishing mortality index** declined sharply between 2003 and 2005, and has since remained low.
- Maintaining the current level of fishery removals would likely have little effect on the exploitation rate in 2011.

Division 3K Offshore

- **Landings** more than doubled from 6,000 t in 2005 to 12,600 t in 2009 but decreased by 24% to 9,600 t in 2010 (13% below the TAC). Meanwhile **effort** changed little until it increased by 73% in 2009 before decreasing by 15% in 2010.
- **CPUE** declined sharply since 2008.
- The **exploitable biomass,** as indicated by the post-season trap and trawl survey indices, declined by about half since 2008.
- **Recruitment** decreased in 2010 and is expected to change little in 2011. Prospects remain poor in the short term. Post-season pre-recruit biomass indices from both trap and trawl surveys have declined by 34-52% respectively since 2008.

- The trawl survey **exploitation rate index** declined sharply between 2006 and 2009 and has since increased back to the 2006 level. The **pre-recruit fishing mortality index** increased from 2006-2009 and changed little in 2010.
- Maintaining the current level of fishery removals would likely result in an increase in the **exploitation rate** and high mortality on soft-shelled immediate pre-recruits in 2011.

Division 3K Inshore

- **Landings** increased by 33% from 2700 t in 2005 to 3,600 t, in 2009, but dropped by 22% to 2,800 t in 2010 (16% below the TAC). **Effort** has increased by 67% since 2008.
- **CPUE** increased sharply from 2005 to a record high level in 2008, but has since declined by half.
- The **exploitable biomass**, as indicated by the post-season trap survey index, decreased gradually between 2007 and 2010 but there is considerable variability among management areas.
- **Recruitment** prospects, as indicated by the post-season trap survey index, have improved slightly, but there is considerable variability among management areas.
- It was not possible to estimate the **exploitation rate index** in 2010 because of uncertainty concerning the 2009 exploitable biomass index. Data are insufficient to estimate the **pre-recruit fishing mortality index.**
- It is not possible to infer how maintaining the current level of removals would affect the exploitation rate in 2011. However, it would likely result in increased wastage of soft-shelled immediate pre-recruits in 2011.

Division 3LNO Offshore

- **Landings** remained at 22,000-25,000 t since 2000. **Effort** increased steadily from 2000-2008 and has since declined by 16%.
- **CPUE** declined steadily from 2000-2008, to the lowest level since 1991, but has increased during the past two years.
- The **exploitable biomass** has recently increased. Both the trap and trawl survey exploitable biomass indices increased sharply in 2009. The trap survey index increased further in 2010, while the trawl survey index decreased. However, both indices remain above 2005-2008 levels.
- Both post-season surveys indicate that **recruitment** has been recently increasing. Prospects remain promising for the next two to three years, as both the trap and trawl survey pre-recruit biomass indices have remained at high levels since 2007.
- Both the **exploitation rate index** and the **pre-recruit fishing mortality index** peaked in 2008 and have since declined. The latter index was near its lowest level in 2010.
- Maintaining the current level of removals would likely have little effect on the exploitation rate in 2011.

Division 3L Inshore

- **Landings** increased by 19% from 6100 t in 2005 to 7,300 t in 2010. Meanwhile, **effort** decreased by 23% from 2005-2008, and has subsequently increased by 21%.
- **CPUE** has changed little during the past four years and remains near the long-term average.
- The post-season trap survey index indicates the **exploitable biomass** has changed little over the past 7 years.

- Overall, **recruitment** prospects have recently improved, but there is considerable variability among management areas.
- The **exploitation rate** index from the post-season trap survey has varied without trend since 2005. Data are insufficient to estimate **pre-recruit fishing mortality** index.
- Maintaining the current level of fishery removals would likely result in little change in the **exploitation rate,** but may increase mortality on soft-shelled immediate pre-recruits in some areas in 2011.

Subdivision 3Ps Offshore

- **Landings** increased by 70% from 2,300 t in 2006 to 3,900 t in 2010. Meanwhile **effort** decreased from 2006 to 2008 and increased slightly to 2010.
- **CPUE** increased from 2005-2009 and changed little in 2010.
- The **exploitable biomass**, as indicated by both the spring trawl survey and the post-season trap survey indices, increased steadily from 2006-2009 and decreased slightly in 2010.
- **Recruitment** appears promising for 2011 but is expected to decline thereafter.
- **Exploitation and pre-recruit fishing mortality rates**, as indicated by spring trawl survey indices, decreased from 2007-2009 but increased in 2010.
- Maintaining the current level of fishery removals would likely have little effect on the exploitation rate in 2011.

Subdivision 3Ps Inshore

- **Landings** increased from 700 t in 2005 to 2,200 t in 2010 while **effort** declined slightly.
- **CPUE** has increased steadily from 2005 to its highest level since 1996.
- The **exploitable biomass**, as indicated by the post-season trap survey index, increased substantially between 2006 and 2008 and has since changed little.
- **Recruitment** has recently increased and prospects for 2011 and 2012 are promising.
- The post-season trap survey-based **exploitation rate index** changed little during 2008-2010. Data are insufficient to estimate a **pre-recruit fishing mortality** index.
- Maintaining the current level of fishery removals would likely have little effect on the exploitation rate in 2011.

Division 4R Offshore

- **Landings** declined by 83% from 190 t in 2007 to a historical low of 30 t in 2010, while **effort** declined by 91%. The TAC has not been taken since 2002.
- **CPUE** declined slightly from 2006-2009 but increased sharply in 2010. However, the 2010 increase was associated with a record low level of both landings and effort.
- The **exploitable biomass** is low as reflected by virtual abandonment of the fishery in recent years. The post-season trap survey index decreased in 2009 and was unchanged in 2010.
- **Recruitment** has been low in recent years and prospects for the short term are poor.
- The time series of information from the post-season trap survey is insufficient to interpret any trend in the **exploitation rate** index. Data are insufficient to calculate a **pre-recruit fishing mortality** index.
- Maintaining the current level of fishery removals would likely result in little change to the exploitation rate in 2011.

Division 4R Inshore

- Landings and effort were at historical lows in 2010. **Landings** declined by 90% from 950 t in 2003 to 190 t in 2010, while **effort** declined by 60%. The TAC has not been taken since 2002.
- **CPUE** declined steadily from 2002 to its lowest level in 2008 and has changed little since.
- The post-season trap survey **exploitable biomass** index changed little between 2005 and 2009 but increased in some management areas in 2010.
- **Recruitment** has recently increased. Prospects remain promising for the next two to three years, but there is considerable variability among management areas.
- The post-season trap survey **exploitation rate** index has changed little since 2005.
- Increased fishery removals would not likely increase the exploitation rate in 2011, but may increase mortality on soft-shelled immediate pre-recruits in some management areas.

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 carapace width (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.

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 adjacent to 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 3200 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. The fishery has started earlier in recent years and is now prosecuted predominately in spring, resulting in reduced incidence of soft-shelled crabs. 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%. In Div. 3L, the closure threshold was reduced to 15% in 2009. 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. 2HJ3KLNOP4R (Fig. 2) increased steadily from 1989 to peak at 69,100 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 44,000 t in 2005, primarily due to a sharp decrease in Div. 3K where the TAC was not taken. Landings increased by 22% from 2005 to 53,500 t in 2009, but then decreased to 52,200 t in 2010, primarily due to a decrease in Div. 3K. Historically, most of the landings have been from Div. 3KL. Effort has increased since the 1980's and has been broadly distributed in recent years (Fig. 3).

The fishery was delayed in northern divisions (Div. 2J and 3K) in 2009 due to severe ice conditions. Late fishing seasons are believed to contribute to a high incidence of soft-shelled immediate pre-recruits in the catch. Such severe ice conditions can affect the spatial distribution of fishing effort and fishery performance. The fishery was also delayed, in many areas, in 2010 due to a dispute relating to the price of crab.

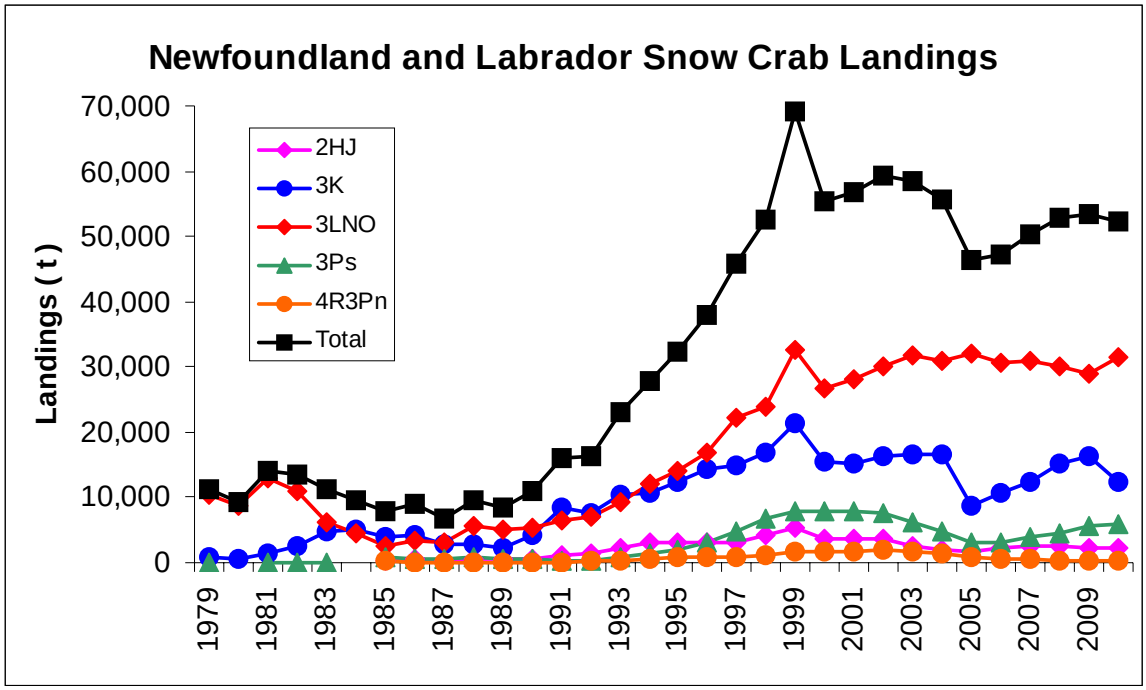


Figure 2: Trends in landings by NAFO Division and in total.

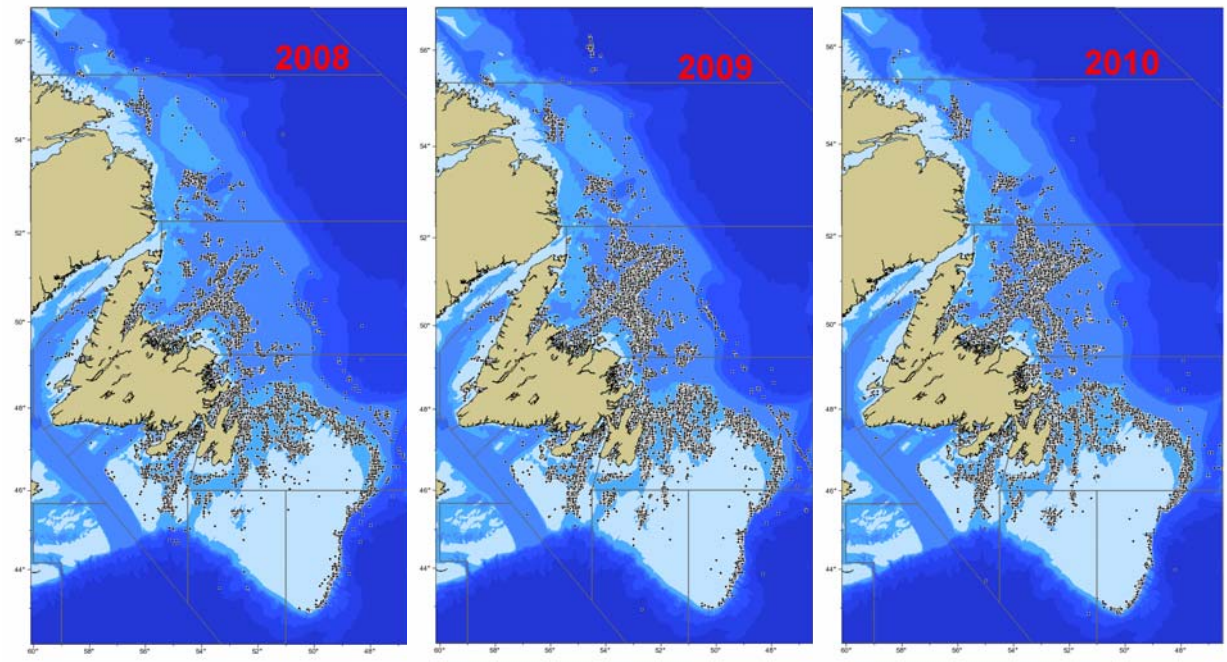


Figure 3: Spatial distribution of commercial fishing effort during 2008-2010.

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 Divs. 2HJ3KLNO, during spring in Subdiv. 3Ps, and during summer in Div. 4R. A Campelen shrimp trawl has been used in these multi-species surveys beginning in 1995 (Div. 2HJ3KLNOPs) or 2004 (Div. 4R). Snow crab sampling during spring Subdiv. 3Ps surveys did not begin until 1999. The fall post-season trawl survey was conducted in Div. 2H every second year since 2004. Spring (pre-fishery) trawl surveys are considered to be less reliable than summer and fall (post-fishery) surveys because some population components are relatively poorly sampled during spring when mating and molting take place. Information was also available from a fall Industry-DFO collaborative post-season (CPS) trap survey initiated in 2003. Fall post-season surveys provide the most recent data available for the annual RAP. Information is also utilized from DFO inshore trap and trawl surveys in Div. 3KLPs, fishery data from VMS, logbooks, and observer catch-effort data, as well as biological sampling data from multiple sources. There are multiple CPUE indices used in the assessment, but in offshore areas VMS-based CPUE is considered the most reliable due to complete coverage and little element of human error.

The resource is assessed separately for offshore and inshore areas of each division, where appropriate (Div. 3KLPs4R; there is no distinction between inshore and offshore areas in Div. 2HJ (Fig. 1). Div. 3LNO offshore is assessed as a unit because the offshore fishery is managed at that spatial scale. More data are available for offshore than inshore areas in most divisions. 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, VMS is used only on offshore vessels.

Spring pre-season (Subdiv. 3Ps), summer post-season (Div. 4R), and fall post-season (Div. 2HJ3KLNO) bottom trawl surveys provide data that are used to predict changes in biomass and recruitment for the upcoming fishery in the same year (Subdiv. 3Ps) or the following year (Div. 2HJ3KLNO4R). These surveys, based on a stratified random sampling scheme, provide an index of the exploitable biomass that is expected to be available for the upcoming fishery. This exploitable biomass index is based on only adults of legal size from the spring and fall surveys, but is based on all legal-sized crabs from the Div. 4R summer survey (where chela height is not measured). This index is used together with an exploitable biomass index (all legal-sized crabs) from the CPS trap survey in offshore areas to evaluate trends in the exploitable biomass. The inshore CPS trap survey exploitable biomass index is compared with commercial CPUE and catch rates from inshore DFO trap surveys, where available (Div. 3KLPs).

Bottom trawl surveys also provide data on recruitment. Recent changes in recruitment are inferred from changes in survey biomass indices in relation to landings. Recruitment prospects for the upcoming fishery (in the next year) are inferred from biomass indices or catch rates of new-shelled legal-sized adults (immediate pre-recruits) from post-season trawl surveys. Trawl surveys also provide an index of pre-recruit biomass, based solely on adolescent (non-terminally-molted) males larger than 75 mm CW from the spring and fall surveys, but is based on all males 76-94 mm CW from the Div. 4R summer survey. The adolescents of these groups would recruit in the short term (about 2-3 years) following the upcoming fishery. Short-term recruitment prospects are also inferred from biomass indices or catch rates of sub-legal-sized (‘under-sized’) males from observer at-sea sampling and post-season trap surveys. However, these males include an unknown portion of under-sized adults (terminally molted) that will never recruit.

Trawl surveys also provide abundance indices for males of all sizes. There is little evidence of annual progression of smallest males (< 40 mm CW) to successively larger sizes from spring or fall multi-species survey size frequency data. Therefore, longer-term (ie. >3 years) recruitment prospects are uncertain.

Trawl survey abundance and biomass indices are calculated based on a set of "core strata" that was common to most years, especially recent years, and does not include inshore strata or deep (>750 m) slope strata that have not been regularly sampled.

The CPS trap survey, based on a fixed-station grid design, is more spatially limited than the trawl survey as it targets only portions of commercial fishing grounds. A set of core stations was selected from this survey for calculating catch rates (number/trap) of legal-sized adults. These core stations represented those that were common to most years, especially recent years. All stations sampled were used in deriving biomass indices from this survey. The stratification scheme was changed in this assessment from one that utilized existing multi-species trawl survey strata. For the present assessment, smaller depth-based strata were created to closely conform with CPS survey stations in inshore or offshore management areas of each division (Fig. 1). The boundary of each stratum extended 5 nmi outside the outermost stations of each survey grid. The set of strata used was common to all years for each zone.

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 most recent trap and trawl surveys. The pre-recruit fishing mortality index reflects an unknown (but likely high) mortality on released pre-recruits. Trends in pre-recruit fishing mortality are inferred from changes in the ratio of the estimated total catch of undersized (<94 mm CW) males (adolescents and adults) to the trawl survey biomass index of pre-recruits plus undersized (76-94 mm CW) adults from the most recent trawl survey. The total catch of under-sized males is estimated as the observed discards of under-sized males scaled to total landings. Pre-recruit fishing mortality indices were not estimated for inshore areas due to inadequate observer coverage.

The percentage (by weight) of the total catch discarded, 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. The percent discarded is not estimated for inshore areas due to inadequate observer coverage.

Overall Resource Status, Divisions 2HJ3KLNOP4R

The spring and fall multi-species trawl surveys indicate that the **exploitable biomass** declined from the late 1990's to 2003. It increased from 2003-2007 and has since changed little (Fig. 4). The fall post-season surveys in Div. 2J3KLNO indicate that the exploitable biomass was highest during 1996-1998. The more limited time series from spring multi-species surveys in Div. 3LNOPs also indicated a decline in exploitable biomass in the early years of the surveys. The spring and fall surveys both showed decreases in the exploitable biomass indices from 2001 to 2003-2004, with little change until the fall index increased in 2007. Most of the increase was due to recovery in the south (Div, 3LNOPs) while the north (Div. 2HJ3K) has decreased, as reflected in the divisional trends. There has been little change overall in both spring and fall indices over the past 4 years (Fig 4).

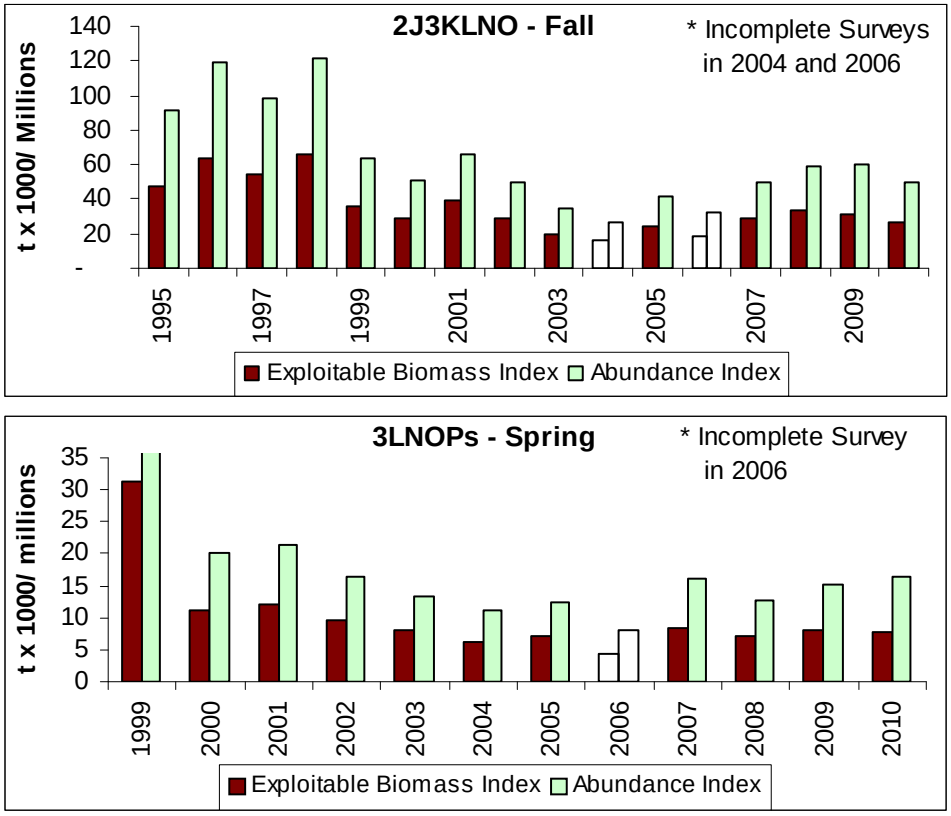


Figure 4: Trends in the multi-species survey exploitable biomass and abundance indices, for Div. 2J3KLNO during fall (above) and for Div. 3LNOPs during spring (below).

Recruitment increased from 2003-2008 and has since changed little. The survey abundance and biomass indices of pre-recruits (Fig. 5) have increased since 2005 due to increases in the south (Div. 3LNOPs). Longer-term recruitment prospects are uncertain.

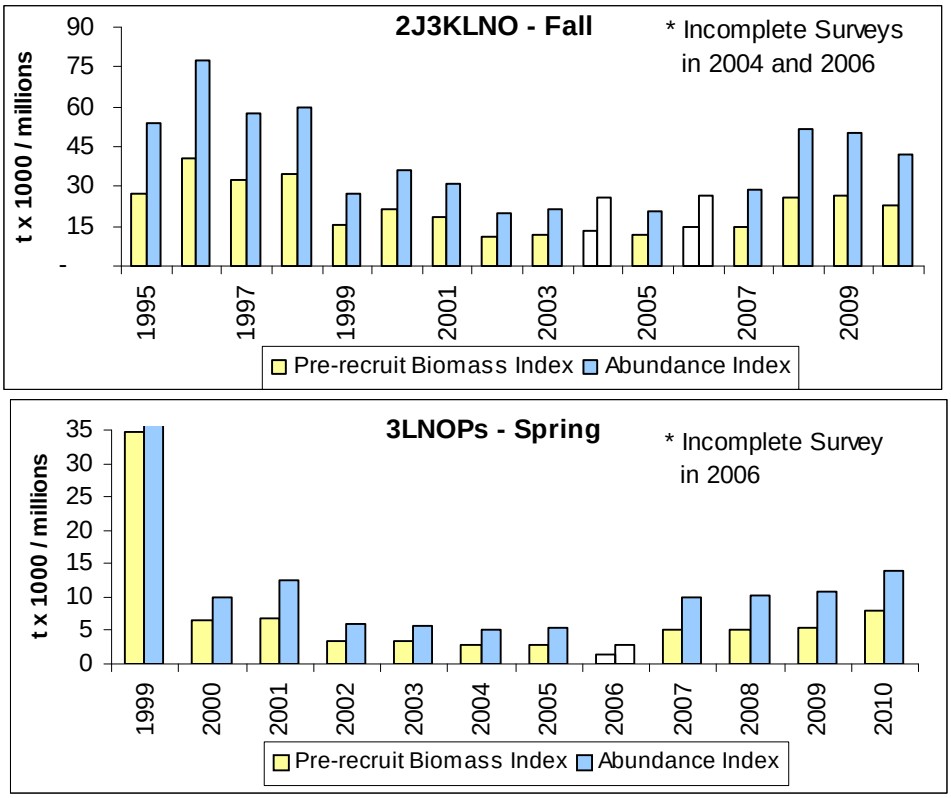


Figure 5: Trends in the multi-species survey pre-recruit biomass and abundance indices for Div. 2J3KLNO during fall (above) and for Div. 3LNOPs during spring (below).

Resource Status, Division 2H

Commercial Fishery

There have been exploratory fisheries since the mid 1990's. A commercial TAC was first established in 2008, and has since been maintained, at 100 t (Fig. 6). Landings increased from 70-190 t during 2005-2007 and subsequently declined by 63% to 70 t in 2010.

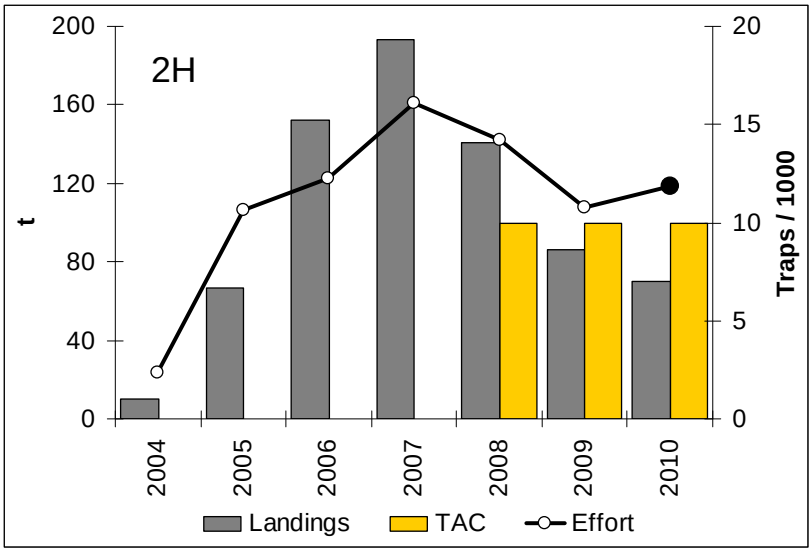


Figure 6: Trends in TAC, landings, and fishing effort in Div. 2H. The 2010 effort value is based on limited logbook data.

CPUE decreased from 2006-2009 and was unchanged in 2010, based on the VMS index (Fig. 7). The logbook index is considered unreliable due to inadequate data resulting from a low rate of logbook returns, especially in 2010.

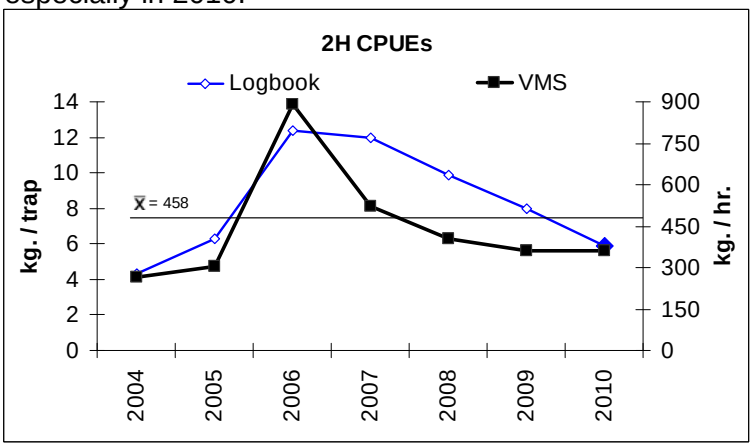


Figure 7: Trends in Div. 2H commercial CPUE. Horizontal line indicates the average based on VMS. The 2010 logbook CPUE value is based on limited data.

Biomass

The **exploitable biomass** changed little from 2008-2010. The post-season trawl survey exploitable biomass index peaked in 2006, decreased by 68% to 2008, and remained unchanged in 2010 (Fig. 8).

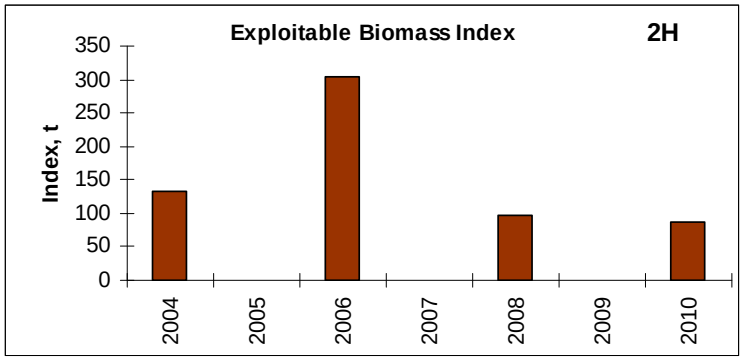


Figure 8: Trends in the Div. 2H exploitable biomass index based on the post-season trawl survey.

Recruitment

Recruitment has decreased since 2004 and is expected to be low over the next several years. There were no pre-recruit males captured in the 2010 post-season trawl survey (Fig.9).

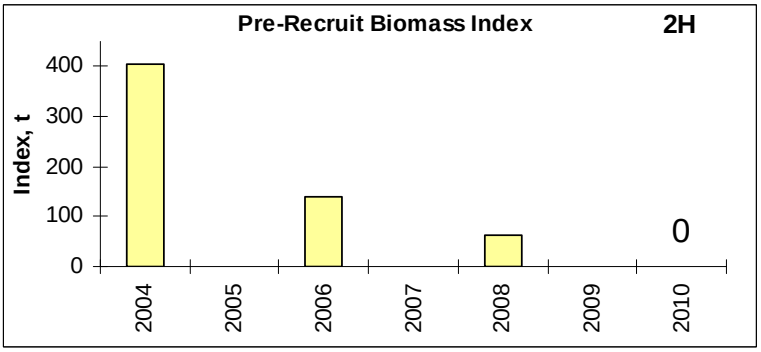


Figure 9: Trends in the Div. 2H pre-recruit biomass index based on the post-season trawl survey.

Mortality

Data are insufficient to calculate annual values for the exploitation rate index due to the biennial frequency of the survey. A pre-recruit fishing mortality rate index cannot be calculated due to the absence of observer data.

Resource Status, Division 2J

Commercial Fishery

Landings (Fig. 10) peaked in 1999 at 5,400 t, decreased sharply to 3,700 t in 2000 and changed little to 2002, before declining to 2005. They increased by 60% from 1,500 t in 2005 to 2,400 t in 2008 and then decreased by 14% to 2,100 t in 2010. **Effort** increased from 2000 to a record high level in 2002-2004. It decreased sharply in 2005 and further declined slightly to 2008. It increased by 27% in 2009 and changed little in 2010.

The 2010 fishery was concentrated in Hawke and Cartwright channels, as it was in the previous four years. In 2006-2010 there was limited fishing on the slope relative to previous years.

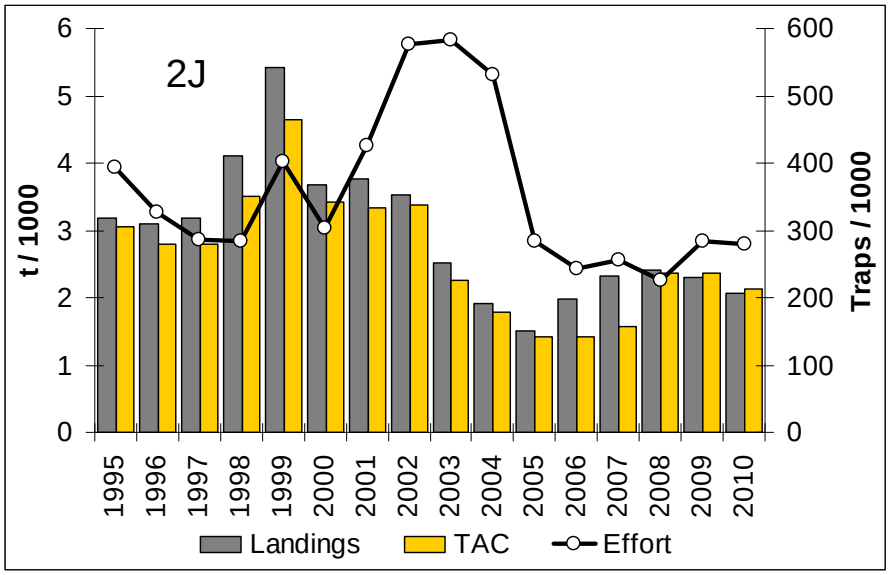


Figure 10: Trends in TAC, landings, and fishing effort in Div. 2J.

Commercial catch rate (**CPUE**) has oscillated over the time series (Fig. 11), initially decreasing from 1991-1995, and increasing to a peak in 1998. It declined steadily by 76% from 1998 to a record low level in 2004. It increased from 2004-2007 and changed little until it decreased sharply in 2010.

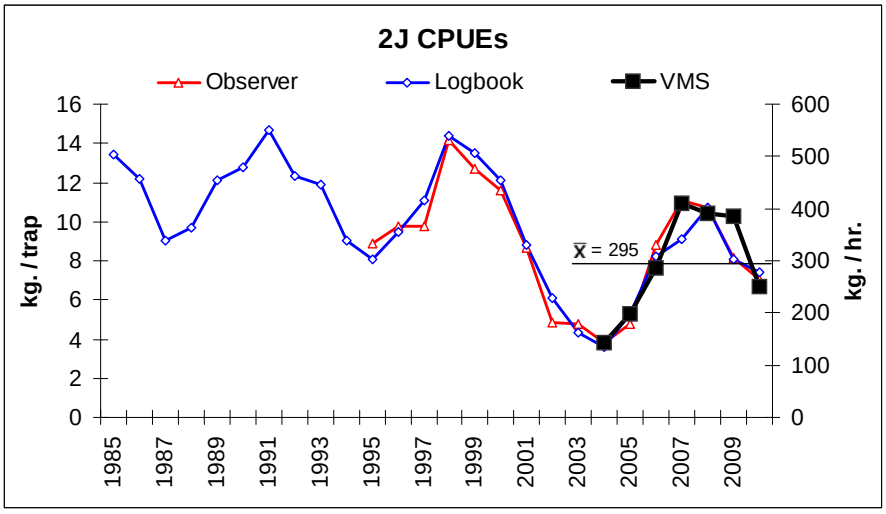


Figure 11: Trends in Div. 2J commercial CPUE. Horizontal line indicates the average based on VMS.

Biomass

The **exploitable biomass** has decreased in recent years. The post-season trawl survey exploitable biomass index decreased steadily by 92%, from 1998-2002 (Fig. 12). It increased from 2002 to peak in 2006 but remained below pre-2002 levels. It has since declined to 2009 and changed little in 2010. The post-season trap survey index declined sharply from 2007-2009 and changed little in 2010. However, that index reflects only the southern portion of the division.

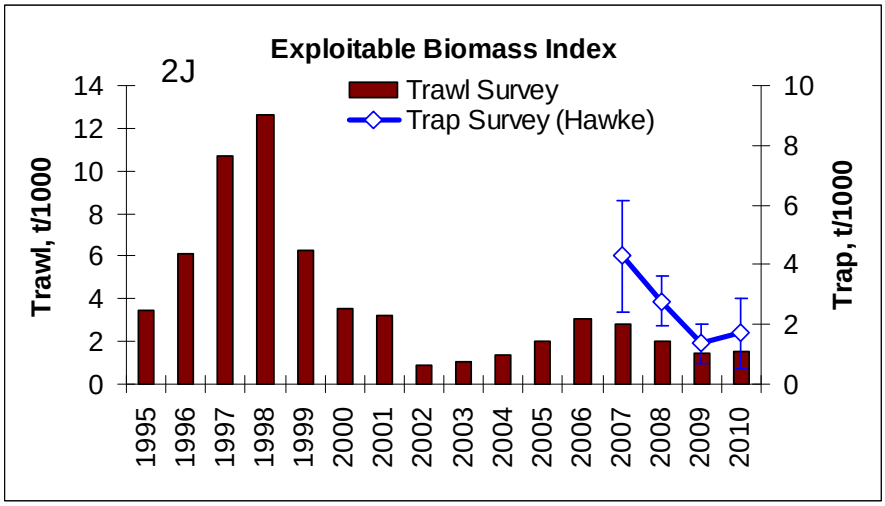


Figure 12: Trends in the Div. 2J exploitable biomass indices based on post season trawl and trap surveys. The trap survey is conducted only in the southern portion of the division.

Recruitment

Recruitment has recently declined as reflected by the decline in exploitable biomass between 2006 and 2009 while landings changed little. It is expected to remain low in the short term. The fall survey **pre-recruit index** decreased sharply in 1999 (Fig. 13). It was exceptionally high in 2004 and has otherwise fluctuated without trend since 1999. The post-season trap survey index has changed little over its limited time series (Fig. 13).

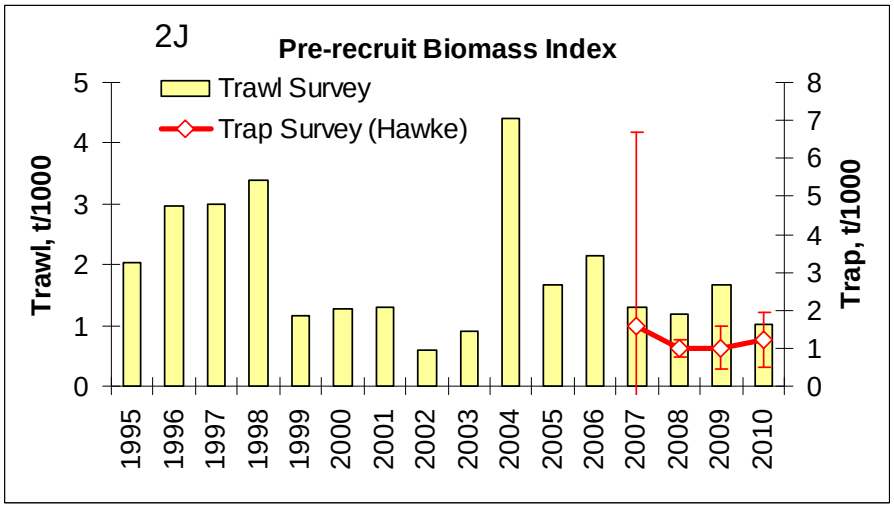


Figure 13: Trends in Div. 2J pre-recruit biomass indices from the post-season trawl survey and the CPS trap survey. The trap survey is conducted only in the southern portion of the division.

Mortality

The percentage of the total catch discarded (Fig. 14) increased from 2001 to a record high level in 2004. It then declined sharply to 2006, implying reduced wastage of under-sized and new-shelled pre-recruits in the fishery. It has since remained relatively low, varying without trend.

The **exploitation rate index** declined from 2003-2007 but has since gradually increased (Fig. 14). The **pre-recruit fishing mortality index** declined sharply from 2003-2005, and has since remained low.

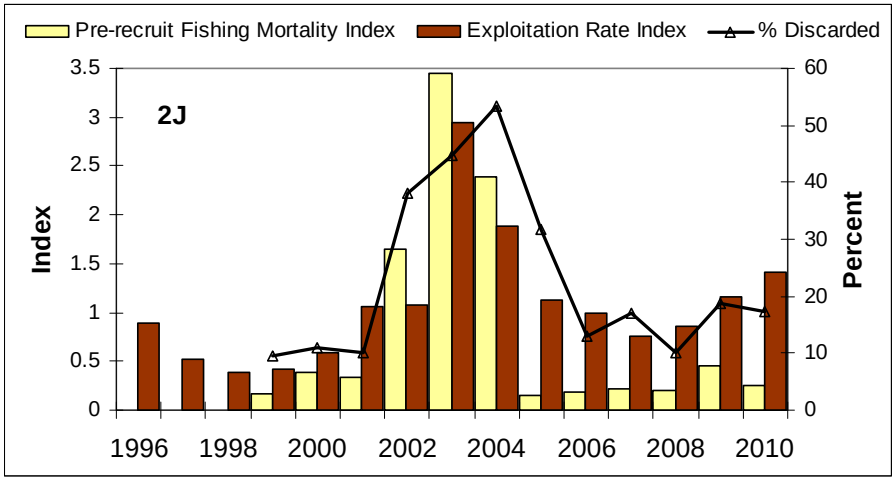


Figure 14: Trends in the Div. 2J exploitation rate and pre-recruit fishing mortality rate indices and percentage of the catch discarded in the fishery.

Resource Status, Division 3K Offshore

Commercial Fishery

Landings peaked in 1999 at 17,900 t (Fig. 15). They decreased to about 13,000 t in 2000-2004, due to a reduction in the TAC. They 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 more than doubled from 6,000 t in 2005 to 12,600 t in 2009 but decreased by 23% to 9,600 t in 2010 (13% below the TAC). Meanwhile **effort** changed little until it increased by 70% in 2009 before decreasing by 15% in 2010.

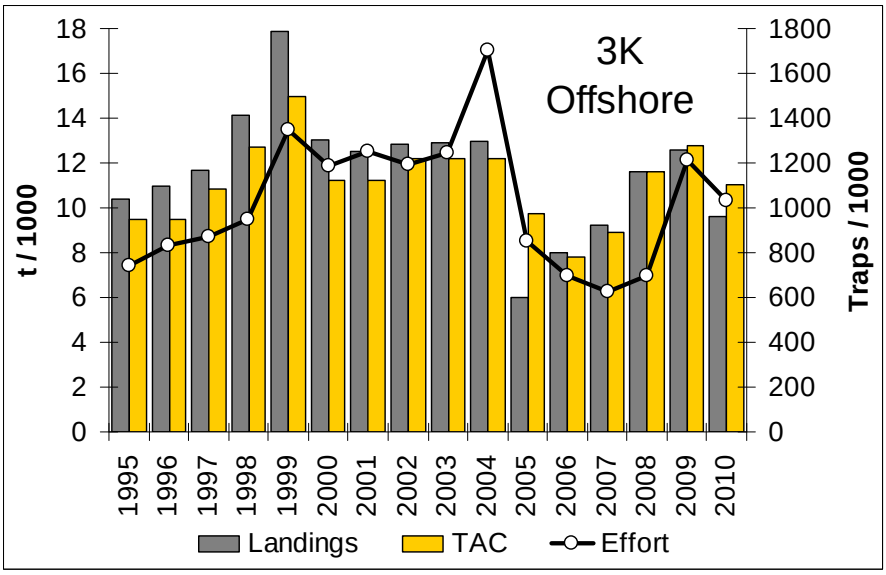


Figure 15. Trends in TAC, landings, and fishing effort in Div. 3K offshore.

Commercial CPUE (Fig. 16) indicates substantial deterioration of fishery performance in recent years. CPUE indices increased sharply from 2005 to record high levels in 2007 (VMS index) or 2008 (logbook and observer indices). All three indices agree that **CPUE** has declined sharply since 2008.

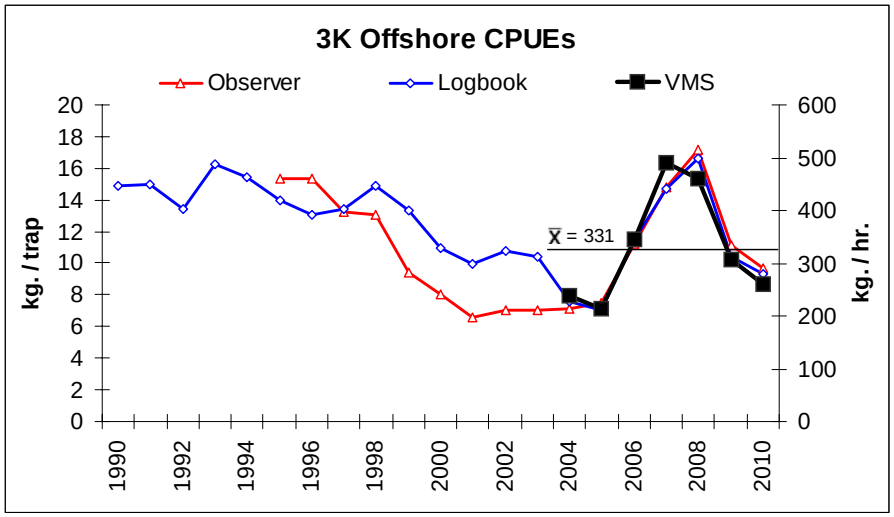


Figure 16: Trends in Div. 3K offshore commercial CPUE. Horizontal line indicates the VMS average.

Biomass

The **exploitable biomass,** as indicated by the post-season trap and trawl survey indices, declined by about half since 2008 (Fig. 17). The post-season trawl survey **exploitable biomass index** decreased from its highest level in the late 1990's to its lowest in 2003, before increasing to 2007. The post-season trap survey exploitable biomass index increased in 2006 (Fig. 17). Both indices remained high to 2008 and decreased sharply to 2010.

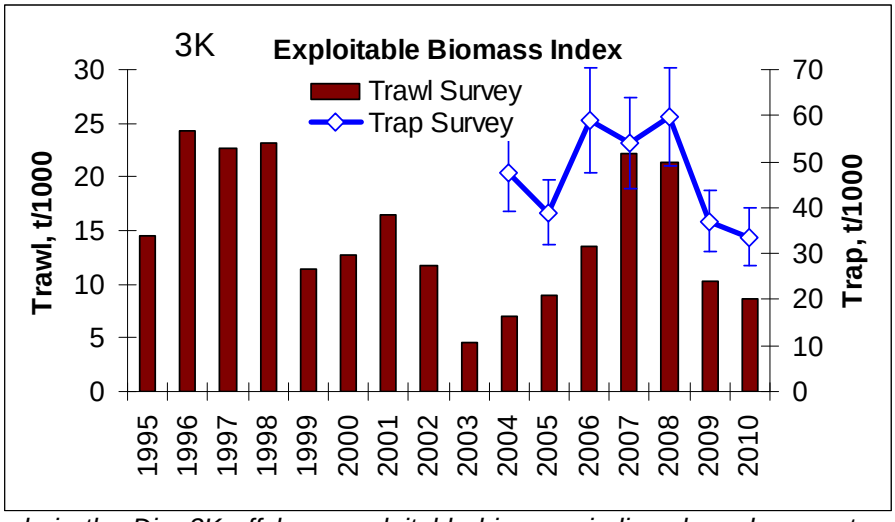


Figure 17: Trends in the Div. 3K offshore exploitable biomass indices based on post-season trawl and trap surveys.

Recruitment

Recruitment decreased in 2010, as reflected by the sharp decrease in the post-season exploitable biomass indices while landings also decreased**.** It is expected to change little in 2011 and prospects remain poor in the short term. Post-season **pre-recruit biomass indices** from trap and trawl surveys have declined by 34 and 52% respectively since 2008 (Fig. 18).

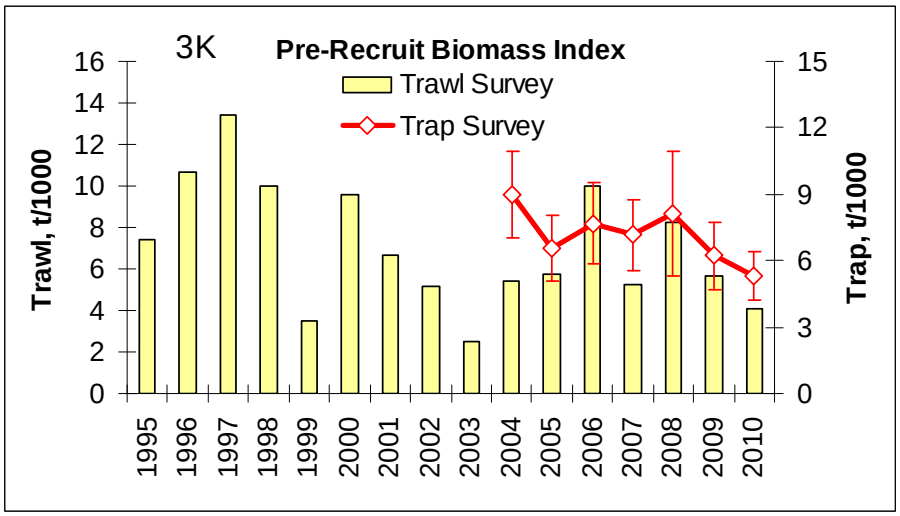


Figure 18: Trends in Div. 3K offshore pre-recruit biomass indices based on post-season trawl and trap surveys.

The recent decrease in recruitment was likely exacerbated by a high handling mortality on soft-shelled immediate pre-recruits, particularly during the 2009 fishery. This handling effect may have been mitigated in the 2010 fishery by reduced fishing effort, particularly late in the season.

Mortality

The percentage of the total catch discarded in the fishery (Fig. 19) declined markedly between 2004 and 2006 and continued to decline to its lowest value in 2008. It increased sharply in 2009, primarily due to a high incidence of soft-shelled immediate pre-recruits in the fishery. This implies an increase in wastage of under-sized and, in particular, soft-shelled pre-recruits in the fishery in 2009. It decreased slightly in 2010, implying a slight reduction in handling of pre-recruits.

The trawl survey **exploitation rate index** declined sharply from 2006-2009 and has since increased back to the 2006 level (Fig.19). The **pre-recruit fishing mortality index** increased from 2006-2009 and changed little in 2010.

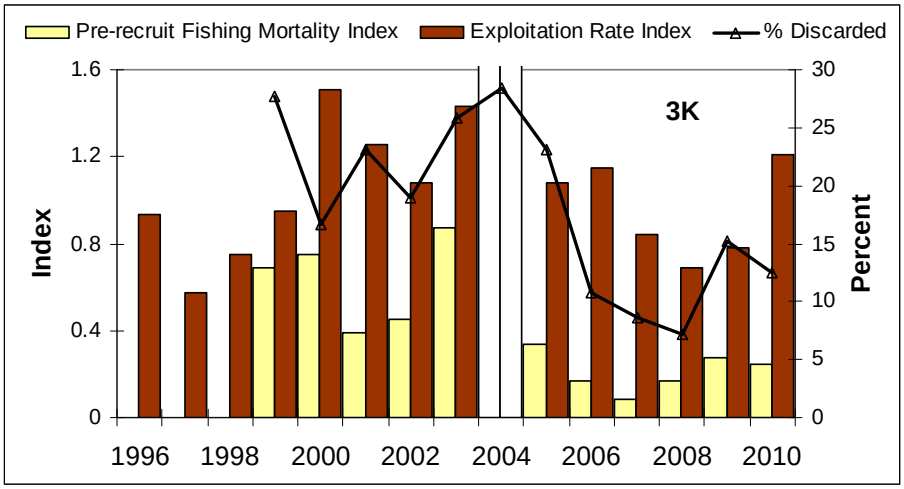


Figure 19: Trends in the Div. 3K offshore exploitation rate and pre-recruit fishing mortality rate indices and percentage of the catch discarded in the fishery. Anomalously high values for 2004 mortality indices are due to very low 2003 biomass indices.

Division 3K Inshore

Commercial Fishery

Inshore landings (Fig. 20) peaked in 1999 at 3,500 t and decreased sharply in 2000 due to a TAC reduction. They increased to 3,300 t in 2003, changed little in 2004, and decreased by 21% in 2005. Landings increased by 33% from 2,700 t in 2005 to 3,600 t, in 2009, but dropped by 22% to 2,800 t in 2010 (16% below the TAC). **Effort** declined from 2004 to 2008 and increased by 67% since 2008.

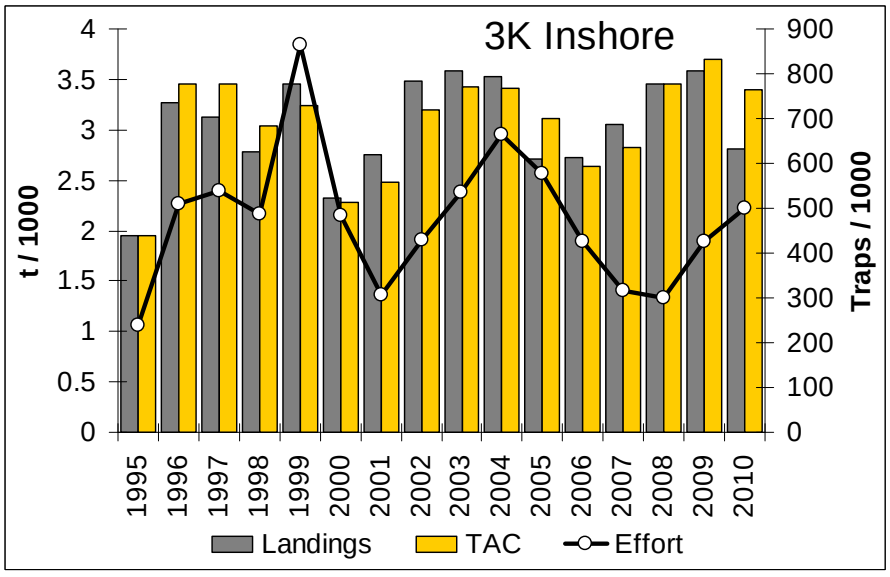


Figure 20: Trends in TAC, landings, and fishing effort in Div. 3K inshore

Commercial CPUE (Fig. 21) indicates substantial deterioration of fishery performance over the past two years. CPUE increased sharply from 2005 to a record high level in 2008, but has since declined by half.

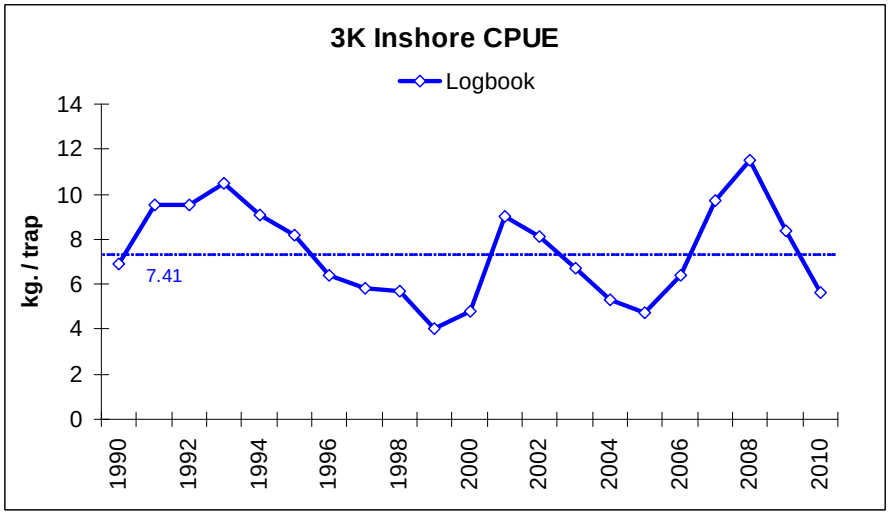


Fig. 21.Trend in Div. 3K inshore commercial CPUE in relation to the long-term average (dotted line).

Biomass

The **exploitable biomass**, as indicated by the post-season trap survey index, decreased gradually between 2007 and 2010 (Fig. 22) but there is considerable variability among management areas. The low 2009 index is believed to be an anomaly due to low capture efficiency of traps in some areas during the 2009 survey.

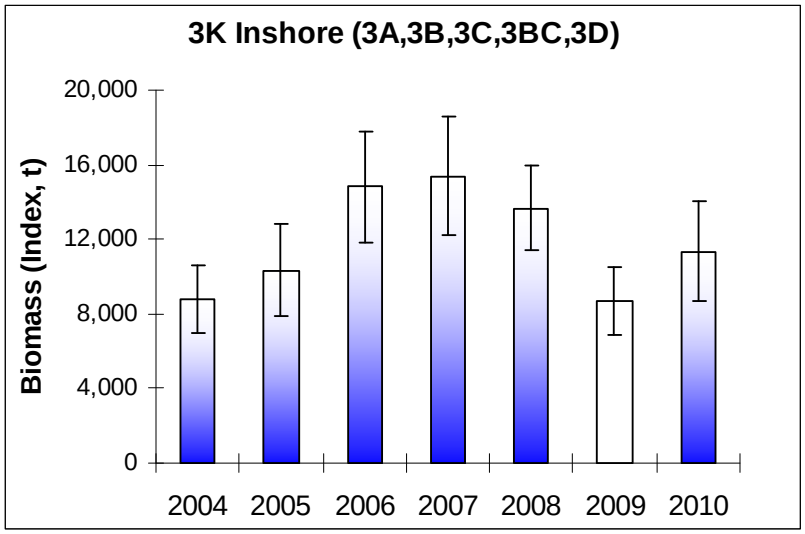


Figure 22: Exploitable biomass index based on the post-season trap survey in inshore Div. 3K. The anomalously low 2009 value is indicated by the white bar.

Recruitment

Recruitment prospects, as indicated by the post-season trap survey index, have improved slightly, but there is considerable variability among management areas. The CPS pre-recruit biomass index of undersized crabs decreased steadily from 2006-2009 but then increased in 2010 (Fig. 23). The 2009 index is believed to be an underestimate due to low capture efficiency

of traps in some areas during the 2009 survey. However, the 2010 index does remain above the 2008 level, implying improved prospects in the short-term.

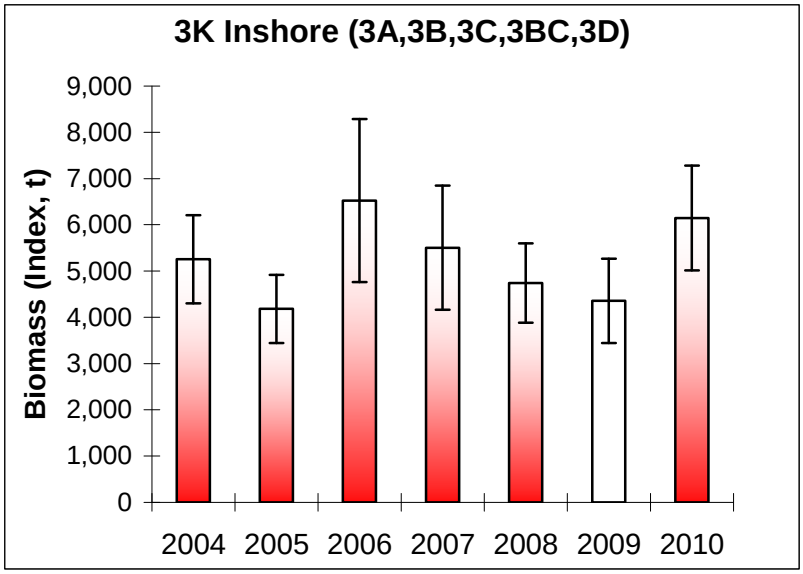


Figure 23: Pre-recruit biomass index of under-sized crabs from the post-season trap survey in inshore Div. 3K. The anomalously low 2009 value is indicated by the white bar.

Mortality

It was not possible to estimate the **exploitation rate index** in 2010 because of uncertainty concerning the 2009 exploitable biomass index. Data are insufficient to estimate a **pre-recruit fishing mortality index**.

Resource Status, Division 3LNO Offshore

Commercial Fishery

L**andings**, mostly in Div. 3L, peaked at 27,300 t in 1999 and decreased to about 22,100 t in 2000 due to a reduction in the TAC (Fig. 24). **Landings** remained at 22,000-25,000 t since 2000. **Effort** increased steadily from 2000-2008 and has since declined by 16%.

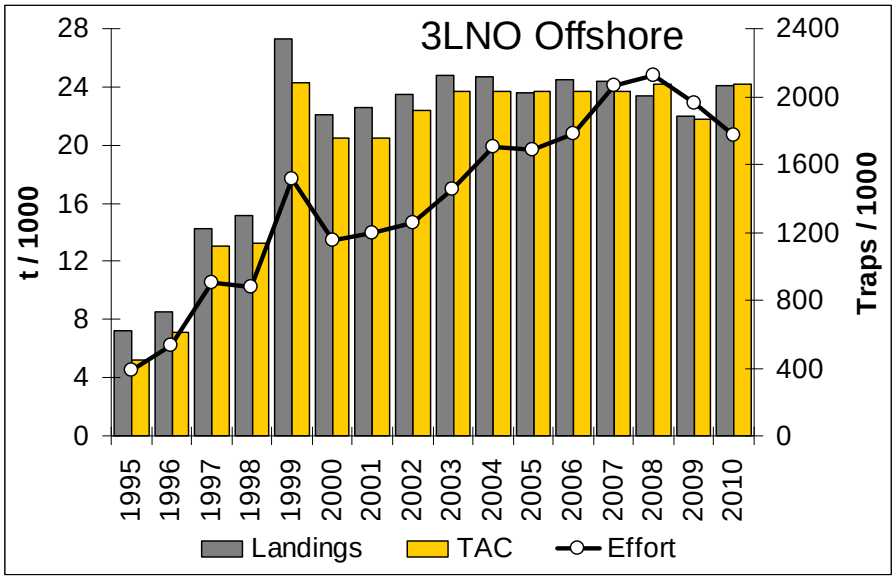


Figure 24: Trends in TAC, landings, and fishing effort in Div. 3LNO offshore.

Commercial CPUE (Fig. 25) indicates that fishery performance has recently improved. **CPUE** declined from 2000-2008, to the lowest level since 1991, but has increased during the past two years. The logbook CPUE series is considered unreliable in this area due to a high degree of inaccurate reporting.

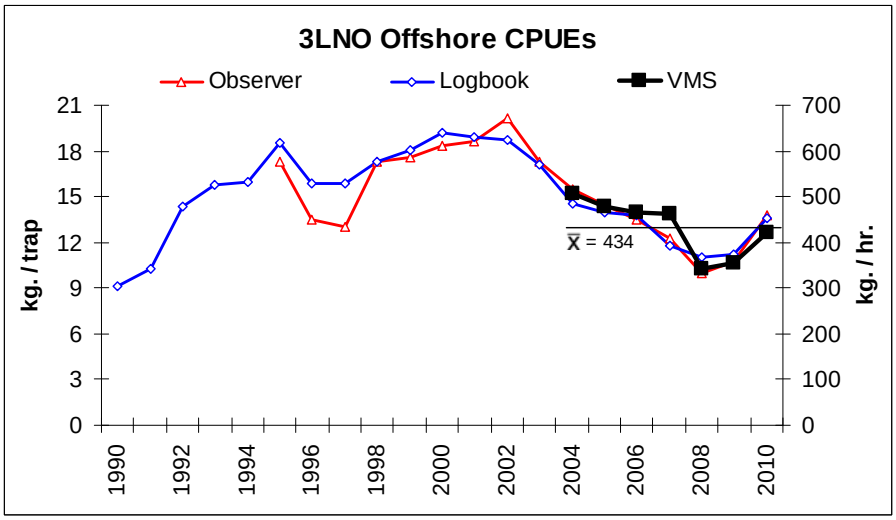


Figure 25: Trends in Div. 3LNO offshore commercial CPUE. Horizontal line indicates the average of the VMS index.

Biomass

The **exploitable biomass** has recently increased. Both the trap and trawl survey exploitable biomass indices increased sharply in 2009 (Fig. 26). The trap survey index increased further in 2010, while the trawl survey index decreased. However, both indices remain above 2005-2008 levels.

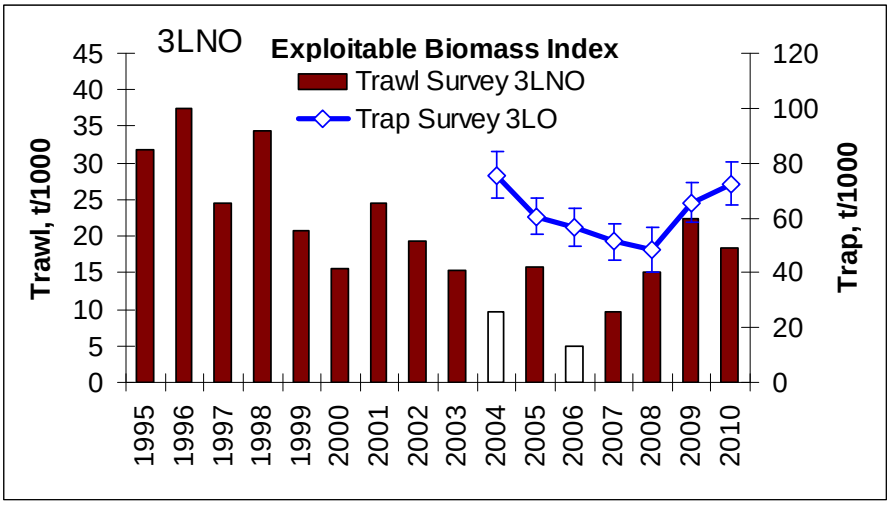


Figure 26: Trends in the Div. 3LNO offshore exploitable biomass indices based on post-season trawl and trap surveys; the trawl survey was incomplete in 2004 and 2006.

Recruitment

Both post-season surveys indicate that **recruitment** has been recently increasing. Prospects remain promising for the next two to three years, as both the trap and trawl survey pre-recruit biomass indices have remained at high levels since 2007. (Fig. 27).

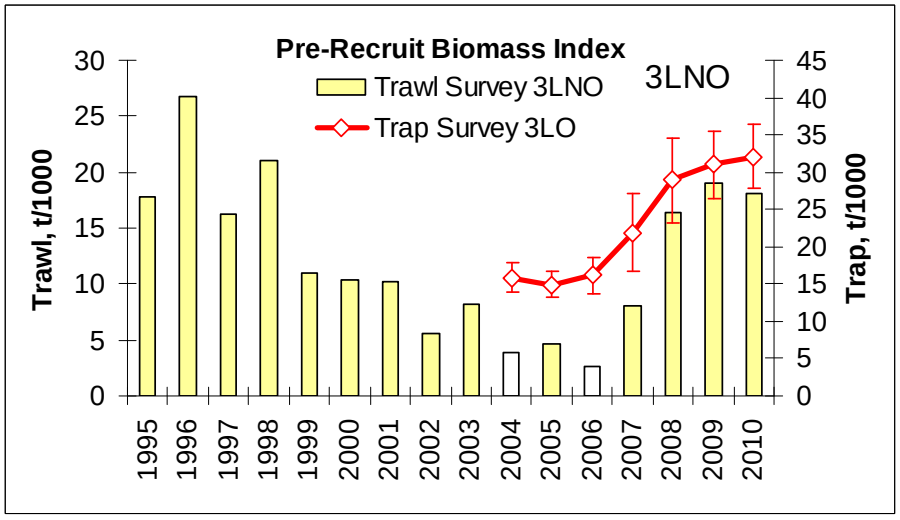


Figure 27: Trends in Div. 3LNO offshore pre-recruit biomass indices based on post-season trawl and trap surveys; the trawl survey was incomplete in 2004 and 2006.

The recent increase in the post-season trawl survey pre-recruit index reflects the progression of a group of adolescents in the trawl survey size distributions, with a modal size of about 90 mm CW in 2009-2010. While much of this recruitment pulse has now recruited to the exploitable biomass the remaining large adolescents are expected to continue to provide strong recruitment for 2-3 years following 2011.

Mortality

The percentage of the total catch discarded in the fishery (Fig. 28) increased sharply in 2008 from a low level during 2004-2007. It has since declined, implying reduced wastage of pre-recruits, primarily sub-legal sized crabs in the fishery.

Both the **exploitation rate index** and the **pre-recruit fishing mortality index** peaked in 2008 and have since declined. The latter index was at its lowest level in 2010.

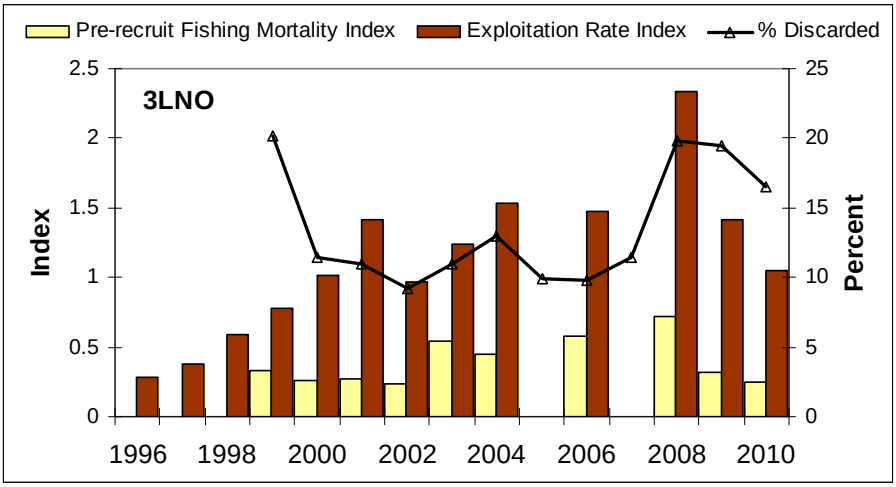


Figure 28: Trends in the Div. 3LNO offshore exploitation rate and pre-recruit fishing mortality rate indices and percentage of the catch discarded in the fishery. Mortality indices were not calculated for 2005 because the survey was incomplete in 2004. The anomalously high 2007 values reflect the low 2006 biomass indices.

Div. 3L Inshore Resource Status

Commercial Fishery

Landings peaked in 1996 at 7,900 t (Fig. 29). They declined to 4,700 t in 2000, increased to 6,800 t in 2003, and decreased slightly to 6,100 t in 2005 due to changes in the TAC. They increased by 19% from 6100 t in 2005 to 7,300 t in 2010. Meanwhile, **effort** decreased by 23% from 2005-2008, and has subsequently increased by 21%.

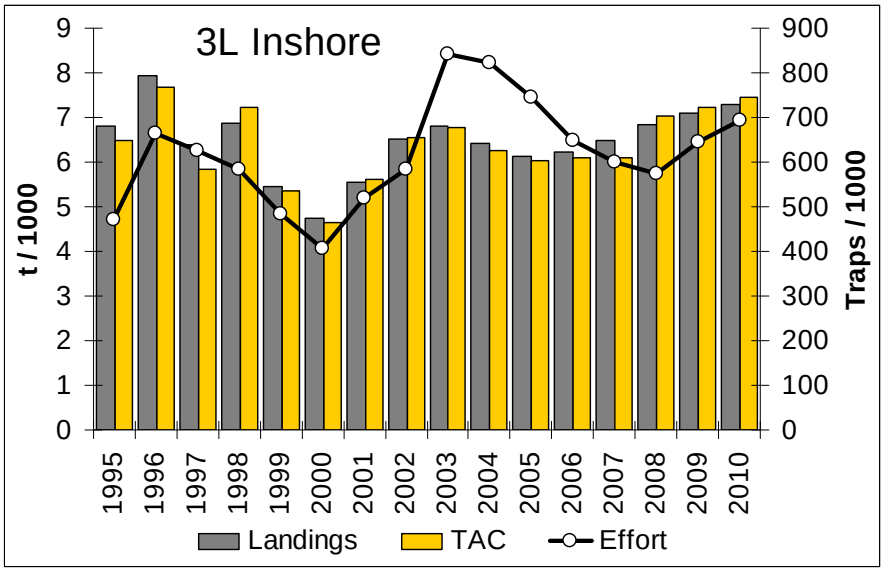


Figure 29: Trends in TAC, landings, and fishing effort in Div. 3L inshore.

CPUE increased from 2004 to the long-term average in 2007 (Fig. 30). It has changed little during the past four years and remains near the long-term average

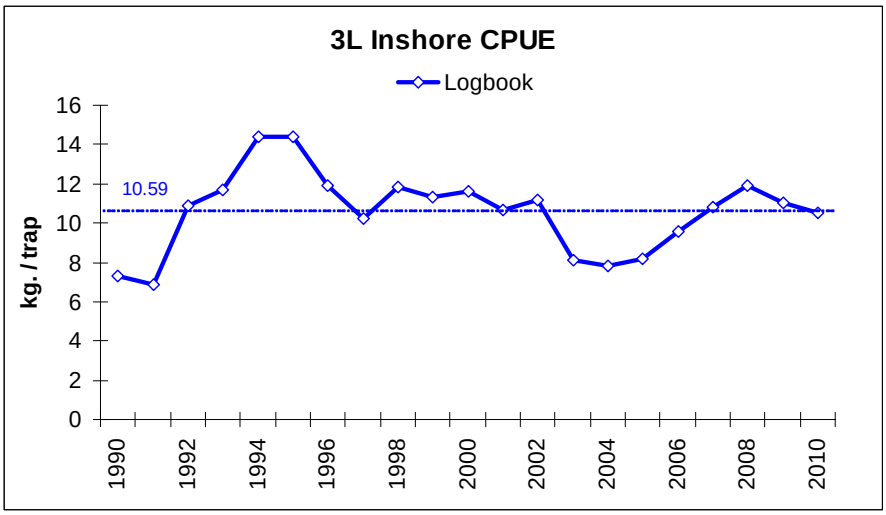


Figure 30.Trends in Div. 3L inshore commercial CPUE in relation to the long-term average (dotted line)

Biomass

The post-season trap survey index indicates the **exploitable biomass** has changed little over the past 7 years (Fig. 31).

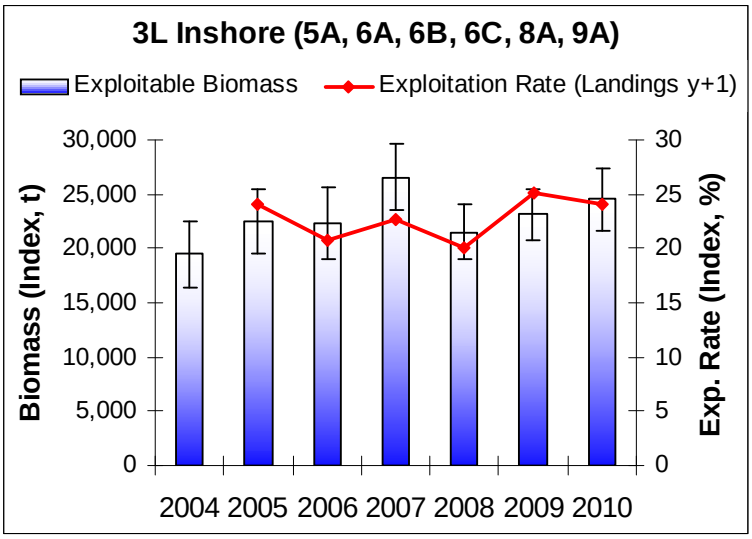


Figure 31: Exploitable biomass and exploitation rate indices based on the post-season trap survey in inshore Div. 3L. Note that exploitation rate is calculated as the landings of the current year divided by the biomass index of the previous year.

Recruitment

Recruitment is expected to increase for 2011 as reflected by an overall increase in the catch rate of legal-sized new-shelled adults in the CPS trap survey in 2010, but there is considerable variability among management areas. Overall, **recruitment** prospects have recently improved, but there is considerable variability among management areas (Fig, 32).

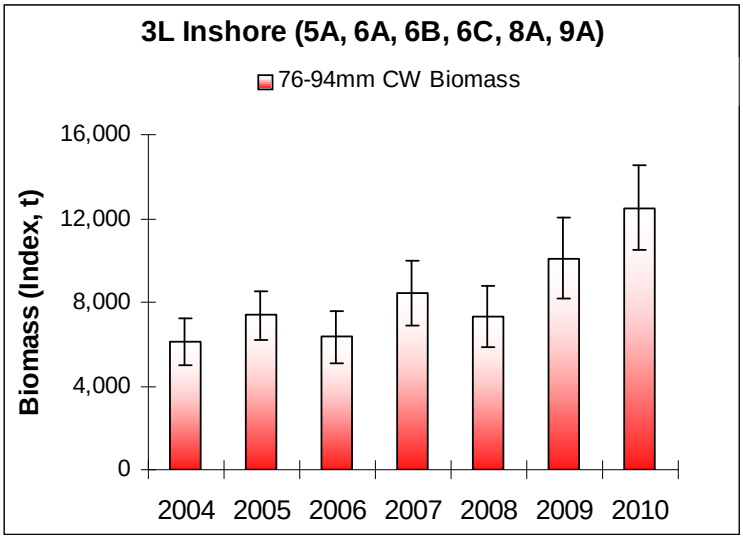


Figure 32: Pre-recruit biomass index of under-sized crabs from the post-season trap survey in inshore Div. 3L.

Mortality

The **exploitation rate** index from the post-season trap survey has varied without trend since 2005 (Fig. 31). Data are insufficient to estimate a **pre-recruit fishing mortality** index.

Resource Status, Subdivision 3Ps Offshore

Commercial Fishery

Landings varied little, at 4,300-4,400 t during 1999-2002, before declining by about half to 2006. They increased by 70% from 2,300 t in 2006 to 3,900 t in 2010 (Fig. 33). Meanwhile **effort** decreased from 2006 to 2008 and increased slightly to 2010.

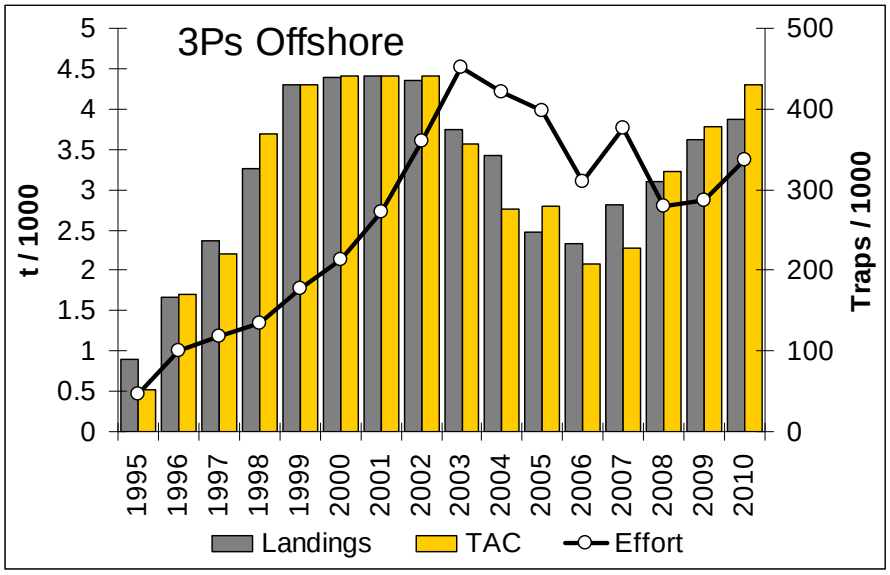


Figure 33: Trends in TAC, landings, and fishing effort in Subdiv. 3Ps offshore

CPUE declined substantially from 1999-2005 before increasing to 2009 and changed little in 2010 (Fig. 34).

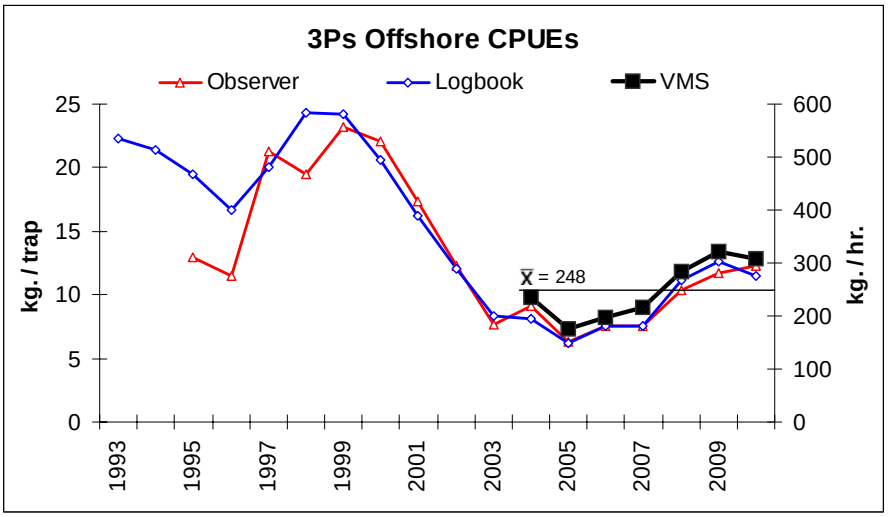


Figure 34: Trends in Subdiv. 3Ps offshore commercial CPUE. Horizontal line indicates the average of the VMS index.

Biomass

The **exploitable biomass**, as indicated by both the spring trawl survey and the post-season trap survey indices, increased steadily from 2006-2009 and then decreased slightly in 2010 (Fig. 35). The trawl survey index remains below the pre-2000 level.

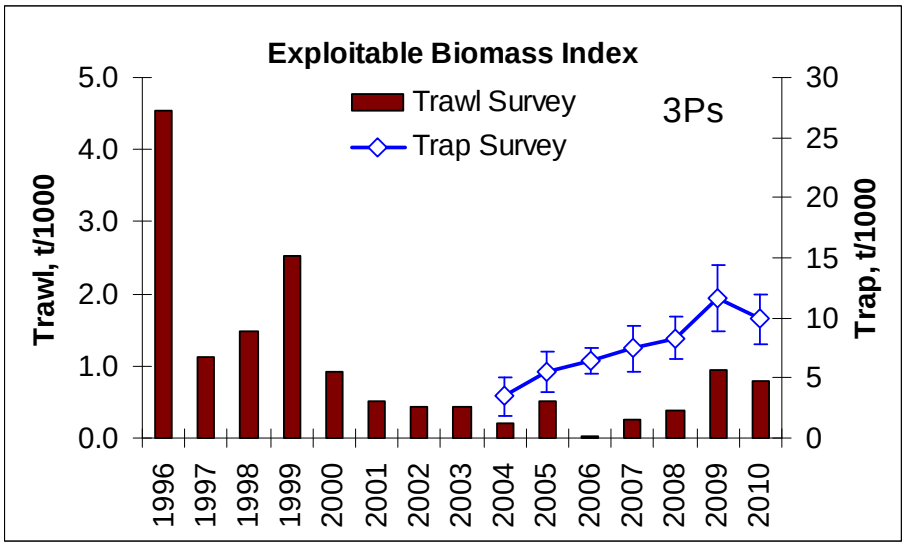


Figure 35: Trends in the Subdiv. 3Ps offshore exploitable biomass indices from the pre-season trawl survey and the post-season trap survey; the trawl survey was incomplete in 2006.

Recruitment

Recruitment has recently increased as reflected by an increase in biomass while landings increased. It appears promising for 2011, as reflected by little change in the post-season survey catch rate of new-shelled legal-sized crabs. The post-season trap survey index has varied without trend since 2005. Meanwhile, the pre-season trawl survey pre-recruit index increased greatly from 2005-2009 but decreased sharply in 2010 (Fig. 36). Therefore, recruitment is expected to decline following 2011.

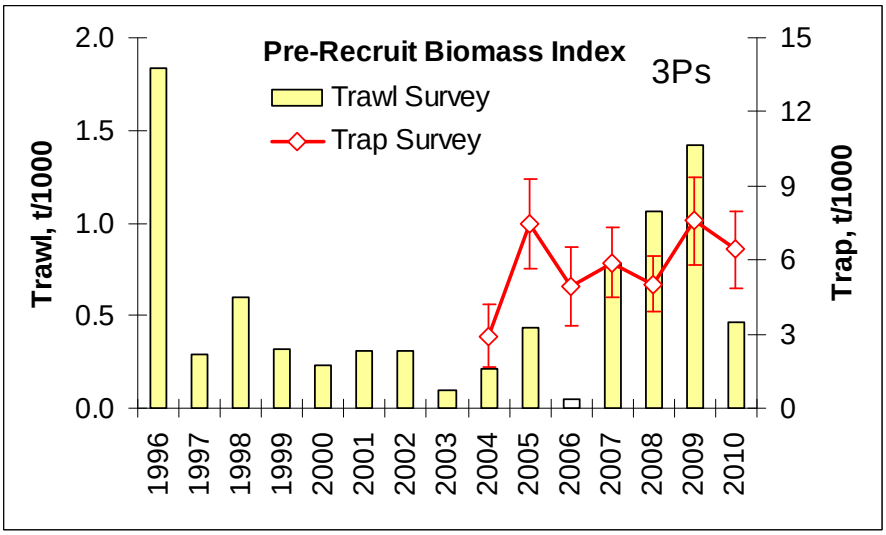


Figure 36: Trends in the pre-recruit biomass indices from the pre-season trawl survey and the post-season trap survey in Subdiv. 3Ps offshore; the trawl survey was incomplete in 2006.

Mortality

The percentage of the total catch discarded in the fishery (Fig. 37) peaked at about 45% in 2005, declined by half to 2008 and has since changed little, implying a reduction in wastage of pre-recruits in recent years. The percent discarded in Subdiv. 3Ps is generally higher than in other areas as it includes a larger component of under-sized crabs, an unknown but high portion of which is comprised of small adults that will never recruit to the fishery.

Exploitation and pre-recruit fishing mortality rates, as indicated by spring trawl survey indices, decreased from 2007-2009 but increased in 2010 (Fig.37). The indices remain well below the peaks in 2003 and 2004.

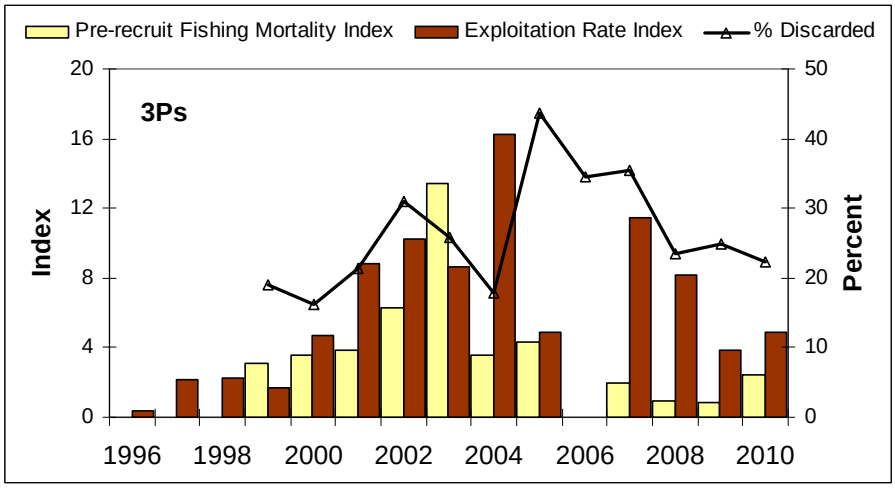


Figure 37: Trends in the Subdiv. 3Ps offshore exploitation rate and pre-recruit fishing mortality indices and percentage of the catch discarded in the fishery. Mortality indices were not calculated for 2006 because the survey was incomplete in that year.

Subdiv. 3Ps Inshore

Commercial Fishery

Landings varied little, at 3,300-3,600 t during 1998-2002, before declining by a factor of 5 to 2005 (Fig. 38). They then increased from 700 t in 2005 to 2,200 t in 2010 as **effort** declined slightly.

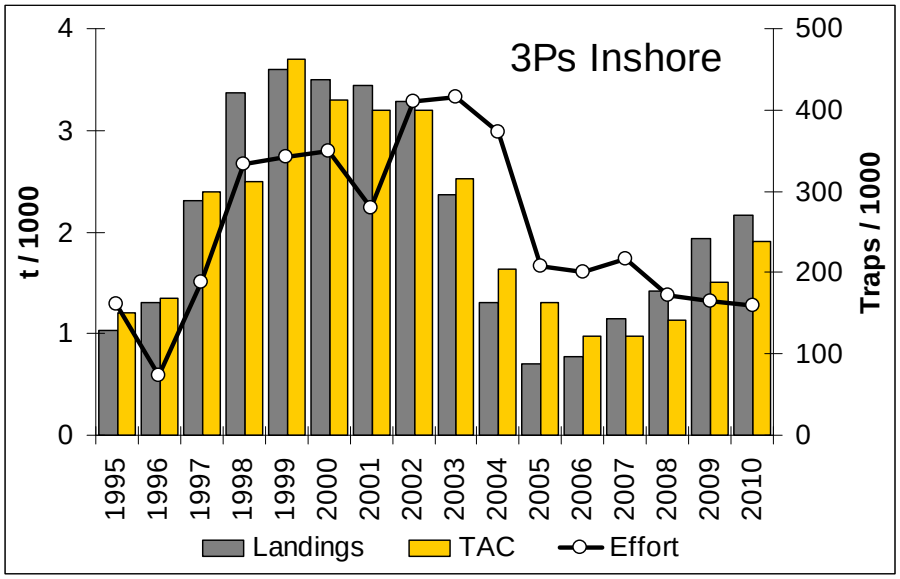


Figure 38: Trends in TAC, landings, and fishing effort in Subdiv. 3Ps inshore

CPUE declined from 2001-2005 and has since increased steadily to its highest level since 1996 (Fig. 39).

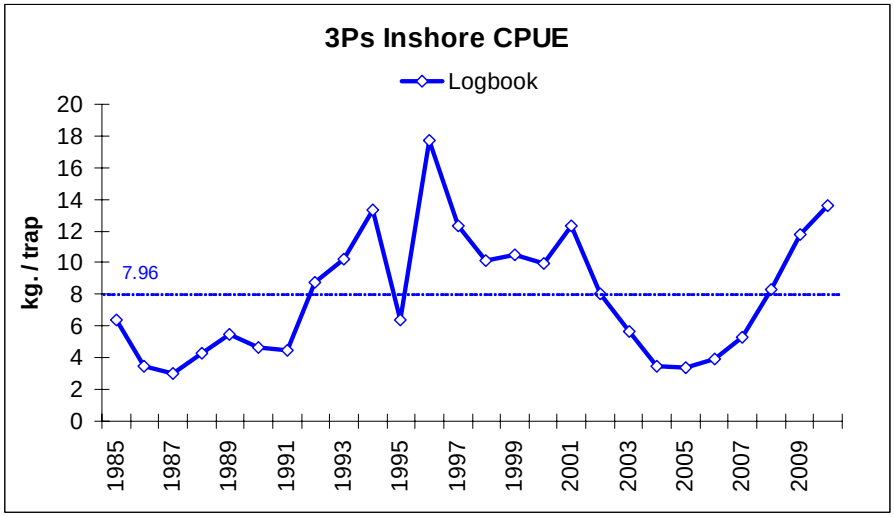


Figure 39: Trends in Subdiv. 3Ps inshore commercial CPUE in relation to the long-term average (dotted line).

Biomass

The **exploitable biomass,** as indicated by the post-season trap survey index, increased substantially between 2006 and 2008 and has since changed little (Fig. 40).

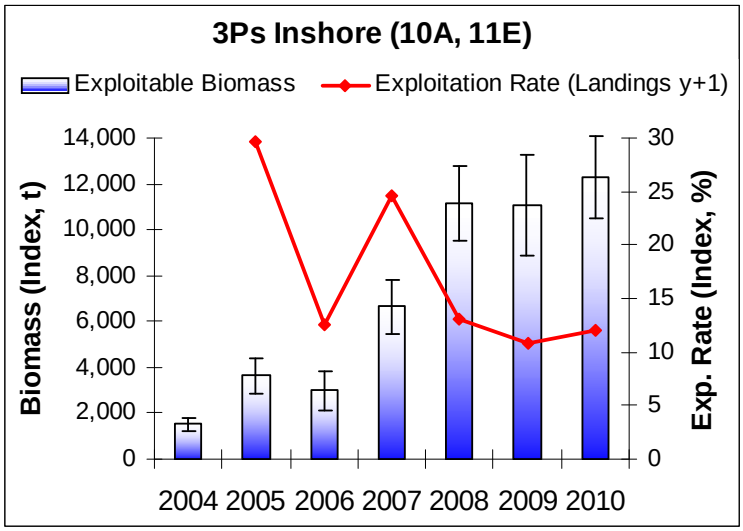


Figure 40: Exploitable biomass and exploitation rate indices based on the post-season trap survey in inshore Subdiv. 3Ps. Note that exploitation rate is calculated as the landings of the current year divided by the biomass index of the previous year.

Recruitment

Recruitment has recently increased, as reflected by an increase in the post-season trap survey catch rate of new-shelled legal-sized adults, and prospects for 2011 and 2012 are promising. The trap survey pre-recruit biomass index increased in 2007 and has since remained above the 2004-2006 level (Fig. 41). The pre-recruit biomass index for this subdivision includes a high proportion of small adults that will never recruit to the fishery.

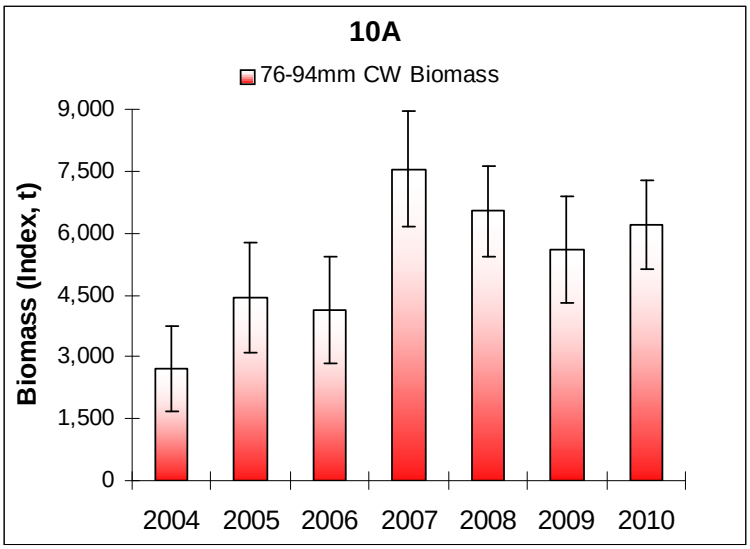


Figure 41: Pre-recruit biomass index of under-sized crabs from the post-season trap survey in inshore Subdiv. 3Ps.

Mortality

The post-season trap survey-based **exploitation rate index** changed little during 2008-2010 (Fig. 40). Data are insufficient to estimate a **pre-recruit fishing mortality** rate index.

Resource Status, Division 4R Offshore

Commercial Fishery

Landings declined substantially from 580 t in 2004 to 80 t in 2006 before more than doubling in 2007 (Fig. 42). They declined by 83% from 190 t in 2007 to a historical low of 30 t in 2010, while **effort** declined by 91%. The TAC has not been taken since 2002.

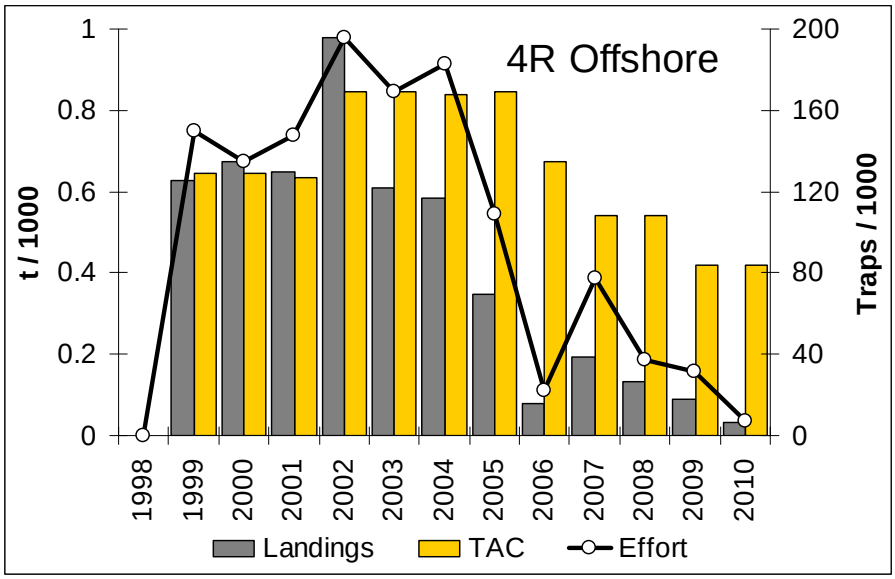


Figure 42: Trends in TAC, landings, and fishing effort in Div. 4R offshore.

CPUE declined slightly from 2006-2009 but increased sharply in 2010 (Fig. 43). However, the 2010 increase was associated with a record low level of both landings and effort. CPUE has consistently been low relative to other divisions.

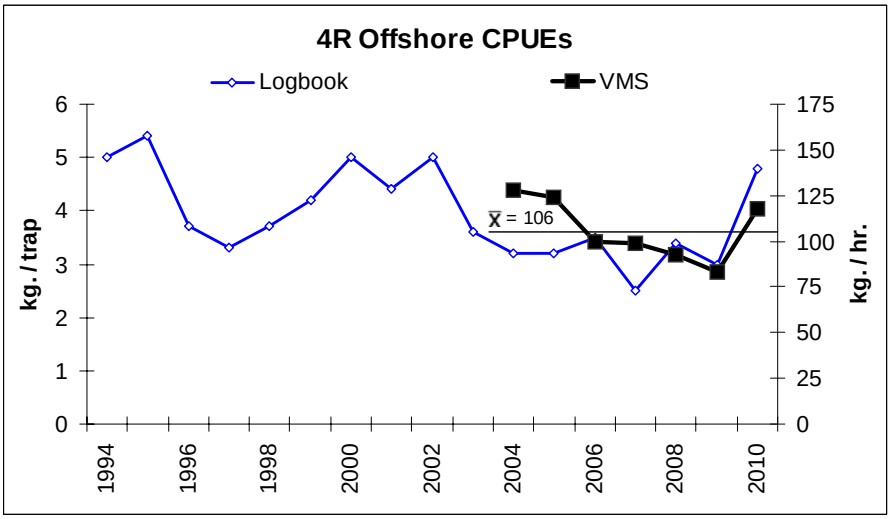


Figure 43: Trends in Div. 4R offshore commercial CPUE. Horizontal line indicates the average of the VMS index.

Biomass

The **exploitable biomass** is low as reflected by virtual abandonment of the fishery in recent years. The post-season trap survey index decreased in 2009 and was unchanged in 2010 (Fig. 44). The post-season trawl survey index has fluctuated without trend throughout the time series, due to sporadic survey catches each year.

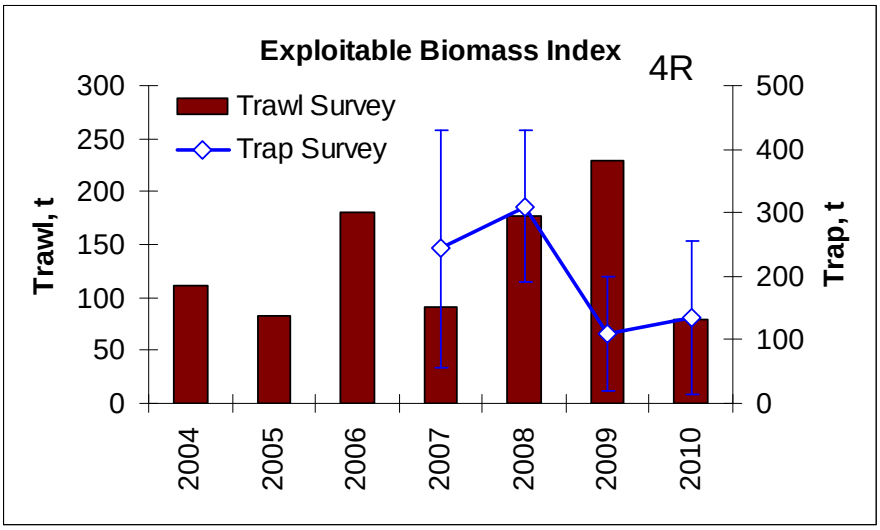


Figure 44: Trends in the Div. 4R offshore exploitable biomass indices from the post-season trawl and trap surveys.

Recruitment

Recruitment has been low in recent years, resulting in a low exploitable biomass despite declining landings. Prospects for the short term are poor. The post-season trap survey index was unchanged during 2007-2009 but decreased in 2010 (Fig. 45).

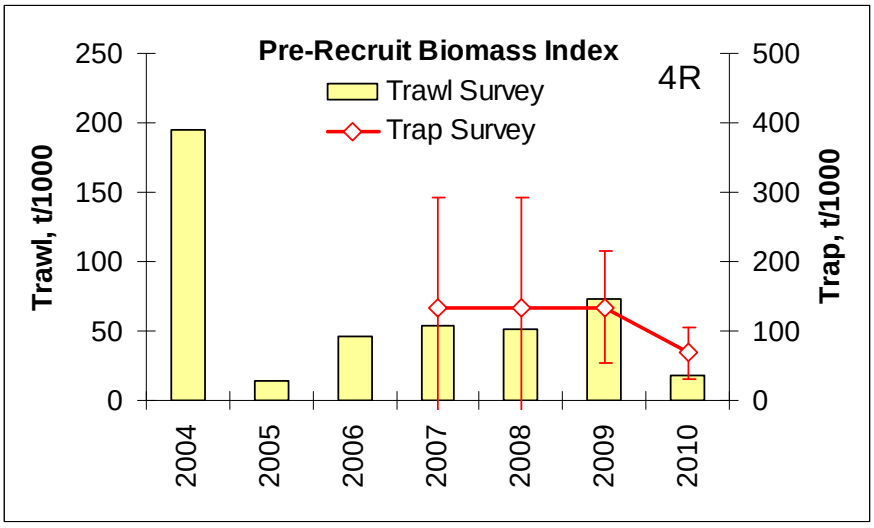


Figure 45: Trends in the pre-recruit biomass indices from the pre-season trawl survey and the post-season trap survey in Div. 4R offshore.

Mortality

The time series of information from the post-season trap survey is insufficient to interpret any trend in the **exploitation rate** index. Data are insufficient to calculate a **pre-recruit fishing mortality** index.

Div. 4R Inshore Resource Status

Commercial Fishery

Landings declined by 90% from 950 t in 2003 to 190 t in 2010 (Fig. 46), while **effort** declined by 60%. Landings and effort were at historical lows in 2010 and the TAC has not been taken since 2002.

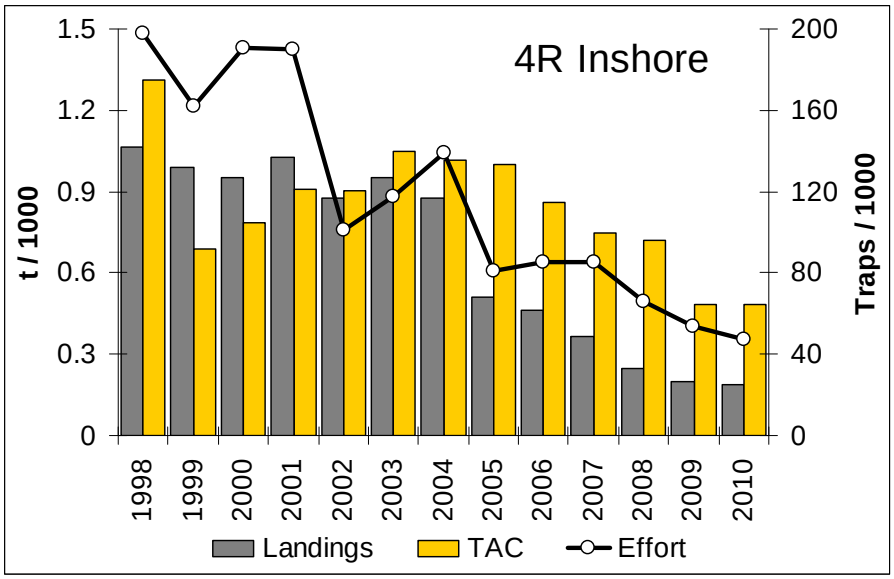


Figure 46: Trends in TAC, landings, and fishing effort in Div. 4R inshore.

CPUE declined steadily from 2002 to its lowest level in 2008 and has since changed little (Fig. 47).

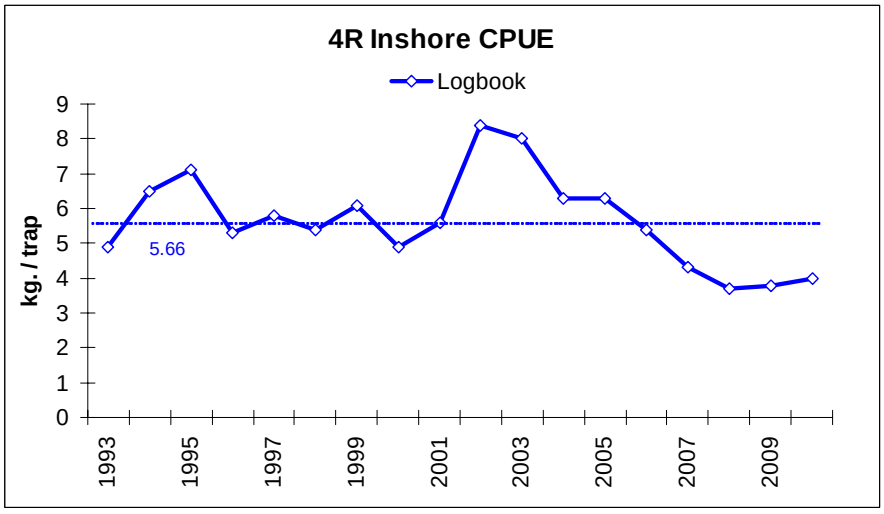


Figure 47: Trends in Div. 4R inshore commercial CPUE in relation to the long-term average (dotted line).

Biomass

The post-season trap survey **exploitable biomass** index changed little between 2005 and 2009 but increased in some management areas in 2010 (Fig. 48).

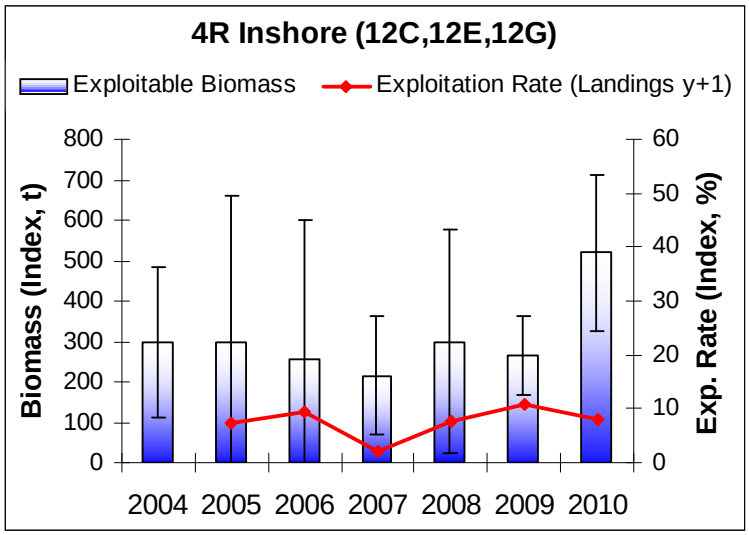


Figure 48. Exploitable biomass and exploitation rate indices based on the post-season trap survey in inshore Div. 4R.

Recruitment

Recruitment has recently increased, as reflected by an increase in the post-season trap survey catch rate of new-shelled legal-sized crabs in 2010. Prospects remain promising for the next two to three years, but there is considerable variability among management areas. The post-season trap survey pre-recruit biomass index increased in 2009 and decreased slightly in 2010 but remained above the pre-2009 level (Fig. 49).

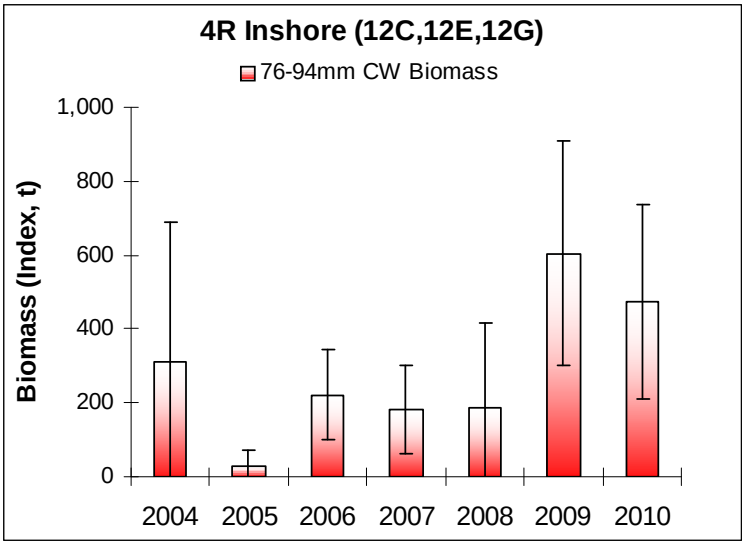


Figure 49. Trends in the pre-recruit biomass index from the post-season trap survey in inshore Div. 4R.

Mortality

The post-season trap survey **exploitation rate** index has changed little since 2005 (Fig. 48). The observer data are insufficient to estimate a **pre-recruit fishing mortality** index.

Sources of Uncertainty

There are several sources of uncertainty that affect the interpretation of trends in biomass, recruitment and mortality that represent the basis for this assessment: Uncertainties that affect post-season survey indices are more important than those that affect indices based on fishery performance.

Biomass and Recruitment Indices

Survey Indices

Interpretation of trends in exploitable and pre-recruit biomass indices from surveys is highly uncertain if the survey was incomplete. The multispecies trawl surveys commonly fail to sample inshore areas so they are used only for offshore areas. This introduces considerable uncertainty for all inshore areas because biomass and recruitment indices are available from only one source, the CPS trap survey. In the present assessment an incomplete DFO trap survey in 2009 introduced considerable uncertainty in interpreting trends for inshore Div. 3K.

Exploitable and pre-recruit biomass indices are also affected by annual variation in the catchability of crabs by the multispecies survey trawl and indices are typically associated with broad confidence intervals. This introduces uncertainty in interpreting annual changes in the exploitable biomass and predictions of changes in future recruitment. Trawl efficiency is directly related to crab size, so it is not possible to evaluate long term recruitment prospects based on the abundance index of smallest crabs. Indices from the spring trawl survey in Subdivision 3Ps carry higher uncertainty than do those from the fall surveys because the effects of the most recent fishery are not accounted for. Furthermore spring (pre-season) surveys are considered to be less reliable than summer and fall (post-fishery) surveys because some population components are relatively poorly sampled during spring when mating and molting take place.

The exploitable biomass index from the summer Div. 4R survey is considered unreliable due to sporadic survey catches each year, associated with low biomass in that division. The pre-recruit biomass index is further compromised in that molt status (adult versus adolescent) is not determined, so the pre-recruit index includes undersized adults that will never recruit to the fishery.

Exploitable and pre-recruit biomass indices from trap surveys are also affected by annual variation in catchability of crabs. Both DFO and collaborative post season trap surveys showed anomalously low biomass indices in inshore Div. 3K in 2009, due to reduced catchability, that resulted in high uncertainty regarding recent trends. There is also uncertainty in interpreting trends in biomass indices from the CPS survey because the time series is short and there is limited spatial coverage, especially in Div. 2J and Div. 3NO. Uncertainty is especially high in interpreting recruitment prospects based on the pre-recruit biomass index from this survey because molt status is not determined (chelae are not measured). Therefore the pre-recruit biomass index includes an unknown portion of under-sized adults (terminally molted) that will never recruit to the fishery. This is of greatest concern in Subdiv. 3Ps where a high proportion of males terminally molt below the legal size limit. There is uncertainty in using shell condition as a proxy indicator of molt status (adult versus adolescent) because of great variation in expertise among observers sampling during these surveys and subjectivity in assignment of shell stages.

Special small-meshed traps are included in sampling by the CPS trap survey on some stations in most areas to provide an index of future recruitment based on catch rates of sub-legal sized adolescents. However predictions of recruitment are uncertain due to very limited spatial coverage by small-meshed traps and high variability in trap catchability. Small adolescents are particularly susceptible to trap catchability effects due to competition with larger and adult males.

Fishery Indices

Completion and timely return of logbooks is mandatory in this fishery. The reliability of the logbook data is suspect with respect to effort (ie. under-reporting) and areas fished. This is especially true of Div. 3LNO offshore, where logbook data are known to be unreliable due to inaccurate reporting. This introduces a strong bias in logbook CPUE as an index of exploitable biomass in some areas. However logbook data provide the best index in most inshore areas because VMS data are not available and observer coverage is commonly insufficient. There is further uncertainty regarding the reliability of logbook data in some areas (eg. Div. 2H and inshore Div. 4R) because of low levels of returns.

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 commercial catch rates (CPUE) and their interpretation as indicators of trends in exploitable biomass. Some of these changes (eg. in mesh size and soak time) also affect catch rates of undersized crabs and so can compromise the utility of catch rate of undersized crabs as an index of future recruitment.

There are concerns regarding the utility of the observer data from at-sea sampling during the fishery due to low and spatiotemporally inconsistent coverage, especially in Div. 2H and 4R and all inshore areas, These concerns introduce a strong bias in interpreting trends in catch rates at broad spatial scales; in most divisions observer data are only useful for some inshore CMAs. Observer-based indices are also biased by inconsistent sampling methods and levels resulting from changing priorities. There are also concerns relating to variability in experience of observers in subjectively assigning shell stages. This introduces uncertainty in inferring recent recruitment trends and prospects based on catch rates of new-shelled crabs.

Mortality Indices

Survey and Fishery Data

Indices of fishery-induced mortality are subject to uncertainties associated with both survey and fishery data. Mortality indices are not estimated for years when the associated survey biomass index was not available or reliable. Trawl-based indices are not available for inshore areas. An exploitation rate index is estimated for inshore areas based on the post-season trap survey biomass index. However this index may be biased by annual changes in the distribution of crabs or fishing effort inside versus outside the limited survey areas. The pre-recruit fishing mortality and discard indices are not estimated for inshore areas due to insufficient observer data.

Low and spatiotemporally variable observer coverage introduces high uncertainty in interpreting the effects of the fishery on pre-recruit mortality. There is particular concern that a low level of compliance by harvesters in accommodating observers may introduce bias in estimates of soft-shelled crab prevalence. This concern is especially relevant to areas of high soft-shell crab prevalence in recent years (ie. Div. 3K) and it introduces high uncertainty regarding the level of fishery-induced mortality on soft-shelled immediate pre-recruits. Ultimately this leads to uncertainty concerning the efficacy of the soft-shelled protocol in minimizing this source of mortality.

ADDITIONAL STAKEHOLDER PERSPECTIVES

Division 2J

Harvesters acknowledge the fact that catch rates are not at the level they were in the late 1990's, but in recent years catches have been relatively stable. As a result harvesters feel that the population has somewhat stabilized.

Division 3K

Catch rates peaked in 2008 in the offshore and have since declined to just below the long-term average in 2010. A price dispute in 2010 resulted in a delayed start for most harvesters, as buyers would not buy crab at the negotiated price. This forced harvesters to fish later in the season when catch rates are usually lower and soft-shell is an issue. Harvesters feel that this delay resulted in lower CPUE's and as a result some had difficulty catching their IQ's. Harvesters that could sell their catch and had an early start, however, experienced much higher catch rates, very little incidence of soft-shell crab, and had no trouble landing their allocations.

Catch rates overall for the inshore declined in 2010 and there were problems with soft-shell crab. This decline was not as significant in some areas nor was the soft-shell issue. Similar to the offshore, harvesters in the inshore areas also felt that the delay in the season was a major contributing factor towards the decline in catch rates as well as an increased occurrence of soft-shell crab.

Division 3LNO

Inshore harvesters are encouraged by the recruitment indicators, which show that the stock is strong with large numbers of undersized animals observed and very little soft-shelled crab. Harvesters noted a significant improvement in recruitment in 2010 compared to 2009.

Harvesters noted that increases in the number of wolfish could be affecting the CPUE.

Harvesters feel that the implementation of voluntary initiatives in Div. 3L such as the Bonus Program, buffer zones, exclusion zones, escape mechanisms and bio-degradable twine, has contributed to the overall health of the stock.

In the offshore, the CPUE has been relatively stable in recent years and is just above the long term average for 2010. Harvesters felt the stock was stronger in 2010 than in previous years and the stock remains strong with no significant occurrence of soft-shelled crabs. Harvesters also noted a significant improvement in recruitment of undersized animals in 2010.

Subdivision 3Ps

Landings increased in 2010 while the CPUE remained stable, indicating to harvesters that the stock is in good shape. Harvesters also noted that due to the distance from land and the cost of fuel and bait, not all of the offshore TAC was taken.

Harvesters expressed concerns with the results of the spring pre-season trawl survey in 2010 that concluded there was a dramatic decline in recruitment compared to 2009. There were also concerns on the effectiveness of the trawl, as the survey did not reflect what harvesters observed in the commercial fishery. The post-season trap survey recruitment index, however, remains consistent and has not varied.

Good catch rates and positive signs of recruitment observed in the 2010 commercial fishery has led harvesters to remain optimistic about the future of the fishery.

Division 4R

There has been a major decline in effort in the offshore in recent years combined with low landings. The high cost of bait and fuel combined with lower catch rates are contributing factors to this decline. Harvesters that did fish in 2010, however, experienced catch rates that were above the long-term average and noted positive signs of recruitment.

There is a high level of variability throughout the inshore areas. While catch rates are at a low level they seemed to have stabilized in most areas. Harvesters feel that a late start to the fishery in 2010 also resulted in lower catch rates and soft-shell problems. Harvesters are adamant that if the season had started on time catch rates would have been higher. In addition, there has been a voluntary closure in place for CMA 12G for the past two fishing seasons. Results from the post-season trap survey for this area show very positive signs of both exploitable crab and recruitment.

CONCLUSIONS AND ADVICE

Division 2H

The **exploitable biomass** changed little from 2008-2010. **Recruitment** has decreased since 2004 and is expected to be low over the next several years. There were no pre-recruit males captured in the 2010 post-season trawl survey.

Maintaining the current level of fishery removals would likely result in little change to the exploitation rate in 2011, but would increase the exploitation rate in future years.

Division 2J

The **exploitable biomass** has decreased in recent years but changed little in 2010. **Recruitment** has recently declined and is expected to remain low in the short term. The **exploitation rate index** declined from 2003-2007 but has since gradually increased. The **pre-recruit fishing mortality index** declined sharply from 2003-2005, and has since remained low.

Maintaining the current level of fishery removals would likely have little effect on the exploitation rate in 2011.

Division 3K

Offshore

The **exploitable biomass** has declined by about half since 2008. **Recruitment** decreased in 2010 and is expected to change little in 2011. Prospects remain poor in the short term. The trawl survey **exploitation rate index** declined sharply from 2006-2009 and has since increased back to the 2006 level. The **pre-recruit fishing mortality index** increased from 2006-2009 and changed little in 2010.

Maintaining the current level of fishery removals would likely result in an increase in the **exploitation rate** and high mortality on soft-shelled immediate pre-recruits in 2011.

Inshore

The **exploitable biomass** decreased gradually between 2007 and 2010 but there is considerable variability among management areas. **Recruitment** prospects have improved slightly, but are also spatially variable. It was not possible to estimate the **exploitation rate index** in 2010.

It is not possible to infer how maintaining the current level of removals would affect the exploitation rate in 2011. However, it would likely result in increased wastage of soft-shelled immediate pre-recruits in 2011.

Division 3LNO Offshore

The **exploitable biomass** has recently increased. Both survey indices increased in 2009 and, despite diverging in 2010, remained above 2005-2008 levels. **Recruitment** has been recently increasing and prospects remain promising for the next two to three years. Both the **exploitation rate index** and the **pre-recruit fishing mortality index** peaked in 2008 and have since declined.

Maintaining the current level of removals would likely have little effect on the exploitation rate in 2011.

Division 3L Inshore

The **exploitable biomass** has changed little over the past 7 years. Overall, **recruitment** prospects have recently improved, but there is considerable variability among management areas. The **exploitation rate** index has varied without trend since 2005.

Maintaining the current level of fishery removals would likely result in little change in the **exploitation rate,** but may increase mortality on soft-shelled immediate pre-recruits in some areas in 2011.

Subdivision 3Ps

Offshore

The **exploitable biomass** increased steadily from 2006-2009 and decreased slightly in 2010. **Recruitment** appears promising for 2011 but is expected to decline thereafter. **Exploitation and pre-recruit mortality rates** decreased from 2007-2009 but increased in 2010.

Maintaining the current level of fishery removals would likely have little effect on the exploitation rate in 2011. However, increased removals to the level of the 2010 TAC would likely increase the exploitation rate in 2011.

Inshore

The **exploitable biomass** increased substantially between 2006 and 2008 and has since changed little. **Recruitment** has recently increased and prospects for 2011 and 2012 are promising. The **exploitation rate index** changed little during 2008-2010.

Maintaining the current level of fishery removals would likely have little effect on the exploitation rate in 2011.

Division 4R

Offshore

The **exploitable biomass** is low. **Recruitment** has been low in recent years and prospects for the short term are poor. The time series of information from the post-season trap survey is insufficient to interpret any trend in the **exploitation rate** index.

Maintaining the current level of fishery removals would likely result in little change to the exploitation rate in 2011.

Inshore

The post-season trap survey **exploitable biomass** index changed little between 2005 and 2009 but increased in some management areas in 2010. **Recruitment** has recently increased. Prospects remain promising for the next two to three years, but there is considerable variability among management areas. The post-season trap survey **exploitation rate** index has changed little since 2005.

Increased fishery removals would not likely increase the exploitation rate in 2011, but may increase mortality on soft-shelled immediate pre-recruits in some management areas.

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)

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

Management Considerations

Negative relationships between bottom temperature and snow crab biomass indices have been demonstrated at lags of 7-8 years, suggesting that cold conditions in early life favour survival and promote subsequent recruitment to the fishery, as they did in the late 1990's (Dawe et al. 2008). A warm oceanographic regime has persisted for more than a decade (Colbourne et al. 2009) suggesting relatively poor long-term recruitment.

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. Pre-recruit mortality is reduced by avoidance in the fishery and, when encountered, careful handling and quick release of pre-recruits. Mortality on sub-legal-sized males, including adolescent pre-recruits, can also be reduced by increasing trap mesh size and soak time, as well as trap modifications such as escape mechanisms and biodegradable panels.

Prevalence of soft-shelled crabs in the fishery is believed to be a function of both fishery timing and exploitable biomass level. Mortality on soft-shelled legal-sized immediate pre-recruits can be minimized by fishing early in spring before recently-molted crabs are capable of climbing into traps. It may be further reduced by maintaining a relatively high exploitable biomass level, thereby maintaining strong competition for baited traps and low catchability of less-competitive soft-shelled immediate pre-recruits.

There is concern that mortality on soft-shelled immediate pre-recruits has increased in Div. 3K in recent years due to declining exploitable biomass. If prevalence of soft-shelled crab is widespread then the current soft-shelled protocol would not likely provide adequate protection of immediate pre-recruits. However there is uncertainty associated with biased spatial coverage by observers. Measures should be taken to ensure representative observer coverage so as to better quantify soft-shell prevalence in the fishery. Meanwhile, it would be precautionary to reduce the exploitation rate so as to promote recovery of the exploitable biomass.

SOURCES OF INFORMATION

This Science Advisory Report is from the Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, Regional Advisory Meeting of February 28 – March 4 and March 7 – 11, 2011 on Snow Crab in NAFO Divisions 2HJ3KLNO, Subdivision 3Ps and Division 4R. Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

Colbourne, E., J. Craig. C. Fitzpatrick, D. Senciall, P. Stead and W. Bailey. 2009. An Assessment of the Physical Oceanographic Environment on the Newfoundland and Labrador Shelf in NAFO Subareas 2 and 3 during 2009. NAFO SCR doc. 10/16. 24 pp.

Dawe, E.G., D.G. Parsons, and E.B. Colbourne. 2008. Relationships of sea ice extent and bottom water temperature with abundance of snow crab (*Chionoecetes opilio*) on the Newfoundland - Labrador Shelf. ICES CM 2008:B02, 18 p.

FOR MORE INFORMATION

Contact:	Earl G. Dawe	Darrell R.J. Mullowney
	Fisheries and Oceans Canada	Fisheries and Oceans Canada
	P.O. Box 5667	P.O. Box 5667
	St. John's, NL A1C 5X1	St. John's, NL A1C 5X1
Tel:	(709) 772-2076	(709) 772-2521
Fax:	(709) 772-4105	(709) 772-4105
E-Mail:	Earl.Dawe@dfo-mpo.gc.ca	Darrell.Mullowney@dfo-mpo.gc.ca

This report is available from the:

Centre for Science Advice (CSA)
Newfoundland and Labrador Region
Fisheries and Oceans Canada
PO Box 5667
St. John's, NL A1C 5X1

Telephone: (709) 772-8892
Fax: (709) 772-6100
E-Mail: dale.e.richards@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas

ISSN 1919-5079 (Printed)
ISSN 1919-5087 (Online)

La version française est disponible à l'adresse ci-dessus.

CORRECT CITATION FOR THIS PUBLICATION

DFO, 2011. Assessment of Newfoundland and Labrador Snow Crab. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/011.