Development of the Jonah Crab, *Cancer borealis*, and Rock Crab, *Cancer irroratus*, Fisheries in the Bay of Fundy (LFAs 35-38) and off Southwest Nova Scotia (LFA 34): Exploratory to Commercial Status (1995-2004)

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2006

Canadian Manuscript Report of Fisheries and Aquatic Sciences 2775

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Canadian Manuscript Report of
Fisheries and Aquatic Sciences 2775

November 2006

Development of the Jonah Crab, *Cancer borealis*, and Rock Crab, *Cancer irroratus*, Fisheries in the Bay of Fundy (LFAs 35-38) and off Southwest Nova Scotia (LFA 34): from Exploratory to Commercial Status (1995-2004)

by

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Cat. No. Fs 97-4/2775E ISSN 0706-6473

Correct citation for this publication:

Robichaud, D.A., and Frail, C. 2006. Development of Jonah crab, *Cancer borealis*, and rock crab, *Cancer irroratus*, fisheries in the Bay of Fundy (LFAs 35-38) and off southwest Nova Scotia (LFA 34): from exploratory to commercial status (1995-2004). Can. Manuscr. Rep. Fish. Aquat. Sci. 2775: iii + 48 pp.

ABSTRACT

Robichaud, D.A., and Frail, C. 2006. Development of Jonah crab, *Cancer borealis*, and rock crab, *Cancer irroratus*, fisheries in the Bay of Fundy (LFAs 35-38) and off southwest Nova Scotia (LFA 34): from exploratory to commercial status (1995-2004). Can. Manuscr. Rep. Fish. Aquat. Sci. 2775: iii + 48 pp.

This report describes the developmental phases and the sequence of events in the management process and changes in regulation that occurred in the exploratory Jonah and rock crab fisheries in Lobster Fishing Areas (LFAs) 34, 35, 36 and 38. After 9 yr as developing fisheries, DFO Fisheries and Aquaculture Management Branch recommended that they become full commercial fisheries. This recommendation was accepted by the Minister and they became commercial in 2004. Analyses of the fishery data from each LFA are provided here. Trends in landings, fishing effort (trap hauls), distribution of effort, catch rates (kg per trap haul), and the size structure of both crab species, are examined. The impact that these crab fisheries have had on the resource, the prospects for further development of these fisheries, and the science issues which remain to be addressed are discussed. A key issue is the effect of removals of Jonah and rock crab by the lobster fisheries, which is currently not well quantified.

RÉSUMÉ

Robichaud, D.A., and Frail, C. 2006. Development of Jonah crab, *Cancer borealis*, and rock crab, *Cancer irroratus*, fisheries in the Bay of Fundy (LFAs 35-38) and off southwest Nova Scotia (LFA 34): from exploratory to commercial status (1995-2004). Can. Manuscr. Rep. Fish. Aquat. Sci. 2775: iii + 48 pp.

Ce rapport décrit les étapes de développement, la séquence des évènements dans le processus d'aménagement, et les changements dans la réglementation qui ont eu lieu dans les pêcheries exploratoires du crabe Jonah et du crabe commun, dans les Zones de Pêche de Homard (ZPH) 34, 35, 36 et 38. Après neuf années comme pêcherie exploratoire, la Direction de la Gestion des Pêches et Aquaculture du MPO a recommandé qu'elles deviennent des pêcheries commerciales. Ces recommandations furent acceptés par le Ministre des Pêche et Océans et sont devenu commerciales en 2004. Présenté ici sont les analyses des données de pêche de chaque ZPH. L'effort de pêche (nombre de cassier levé), la distribution de l'effort de pêche, les tendances et le taux des prises (kg par cassier levé), et la structure des tailles des deux espèces de crabe sont examinés. L'impact que ces pêcheries de crabe ont eu sur la ressource, le potentiel de développement additionnel de ces pêcheries, et les questions scientifiques qui restent à résoudre sont discutés. Une question clef, est quel est l'effet de la capture de crabe Jonah et de crabe commun par les pêcheries de homard, qui présentement n'est pas très bien quantifié.

INTRODUCTION

BIOLOGICAL BACKGROUND

Jonah crab

Jonah crab, *Cancer borealis*, can be found from Newfoundland to Florida (Haefner 1977; Stehlik et al. 1991; Wenner et al., 1992). Off Nova Scotia and in the Bay of Fundy, Jonah crab is found primarily at depths between 50 and 300 m. The habitat preferred by Jonah crab varies from rocky substrates in Narragansett Bay (Jeffries 1966) and the coast of Maine (Krouse 1980), to silt and clay bottom on the continental slope (Musick and McEachran 1972; Wenner et al. 1992). In Norfolk Canyon, off the mouth of Chesapeake Bay, Virginia, males mature at 90-100 mm carapace width (CW), and female Jonah crabs mature at 85 mm CW (Carpenter 1978; Wenner et al. 1992). More recently, on the Scotian Shelf, Moriyasu et al. (2002) have shown that the size at 50 % morphometric maturity (or functional maturity) for males occurred at 128 mm CW and the size of 50 % gonadal maturity occurred at 69 mm CW. The size of 50% maturity for female Jonah crab was estimated to occur at 92 mm CW (Mikio Moriyasu, unpublished data). In the Gulf of Maine, male Jonah crab can reach a maximum carapace width of over 222 mm (Robichaud et al. 2000a, b); females usually do not exceed 150 mm CW.

Rock crab

Rock crab, *Cancer irroratus*, can be found from Newfoundland to Florida at depths ranging between 6 and 456 m (Stehlik et al. 1991). Off Nova Scotia and in the Bay of Fundy, rock crabs are commonly found in water less than 20 m (Krouse 1980; Robichaud et al. 2000b). Bigford (1979) summarized the numerous studies of the biology and ecology of Rock crab. Rock crab prefer sandy or mud bottom, but are commonly found on coarse gravel or mixed rocky bottom (Jeffries 1966; Krouse 1972; Scarratt and Lowe 1972; Winget et al. 1974; Gendron and Cyr 1994). Rock crab molt during the winter (Haefner and Van Engel 1975; Reilly and Saila 1978). The size at which 50% of rock crab is physiologically mature occurs at about 49 mm CW for females and 62 mm CW for males (Campbell and Eagles 1983). In the Gulf of Maine, male rock crab reach a maximum of only 150 mm CW while female rock crab rarely reach 110 mm CW (Robichaud et al. 2000b). Based on estimate in growth with respect to age and instars in Rhode Island waters, it was estimated that male rock crab can reach the minimum legal size of 102 mm CW in approximately 5-6 yr (Reilly and Saila 1978).

CRAB FISHERY BACKGROUND

Since the 1960s, Jonah crab and rock crab have been occasionally landed as by-catch in lobster fisheries across the Maritimes, as well as in intermittent directed fisheries (Wilder 1966; Scarratt and Lowe 1972; Elner and Robichaud 1984, 1985; Elner 1986). Due to favorable market conditions during the late 1980s and early 1990s, several rock or Jonah crab exploratory fisheries were initiated across the Maritimes. New exploratory rock and Jonah crab fisheries were initiated in southwest New Brunswick (Lobster Fishing Areas (LFAs) 36 and 38) in 1995 and in southwest Nova Scotia (LFAs 34 and 35) in 1996 (Fig. 1), (Robichaud et al. 2000a, b). Two Developing Species Advisory Boards (DSABs) were created to provide advice to

management, for these exploratory crab fisheries, as well as other new commercial species. The two DSABs evolved independently, with science as the only common link. Crab permits were distributed to fishermen from a number of ports to ensure that exploratory fishing occurred over a wide geographical range. Permits were valid only within the particular LFA of issue. With the creation of a Regional Developing Species Advisory Board (RDSAB) in 1998 there was a concerted effort to coordinate a more uniform approach to the management of developing fisheries on a region-wide basis.

This document describes the development of the exploratory rock and Jonah crab fisheries within each LFA. After 9 yr as developing fisheries, the Department of Fisheries and Oceans (DFO), Fisheries and Aquaculture Management Branch recommended to the Minister that these directed rock and Jonah crab fisheries move to full commercial status. This recommendation was accepted. The impact that these fisheries have had on the resource is not fully understood. In this report trends in landings, effort and catch rates (kg per trap haul), as well as size structure of both crab species, are examined. The developmental phases of these crab fisheries are described. Prospects for further development of these fisheries, and the outstanding science issues are discussed.

HISTORY OF THE JONAH AND ROCK CRAB FISHERIES

The first rock/Jonah crab exploratory fishing permits were issued during 1995 in the Bay of Fundy (LFAs 36 and 38) and in 1996 in the Bay of Fundy (LFA 35) and southwest Nova Scotia (LFA 34). At the outset of these exploratory crab fisheries, several regulations were put in place in an attempt to prevent over-fishing and to protect the reproductive capacity of the crab population (Tables 1, 2, 3, 4). These conservation measures were changed, replaced, or added to as these crab fisheries developed, as the fishermen became more experienced at catching crabs, and as scientific knowledge improved. In 2004, all of the exploratory crab permits became permanent commercial crab fishing licenses.

Southwest Nova Scotia (LFA 34)

During the first year (1996), nine rock/Jonah crab exploratory permits were issued. In subsequent years, changes occurred in the number of permits issued each year (see Table 1 for details). The crab fishing season was set to open 1 wk after the close of the spring lobster fishing season (31st of May) until 1 wk prior to the opening of the fall lobster season (last Monday in November). They were permitted to use modified lobster traps which eventually became the standard trap for this crab fishery. Throughout the years several modifications were made in the size of escape vents, trap head size, location of the entrance, and in the size of the traps (see Table 1 for details). Originally, a maximum trap limit of 100 traps was set. However, in 1997, the maximum trap limit was increased to 150 traps if the fishery directed for rock crab, and to 250 if directed for Jonah crab. In 1998, the maximum trap limit was increased to 375 if directed for Jonah crab. In 1996, a minimum size limit of 130 mm CW was set for Jonah crab, and 102 mm CW for rock crab. In addition, there were minimum landings requirements: 9 MT (20,000 lb) of Jonah or 4.5 MT (10,000 lb) of rock crab. In 1998, the exploratory rock/Jonah crab permits were divided into separate permits by species: five Jonah crab and two rock crab permits were issued. These Jonah crab permits did not allow the landing of rock crab as a by-catch, and

the rock crab permits did not allow the landing of Jonah crab (Table 1). In 2004, five Jonah crab and two rock crab exploratory permits became permanent commercial crab licenses.

Bay of Fundy (LFA 35)

During the first year (1996), five rock/Jonah crab permits were issued. Changes occurred in the number of permits issued each year (see Table 2 for details). The crab fishing season was set to open 1 wk after the close of the spring lobster fishing season (31st of July) until 1 wk prior to the opening of the fall lobster season (15th of October). They were permitted to use modified lobster traps which eventually became the standard trap for this crab fishery. Throughout the years, several modifications were made in the size of escape vents, the head size, and in the size of the traps (see Table 2 for details). In 1996, a minimum size of 130 mm CW was set for Jonah crab, and 102 mm CW was set for rock crab. In addition, there were minimum landings requirements: 9 MT (20,000 lb) of Jonah or 4.5 MT (10,000 lb) of rock crab. Originally (1996), a maximum limit of 100 traps was set. However in 1997, the maximum trap limit was increased to 150 traps if the fishery was directed for rock crab, and to 250 if directed for Jonah. In 1998, the exploratory rock/Jonah crab permits were divided into separate permits by species: five rock crab permits but no Jonah crab permits were issued. These rock crab permits did not allow the landing of Jonah crab as a by-catch. In 2004, these five rock crab exploratory permits became permanent commercial rock crab licenses (Table 2).

Bay of Fundy (LFA 36)

In 1995, five rock/Jonah crab permits were issued. Changes occurred in the number of permits issued each year (see Table 3 for details). The crab fishing season was set to be open all year and only conical crab traps were permitted to be used. Only male crabs were allowed to be landed. Throughout the years, several modifications were made in the size of escape vents, the head size, and in the size of the traps (see Table 3 for details). In 1995, the maximum trap limit was set at 100 traps per fishermen. In 1996, the maximum trap limit was increased to 200 traps, and in 2000, was increased to 300 traps. In 1995 no minimum size limit was established for either species; however, in 1996, a minimum size limit of 121 mm CW was set for Jonah crab, and 102 mm CW was set for rock crab. In 1996, a minimum requirement of 20 fishing trips was established. Crab fishers were also required to fully participate in an approved Dockside Monitoring Program (DMP). In the following year, the minimum requirement was reduced from 20 to 15 fishing trips, and in 1999 a minimum requirement of crab landings was set at 30% of the average landings. In 2001, in addition to a minimum fishing effort of 15 trips, a minimum of 1000 kg of crab had to be sold. In 2004, the exploratory rock/Jonah crab permits were divided into separate permits by species: seven rock crab but no Jonah crab permits were issued. These rock crab permits did not allow the landing of Jonah crab as a by-catch (Table 3). In 2004, the seven rock crab exploratory permits became permanent commercial rock crab licenses.

Bay of Fundy (LFA 38)

In 1995, only one rock/Jonah crab permit was issued (Table 4). It was not until 1998 that four additional permits were issued. The crab fishing season was set to be open all year and only conical crab traps were permitted. Only male crabs were allowed to be landed. Throughout the

years several modifications were made in the size of escape vents, the head size, and in the size of the traps (see Table 4 for details). In 1995, the maximum trap limit was set at 100 traps per fishermen. In 1996, the maximum trap limit was increased to 200 and in 1999 was increased to 300. In 1995, no minimum size limit was established. However, in 1996, a minimum size limit of 121 mm CW was set for Jonah crab and 102 mm CW was set for rock crab. In 1996, a minimum requirement of 20 fishing trips was established. Crab fishers were also required to fully participate in an approved DMP. The following year the minimum requirement was reduced to 15 fishing trips and in 1999 a minimum requirement of crab landings was set at 30% of the average landings. In 2004, the exploratory rock/Jonah crab permits were divided into separate permits by species: five Jonah crab permits, but no rock crab permits were issued. These Jonah crab permits did not allow the landing of rock crab as a by-catch (Table 4). In 2004, the five Jonah crab exploratory permits became permanent commercial Jonah crab licenses.

ASSESSMENT METHODOLOGY

BIOLOGICAL INPUTS

An at-sea program, sampling the non-landed portion of the catch has provided detailed information on the population size structure including sub-legal males, females, berried females, and soft-shell crabs. Sampling at sea has also provided catch-effort information, and the data were used for monitoring changes in the mean size and abundance of legal-size crabs. All crabs retained in individual trap hauls were measured (carapace width in mm) by a person trained by personal from DFO, Science Branch. In this report these sea samples will be referred to as DFO sea samples. Catches were examined to determine species, sex, presence or absence of eggs for female crabs and molt condition. For each trap haul on a given day of sampling, the location, depth, and trap type was recorded. As the exploratory rock/Jonah crab fisheries were developing, sea sampling was conducted on an opportunistic basis, with emphasis on developing a time series whenever possible from a series of representative ports, and at times when high fishing activity occurred. However, due to a lack of funding, inadequate sampling was done, and during several fishing seasons no sea samples were obtained.

In LFAs 34 and 35, during the 2003 and 2004 fishing seasons, crab fishermen began to do their own sea sampling, which is referred to in this report as industry sea sampling. During each fishing trip, fishermen sampled two regular commercial traps set adjacent, one trap with blocked escape vents, and the second trap with open vents. All crabs captured were measured, sexed, and molt condition determined by fishermen.

LANDINGS AND EFFORT ANALYSIS

Logbook data were used for monitoring fishing activity. All participants in the exploratory rock and Jonah crab fisheries were required to complete daily logbooks. The information requested was the number of traps hauled, soak days, live weight landed, the species of crab fished, depth, date, location (latitude and longitude), and the type of trap fished. Logbook information, landing and effort data were used to evaluate trends in catch rates by time period (weekly or monthly intervals) for the various fishing locations. Fishery information was also used to determine the distribution of effort.

RESULTS

EFFORT DISTRIBUTION

Jonah crab

Since 1995, two main commercial concentrations of Jonah crabs have been fished. One is located off southwestern Nova Scotia in the midshore within LFA 34, and the other is located off southern Grand Manan in LFA 38 (Fig. 2). Jonah crabs were found in commercial concentrations only in waters deeper than 75 m. Off southwestern Nova Scotia (LFA 34), during 2003 and 2004, there was a shift from the traditional fishing ground toward the north along the 80 km boundary line (50-mile line) which separates the inshore and offshore lobster fisheries (Fig. 3). For the size-frequency analysis, the Jonah crab fishing grounds in LFA 34 was divided into two areas: Area 1 representing the traditional fishing ground, and Area 2 the new fishing ground. Although some Jonah crabs were found in southern New Brunswick (LFA 36), off Digby Neck (LFA 35), and in St Mary's Bay (LFA 34), no commercial concentrations were found.

Rock crab

Since 1995, the exploratory rock crab fishery has located several commercial concentrations (Fig. 4). Rock crabs were found in the St. Marys Bay area (LFA 34), in the Annapolis Basin area (LFA 35) and in several areas situated between Passamaquoddy Bay, and Point Lepreau, in southern New Brunswick (LFA 36). In 1995, some rock crabs were found off Grand Manan in LFA 38. However, the search for a viable concentration of rock crab in LFA 38 was abandoned as effort was diverted to the more lucrative Jonah crab fishery.

CATCH SIZE STRUCTURE FROM DFO AND INDUSTRY SEA SAMPLING

LFA 34, midshore Jonah crabs

Since 1996, most of the Jonah crab fishing occurred in the midshore (Area 1 in Fig. 3). During 2003 and 2004, there was a migration of fishing effort into new fishing grounds (Area 2 in Fig. 3). For the analysis of the population size structure, the sea sampling data was separated between these two fishing areas: Area 1 (traditional fishing grounds) and Area 2 (new fishing grounds). All samples were obtained from modified lobster traps.

Since 1996, in the midshore area of LFA 34, the DFO sea sampling was sparse (Fig. 5). The first sea samples were obtained during August and October 1998 and in August 1999 (Fig. 6). After a lag of 3 yr, in 2003, DFO and the LFA 34 Jonah crab fishermen entered into a joint project agreement in which fishers provided funding for DFO sampling at sea. Size-frequency samples were taken monthly from August to November in Area 1 and during July and August in Area 2. During 2004, little funding was available, and only one sample was taken in August. During 2003 and 2004, crab fishers initiated a volunteer sea sampling project. During each fishing trip, fishermen voluntarily measured all the Jonah crabs captured in two traps set

adjacent. The two traps were regular commercial traps, one with escape vents open (vented trap) and the other with escape vents closed off (unvented trap).

There were no significant differences in the mean size of male Jonah crabs between the monthly DFO sea samples collected in Area 1 during 2003 (varied from 138 and 142 mm CW), and those DFO sea samples collected earlier in this crab fishery during 1998 and 1999 (varied from 139 and 142 mm CW) (Fig. 6). However, overall there was a decrease in the number of legal-size crab (>130 mm CW) per trap haul (#/th) in 2003 (ranged from 5.4 to 10.7 legal crab/th) compared to 1998 and 1999 (ranged from 9.8 to 12 legal crabs/th). In 2003, monthly DFO sea sampling from August to November, indicated that the catch rate peaked during September (10.7 legal crabs/th) and was the lowest in August (5.4 legal crabs/th) (Fig. 6). In 2004, only one DFO sea sample was taken in August and no seasonal comparison could be made. However, the number of legal crab per trap haul was lower (4.8 legal crabs/th) than the catch rate observed in August 2003 (5.4 legal crabs/th).

Throughout the years, the number of sub-legal male Jonah crabs (<130 mm CW) per trap haul has remained low (less than 2.5 sub-legal crabs/th) (Fig. 6). The only exception was in August 2004 when the number of sub-legal crab increased to 3.8. The main reason for the low catch rate of small crabs is that it is mandatory that all commercial crab traps be fitted with escape vents which allow sub-legal crabs to escape. Also, crab fishermen try to avoid areas where large numbers of sub-legal crabs are found.

Area 2 was only sampled during July and August of 2003. The month of August, was the only time period during which sea sampling was done in both Areas. In Area 2, during August 2003, the mean size of males (145 mm CW), and the catch rate of legal size males (9.1 crabs/th) were higher than in Area 1 (142 mm CW and 5.4 crabs/th, respectively) (Fig. 6). The catch rate of sub-legal males was low in both Areas (0.5 sub-legal crab/th in Area 2, and 0.8 sub-legal crab/th in Area 1).

Throughout the years, there was no significant change in the mean size of females (ranged between 118 and 125 mm CW). Although there was more variability in the catch rate of females, the number of females per trap hauls remained low (<7 females/th). The main reason for the low catch rate would be the same as for small male crabs. It is mandatory that all commercial crab traps be fitted with escape vents which allow small female crabs to escape. Also, crab fishermen try to avoid areas where large numbers of female crabs are found. The catch rate of females in Area 2 during August 2003 was three times higher (6.1 females/th) than in Area 1 (2 females/th) (Fig. 6).

Less than 1% of all females captured in the traps sampled were berried. The only exception was in the first sample taken in August 1998 where the proportion of berried female crab was 5.8 % (Fig. 6).

During 2003 and 2004, industry sea sampling provided valuable information on Jonah crab size structure and shell condition (Figs. 7, 8). In 2003, fishermen measured, sexed, and determined the shell condition of 2427 Jonah crabs. Of these, 2314 crabs were measured in Area

1 and 113 in Area 2. In 2004, a total of 1978 Jonah crabs were measured, sexed, and shell condition determined. Of these, 1489 crabs came from Area 1 and 489 from Area 2.

In Area 1, during 2003 and 2004, the mean size of male Jonah crabs in vented traps was larger than males captured in unvented traps (Figs. 7, 8). The lower mean size of males in the unvented traps was due to the presence of high numbers of sub-legal size males. In Area 2, due to the low number of sub-legal males, the mean size of males in the unvented traps was similar to those in vented traps.

Large numbers of sub-legal male and female crabs were captured in unvented traps (up to 45.5 sub-legal males/th and 24.7 females/th) (Figs. 7, 8). The main reason for sampling unvented traps is to determine the distribution and concentration of small male and female crabs. Surprisingly, the numbers of legal size males per trap haul in the unvented traps were either similar to or greater than those from the regular commercial vented traps.

In Area 1, during 2003 and 2004 the catch rate of females was low (high of 6.3 females/th) in vented traps compared to unvented traps (high of 24.7 females/th) (Figs. 7, 8). Due to the higher number of small females caught in unvented traps, the monthly mean size of females (105 to 113 mm CW) was generally smaller then those in vented traps (108 to 123 mm CW). In Area 2, the catch rate of females was low, both in vented (<5.3 females/th) and unvented (<5.9 females/th) traps. The proportion of females that were berried was generally higher in 2004 than in 2003 and generally higher in the unvented traps (Figs. 7, 8).

The industry sampling during June-July and August 2003 did not seem to accurately reflect the size composition of the crab population (Fig. 7). During June/July, the size-frequency data was collected in 10-mm size groupings and in August there was a large number of small crabs (<80 mm CW) captured in the vented traps. These small sizes of crabs were never observed again in subsequent sampling by industry (in the vented traps) or in the DFO sampling. During this time period (June-August 2003), the industry was just beginning to familiarize itself with sea sampling protocol, and comparison with these data should be done with discretion. Although the number of traps sampled each month was low, subsequent sampling by industry during 2003 and 2004 seem to reflect similar trends in seasonal catch rates as the DFO sampling. For example, in 2003 both sampling methods showed that the highest monthly catch rates of legal-size males were observed in September (10.7 and 19.2 legal males/th for DFO and industry sampling, respectively). An expansion of industry sea sampling is recommended before it can be expected to provide a suitable alternative to DFO sampling.

The industry sea sampling seems to better reflect the incidence of soft-shell males than the DFO sea sampling. The proportion of soft-shell males was higher in Area 1 than in Area 2 and was the highest during 2004. During 2003, in Area 1, the percentage of soft-shell males was 14% in June/July, 37 % in August and 22% in September/October compared with no soft-shell males found in Area 2. During 2004, the proportion of soft-shell males increased in Area 1, to 17% in July, 40% in August and 38% in September/October. In Area 2, the percentage of soft-shell males was 13% in August and 14% in September/October. The DFO sea sampling indicated lower incidence of soft-shell males in Area 1 during 2003 and 2004 than the industry sea sampling. During 2003, the proportion of soft-shell males was 5% in August, 6% in

September, 16% in October and 12% in November, and in August 2004 was only 2%. An explanation for the lower proportion of soft-shell males in the DFO sea sampling could be partially attributed to the subjectivity in deciding what constitutes a soft-shell male. Another explanation for the discrepancy between the two methods is that the DFO sampling is done during a 1- or 2-d period throughout a monthly period, whereas the industry sampling represents a larger number of sampling days each month. By sampling every week, industry sea sampling would be best suited at detecting periods of increased presence of soft-shell males. However, the low number of traps sampled each month by industry increases the variability in the data. The intensity of industry sampling needs to increase in order to augment the number of traps sampled and to improve the accurateness of the data.

LFA 38, Jonah crabs

Since 1995, in LFA 38, Jonah crab has been sampled at least once a year with the exception of 2002 (Fig. 9). All DFO sea samples were obtained from conical crab traps. Between August 1995 and September 2001, the mean size of male Jonah crab varied between 130 and 136 mm CW and the number of legal-size crabs (≥121 mm CW) per trap haul varied between 18.8 and 36.8 (Fig. 9). The lower mean size (122 mm CW) and number of legal-size crabs per trap haul (3.0 legal crabs/th) observed in July 1995 is considered biased because this sample was taken at the outset of the exploratory crab fishery when the best Jonah crab fishing grounds had not yet been found. During 2003 and 2004, the average monthly mean size of males (ranged between 127 and 123mm CW), and the number of legal size crabs per trap haul (varied between 8.8 and 21.1 legal crabs/th) were lower than the previous years (Fig. 9).

Since 1995, the number of sub-legal crabs per trap haul remained low (<11.0 sub-legal crab/th) (Fig. 9). However, the highest catch rate of sub-legal crab occurred in 2004. The main reason for this low catch rate is that it is mandatory that all commercial crab traps be fitted with escape vents which allow small males and female crabs to escape. Also, crab fishermen try to avoid areas where large numbers of small male crabs are found.

No yearly or monthly trend was detectable in the mean size and number of females per trap haul. From 1995 to 2003 the mean size of females varied between 113 and 117 mm CW (Fig. 9). However, during August 2004 the mean size of females declined to a low of 105 mm CW. The number of females per trap haul varied widely (0.6 and 24.5 females/th) and no trend was evident. The highest catch rate of females occurred in August 2000.

The proportion of berried females never exceeded 11 % until 2003 and 2004. During August 2003, the proportion of berried females was 35% and during July 2004 was 34%. However, during September 2003 and August and September 2004, the proportion of berried females remained below 10% (Fig. 9).

Since 1995, the incidence of soft-shell crab remained below 3% until 2004. In July and August 2004, the incidence of soft-shell crab increased to 21%. However, in September 2004, the proportion of soft-shell crabs had declined to 1.5%.

LFA 34, rock crab

In LFA 34, the only commercial concentration of rock crab was found in St Marys Bay (Fig. 5). DFO sea samples from St Marys Bay were obtained in September 1996, August 1999 and August and September 2004 (Fig. 10). Due to insufficient sea sampling, it was impossible to detect any changes that could have occurred in the population size structure due to fishing. The average size of male rock crab decreased from 121 mm CW in September 1996 to 113 mm CW in September 2004. However, the number of legal-size males (≥102 mm CW) per trap haul in September 2004 (15.2 legal crabs/th) was similar to the catch rate in September 1996 (16.1 legal crabs/th). The catch rate of sub-legal crabs (<102 mm CW) was low (<2.7 sub-legal crabs/th) (Fig. 10).

During 2003 and 2004, industry sampling provided valuable information on rock crab size structure and shell condition (Fig. 11). As in the LFA 34 Jonah crab fishery, fishermen in St Marys Bay voluntarily measured, during each fishing trip, all the rock crabs captured in traps set adjacently. Both were regular commercial traps, one with opened escape vents (vented trap) and the other with closed escape vents (unvented trap). Industry sampling was done for the months of August through October, 2003 and the months of July through October 2004. Due to a low number of trap hauls, the industry sampling done in August and September 2003 was combined, as well as those collected in July and August 2004 (Fig. 11).

The industry sea sampling of vented and unvented traps during 2003 and 2004 showed that the mean size of males declined monthly from 122 to 124 mm CW in July and August to 100 and 107 mm CW in October (Fig. 11). The highest catch rate of legal-size males (≥102 mm CW) occurred in October 2003 (49.4 and 40.5 legal crabs/th in vented and unvented traps, respectively), and the lowest catch rate happened in September 2004 (14.5 and 16.4 legal crabs/th in vented and unvented traps, respectively). In the unvented traps, the mean size of males was always smaller and the catch rate of legal-size males was always larger than those captured in vented traps (Fig. 11). As expected, the catch rate of sub-legal male crabs was higher in the unvented traps. The highest catch rates occurred in October 2003 (12.5 sub-legal males/th) and during October 2004 (28.3 sub-legal males/th) (Fig. 11).

The DFO sea sampling showed that the monthly mean size of female rock crab varied between 90 mm CW during 2004 and 93 mm CW in 1996 and 1999 (Fig. 10). The mean size of females in the industry sea sampling in both vented and unvented traps (varied between 83 and 88 mm CW) was lower than in those from the DFO sampling at sea (Fig. 10, 11). During 2003 and 2004, the catch rate of females was always higher (27.9-34.3 females/th) in the unvented traps than in the vented traps (11.2-20.3 females/th) and the DFO sea sampling (15.9-17.8 females/th). In the DFO sea samples, the proportion of females that was berried was low (<4%) (Fig. 10). In the industry sea sampling the proportion of berried females captured in the vented traps remained low (<8%) with the exception of October 2004 when the proportion of berried females increased to 23% (Fig. 11). During 2004, the proportion of berried females in the unvented traps was higher, and ranged from 11% in July/August to 24% in October.

LFA 35, rock crab

In LFA 35, the only commercial concentration of rock crab was found in Annapolis Basin (Fig. 5). DFO sea samples from Annapolis Basin were obtained during the months of September 1996, August 1999, and August 2004 (Fig. 12). During those three sampling periods, the average size of male rock crab ranged between 111 and 114 mm CW. However, the number of legal-size rock crabs per trap haul was high and ranged between 27.5 and 48.1 legal crabs/th

During 2004, industry sea sampling provided additional information on the size structure of rock crabs in Annapolis Basin (Fig. 12). Due to only three traps sampled at the beginning of September, these samples were combined with the August sampling. The monthly mean size of males was higher both in the vented (119 mm CW) and unvented (116 mm CW) traps, compared to the mean size of male crabs obtained from the DFO sea sample in August 2004 (114 mm CW). The high catch rate of legal-size rock crab (≥102 mm CW) in the industry samples (44.4 and 45 legal crabs/th) was similar to the rate observed from the DFO sea sample in August 2004 (48.1 legal crabs/th) (Fig. 12). The catch rate of sub-legal males (<102 mm CW) was relatively low (<7 sub-legal/th) both in the DFO samples and the industry samples. During 2004, the size-frequency histogram showed a large mode composed of large males, which was not evident during 1996 and 1999 (Fig. 12).

In the DFO sea samples, the monthly mean size of females was larger (87-90 mm CW) than those from industry sampling (78-79 mm CW) (Fig. 12). The catch rate of females was very high in the unvented traps (86.5 females/th). However, the catch rate of females in the vented traps (29.3 females/th) was similar to the catch rate in DFO sampled traps during August 2004 (24.1 females/th). In the DFO sea samples, the proportion of total females that was berried was less than 1%. However, in the industry sampling, the proportion of berried females was 20% in vented traps and 18% in unvented traps.

LFA 36, rock crab

DFO sea sampling in LFA 36 was sparse. One sea sample was taken in July 1995, one in August and September 1999, respectively, and one in July 2000 (Fig. 13). During 2003, three sea samples were taken during September. The samples lack resolution in that the number of traps sampled was not recorded, and the size distribution was displayed as total number of individual per size category. In 2004, three sea samples were taken in August, and two sea samples were taken in September and October, respectively. The size frequencies between locations were similar and were combined by month.

During 2003 and 2004, there was a significant increase in the mean size of males and in the catch rate of legal-size rock crabs (≥102 mm CW) (Fig. 13). During 2003 and 2004, a large mode (overall mean 121 mm CW) of large males was present. This mode was absent in the DFO sea samples collected between 1995 and 2000. In 2004, virtually no sub-legal size crabs (<102 mm CW) and very few male crabs <110 mm CW were captured (Fig. 13). In addition, the catch rate of female was also low (<0.6 females/th). The absence of small crabs in the traps during 2003 and 2004 was due to a larger size of escape vents used in the traps. In order to avoid the extra work of sorting out small crabs in the traps, LFA 36 fishermen began using larger circular

escape vents of 76 mm (3 in.) in diameter, instead of the smaller, mandated escape vents of the minimum size of 63.5 mm (2½ in.) in diameter. This change to larger vent size occurred between 2000 and 2003. However, the increase in catch rate during 2003 and 2004 may be due to an actual increase in the number of legal-size rock crab (≥102 mm CW) in the population (Table 6; Fig. 18).

FISHERIES LANDINGS AND CATCH RATE INFORMATION

Landings and catch rate information were obtained from crab fishermen logbooks. The amounts are based only on the logbooks that were received for data entry and likely do not represent the total landings.

LFA 34 midshore Jonah crab fishery

In LFA 34, between five and eight crab fishers have actively fished for Jonah crab since 1996 (Table 5; Fig. 14 A). Commercial concentrations of Jonah crabs were found only in the midshore area (Fig. 2). During 2003 and 2004, there was a shift in the distribution of fishing effort toward the north along the 80-km line (Area 2 in Fig. 3). Most of the fishing took place between June and November when the lobster fishing season was closed (Fig. 14). Modified lobster traps were used.

Jonah crab landings increased yearly until a peak in 2000 of a total of 280 MT (Table 5; Fig. 14A). Subsequently, landings decreased yearly to a low of 58 MT in 2004. Effort in number of trap hauls increased yearly to 59,955 th in 2001. Since 2001, yearly effort decreased by 73%, to 15,954 th in 2004.

From 1996 to 2000, the annual catch rate varied between 4.0 and 5.6 kg/th (Fig. 14A). Between 2002 and 2004, the annual catch rates leveled off at a lower catch rate of between 3.3 and 3.6 kg/th. During 2003 (2.8 kg/th) and 2004 (2.7 kg/th), the overall catch rates in the new fishing area (Area 2) were lower than those from the traditional fishing grounds (Area 1) (3.8 and 4.2 kg/th, respectively) (Fig. 3). There was no trend in weekly catch rates throughout each fishing season, and the range in weekly catch rates within each season was from 1.0-7.9 kg/th (Fig. 15).

During 2002-04, the Jonah crab fishery appears to have stabilized at a lower catch rate. The expansion of fishing effort into Area 2 seems to coincide with the increase incidence of soft-shell crab in Area 1. Although the catch rates were lower in Area 2, the proportion of soft-shell crabs was also lower. The low effort in the midshore during 2004 was probably due to a number of factors: lower catch rates, a higher cost of fishing (fuel cost increased), high incidence of soft-shell crabs and low prices for crabs.

LFA 38, Jonah crab fishery

In LFA 38, commercial concentrations of Jonah crabs were found only in the south of Grand Manan (Fig. 4). Although the crab fishing season was open all year, most of the fishing

took place between June and October (Fig. 16). All Jonah crab landings were obtained with conical crab traps.

In LFA 38, between 1995 and 1997, only one Jonah crab fisher was active (Table 5; Fig 14B). In 1998, four additional participants were given exploratory permits; however, it was not until 2000 that all five crab fishers were fully active. Landings peaked at 227 MT during 2001, and effort peaked at 59,183 th during 2002. By 2004, both landings and effort declined to 200 MT and 50,702 th, respectively (Table 5; Fig 14B).

From 1995 until 2001, the annual catch rates ranged between 4.8 and 6.5 kg/th (Fig. 14 B). Between 2002 and 2004, the annual catch rate remained stable at a lower level of between 3.7 and 3.9 kg/th. There was no trend in weekly catch rates throughout each fishing season, and the variability in weekly catch rates within each season ranged from 1.9-10.9 kg/th (Fig. 16). During 2002-04, the LFA 38 crab fishery seems to have stabilized. Based on effort distribution data from logbooks, there was no obvious expansion of effort in new Jonah crab fishing grounds.

During 2002, as a result of a dispute over lobster fishing ground between Canada and the United States, a summer lobster fishery was initiated in a disputed area called the Grey Zone (Fig. 1). The Grey Zone is a fishing area located between Canada and US disputed boundary lines in LFA 38 (Fig. 1). Lobster fishing was permitted between the months of July and October (Table 5). The lobster fishers were also allowed to land Jonah crab as a by-catch. These Jonah crabs were caught with regular commercial lobster traps.

Due to low lobster catch rates in the Grey Zone during the summer months, lobster fishers directed more fishing effort toward Jonah crab. In 2002, the total Jonah crab landings were 74 MT, with a seasonal effort of 74,352 th (Table 5). In 2003, crab landings increased to 116 MT and effort to 83,156 th. In 2004, the lobster catch rates were lower, and it became less worthwhile to fish in the Grey Zone. Lobster fishing effort decreased by almost half (46,718 th) and those that continued fishing directed mainly for Jonah crabs. As a result crab landings (78 MT) were higher in 2004 than in 2002. Overall catch rates currently remain relatively stable between 1.2 and 1.7 kg/th (Table 5).

LFA 34, rock crab fishery

In LFA 34, at the start of the exploratory rock crab fishery only fishermen from the St. Marys Bay area made an effort to explore for rock crab. Due to the low potential of finding commercial densities of rock crabs in other locations, there was little interest by other fishermen in searching for rock crab. Consequently, during the last nine years, all rock crab fishing activity has remained within St. Marys Bay.

Most of the fishing activity occurred between June and October (Fig. 4, 17). Only two exploratory permits were issued, and only modified lobster traps were allowed. Since 1996, rock crab landings (16-72 MT) and effort (4,328-13,916 th) have widely fluctuated (Table 6). The fluctuations in annual effort were mainly attributable to a lack of market demand or low prices for rock crab.

From 1996 to 2000, annual catch rates varied between 2.3 and 4.3 kg/th (Table 6; Fig. 14C). The annual catch rate reached a high of 7.3 kg/th in 2001 and remained relatively high between 5.6 and 6.5 kg/th during 2003 and 2004. There was no seasonal trend in weekly catch rates throughout each of the fishing seasons (Fig. 17). Between 2002 and 2004, the catch rates remained relatively stable though the fishing effort substantially declined (12,858 to 5,004 th) (Table 6; Fig 14C).

LFA 35, rock crab fishery

In LFA 35, the only commercial concentration of rock crab was found in Annapolis Basin, although exploration for rock crab occurred in other areas along the coast. Fishing occurred between August and September during the closed season of the lobster fishery (Fig. 4, 18). A maximum of four exploratory permits were issued, and only modified lobster traps were used. Between 1996 and 2004, both rock crab landings (14-63 MT) and effort in trap hauls (1,685-6,445 th) fluctuated widely (Table 6; Fig. 14D). In 2002, no fishing occurred. As in St. Marys Bay, these wide fluctuations in annual effort were mainly attributable to a lack of market demand or low prices for rock crab.

From 1996 to 1999, the annual catch rate in Annapolis Basin ranged between 5.6 and 8.1 kg/th (Table 6; Fig. 14D). From 2000-04, the annual catch rate increased from 10.0-15.6 kg/th. Each year, the weekly catch rates had a tendency to decline slightly as the season progressed (Fig. 18).

LFA 36, rock crab fishery

In LFA 36, rock crabs were found in commercial concentrations only along the shores of southeastern New Brunswick between Passamaquoddy Bay and Maces Bay (Fig. 4). Although the crab season was open all year, most of the fishing occurred between June and October (Fig. 19). A maximum of eight exploratory permits were issued. They were only allowed to use conical crab traps.

From 1995 to 2001, landings ranged from 9 MT in 1997 to 42 MT in 2000 (Table 6; Fig. 14E). In 2000, effort was also the highest at 16,230 th. From 2002-04 landings increased from 49-74 MT and effort increased from 12,618-14,549 th. From 1995 to 2001, the annual catch rate ranged from 2.3-3.5 kg/th (Table 6; Fig. 14E). From 2002-04, the annual catch rates increased from 3.9-5.1 kg/th. There was no trend in weekly catch rates within each fishing season (Fig. 19).

Crab by-catch

Jonah and rock crab landed as by-catch during the lobster fishing season has been a management concern since the inception of the exploratory crab fishery. Crab by-catch has become more of an issue as the market and price for crab increased with the development of the directed exploratory crab fisheries. The amount of crab landed as a by-catch to the lobster fishery is not well documented. Nevertheless, some of the crab landings statistics shows that crab landed

as a by-catch to the lobster fishery on occasion exceeded the crab landings from the directed fishery (Table 5).

Lobster by-catch in the crab fisheries

Lobster caught as a by-catch to the crab fishery was a management concern at the inception of the exploratory crab fishery (Robichaud et al. 2000b). However, based on logbook information and sea sampling, lobster by-catch has always been negligible (weekly averages reported in logbooks of less than 0.4 lobster/th) in the Jonah crab fisheries, which are located in deep water (>75 m), in the midshore area of LFA 34, and off southern Grand Manan in LFA 38 (Fig. 2). Lobster by-catch was more of a problem in the early years of the rock crab fisheries in LFAs 34 and 35 (Robichaud et al. 2000b). These rock crab fisheries took place close to shore in shallow warm water during summer, with modified lobster traps. For example, in St Marys Bay during the month of August 1997, the weekly average number of lobsters per trap haul reached highs of between 2.2 and 4.2. In this fishery, the rock crab fishermen in LFA 34 and 35 were allowed to use modified lobster traps and the design of this gear remained quite efficient at catching lobsters. Subsequently, with the restrictions and modifications of the type of traps used, and limitations imposed on the size, shape and location of the entrances and escape vents, the incidence of lobster by-catch was reduced to weekly averages of less than 0.4 lobster/th. This issue for most part has been resolved. Lobster by-catch was never a problem in LFA 36 and 38, because conical crab traps have been in use since the onset of this fishery (Robichaud et al. 2000b). The conical traps were very effective at preventing the capture of lobsters.

DISCUSSION

This review is based on logbook reports that we received and represents the majority of the landings. DFO sea sampling of the catch has been sparse, and has been limited to the summer months and to a few main fishing areas. The industry sampling in LFAs 34 and 35, during the last two years has provided additional information about crab population size structure and catch rates. With increased participation, and the growing experience in collecting scientific information, the industry sampling could become a suitable alternative to DFO sampling. Overall, based on the limited scientific information gathered in the last decade, it's not possible to fully evaluate the potential sustainability of these crab fisheries.

JONAH CRAB

The data gathered in this report, indicates that the current level of effort has had some negative impact on the Jonah crab resource. During the last 3 yr, in both LFAs 34 and 38, the annual catch rates have stabilized at lower levels (3.3-3.9 kg/th). Despite the fact that different trap types and minimum legal size limits were used, the annual catch rates in the two LFAs were similar. In both LFAs, during the last 3 yr, there was a decline in the mean size of males and an increase in the proportion of sub-legal size males in the catch. In LFA 34, during 2003 and 2004 there has been a higher incidence of soft-shell Jonah crab. This event was not as evident in LFA 38. Although fishing could have had some influence on the presence of soft-shell crabs, the high incidence of soft-shell crab can be partially attributable to colder than normal water temperatures in the midshore and in the Gulf of Maine during 2003 and 2004 (DFO 2006; Petrie et al. 2005).

The lower temperatures could have delayed molting. The presence of soft-shell lobsters also occurred during the fall and winter of 2003.

The accumulated virgin biomass appears to have been depleted and the Jonah crab fisheries will have to rely more on annual recruitment and growth. The current Jonah crab fisheries in LFA 38 and the midshore in LFA 34 are regulated under minimum size limits of 121 and 130 mm CW, respectively. The minimum size limits were set based primarily as related to markets. The reproductive potential of the resource was believed to be protected (Elner and Robichaud 1984, 1985). Females are not allowed to be retained regardless of size, and therefore the potential reproductive capacity of females is protected. If morphometric maturity (occurring at CW_{50} = 128 mm CW), estimated by Moriyasu et al. (2002), can be considered functional maturity, these Jonah crab stocks would not be fully protected with the current size limits. Based on logistic maturity curve calculation by Moriyasu et al. (2002), the proportion of morphometrically mature males was estimated to be 66% at 130 mm CW and 15% at 121 mm CL. The proportion of mature males at the current minimum size limit of 121 mm CW is relatively low (15%) and there could be potential for overfishing fully mature males. Based on the precautionary approach for fisheries management, a minimum size increase was recommended (Moriyasu et al. 2002). More evidence is needed, on a rigorous scientific basis, to clearly link morphometric maturity with functional maturity (Moriyasu et al. 2002). Even if 128 mm CW is the best estimate for size at 50% maturity, an important portion (15% and 66%) of male Jonah crab would still mature below the current minimum legal size limits (121-130 mm CW).

In LFA 34 during 2004, the fishing effort had declined to the lowest level since 1997. Lower catch rates, a high percentage of soft-shell crabs, the long distances to the crab fishing grounds and increased fuel costs are some of the reasons for reduced fishing effort. Closer monitoring of this fishery during the next few years is needed to provide more reliable information on the status of this resource. However, based on the distribution of effort, there may still be limited room for expansion of this fishery into marginal areas (Robichaud et al. 2000a).

In LFA 38, the annual catch rates have stabilized at lower levels during the last 3 yr, and fishing effort remains close to its peak. The LFA 38 Jonah crab fishery has not experienced the soft-shell problem which was present in the midshore in LFA 34. Significant molting events likely occur outside the Jonah crab fishing season (Adams et al. 2000). In the offshore area (LFA 41), there was no obvious period when there was a high prevalence of soft-shell crab, although sea sampling was conducted throughout the year, (Robichaud et al. 2000a). Based on information from processing plants, the lowest meat yield for Jonah crab occurs during March and April on southeast Browns Bank and during October and November on Georges Bank (Robichaud et al. 2000a). To determine if the molting period is during the winter and early spring in LFA 38, further studies are required.

The prospect for the LFA 38 fishery will depend largely on the future development of the Grey Zone summer fishery and the Jonah crab by-catch from the lobster fishery. Based on the distribution of effort, there may still be limited room for expansion of this fishery into marginal areas further from shore in deeper water. Jonah crabs are fished by a directed fishery, and as by-catch from the lobster fishery. The information on Jonah crab by-catch from the lobster fishery is

based on reporting in the lobster logbooks, and is likely underestimated (Adams et al. 2000; Robichaud et al. 2000a, b). However, the information that we were able to collect indicates that the potential effort by the lobster fishery is far greater than the current directed fishery (Table 1). Removals by the lobster fishery are a fundamental piece of information needed for the assessment of Jonah crab stocks. Until the quantity of Jonah crab removals by the lobster fishery can be evaluated and controlled, biological sustainability of the directed fishery cannot be assessed. The by-catch issue should be reviewed within each LFA, since this issue can be more easily resolved in some LFAs than in others. Lobster fishermen should be encouraged to report their by-catch whether it is used directly as bait or sold. In LFA 34, during the 2004/05 lobster fishing season, crab used as bait were supposed to be recorded on lobster logbooks, and any Jonah crab sold as by-catch was to be recorded by a DMP company. A separate crab logbook is supposed to be completed, and a DMP company is meant to enter the data.

ROCK CRAB

The current level of effort does not appear to have any impact on the rock crab resource in LFAs 35 and 36. In LFA 34, over the last 3 yr, despite a decline in the mean size of males and an increase in the proportion of sub-legal size males, the annual catch rates have remained stable.

In LFA 35 (Annapolis Basin) and 36, the mean size and the catch rate of legal-size male rock crab have peaked in 2003 and 2004, and the proportion of sub-legal size males has declined. Modified lobster traps are used in LFA 35, and conical traps are used in LFA 36. The catch rate in LFA 35 (28-48 legal males/th) has always been higher than in LFA 36 (5-22 legal males/th) and the average size of males has mostly been larger in LFA 36 (112 to 122 mm CW) compared to LFA 35 (111-114 mm CW). The differences in catch rates of legal-size males, the mean size of males, the low catch rate of sub-legal males between the two LFAs and the high catch rates of females in LFA 35 is most likely due to the different development of trap designs and to the catchability of rock crabs (Richards et al. 1983; Gendron and Hébert 1991; Miller and Duggan 1997). The rock crab fisheries in LFAs 34, 35 and 36 are regulated under a minimum size limit of 102 mm CW. The reproductive potential of the resource is believed to be well protected. Male rock crab mature well below the minimum size limit (occurring at CW_{50} = 62 mm CW) and females are not allowed to be landed (Campbell and Eagles 1983). Based on the available information, the rock crab stock in LFA 35 and 36 seems to be increasing and the prospect seems to be good.

The total removals of rock crab in the Gulf of Maine are not known because the by-catch of rock crab by the lobster fishery is not well documented. Anecdotal evidence indicates few rock crab are retained by lobster fishers in some areas (e.g. LFA 38), but in other areas lobster traps are set specifically for rock crab to be used as bait or sold. Reported landings in Table 6 indicate that in LFAs 34 and 35, the by-catch of rock crabs can surpass landings from the directed fishery, and by-catch of rock crab could potentially increase in response to economic factors.

The risk of over fishing of rock crab by the directed fishery is low given current effort levels, and the high protection of brood stock provided by minimum size regulation and the

protection of females. Due to the low commercial value of rock crab, this fishery is presently marginally viable.

ACKNOWLEDGEMENTS

The authors would like to express their appreciation for the co-operation and input of the fishermen involved in the industry sampling and for their financial contributions for the sea sampling. A special thanks to those who did the DFO sea sampling. The authors would like to thank Dr. R. Miller for reviewing the first draft of this manuscript and to Dr. J. Tremblay and M. Strong for the final review of this manuscript.

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Table 1. Listing of exploratory crab fishery regulations as they evolved in LFA 34, from 1996 to 2004. Each regulation is listed in the year during which it became in force and is assumed to remain in effect until otherwise indicated.

Year	Historical Regulatory Changes in LFA 34
1996	- An inshore zone (0-20 km) and a midshore zone (20-80 km) were created. - Two exploratory crab permits were issued in the inshore zone and seven were issued in the midshore zone - The season was set to open 1 wk after the close of the spring lobster fishing season (31st of May) and was set to close 1 wk prior to the opening of the fall lobster fishing season (last Monday of November) - A minimum size limit was set at 130 mm CW for Jonah crab and 102 mm CW for rock crab. - They were permitted to use modified lobster traps as well as conical traps. - The trap limit was set at 100 traps if directing for rock crab and 125 traps if directing for Jonah crab in the midshore. - When fishing for rock crab, each trap was required to have a minimum of two circular escape openings of 63.5 mm (2.5 in.) in diameter. - When fishing for Jonah crab, each trap was required to have a minimum of two circular escape openings of 91 mm (3.5 in.) in diameter.
1997	- The inshore/midshore boundary was removed. - Two rock crab and eight Jonah crab permits were issued. - The trap limit was increased to 150 traps if directing for rock crab and to 250 traps when directing for Jonah crab. - When fishing for rock crab, the minimum size of two circular escape openings was increased to 69 mm (2.75 in.) in diameter. - A minimum requirement of 9.07 MT (20,000 lb) of rock crab had to be sold. - A minimum requirement of 4.54 MT (10,000 lb) of Jonah crab had to be sold.
1998	- The exploratory rock/Jonah crab permits were separated into either rock crab or Jonah crab permits. - Five Jonah crab and two rock crab exploratory permits were issued. - The trap limit was increased to 375 traps when directing for Jonah crab. - When fishing for Jonah crab, the minimum size of two circular escape openings was decreased to 79 mm (3.125 in.) in diameter. - The entrance of all modified lobster traps were required to have a rectangular opening no more than 76 mm (3 in.) in height with no limit on the length.
1999	- Only modified lobster trap are allowed to be used for fishing crabs. - Only five Jonah crab permits and two rock crab permits are issued. - The width of the entrance was reduced from 76 mm (3 in.) to 48 mm (1 7/8 in.).
2000	- No change, the same regulations as previous year
2001	- No change, the same regulations as previous year
2002	- No change, the same regulations as previous year
2003	- Joint Project Agreements (JPA) between DFO Science and each crab fisher were endorsed to provide science with funding for sea sampling.
2004	- No change, the same regulations as previous year.

Table 2. Listing of exploratory crab fishery regulations as they evolved in LFA 35, from 1996 to 2004. Each regulation is listed in the year during which it became in force and is assumed to have remained in effect until otherwise indicated.

Year	Historical Regulatory Changes in LFA 35
1996	- Five new exploratory rock/Jonah crab permits were issued. - The season was set to open 1 wk after the close of the spring lobster fishing season (31st of July) and was set to close 1 wk prior to the opening of the fall lobster fishing season (15th of October). - A minimum size limit was set at 130 mm CW for Jonah crab and 102 mm CW for rock crab. - They were permitted to use modified lobster traps as well as conical traps. - The trap limit was set at 100 traps if directing for rock crab and 125 traps when directing for Jonah crab. - When fishing for rock crab, each trap was required to have a minimum of two circular escape openings of 63.5 mm (2.5 in.) in diameter. - When fishing for Jonah crab, each trap was required to have a minimum of two circular escape openings of 91 mm (3.5 in.) in diameter.
1997	- Four rock crab permits were issued. - The trap limit was increased to 150 traps if directing for rock crab. - When fishing for rock crab, the minimum size of two circular escape openings was increased to 69 mm (2.75in.) in diameter. - A minimum requirement of 9.07 MT (20,000 lb) of rock crab had to be sold.
1998	- The exploratory rock/Jonah crab permits were separated into either rock crab or Jonah crab permits. - Five exploratory rock crab permits were issued. - The entrance of all modified lobster traps were required to have a rectangular opening no more than 76 mm (3 in.) in height with no limit on the length.
1999	- Only modified lobster trap are allowed to be used for fishing crabs - The width of the entrance was reduced from 76 mm (3 in.) to 48 mm (1 7/8 in.).
2000	- No change, the same regulations as previous year
2001	- No change, the same regulations as previous year
2002	- No change, the same regulations as previous year
2003	- No change, the same regulations as previous year
2004	- No change, the same regulations as previous year.

Table 3. Listing of exploratory crab fishery regulations as they evolved in LFA 36, from 1995 to 2004. Each regulation is listed in the year during which it became in force and is assumed to have remained in effect until otherwise indicated.

Year	Historical Regulatory Changes in LFA 36
1995	- Five new exploratory rock/Jonah crab permits were issued. - The season was set to be open all year. - No minimum size limits. - Only conical crab traps were allowed to be used. - The trap limit was set at 100 traps. - Each conical trap required a minimum of two circular openings of 63.5 mm (2 ½ in.) in diameter. - Only male crabs were allowed to be landed.
1996	- The trap limit was increased to 200 traps. - A minimum size limit was set at 121 mm CW for Jonah crab and 102 mm CW for rock crab. - A minimum of 20 fishing trips was required. - They were required to fully participate in an approved Dockside Monitoring Program.
1997	- The number of exploratory rock/Jonah crab permits issued was increased to eight. - The minimum number of fishing trips required was reduced to 15.
1998	- Eight rock/Jonah crab permits were issued.
1999	- A minimum requirement of crab landings was set at 30% of the average landings.
2000	- The trap limit was increased to 300 traps.
2001	- In addition to the minimum of 15 fishing trips a minimum of 1000 kg of crab had to be sold.
2002	- No change, the same regulations as previous year.
2003	- Joint Project Agreements (JPAs) between DFO Science and each crab fisher were endorsed to provide science with funding for sea sampling.
2004	- The exploratory rock/Jonah crab permits were separated into either rock crab or Jonah crab permits. - Seven rock crab permits were issued.

Table 4. Listing of exploratory crab fishery regulations as they evolved in LFA 38, from 1995 to 2004. Each regulation is listed in the year during which it became in force and is assumed to have remained in effect until otherwise indicated.

Year	Historical Regulatory Changes in LFA 38
1995	- One new exploratory rock/Jonah crab permits was issued. - The season was set to be open all year. - No minimum size limits. - Only conical crab traps were allowed to be used. - The trap limit was set at 100 traps. - Each conical trap required a minimum of two circular openings of 63.5 mm (2 ½ in.) in diameter. - Only male crabs were allowed to be landed.
1996	- The trap limit was increased to 200 traps. - A minimum size limit was set at 121 mm CW for Jonah crab and 102 mm CW for rock crab. - A minimum of 20 fishing trips was required. - They were required to fully participate in an approved Dockside Monitoring Program.
1997	- The minimum number of fishing trips required was reduced to 15.
1998	- The number of exploratory rock/Jonah crab permits issued was increased to five.
1999	- The trap limit was raised to 300. - A minimum requirement of crab landings was set at 30% of the average landings.
2000	- No change, the same regulations as previous year.
2001	- No change, the same regulations as previous year
2002	- No change, the same regulations as previous year.
2003	- Joint Project Agreements (JPAs) between DFO Science and each crab fisher were endorsed to provide science with funding for sea sampling.
2004	- The exploratory rock/Jonah crab permits were separated into either rock crab or Jonah crab permits. - Five Jonah crab permits were issued.

Table 5. Annual landings, effort and annual catch rates (based on total landings (kg) divided by total effort (th)) from Jonah crab fisheries logbooks from LFAs 34, 35, 36 and 38, from 1995-2004. The weight of Jonah crab by-catch landed during the lobster fishery is mostly based on voluntary reporting in lobster logbooks and is likely underestimated.

Lobster Fishing Area (LFA)	Year	Jonah crab landings (MT)	Trap hauls (th)	Annual mean cpue (kg/th)	By-catch (MT)
LFA 34 (Midshore)	1996	19.4	4,079	4.8	*
	1997	145.8	36,589	4.0	*
	1998	168.7	36,492	4.6	289
	1999	185.0	33,321	5.6	152
	2000	280.0	49,983	5.6	
	2001	256.0	59,955	4.3	
	2002	158.6	47,895	3.3	
	2003	92.1	27,998	3.3	
	2004	57.8	15,954	3.6	
LFA 35 (Annapolis Basin)	1996	0.2	3,010	0.07	0
	1997	0.2	4,165	0.05	0
	1998	0.2	2,550	0.09	0
	1999	0.0	0	0	
	2000	0.0	0	0	
	2001	**	**	**	
	2002	**	**	**	
	2003	**	**	**	
	2004	**	**	**	
LFA 36	1995	0.0	1,359	0.03	*
	1996				
	1997				
	1998	1.8	3,422	0.5	0
	1999	2.3	3,210	0.7	0
	2000	0.7	2,757	0.3	
	2001	0.2	817	0.2	
	2002				
	2003				
	2004	**	**	**	
LFA 38	1995	20.7	3,875	5.3	*
	1996	25.3	3,875	6.5	*
	1997	26.9	5,125	5.3	*
	1998	60.9	12,760	4.8	27
	1999	51.0	8,939	5.7	86
	2000	212.4	38,720	5.5	
	2001	227.2	47,628	4.8	
	2002	216.5	59,183	3.7	
	2003	206.8	55,105	3.8	
	2004	199.6	50,702	3.9	
LFA 38B (Grey Zone)	2002	74.4*	74,352	1.2	74.4
	2003	116.1*	83,156	1.4	116.1
	2004	78.3*	46,718	1.7	78.3

*** In the Grey Zone, Jonah crab are landed as by-catch to the lobster fishery**

*** Unknown**

**** Not permited to land Jonah crab**

Table 6. Annual landings, effort and annual catch rates (based on total landings (kg) divided by total effort (th)) from rock crab fisheries logbooks from LFAs 34, 35, 36 and 38, from 1995-2004. The weight of rock crab by-catch landed during the lobster fishery is mostly based on voluntary reporting in lobster logbooks and is likely underestimated.

Lobster Fishing Area (LFA)	Year	Rock crab landings (MT)	Trap hauls (th)	Annual mean cpue (kg/th)	By-catch (MT)
LFA 34 (St. Marys Bay)	1996	36.7	8,558	4.3	*
	1997	33.5	13,916	2.4	*
	1998	22.0	9,407	2.3	48
	1999	16.1	5,451	3.0	33
	2000	18.3	4,328	4.2	
	2001	59.8	8,200	7.3	
	2002	72.0	12,858	5.6	
	2003	48.4	7,470	6.5	
	2004	28.2	5,004	5.6	
LFA 35 (Annapolis Basin)	1996	19.1	2,618	7.3	*
	1997	45.5	6,445	7.1	*
	1998	23.7	4,235	5.6	13
	1999	13.6	1,685	8.1	26
	2000	40.8	4,072	10.0	
	2001	63.4	5,802	10.9	
	2002	0	0		
	2003	42.2	2,737	15.4	
	2004	60.6	3,879	15.6	
LFA 36	1995	22.8	7,383	3.1	*
	1996	16.3	6,103	2.7	*
	1997	9.1	2,608	3.5	*
	1998	37.1	14,696	2.5	0
	1999	24.3	10,748	2.3	23
	2000	41.6	16,230	2.6	
	2001	30.4	10,031	3.0	
	2002	49.0	12,618	3.9	
	2003	59.7	13,290	4.5	
	2004	74.3	14,549	5.1	
LFA 38	1995	1.9	2,023	1.0	*
	1996	0.0	0.0		*
	1997	0.0	0.0		*
	1998	0.0	0.0		0.9
	1999	0.0	0.0		5.7
	2000	0.0	0.0		
	2001	0.0	0.0		
	2002	0.0	0.0		
	2003	0.0	0.0		
	2004	**	**	**	

*** Unknown**

**** Not permited to land rock crab**

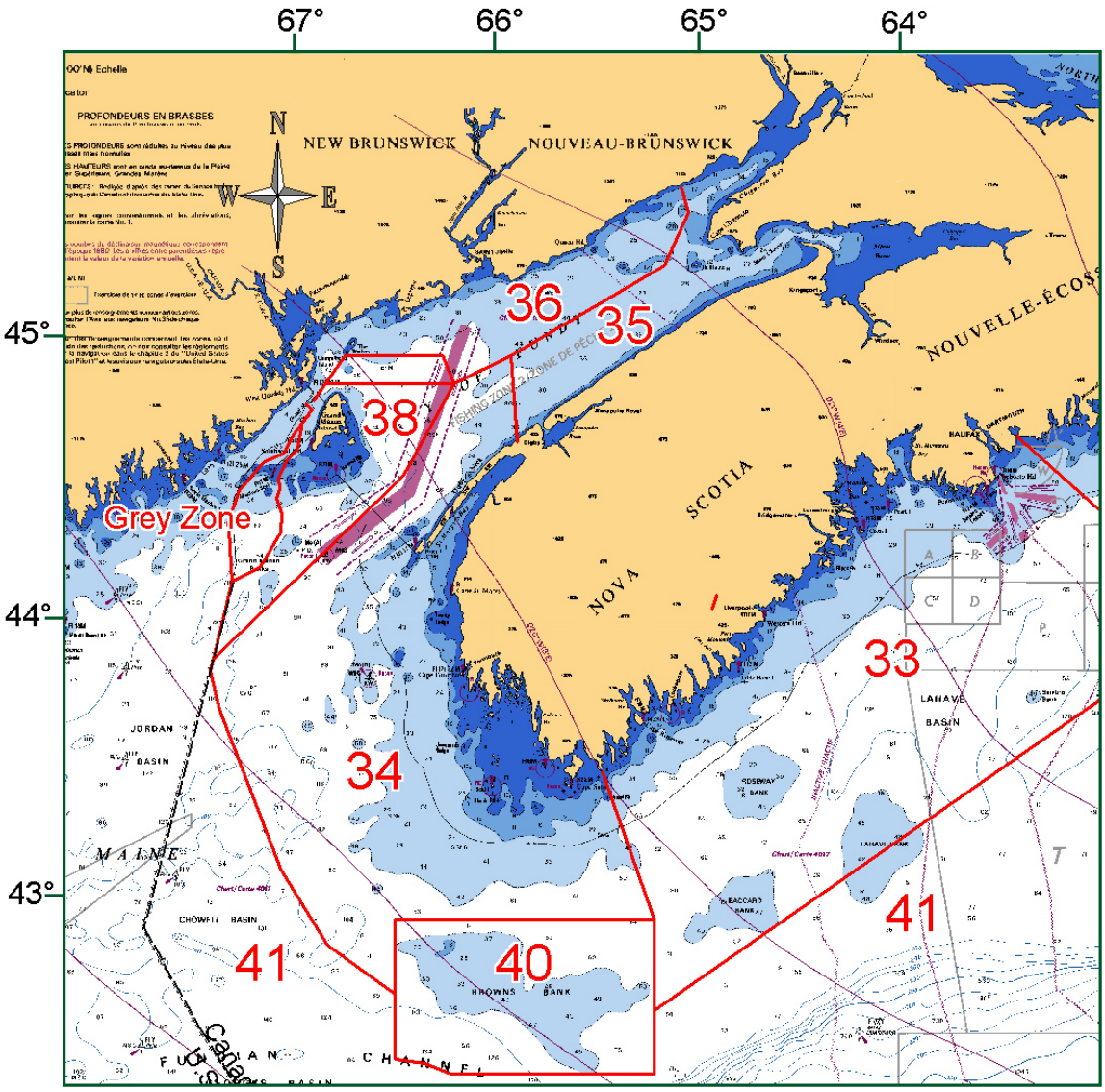

Fig. 1. Map showing the location of LFAs in the Bay of Fundy and Southwest Nova Scotia and the Grey Zone (in LFA 38) which is situated in a fishing area in the middle of the disputed boundary lines between Canada and the United States.

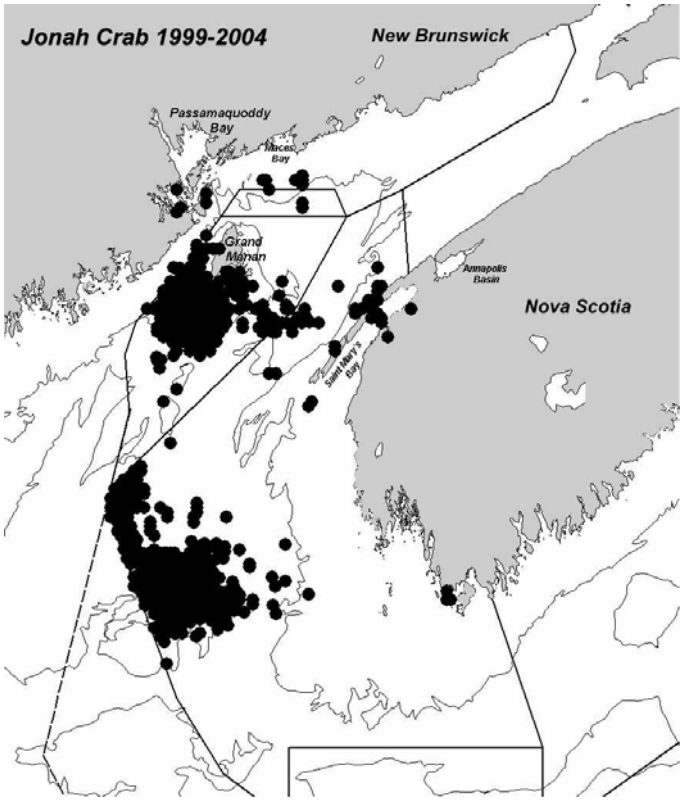

Fig. 2. Map showing the distribution of fishing effort for Jonah crab between 1999 and 2004, as recorded by fishing locations in logbooks (There is no scaling of effort applied at each location. Minimum effort equals one trap haul.)

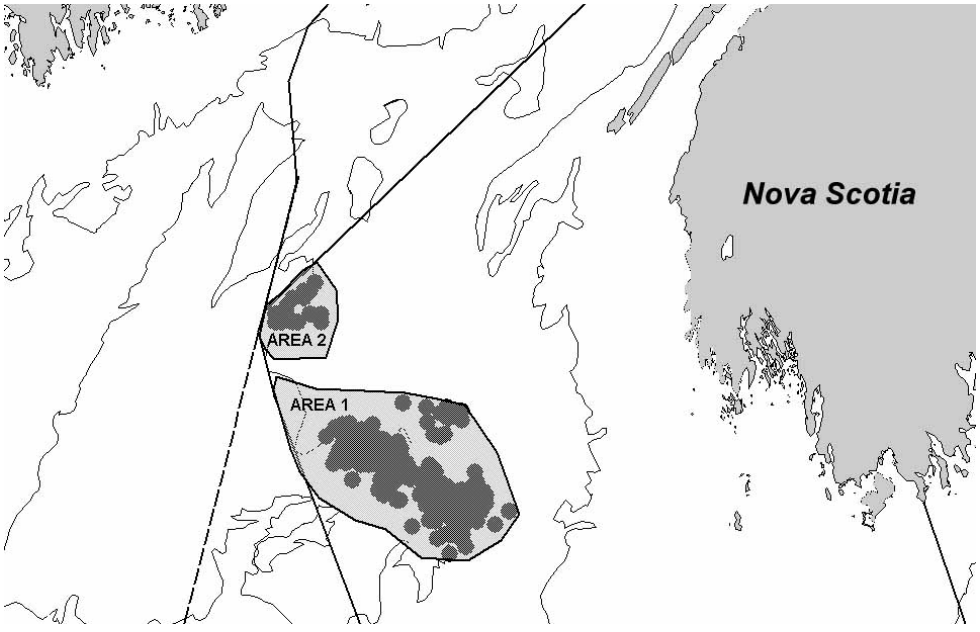

Fig. 3. Map showing two distinct Areas within LFA 34 where fishing effort for Jonah crab was mostly concentrated during 2003-04.

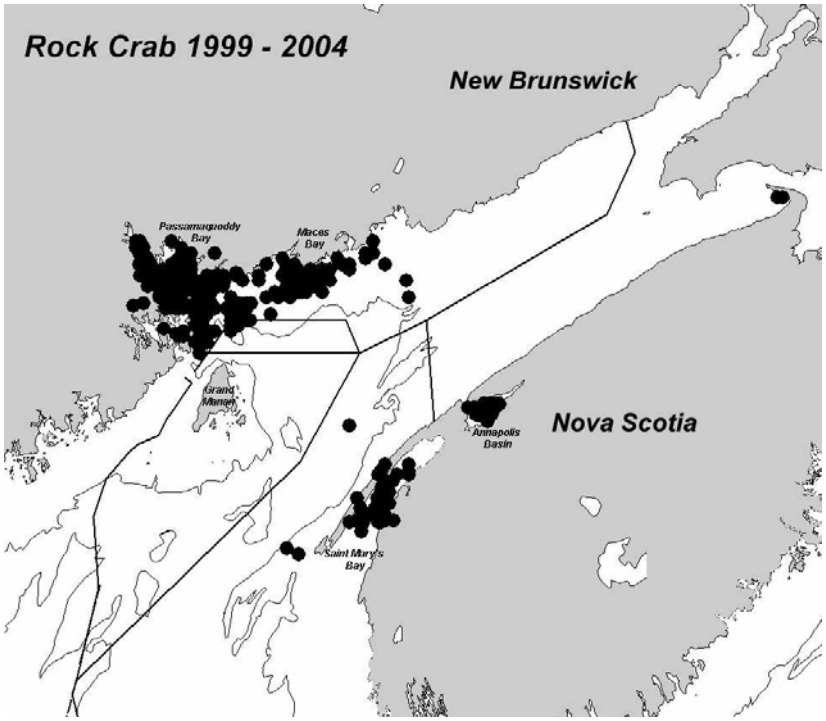

Fig. 4. Map showing the distribution of fishing effort for rock crab between 1999 and 2004, as recorded by fishing locations in logbooks (There is no scaling of effort applied at each location. Minimum effort equals one trap haul.)

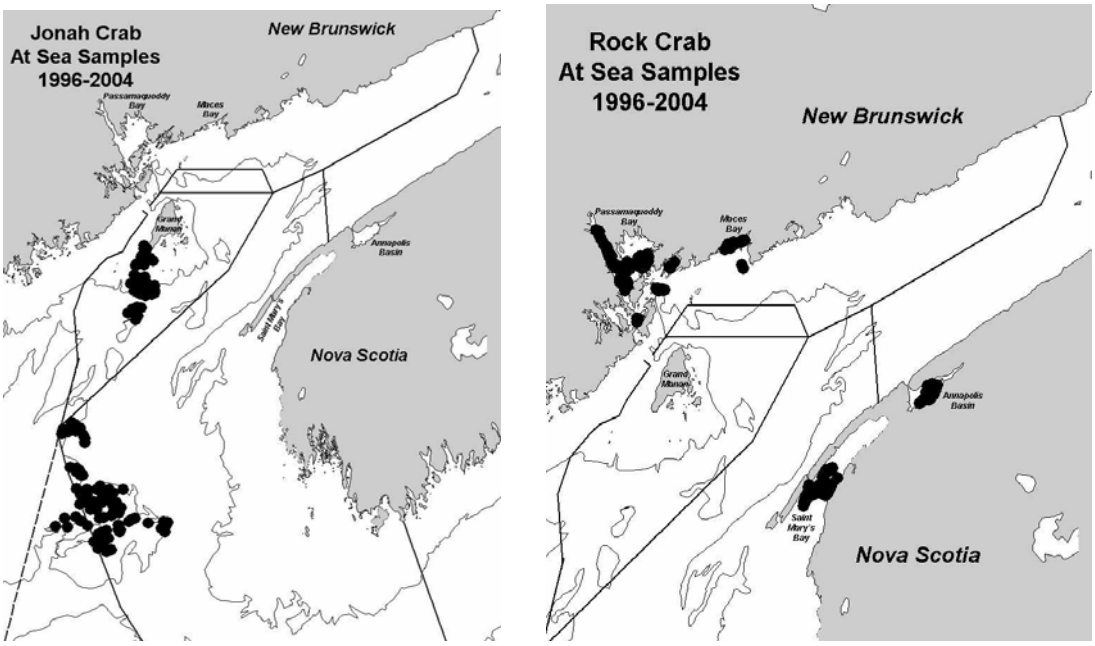

Fig. 5. Maps showing the distribution of DFO sea sampling for Jonah crab (left) and rock crab (right) in LFAs 34, 35, 36 and 38 since 1996.

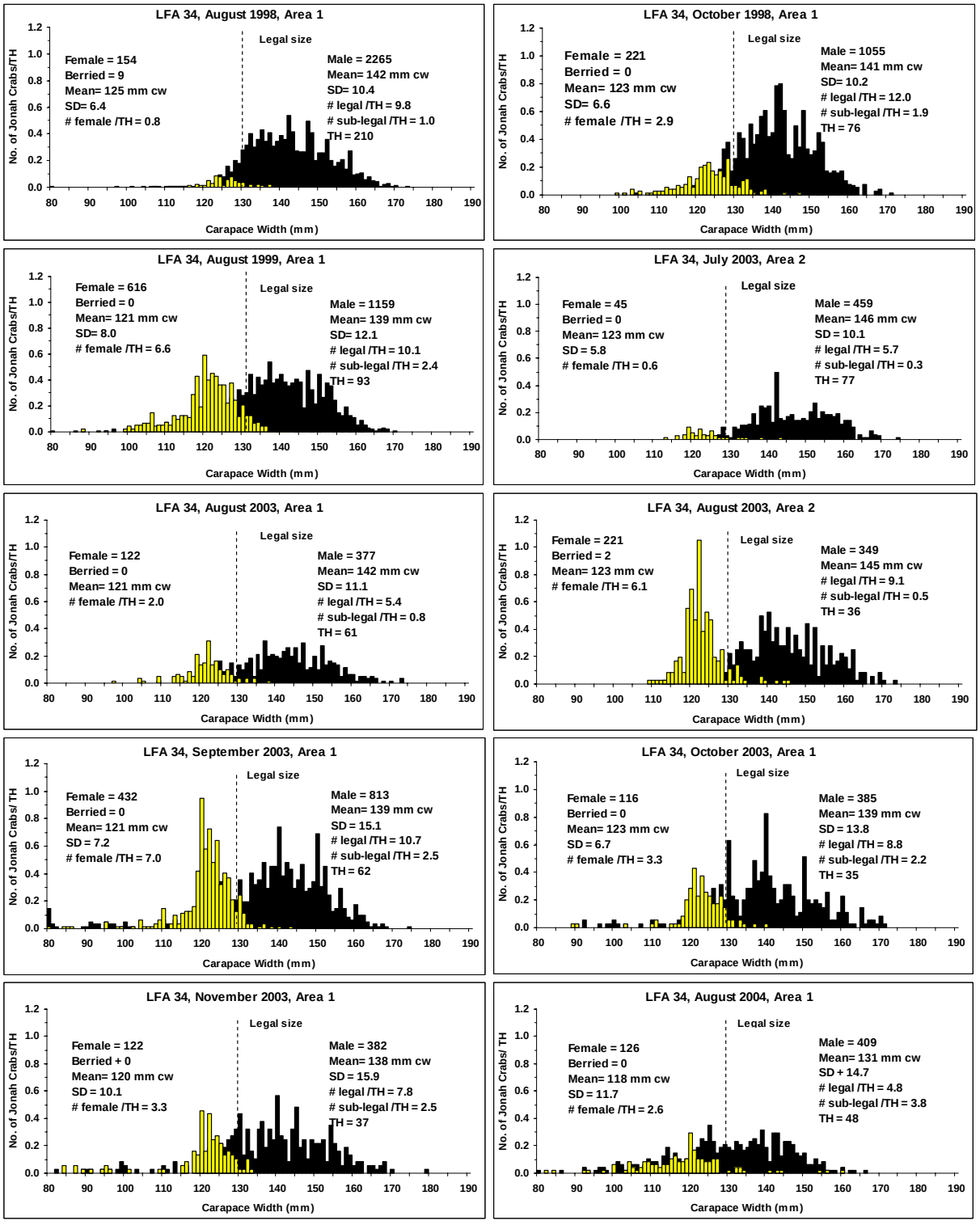

Fig. 6. Jonah crab size frequency histograms from DFO sea sampling for two fishing areas within LFA 34 (midshore) from the 1998 to 2004 crab fishing season. See Fig. 3 for location of areas 1 and 2. Males are in dark histograms and females in light histograms. Berried females are included in data for females. Legal size males (≥130 mm CW), sub-legal size males (<130 mm CW) and females are expressed in number per trap haul (#/th).

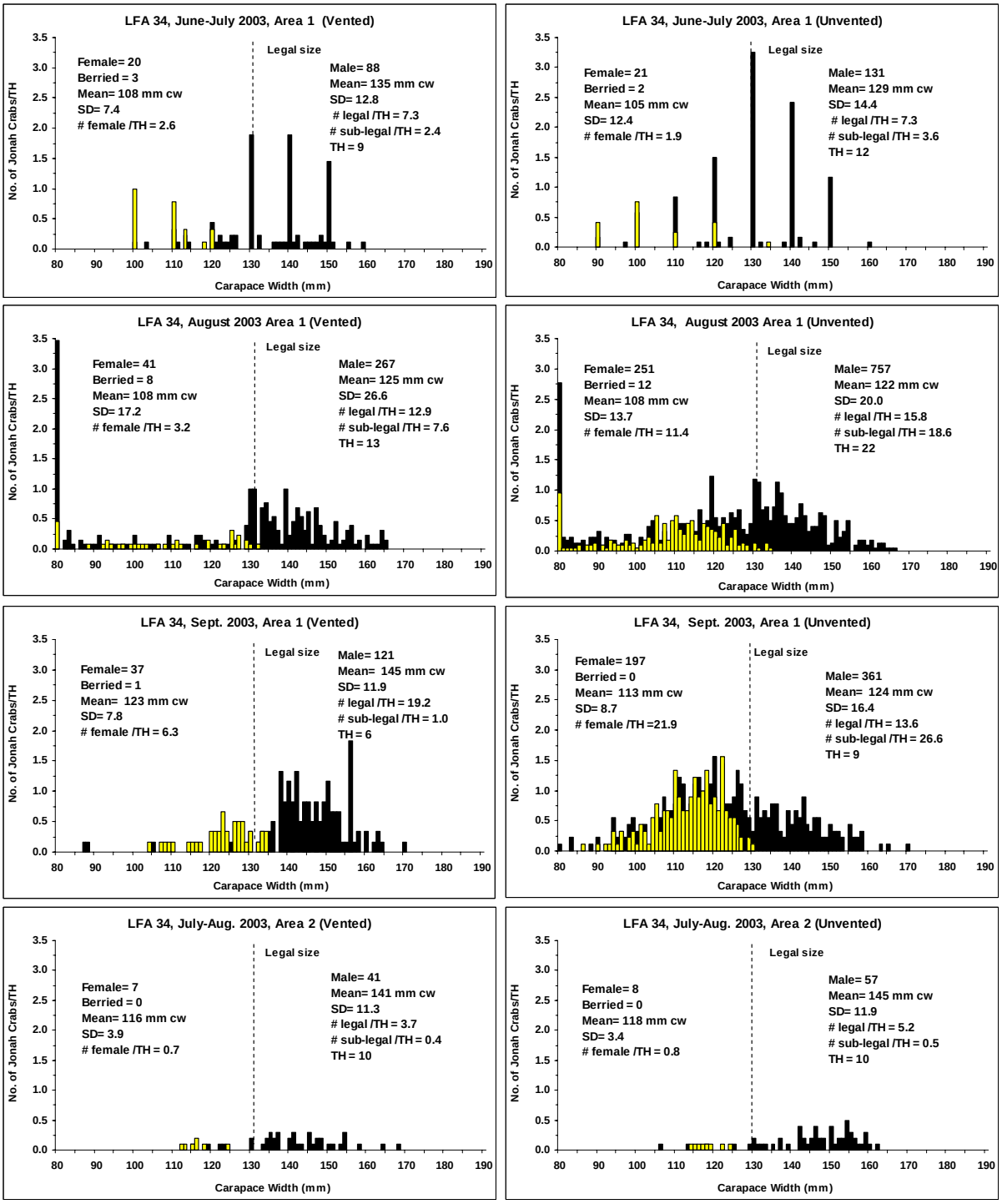

Fig. 7. Jonah crab size frequency histograms from industry sea sampling in two areas within LFA 34 (midshore) during the 2003 crab fishing season. See Fig. 3 for location of areas 1 and 2. Males are in dark histograms and females in light histograms. Berried females are included in data for females. Legal size males (≥130 mm CW), sub-legal size males (<130 mm CW) and females are expressed in number per trap haul (#/th).

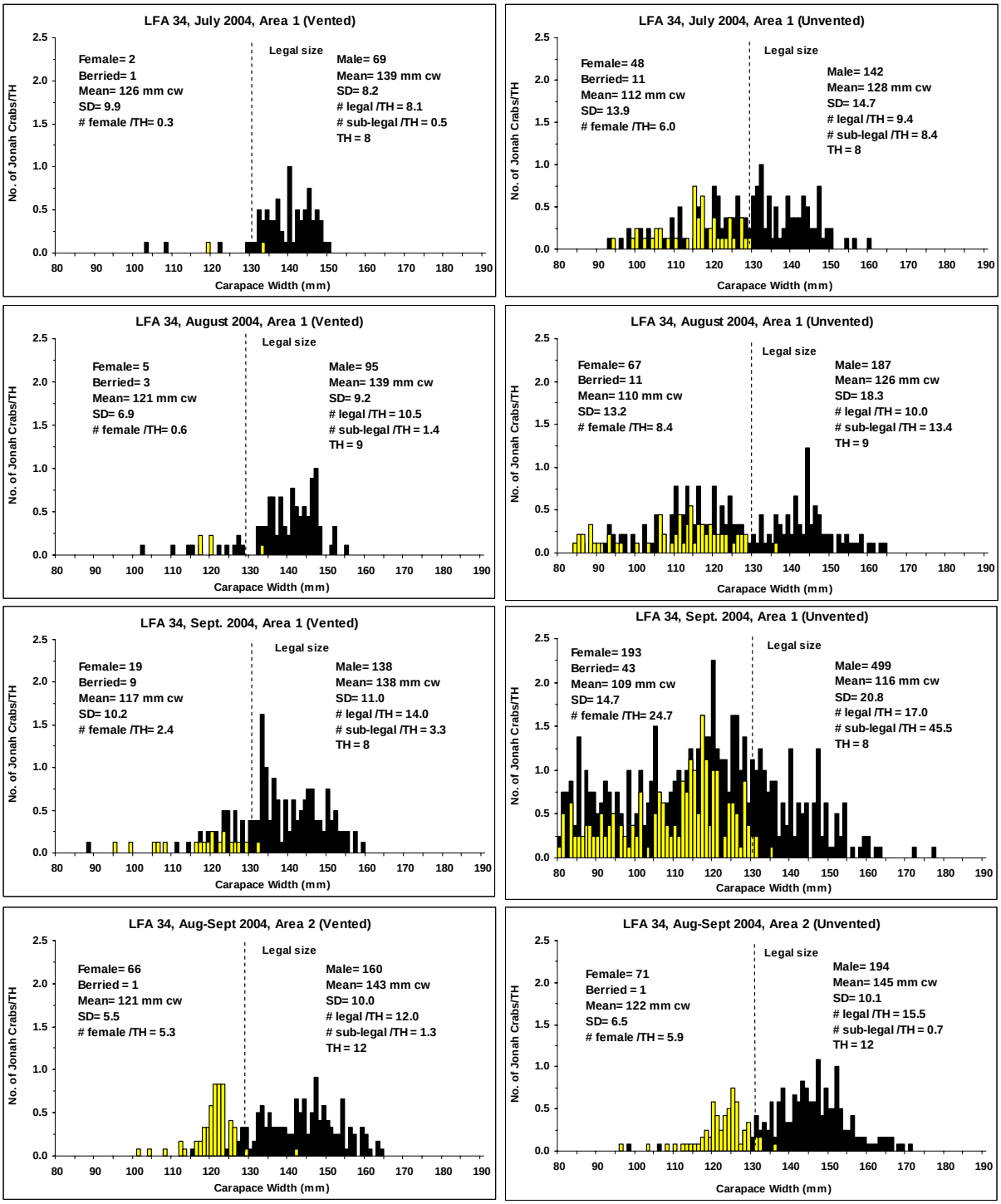

Fig. 8. Jonah crab size frequency histograms from industry sea sampling in two areas within LFA 34 (midshore) during the 2004 crab fishing season. See Fig. 3 for location of areas 1 and 2. Males are in dark histograms and females in light histograms. Berried females are included in data for females. Legal size males (≥130 mm CW), sub-legal size males (<130 mm CW) and females are expressed in number per trap haul (#/th).

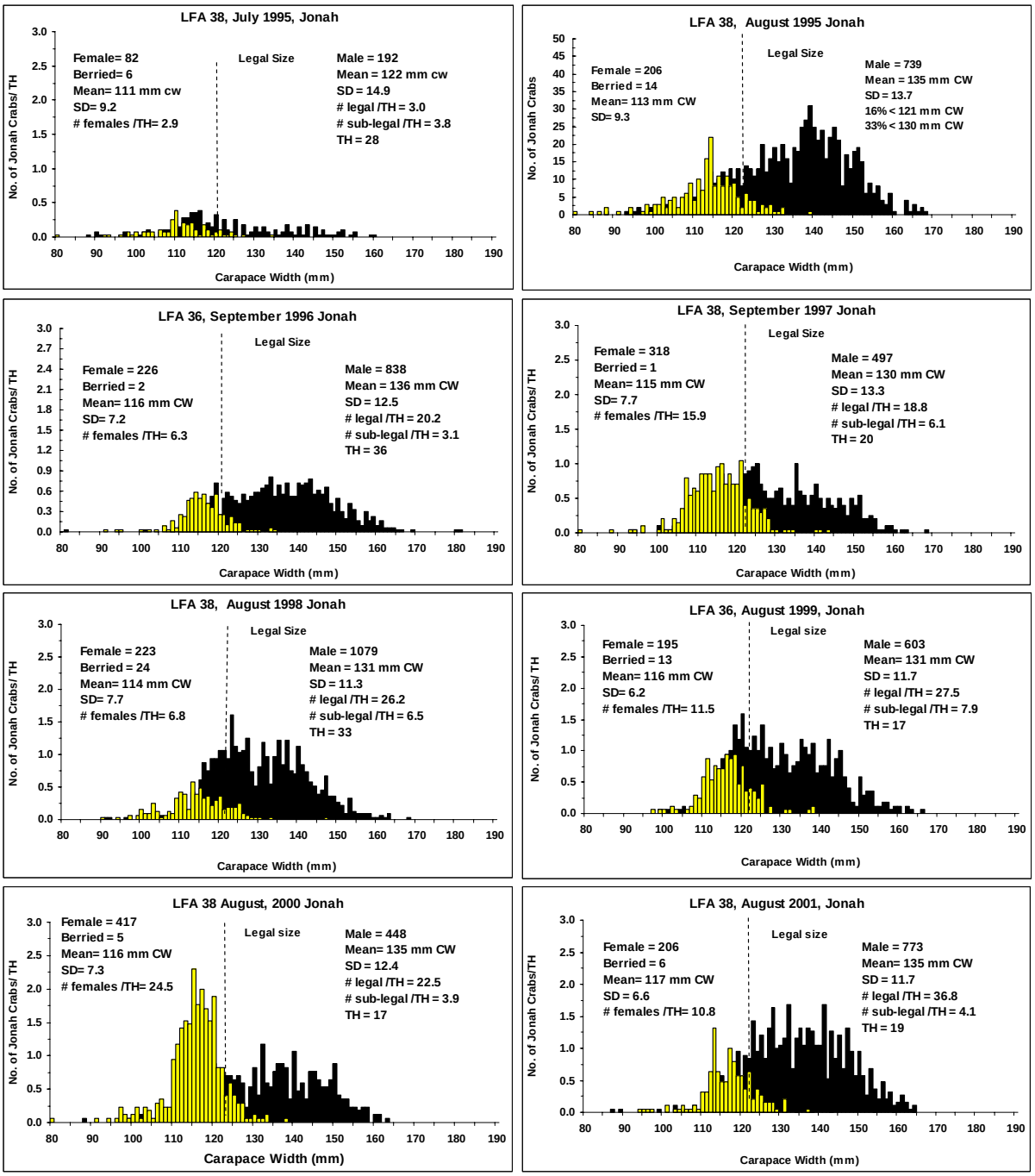

Fig. 9. Jonah crab size frequency histograms from DFO sea sampling in LFA 38, for the 1995-2004 crab fishing season. Males are in dark histograms and females in light histograms. Berried females are included in data for females. Legal size males (≥121 mm CW), sub-legal size males (<121 mm CW) and females are expressed in number per trap haul (#/th).

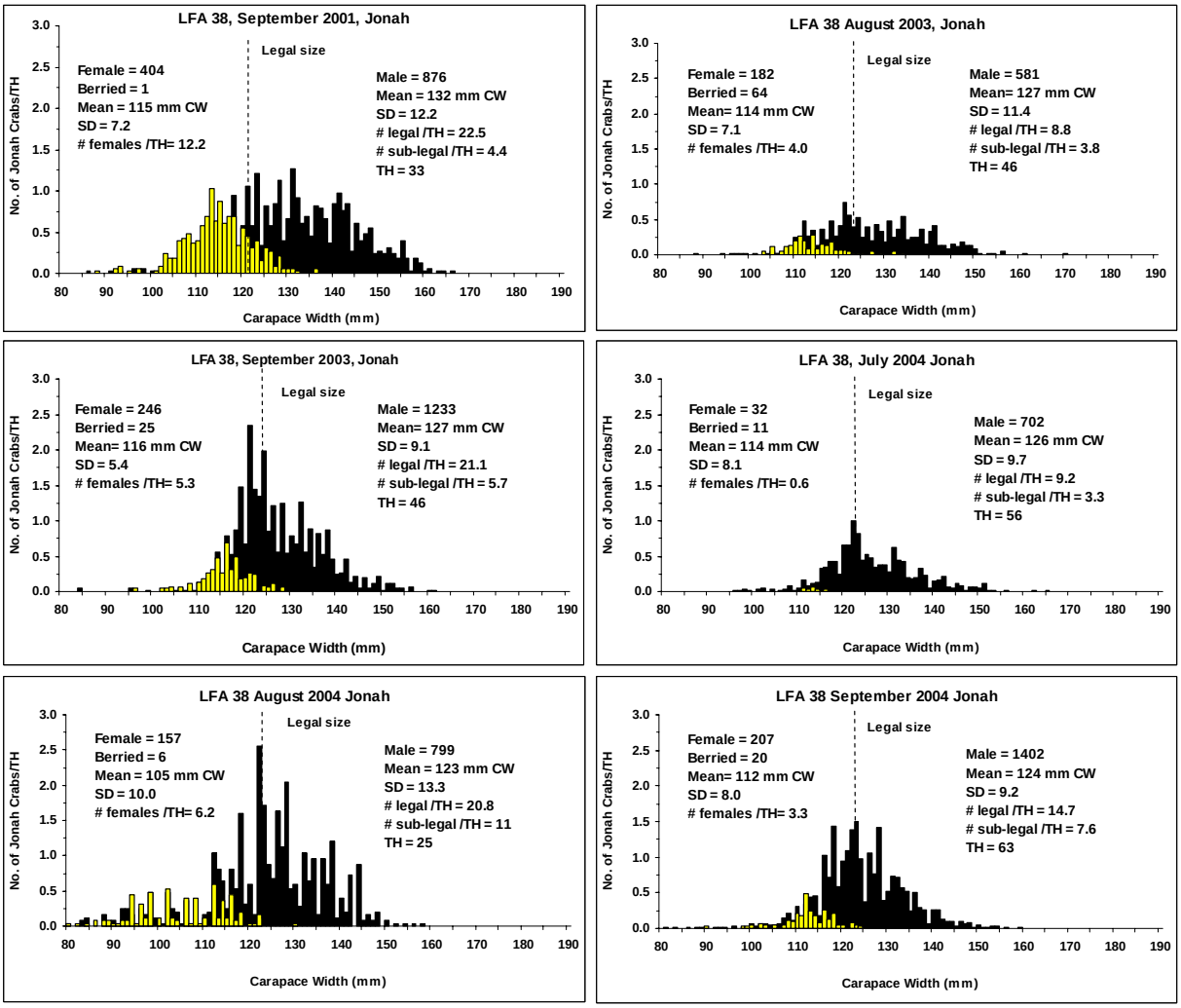

Fig. 9. (continued)

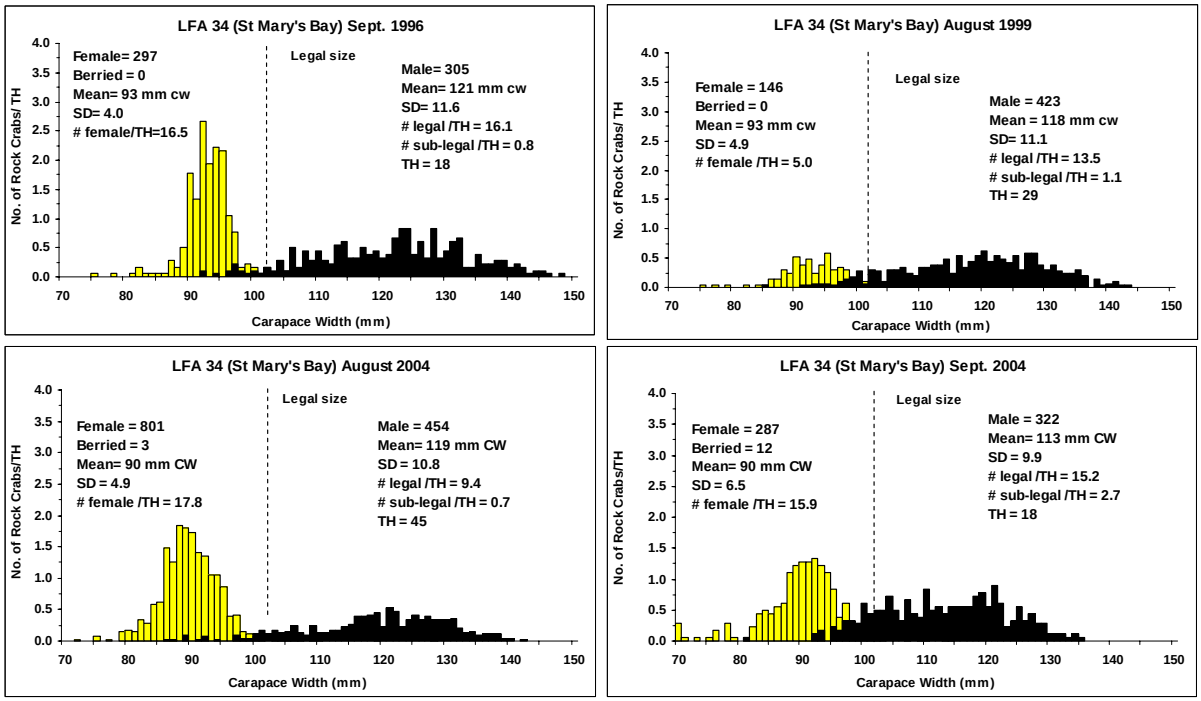

Fig. 10. Rock crab size frequency histograms from DFO sea sampling in LFA 34, for the 1996, 1999 and 2004 crab fishing season. Males are in dark histograms and females in light histograms. Berried females are included in data for females. Legal size males (≥102 mm CW), sub-legal size males (<102 mm CW) and females are expressed in number per trap haul (#/th).

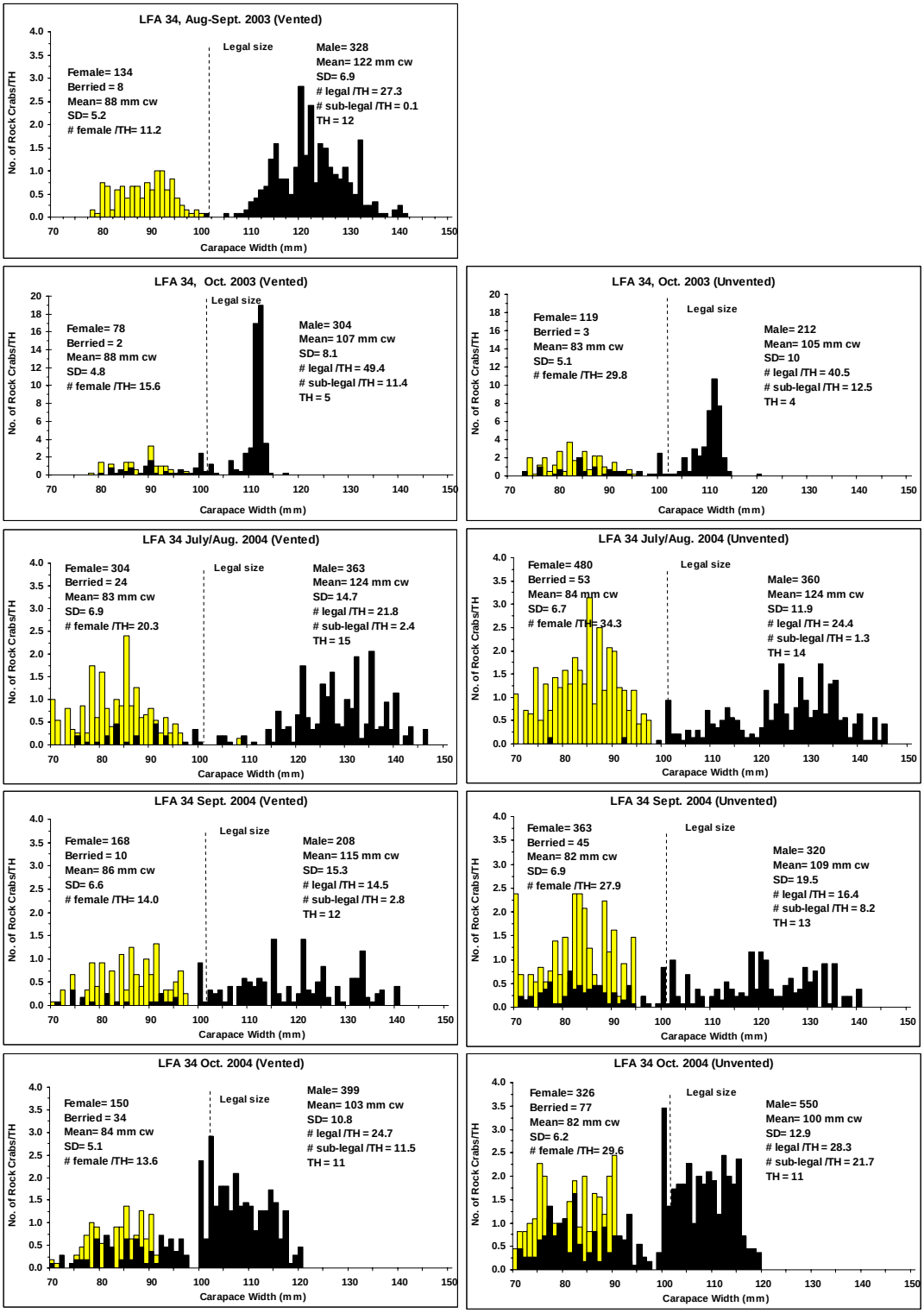

Fig. 11. Rock crab size frequency histograms from industry sea sampling in LFA 34, for the 2003 and 2004 crab fishing season. Males are in dark histograms and females in light histograms. Berried females are included in data for females. Legal size males (≥102 mm CW), sub-legal size males (<102 mm CW) and females are expressed in number per trap haul (#/th).

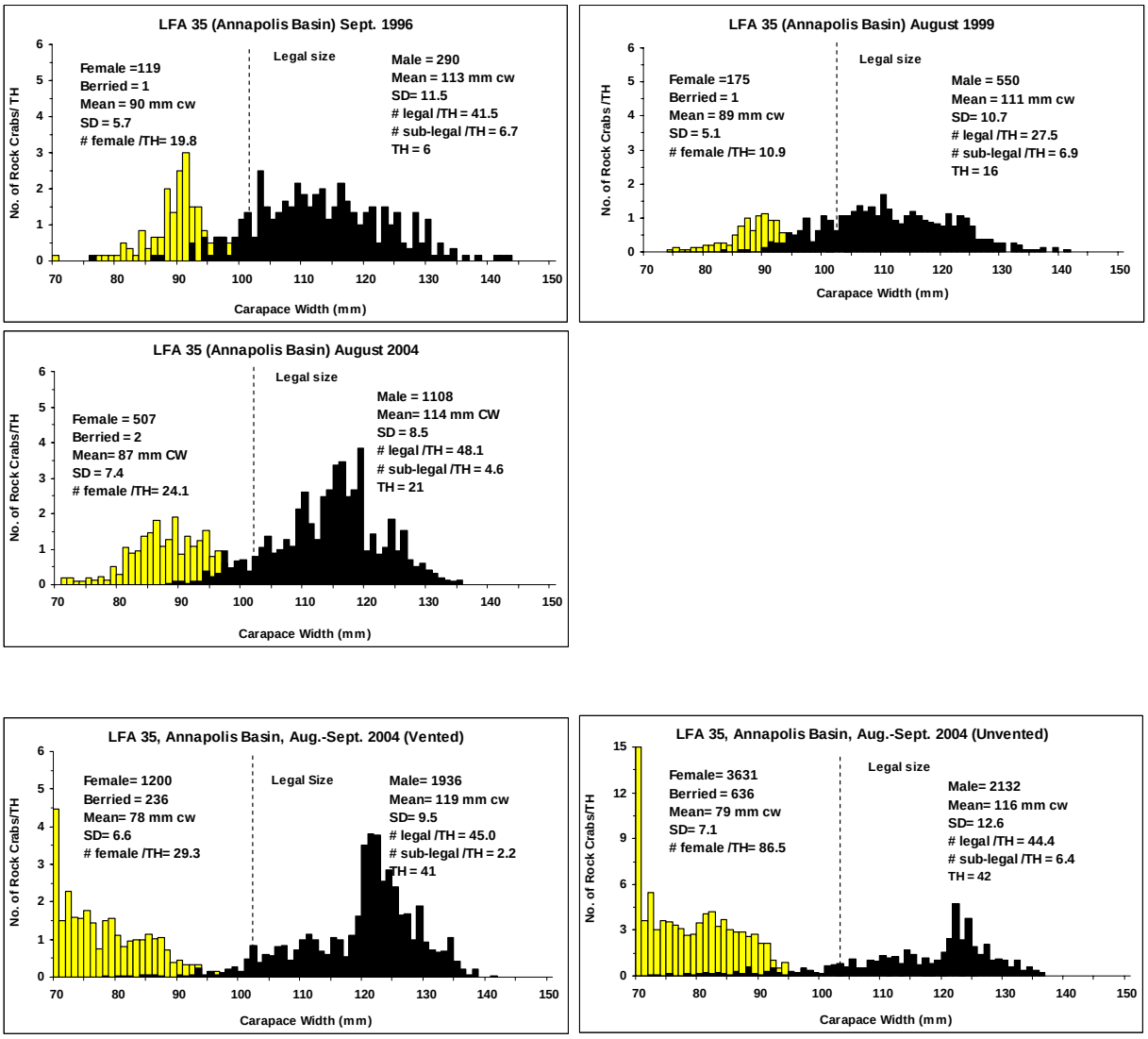

Fig. 12. Rock crab size frequency histograms from DFO sea sampling (top) and industry sea sampling (bottom), in LFA 35, during the 1996, 1999 and 2004 crab fishing season. Males are in dark histograms and females in light histograms. Berried females are included in data for females. Legal size males (≥102 mm CW), sub-legal size males (<102 mm CW) and females are expressed in number per trap haul (#/th).

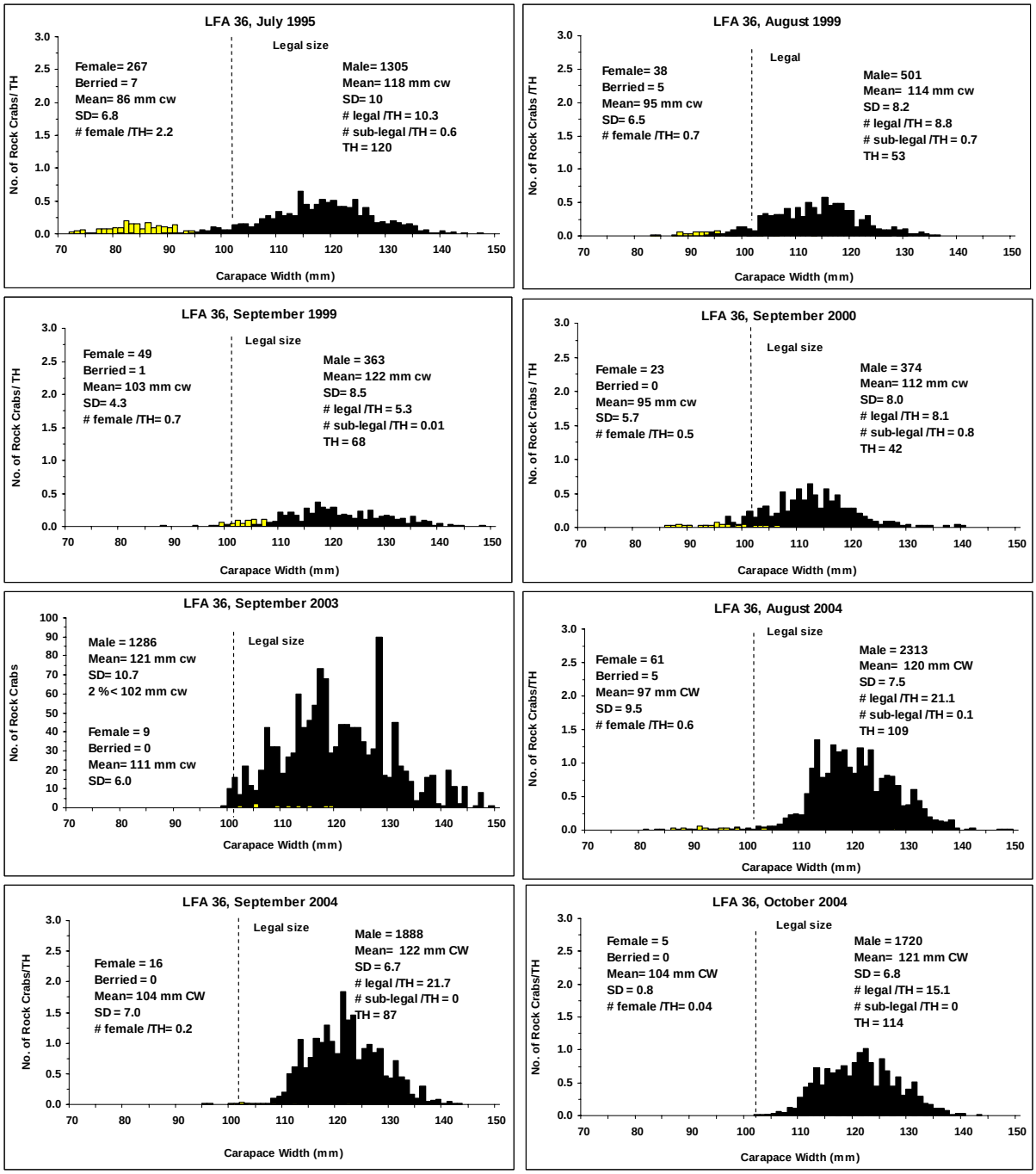

Fig. 13. Rock crab size frequency histograms from DFO sea sampling in LFAs 36 for the 1995-2004 crab fishing season. Males are in dark histograms and females in light histograms. Berried females are included in data for females. Legal size males (≥102 mm CW), sub-legal size males (<102 mm CW) and females are expressed in number per trap haul (#/th).

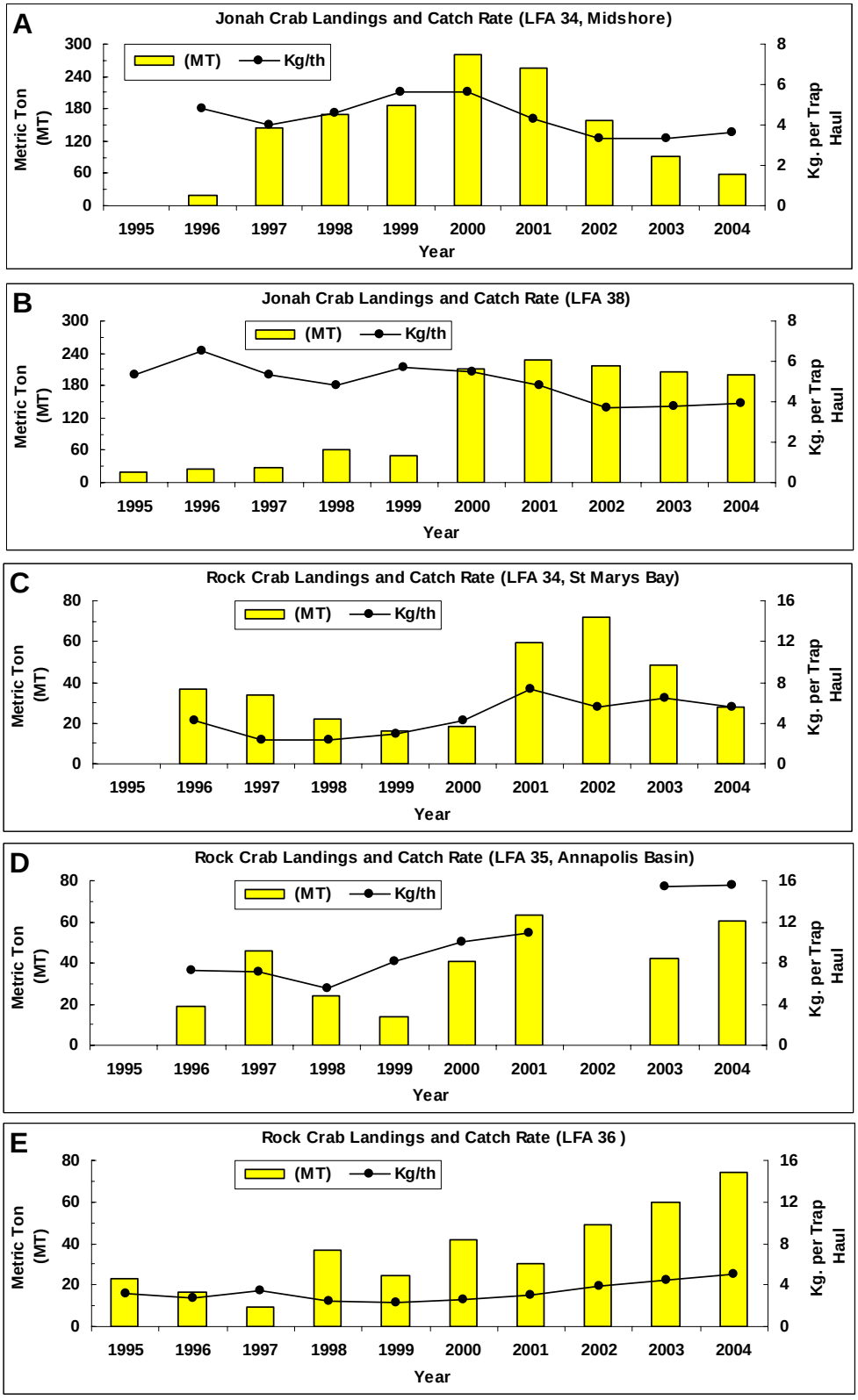

Fig. 14. Jonah and rock crab yearly landings in metric tons (MT) and the average yearly CPUE (kg/th) from LFAs 34, 35, 36 and 38 logbook data between 1995 and 2004 crab fishing season.

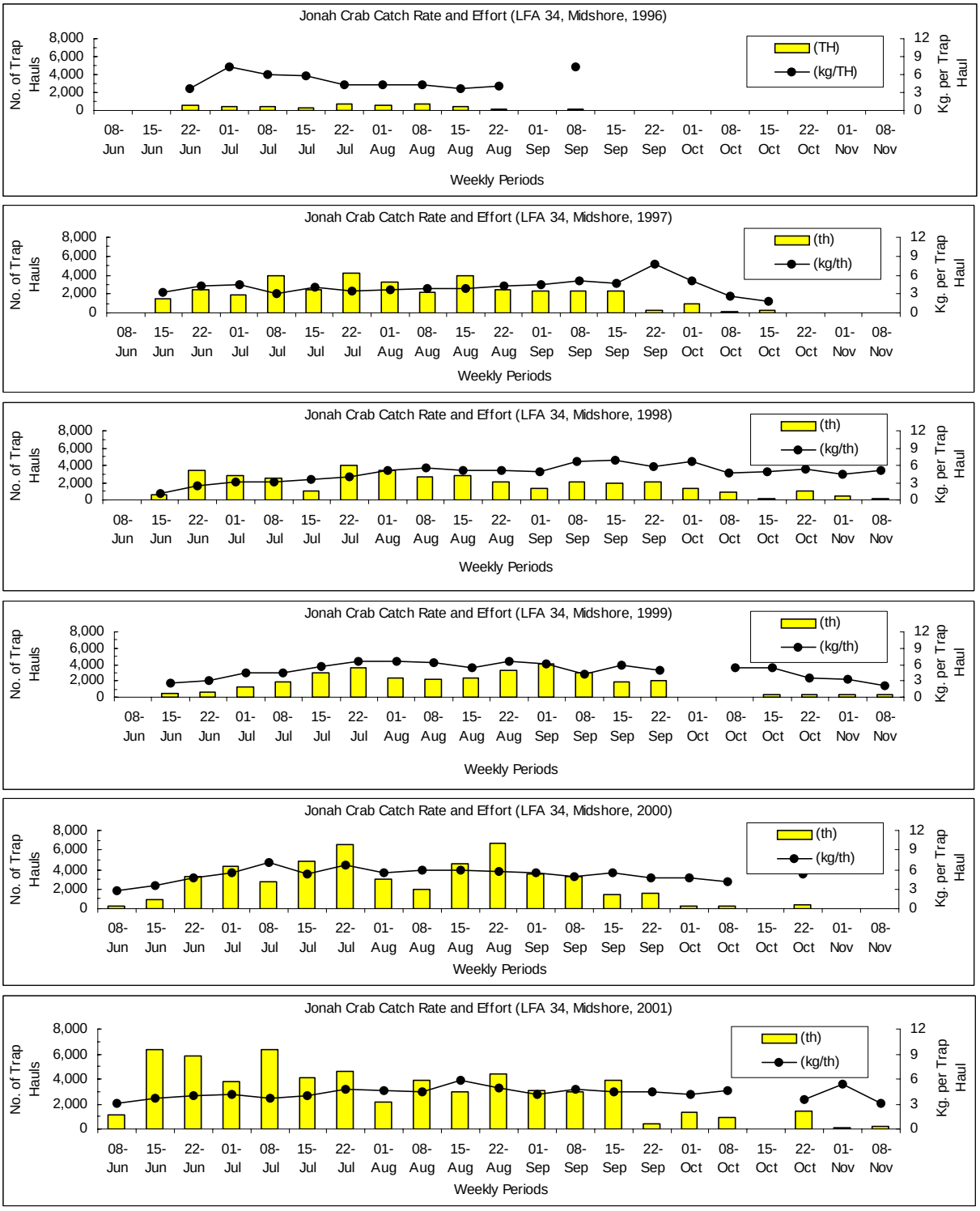

Fig. 15. Jonah crab weekly effort in trap hauls and CPUE (kg/th) from LFA 34, midshore logbook data for the 1996-2004 crab fishing season.

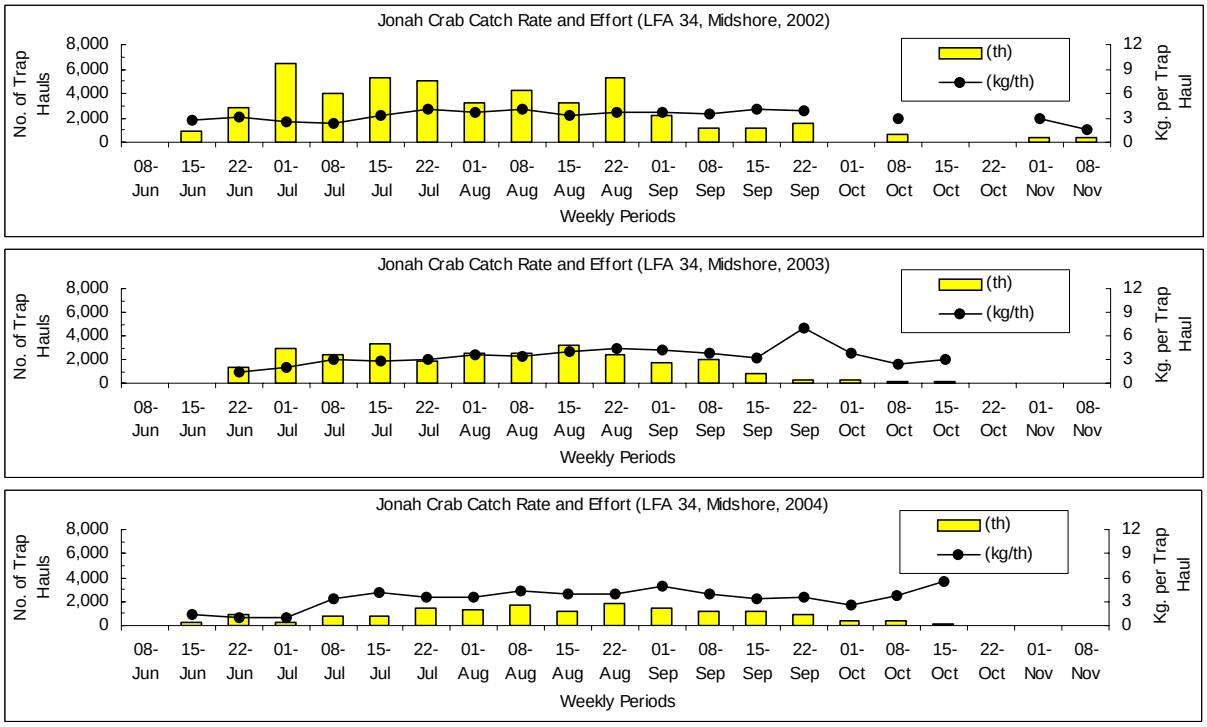

Fig. 15. (continued)

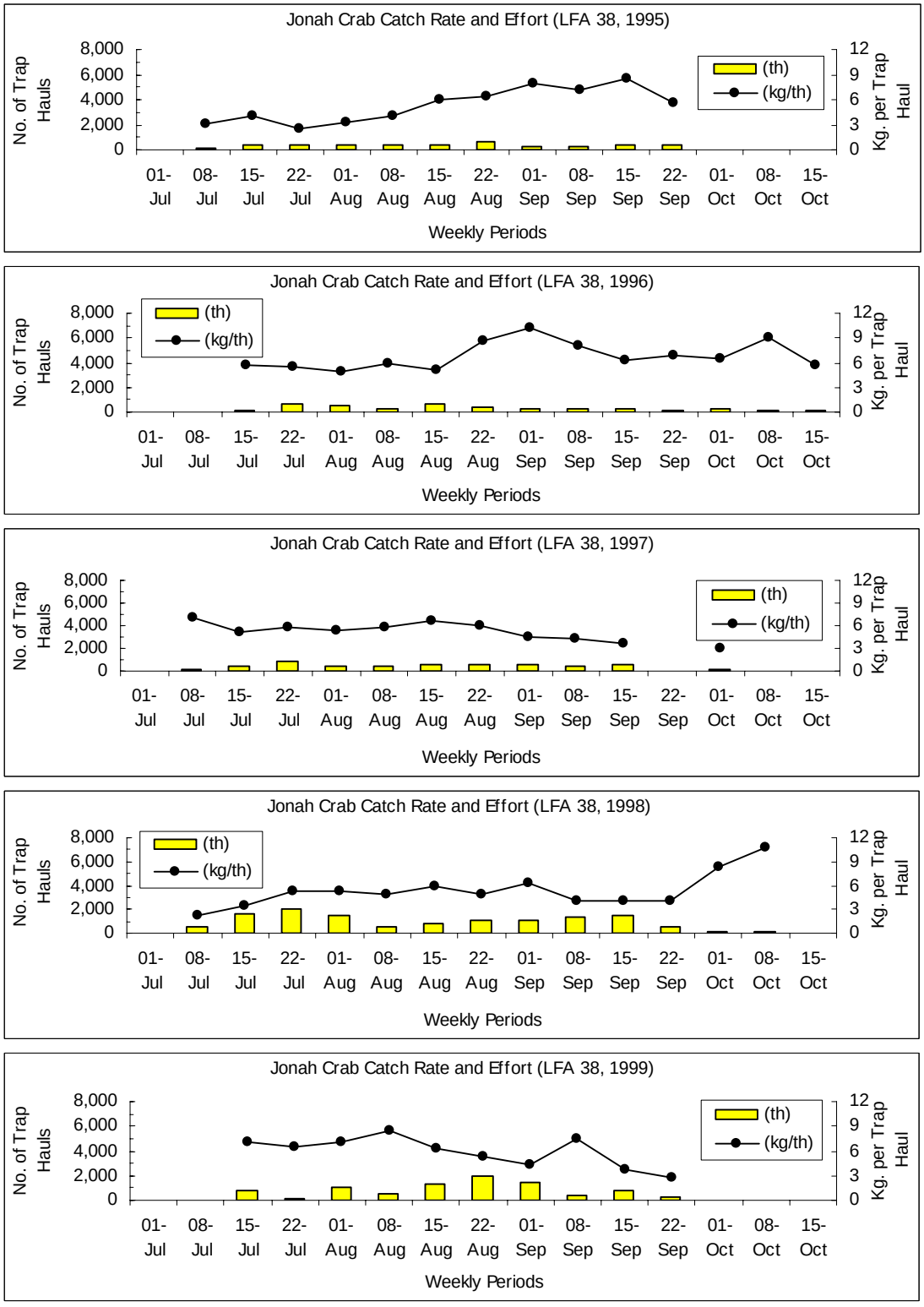

Fig. 16. Jonah crab weekly effort in trap hauls and CPUE (kg/th) from LFA 38, logbook data for the 1995-2004 crab fishing season.

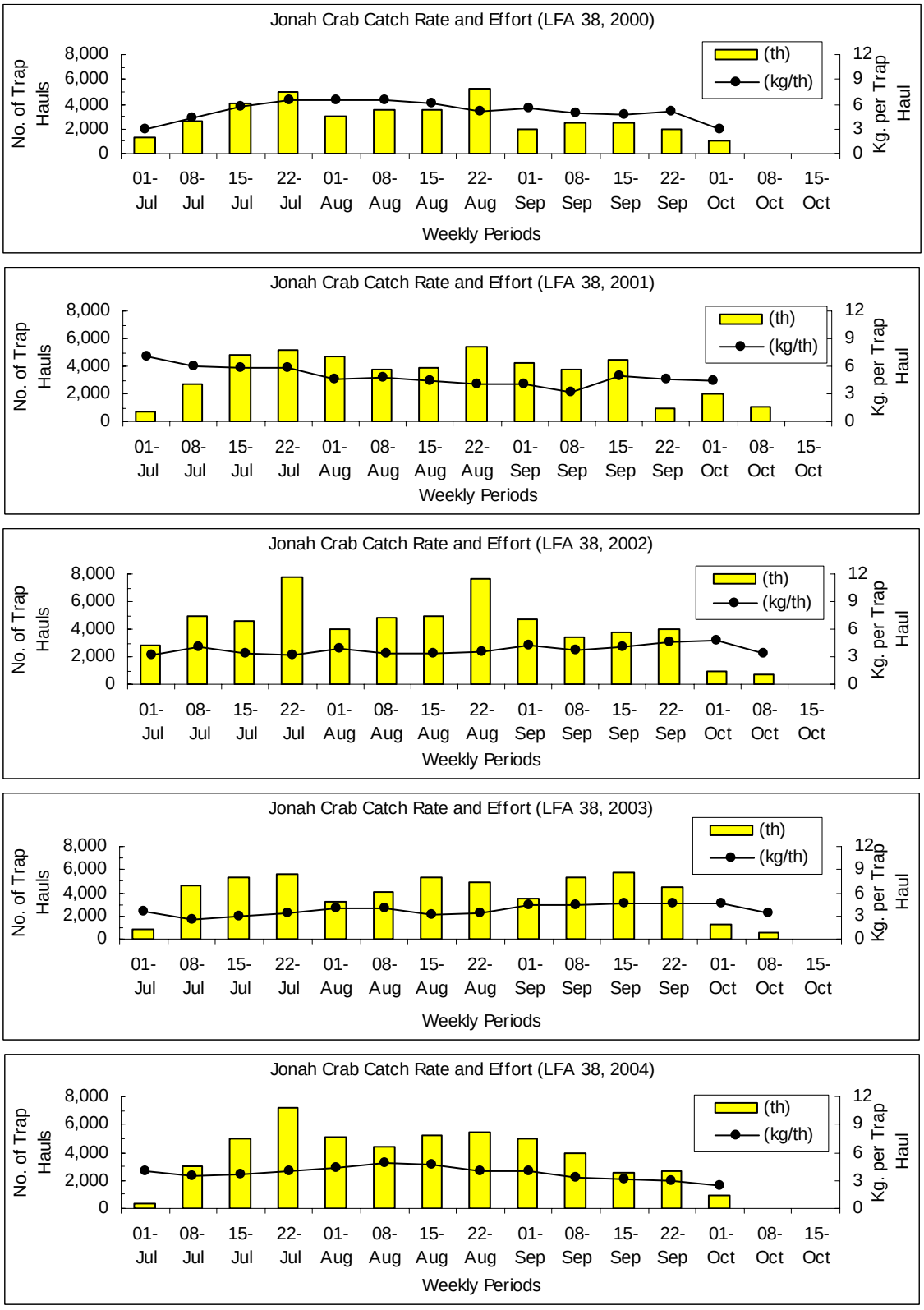

Fig. 16. (continued)

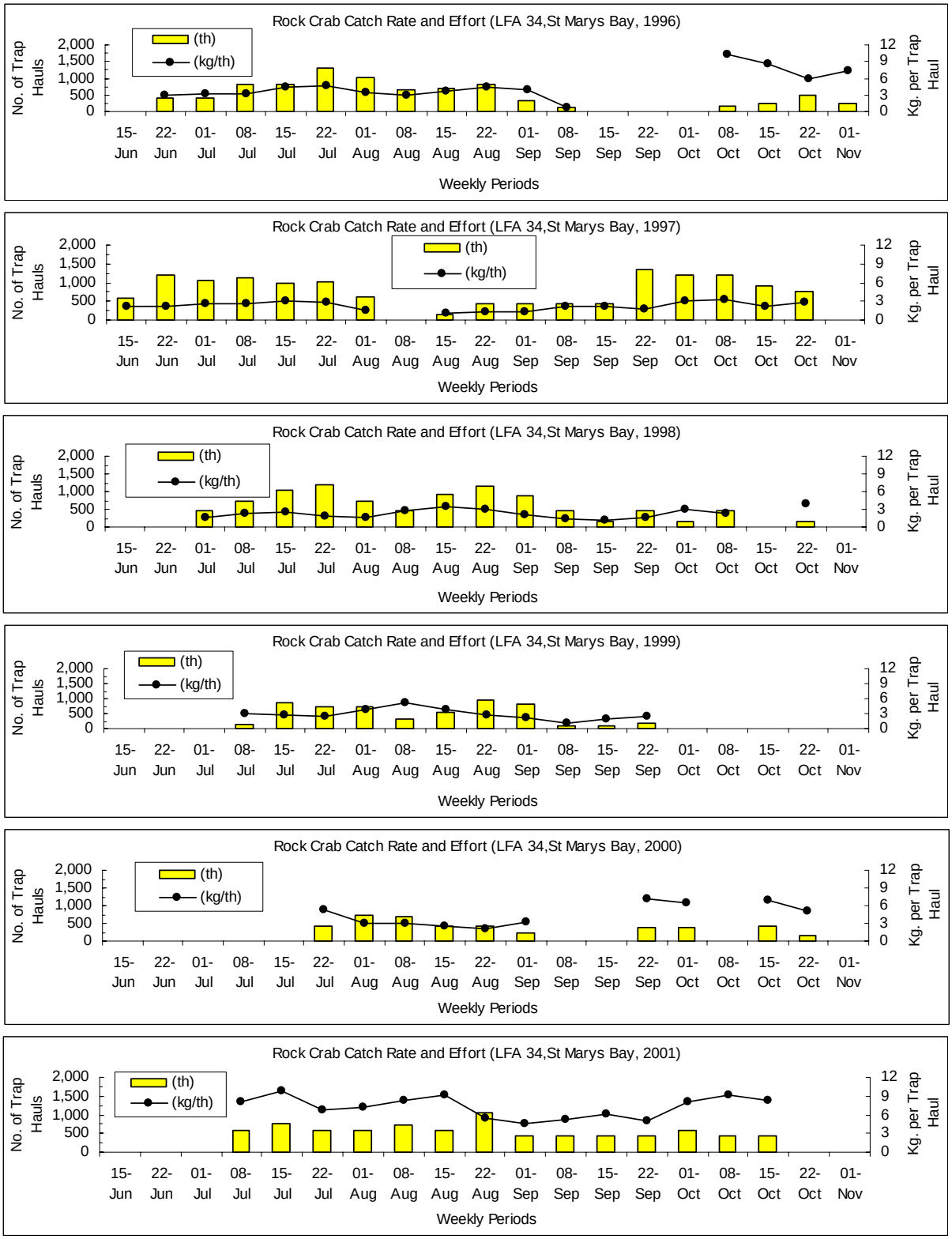

Fig. 17. Rock crab weekly effort in trap hauls and CPUE (kg/th) from St Marys Bay, LFA 34, logbook data for the 1996-2004 crab fishing season.

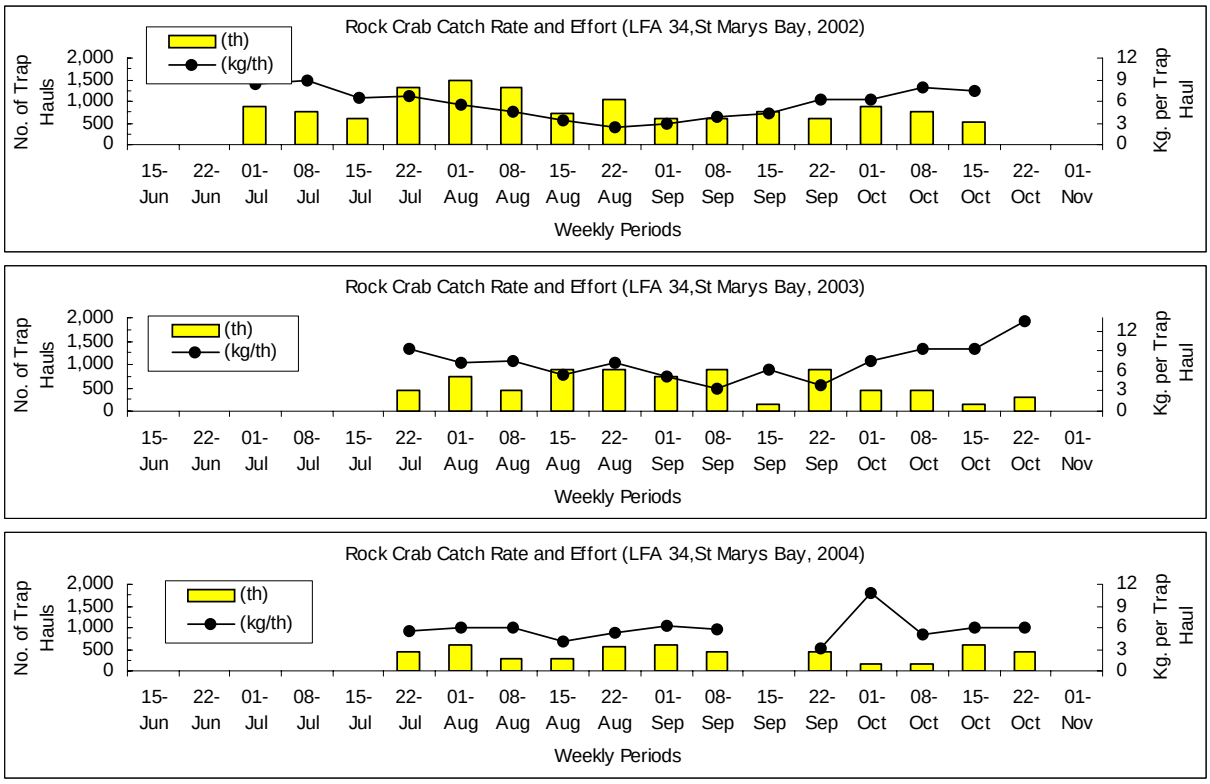

Fig. 17. (continued)

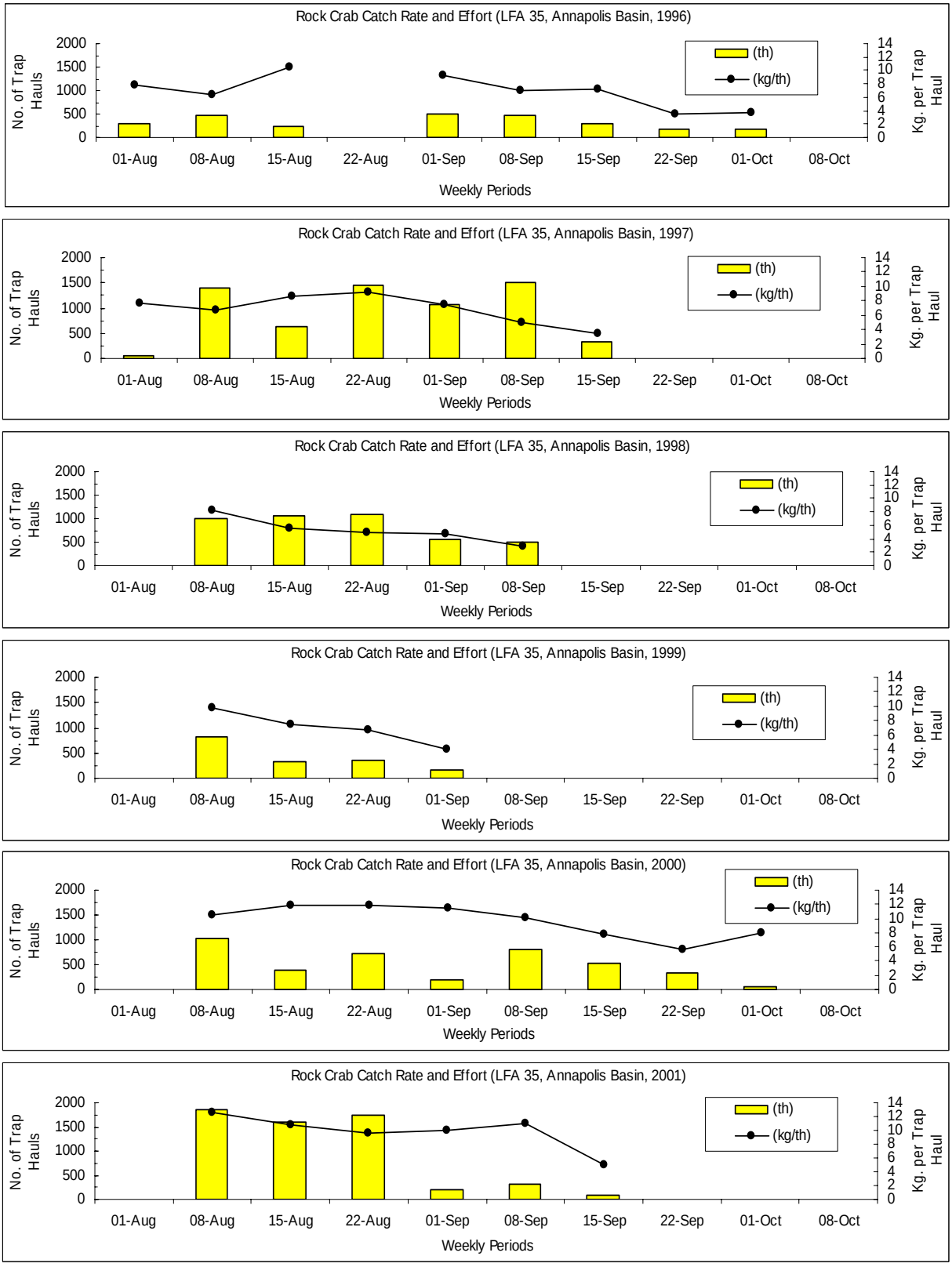

Fig. 18. Rock crab weekly effort in trap hauls and CPUE (kg/th) from Annapolis Basin, LFA 35, logbook data for the 1996-2004 crab fishing season.

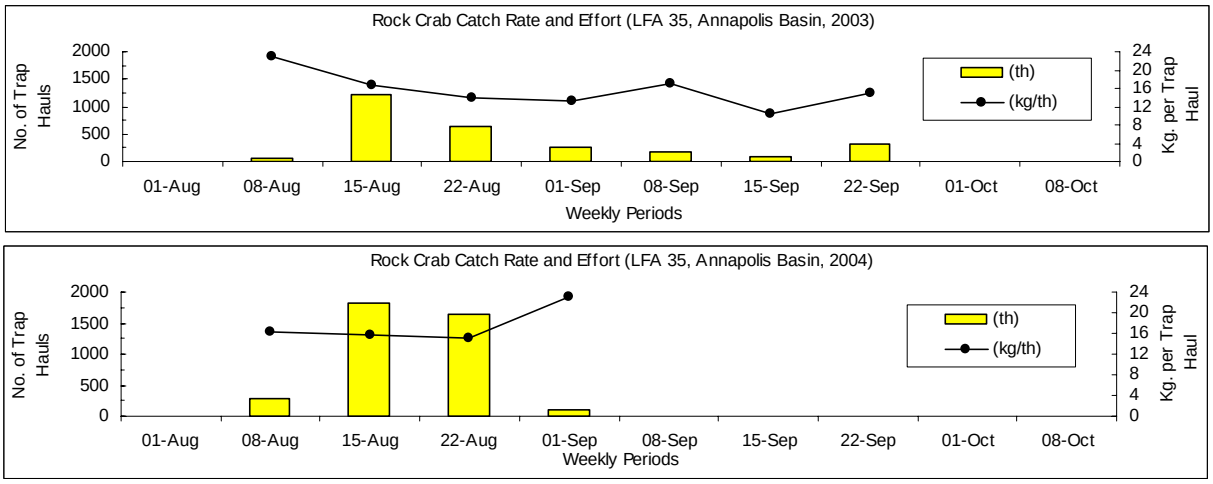

Fig. 18 (continued).

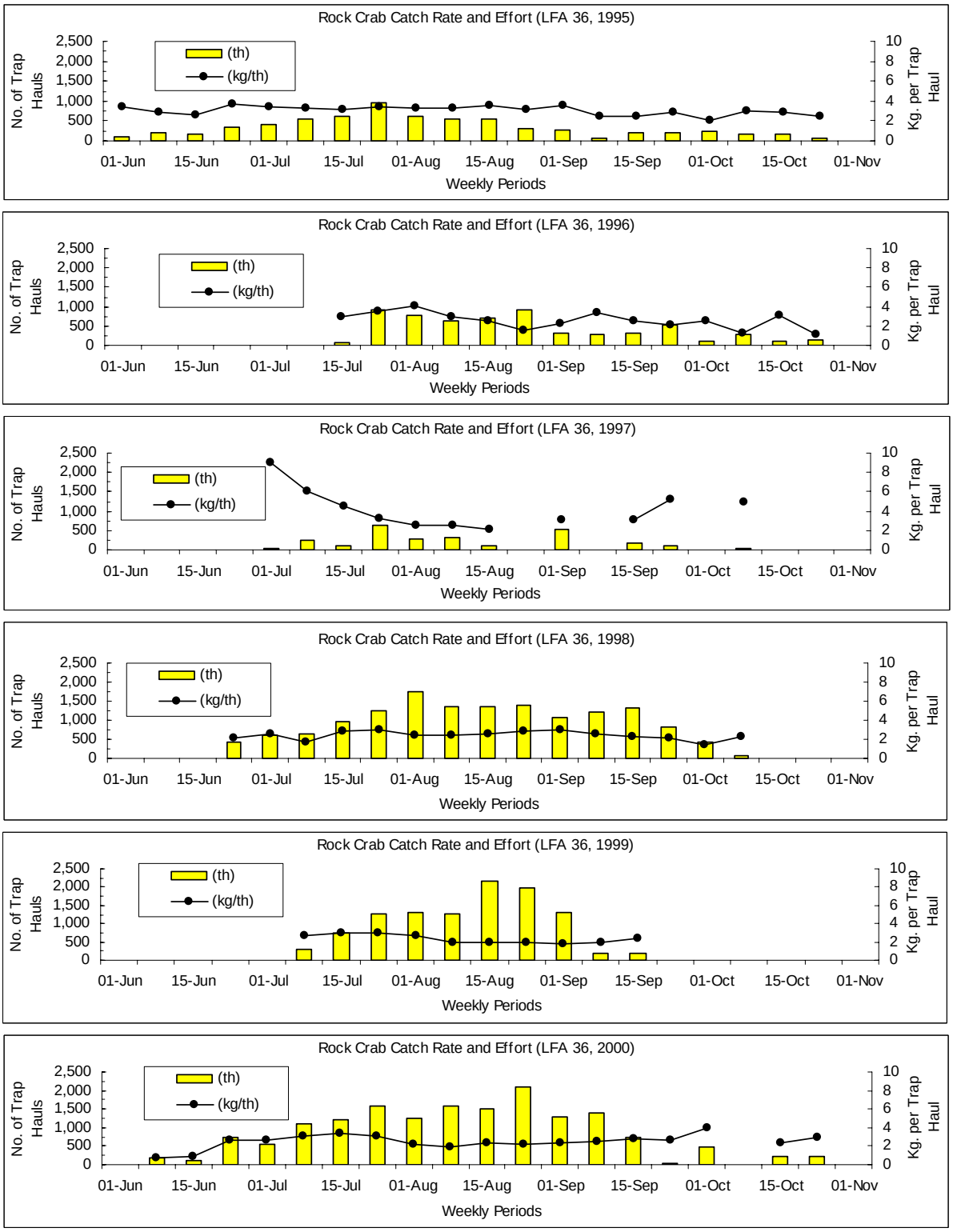

Fig. 19. Rock crab weekly effort in trap hauls and CPUE (kg/th) from southeastern N.B. LFA 36, logbook data for the 1995-2004 crab fishing season.

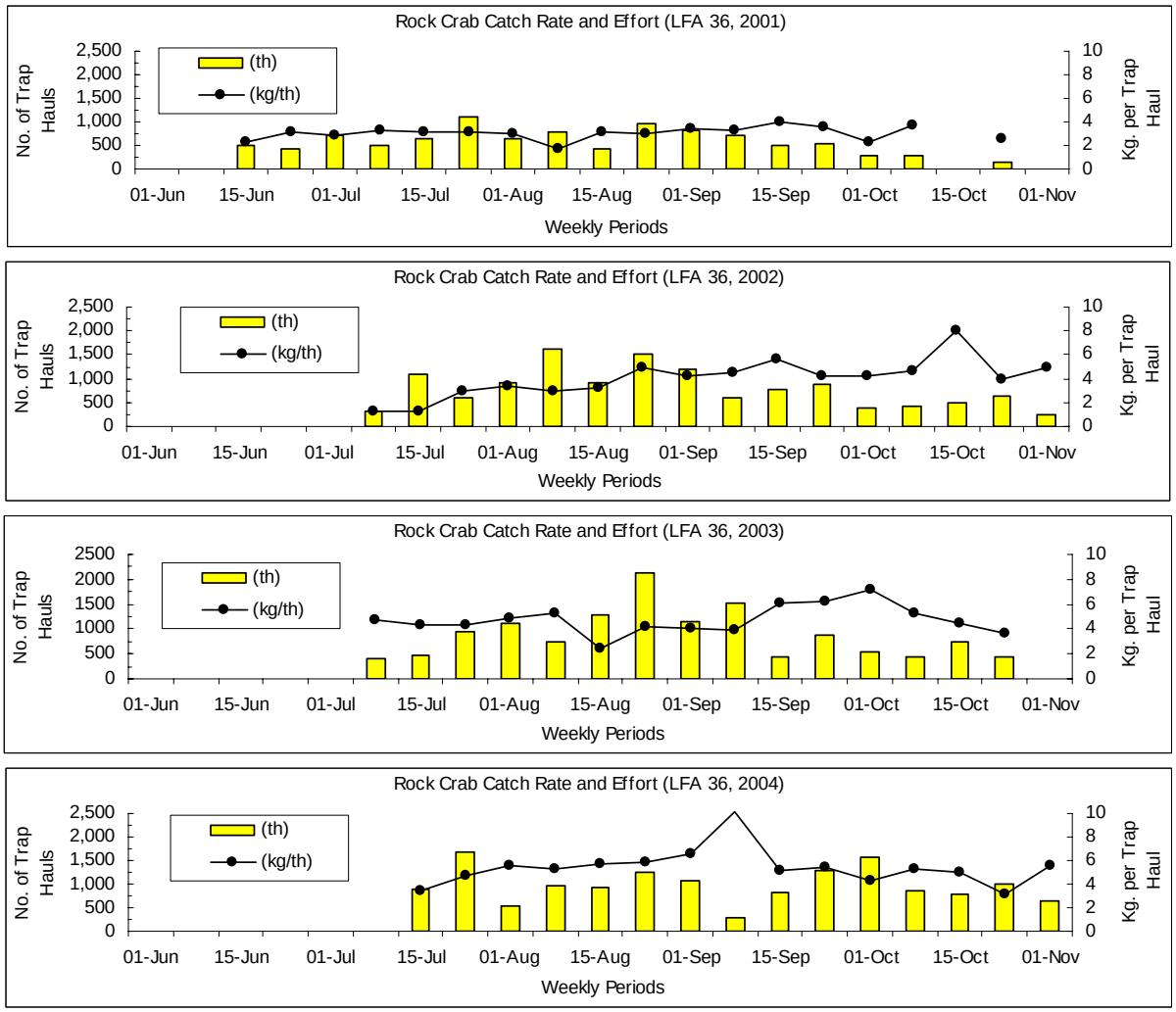

Fig. 19 (continued)