SEASONAL TRENDS IN SPAWNING CONDITION AND CATCH RATES OF ATLANTIC COD (*Gadus morhua*) IN NORTHERN PLACENTIA BAY, NEWFOUNDLAND, OVER 1995-1999

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by

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ABSTRACT

To describe the temporal spawning of cod and its relation to water temperature, sexual maturity, length, and age, the condition and gonado-somatic index of Atlantic cod sampled at four sites in northern Placentia Bay were monitored from March 1998 to April 1999. Similar information collected by the Department of Fisheries and Oceans over 1995-1997 was added to this data set. A histological procedure was used to verify spawning condition and improve the visual classification of spawning females. The visual classification was found to underestimate the percentage of spawning females by up to 29.7 %. No significant differences of biological variables and temperatures were found among the four fishing locations. Spawning fish were present from March to August, and several peak spawning periods per year were observed. A correlation between spawning patterns and temperature existed, but with a difference between sexes. Catch per unit effort, which gave a representative image of movement and abundance of fish, was more important in fixed than free locations, and was low during the spawning season.

ACKNOWLEDGEMENTS

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Chapter 1. Introduction

1.1. General Situation of the Subdivision 3Ps Cod Fishery

The "St. Pierre Bank" Atlantic cod (*Gadus morhua*) stock (NAFO Subdivision 3Ps; hereafter "3Ps") of the Northwest Atlantic, extends from Cape St. Mary's (Newfoundland) to just west of Burgeo Bank, and over St. Pierre Bank and most of Green Bank (Fig.1.1). Catches from this stock, which may consist of several substocks, have supported an inshore fixed gear fishery for centuries and have been of vital economic and social importance to the area (Brattey, 1998). The stock was heavily exploited by foreign and Canadian fleets in the 1960s and early 1970s. Following a moratorium on fishing initiated in August 1993 and ending in 1997, a commercial test fishery was opened in May 1997 with a quota set at 10,000t. Because of concerns regarding recruitment, it was suggested that this seasonal fishery occur after the peak-spawning period, when most of the year's egg production was in the water. The question then arises: when do these 3Ps cod spawn?

1.2. Review of Cod Spawning Season in North Atlantic

The peak spawning period for cod stocks in the North Atlantic shows several geographic variations: in the Northwest Atlantic, peak spawning starts in January for the NAFO Subdivision 5Zw (Nantucket Shoals) (Colton *et al.*, 1979) and is delayed towards the North to reach peak spawning in May-June for the

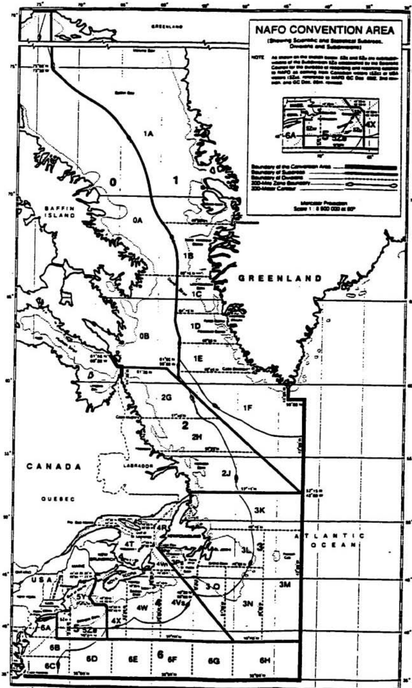


Fig.1.1. Subareas and divisions of the NAFO Convention Area and limits of Canadian fishing zones (east coast). Taken from NAFO Statistical Bulletin Vol. 43; Fishery Statistics for 1993; Dartmouth, Nova Scotia; 1997.

subdivision 3Ps (Fig.1.2). Curiously, this trend then appears to reverse as one proceeds north of the Grand Banks with peak spawning occurring in March for Division 2J (Southern Labrador). For the Central Atlantic (Greenland, Iceland, and Faroe Islands), the peak spawning times are condensed in the month of April and May. As in the NorthWest Atlantic, the Northeast Atlantic is characterised by a peak spawning period starting first in the south (February in the English Channel) and then delayed going to the north with peak spawning occurring in April along the Norway coast. Although this geographical variability in Atlantic cod spawning times is well documented, it describes mostly the offshore cod stocks. On a smaller scale, much less is known of the temporal variability in spawning in the nearshore and inshore areas.

Several authors argue that inshore cod have different spawning times than the fish found offshore. Indeed, Pinsent and Methven (1997) and Hutchings *et al.* (1993), stated that hydrated eggs or actively spawning females are found along the coast of Newfoundland from April until September, but that inshore spawning is concentrated in May-June. Also, Smedbol and Wroblewski (1995) estimated peak spawning in a western portion of Trinity Bay to have occurred from mid-June to mid-July for the years 1991-1993. This spawning was delayed relative to estimated times for offshore spawning (April-May for the Division 3L; Myers *et al.* 1993). In the 3Ps stock, the offshore peak spawning has been observed in the month of May and June (Fitzpatrick and Miller 1979). It is not known whether the Placentia Bay cod follow the peak spawning time of the 3Ps offshore cod.

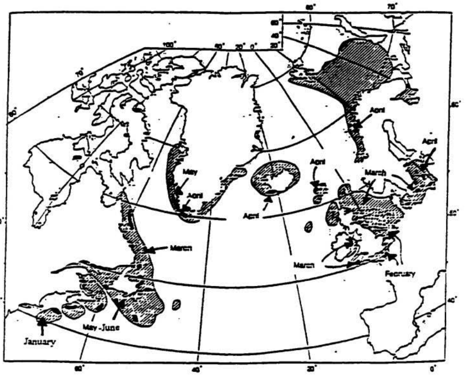


Fig. 1.2. Distribution of cod stocks in the North Atlantic, with their principal spawning sites and dates (month) of peak spawning (based on Anon, 1990).

1.3 Review of Spawning Time and Location in Placentia Bay

Reports of Atlantic cod (*Gadus morhua*) in spawning condition in major Newfoundland bays are not new (Neilsen 1894; Graham 1922; Goddard *et al.* 1994). However, few data exist on the spawning patterns of the 3Ps cod stock component in Placentia Bay. Nielsen (1895), quoted by Graham (1922) reported that during May, June, August and September, spawning cod could be found in Placentia Bay. Fitzpatrick and Miller (1979) showed spawning as occurring "primarily in the months of May and June". Hutchings *et al.* (1993) presented data from research gillnet surveys on the presence of spawning cod in two locations in Placentia Bay (Merasheen and Woody Island) over the years 1964-66. Recent indirect evidence for inshore spawning in Placentia Bay also arises from an acoustic survey of cod spawning aggregations during May 1997 (Rose and Lawson, 1998). From this survey, one dense spawning school was found near Woody Island, in the northern part of the bay. It can not be determined from these reports whether spawning occurs on one or on several identifiable peaks throughout the year.

1.4. Temperature and Age Dependent Spawning Season of Cod

Having shown the existence of temporal spawning variability, a review of the potential causes for this variability was undertaken. According to Brander (1993), water temperature is one of the principal factors causing variation in timing between areas. Kjesbu (1994) suggested that the differential timing of spawning of cod in various geographical areas may well be due to temperature differences experienced by the cod during vitellogenesis in the fall and winter months. Indeed, a drop in the temperature of 1^0C during the autumn (i.e. during the time of incorporation of the yolk in the oocytes) delays the time of spawning by about 8-10 days (Kjesbu, 1993). Moreover, the average effect of a change in temperature depends upon how long and when this change has been operating: a drop in temperature of 2^0C at an oocyte diameter of 300 μm caused a delay in spawning by 16-21 days compared with 3-4 days at 700 μm (Kjesbu, 1994). Therefore, it seems that the rate of gonad development is highly dependent on ambient water temperature. An example can be seen for the cod overwintering in Trinity Bay (Newfoundland) which experience lower temperatures (Goddard *et al.* 1994) than cod on the continental shelf during the winter months (Rose, 1993). The Trinity Bay aggregations have a peak spawning time delayed by two months, relative to offshore cod (Smedbol and Wroblewski, 1995). Thus, colder temperature in inshore waters may delay spawning for cod that spend the winter near the coast. Furthermore, temperature may also affect the nauplii production available to cod larvae as food, and therefore, have an influence on the growth and survival of larvae. Consequently, temperature can exert a physiological effect on gonad maturation as well as play an indirect role on recruitment through prey availability. Several examples of delayed spawning due to temperature have been reported in the North Atlantic: the timing of reproduction at the main spawning site of the Arcto-Norwegian cod, at Lofoten, is about two weeks earlier than at the northern most spawning ground (Brander, 1993). A time difference even more dramatic has been observed for Icelandic cod which spawn in April off southern Iceland and only in May-June in the northern fjords (Schopka *et al.*, 1990). Through their variability

among years, temperatures could be a possible cause of the interannual variation of spawning times.

Spawning time variability may also be due to the age composition of the stock involved. For example, over the period 1930-60, Arcto-Norwegian spawning tended to occur about 7-15 days later relative to the long term average, and the delay was ascribed to a decline in the average age of spawning fish over that period (Pedersen, 1984). Indeed, according to Hutchings and Myers (1993), time of spawning in cod is associated with age. For Icelandic cod, Marteinsdottir and Petursdottir (1995) observed that larger cod start spawning earlier in the season than smaller cod. However, similar trends are not necessarily seen in Newfoundland/Labrador: younger cod start spawning earlier than older cod which in turn complete spawning later in the season than the younger ones (Hutching and Myers, 1993). Therefore, a change in the age of a stock composition (eg. truncation of the older ages as seen in the northern cod 2J3KL stock) between years may influence the spawning time variability.

1.5. Inshore Surveys

Since the end of the 1980s, researchers from the Department of Fisheries and Ocean (DFO), St. John's, Newfoundland, have been regularly consulting with inshore fishermen. The aim was to determine how to collect and interpret the data from the inshore cod fishery. In 1994, commercial inshore fishermen and researchers of the DFO started to work together in a newly created program called the Inshore Sentinel Survey. This program had the principal goal of enabling a constant survey of the cod stocks in the inshore waters of Newfoundland and Labrador. As part of this project, fishermen using gillnets were asked to set their nets at three different locations for each fishing date. Two of those fishing locations were of the fishermen's choice ("experimental" locations), and one was a constant or "control" location. The aim of having two different fishing strategies (fixed and free fishing locations) was to observe if the choice of a constant fishing location would have an impact on the catch rate and therefore, on any direct or indirect abundance estimates of cod. In addition, the two methods allowed an indirect analysis of the distribution of fish on the fishing grounds. In this thesis, seasonal change of catch per unit effort will be examined, and the significance of catches obtained between the two fishing procedures will be compared.

1.6. Visual Versus Histological Maturity Staging Procedures

Describing the spawning time of a particular fish stock is done through determination of the fish's individual gonad maturation stage. The most frequently used method is a visual description of the gonad (Templeman *et al.*, 1978). However, since cod are batch spawners (McEvoy and McEvoy, 1992), the eggs are not released all at once, and any gross visual observations may be misleading with respect to maturity stages. According to Morgan and Brattey (1996), it is difficult to classify a fish visually during the period in-between batch releases. The solution to this maturity staging dilemma may be a histological procedure used as verification of the visual procedure. Indeed, postovulatory follicles are obvious structures left in the ovary after maturation and oocyte ovulation (Saborido-Rey, 1997), and their presence is a clear indication that a fish has spawned. Therefore, a histological method used for the determination of spawning time would improve and validate the accuracy of the gross observations. To date, a comparison of fish in spawning stages through the two procedures has not been documented.

The first objective of this thesis is to determine whether, and how much, the classification of spawning stages could be improved through a histological procedure.

The second objective is to describe the seasonal spawning trends of cod sampled in northern Placentia Bay during 1998-1999 and to relate it to the age, length, weight of the fish as well as to water temperature.

The third objective is to compare the 1998-1999 spawning trends to the spawning trends of the three previous years (1995-1997) observed in northern Placentia Bay.

The last objective is to compare the catch rates between spawning and post-spawning season and between fixed and free fishing locations and relate them to the spawning patterns of cod in the head of the bay.

Chapter 2. Materials and Methods

2.1. Biological Sampling

Five local fishermen involved in the DFO Sentinel Survey Program in Placentia Bay were interviewed in February 1998. Detailed questions were asked in order to describe temporal and spatial aspects of Atlantic cod spawning in the north of the bay (Appendix A). From this information and from acoustic survey results of cod spawning aggregations in May 1997 (Rose and Lawson, 1998), four sites were chosen in the north of the bay (Fig.2.1): two sites on the western side of the bay (W1: latitude and longitude: 47.717, –54.191 and W2: latitude and longitude: 47.751, -54.226); one in the north (N: latitude and longitude: 47.801, -54.080) and one in the east (E: latitude and longitude: 47.635, -53.963). All four sites had depths between 30 and 70 m, and were chosen to maximise the chances of having some fish present over the entire year. Thirty fish per site were than sampled every two weeks from March 1998 to March 1999. The fish were collected using monofilament gillnets (each 91.5m long and 3m deep with 13.8cm (5.5-in) mesh). Only fish with standard length greater than 50cm were examined.

Variables recorded included stage of maturity, round weight (g), gutted weight (g) gonad weight (g), standard length (cm), sex, date, temperature and salinity of the water as well as time of set or deployment of the fishing gear, soak time (total time when the nets were in the water) and number of gillnets. Stage of maturity, weights and lengths of the fish were recorded on each fishing day.

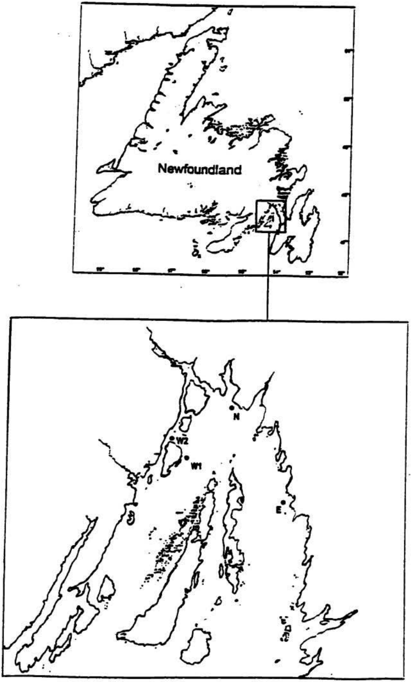


Fig. 2.1. Four sampling sites selected in northern Placentia Bay.

Assessment of frozen samples was avoided to minimise any misclassification of variables due to freezing effects. Temperature and salinity profiles of the water column were recorded using a Sea-Bird Electronics CTD (Conductivity, Temperature, Depth recorder: model SBE 19-03) and weights were measured using an electronic balance (model Mettler PE 24). Age was determined from otolith microstructure (Kennedy and Steele, 1971).

The reproductive stage of cod was assessed using two different methods. The first involved a visual description of the gonad following the criteria of Templeman *et al.* (1978), and Morrison (1990). The fish were classified into three stages (ripening, spawning, spent).

The description for female stages was:

Ripening/Maturing: eggs opaque and visible to the naked eye, blood vessels visible on a white background. Since cod are batch spawners (McEvoy and McEvoy, 1992), this stage was carefully observed for an eventual translucent egg leftover in the middle of opaque eggs indicating a previous spawning.

Spawning: presence of translucent (hydrated) eggs in the ovaries. Given that egg formation is rapid and occurs 1-2 days in advance of spawning and that the number of hyaline (hydrated) oocytes present in the ovary varies in a cyclic manner, the eggs will normally be released within 3 days of hydration (Kjesbu, 1988a). Consequently, the presence of hyaline oocytes indicates that the specimen has spawned or will spawn in the near future. These findings justify the designation "spawning" for this stage.

Spent: ovaries whitish-gray or bluish-gray, shrunken, soft and "flabby" with whitish cast. Residual eggs often present.

For males, the classification categories were:

Ripening/Maturing: colour of testes ranging from gray or pink to white; translucent on the edges; little or no sperm in the efferent ducts.

Spawning: testes and efferent ducts completely opaque and white with milt present.

Spent: testes thin, gray or pink and milt not evident.

The second method used to classify the gonads was a histological procedure. It was only applied to females. A representative piece of gonad was immediately fixed in "Bouin's fixative" (25% Picric Acid; 75% Strong Formalin and 5% Acetic Acid (37%)). In the laboratory, 0.5 cm thick pieces were than embedded in paraffin based on conventional histological processing, and 7 μm sections of tissue were stained with Harris hematoxyline and eosine-floxine. The Kjesbu and Krivi (1993) and Morrison (1990) criterion was used to differentiate maturity stages. As cod are batch spawners and as postovulatory follicles (POF) are the structures left in the ovary after maturation and oocyte ovulation (Saborido-Rey, 1997), the presence of POF simultaneous to oocytes in vitellogenesis stage characterises a female which is in the stage of spawning. The histological procedure was applied only to females for which visual classification was uncertain.

Biological data from 1995 to 1997 was obtained from the Sentinel Survey data collected by the Department of Fisheries and Ocean, St. John's, Newfoundland. The fish collected for analysis were not always randomly chosen but selected according to a stratified length sampling strategy. Two fishing strategies were applied: one where the fishermen had to fish repeatedly in the same location (these locations where called fixed locations), and the other where they could fish in any randomly chosen site, mostly selected from their own knowledge of where the fish were located (these locations were called free locations).

2.2. Data analysis

For each date, the difference between proportions of spawning females obtained through histological procedures versus proportions of spawning females obtained through visual procedures, with their 95% confidence intervals, was calculated. This difference was then compared among sites and dates, using a two-way ANOVA (General Linear Model), using SAS software (SAS Institute Inc., 1996). A tolerance for type I error as a criterion of significance was set at 5% ($\alpha = 0.05$). The assumptions for the use of the p-value from the F-distribution were then checked. If the homogeneity, normality and independence of the residuals were not met, (eg.) the sample size was small ($n<30$) and the p-value was near α, an acceptable p-value from an empirical distribution of F-statistic was computed using randomization methods, instead of the F-distribution.

From the temperatures of the water column collected at each site and each date, only those from 10 meters off the ocean bottom were selected, as cod are known to be ground fish, and therefore, would be exposed to these temperature ranges. From each 10m water temperatures, an average temperature was then calculated. Finally, a two-way ANOVA was applied to compare the average temperature variability among sites and dates, with the same α criterion and p-value accuracy procedures used previously. To enable correct degrees of freedom in the two-way weighted ANOVA, temperatures were grouped together by month. Temperature data from 1995 to 1997 was obtained from the Department of Fisheries in Ocean, St. John's, NF. This data was added to my 1998-1999 temperature data and the total was divided in temperatures of three different zones (West, North, and East part of the head of the bay) (Fig.2.2). Only water column temperature from all casts ranging between maximum depths of 50 meters and casts from maximum depths of 30m were selected. Again, an average temperature from within 10 meters of the ocean bottom was calculated.

The relative abundance of cod in each maturity stage was compared between sites, dates and sexes, using a General Linear Model through a 3-way weighted ANOVA. Weighted ANOVAs were used unstead of simple ANOVAs when the sample sizes in fish numbers among dates were very different from each others. A criterion of significance was also set at 5% and the same procedure as previously used was applied to check the accuracy of the p-value.

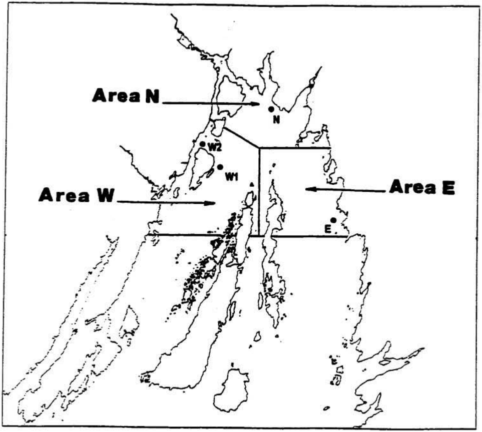


Fig. 2.2. Three areas of northern Placentia Bay, chosen to regroup temperature data collected during the years 1995 to 1997.

The condition of each fish was expressed using Fulton's condition factor ($(W/L^3)*100$); where W is gutted weight (kg) and L is standard length (cm). The Gonado Somatic Index based on standard length (GSI) was expressed using the same formula but with the weight of the gonad (kg) instead of the gutted weight (deVlaming *et al.* 1982, Cayre and Laloe 1986). For each date, an average Fulton's condition factor and GSI were calculated with their corresponding 95% confidence intervals. A three-way weighted ANOVA ($\alpha = 0.05$) was used to access the degree of significance for the differences of Fulton's condition factor and GSI among sites, dates and sexes.

Length of cod were classified into 12 groups: ≤ 50 cm; 51-55cm; 56-60cm; 61-65cm; 66-70cm; 71-75cm; 76-80cm; 81-85cm; 86-90cm; 91-95cm; 96-100cm; ≥ 101cm. These intervals were chosen as a compromise between detail (more intervals lead to more detail) and practicality of avoiding intervals with zero values (more intervals lead to more cases of zero frequency). The size of the interval is also set by the precision of measurement. The proportion of fish obtained in each group among sites, dates and sexes was analysed using a four-way ANOVA ($\alpha = 0.05$) and a three-way ANOVA ($\alpha=0.05$). A similar analysis was applied on the ages of cod.

Fishing effort and Catch Per Unit Effort (CPUE) were calculated for each fleet of nets as follow:

Effort = Nets/SST (net-hours per 12 hours)

CPUE = CN/Effort (kg or number of fish /net)/(net-hours per 12 hours)

With:

Catch = number or weight of fish caught for each fleet of nets.

Nets = number of nets set in each fleet of nets.

ST = soak time =hours of soak time for each fleet of nets.

SST = standardised soak time = ST/12 hours.

CN = Catch/nets (kg or number of fish/net).

From all CPUE and Effort obtained per fleet of nets each day, an average CPUE and Effort was calculated.

Finally, graphs showing the relation between CPUE of free and fixed fishing locations were discussed to report the pattern of systematic deviation from 1:1 relation.

Chapter 3. Maturity Stage Accuracy through Histological Procedures

3.1. Maturity Identification Methods

Tracking the reproductive cycle of any fish involves a determination of its gonad maturation stage. Indeed, during the reproductive cycle, the fish's gonad follows a pattern of stages which are, for most of them, distinctive through macro visual observation (Immature, Maturing, Spawning, Spent). However, some of those stages are less distinctive, and the mixing of fish coming from different areas renders the assessment of the temporal limit between two reproduction cycles difficult. To increase the precision of visual methods, maturity stage classes have been added to enable the classification of each fish into one or the other of two consecutive reproduction cycles. An example of such a classification table, which is used in the Newfoundland DFO region, is shown in Appendix B. Such visual classification is not always simple, and often requires an experienced, trained observer.

Most of the studies involving maturity stage determination of fish have the goal of determining the fish's spawning period. Since cod are batch spawners (McEvoy and McEvoy, 1992), their spawning period can extend over a long time. A spawning cod could be visually misclassified in the maturing category. Indeed, for females, the gonad could have the external characteristics of a maturing gonad (Plate 3.1) but in fact, be in the inter-batch stage where a certain number of eggs have already been released. Visual misclassification can therefore take place

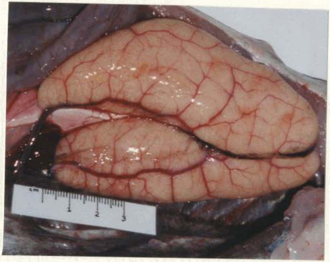


Plate 3.1. Sample of female cod gonad in maturing or inter-batch stage.

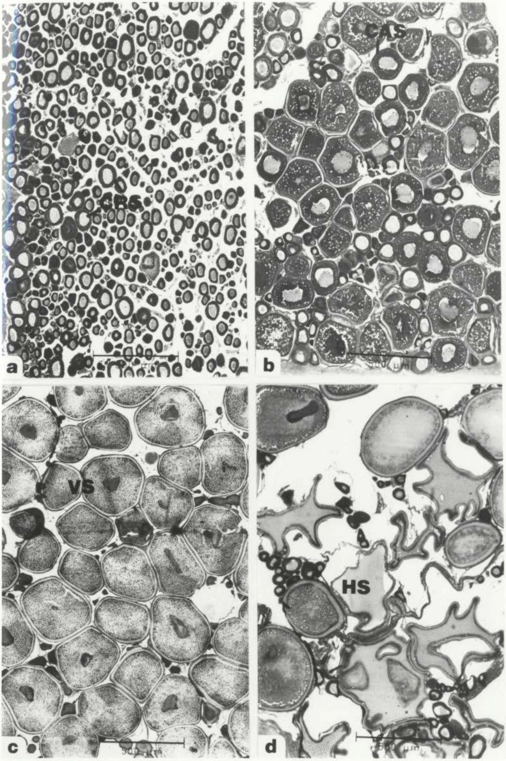
when determining the spawning time or percentage of spawning fish of a cod stock. Such misclassification can have important management implications if for example, opening and closing fisheries is dependent on spawning periods. Nevertheless, visual procedures used to classify the fish into maturity stages are not the only methods available to researchers. Histological methods could be used to enhance the accuracy of results.

3.2. Histological Information

In the process of determining the maturity stage of fish gonads, histological procedures can be used as more accurate measures. For females, each ovary contains oöcytes whose developmental stage enables classification of the fish in each of the maturity categories. Sections of oöcytes, observed under the microscope show the following distinctive stages:

- Circumnuclear ring stage: characterises immature females, if there are no later stages present (Plate 3.2a).
- Cortical alveoli stage: present in females which will spawn the following year and which enabled their classification as maturing females (Plate 3.2b).
- Vitellogenesis stage: this is an intermediate stage between the cortical alveoli stage and the hydration stage. Such females were also classified as maturing females (Plate 3.2c).

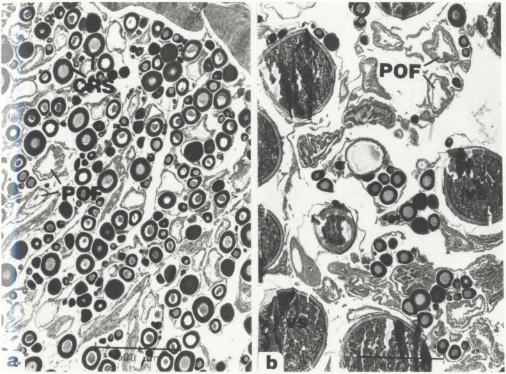
Plate 3.2. Microscopic views of oöcyte sections in different stages. **a**. Circumnuclear Ring Stage (CRS); **b**. Cortical Alveoli Stage (CAS); **c**. Vitellogenesis Stage (VS); **d**. Hydration Stage (HS).


CRS
a
CAS
500 μm
b
VS
500 μm
c
HS
d

- Hydration stage: presence of hydrated oöcytes. Such females were categorised as spawning, as cod eggs has been stated to be released within three days of hydration (Kjesbu, 1988a) (Plate 3.2d).
- Postovulatory follicles stage: these are the structures left in the ovary after maturation and oöcyte ovulation (Saborido-Rey, 1997). Ovaries sections containing only postovulatory follicles (POF) with circumnuclear ring stage oöcytes or cortical alveoli stage oöcytes, were characteristic of spent females (Plate 3.3a). However, the presence of POF simultaneous to oöcytes from the maturing categories characterised females which were in the spawning stage (inter-batch stage) (Plate 3.3b).

Several authors have noted that some fish may not spawn every year (Federov, 1971; Tyler and Dunn, 1976; Templeman *et al.*, 1978; Burton and Idler, 1984). It was suggested that such fish would either miss spawning due to the effect of adverse environmental factors on the concluding stages of the development of gametes (atresia), or extend their sexual cycle for several years, or finally, be in a stage of senescence. Woodhead and Woodhead (1965) reported that numbers of atretic eggs rarely formed more than one percent of ripening eggs in the ovary, and did not affect spawning. During my study in Placentia Bay, the presence of post-mature, non-reproductive fish were rarely observed and were not taken into account in the results.

Plate 3.3. Microscopic views of oöcyte sections in different stages. **a**. Postovulatory Follicles (POF) stage; **b**. Inter-batch stage.


CRS
POF
a
POF
VS
VS
b

3.3 Visual Versus Histological Maturity Identification Results and Discussion.

3.3.1 Results

The comparison of females' spawning percentages obtained through visual and histological procedures for the four sites is presented in Fig. 3.1. and data are shown in Appendix C. The percentage of spawning females obtained through histological procedures (PSFH) was never less than the percentage of spawning females obtained through visual procedures (PSFV). The two-way ANOVA applied on the differences in percentage of spawning females obtained through the two methods showed that this percentage difference is not significantly different among the four sites but is significantly different between dates (Table 3.1). As the residuals were homogeneous, normal and independent the p-values for the F-distribution were reliable. As no significant difference existed among sites, the data for the four sites were grouped together (Fig. 3.2 and 3.3). These resulting graphs show that the difference between PSFH and PSFV is at its highest from the end of April to the end of May for the year 1998. The largest difference between the two percentages was of 29.7% and the minimum was of 1.7%. In 1999, the difference between PSFH and PSFV appears to happen sooner than in 1998.

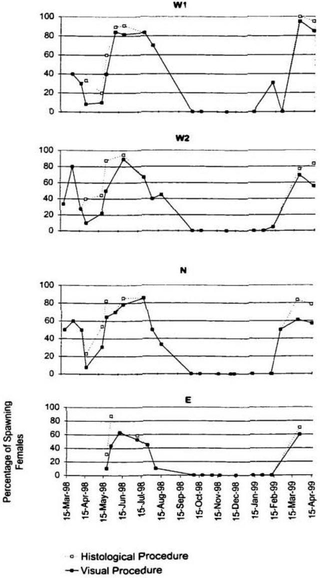


Fig.3.1. Comparison of spawning female percentages obtained through visual and histological procedures for the four sites during 1998-1999. See text for details.

Table 3.1. Results of the spawning female percentage differences between and visual histological procedure among sites and dates (ANOVA, GLM).

Y= Spawning female percentage differences between histological and visual procedure

X= Site and Date

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SITE	3	86.0547	28.6849	0.43	0.7326
DATE	12	4775.3045	397.9420	5.98	0.0001
SITE*DATE	30	722.8572	24.0952	0.36	0.9957
Error	25	1663.6269	66.5451		
Corrected Total	70	7314.8507			

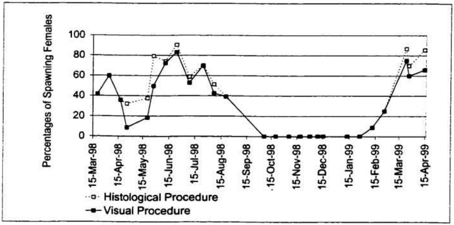


Fig.3.2. Comparison of spawning female percentages obtained through visual and histological procedures for the four sites during 1998-1999.

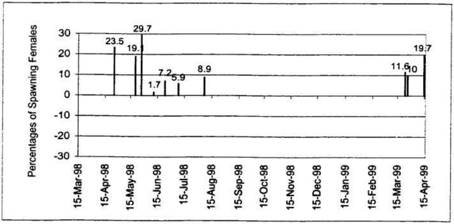


Fig. 3.3. Percentage difference between the spawning females obtained through histological procedure and the spawning females obtained through visual procedures for the four sites during 1998-1999.

3.3.2. Discussion

The difference between PSFH and PSFV was highest from the end of April to the end of May. This represents the later stages of the female's annual spawning time, which seems to go from mid-March to the end of August 1998 (see chapter 4). This early stage in the spawning period corresponds to the first release of eggs, but also to the time when most of the eggs present have not yet been hydrated and released. An ovary containing mostly maturing oöcytes and which batches of hydrated eggs have already been released, would have an external appearance of a "maturing" stage gonad. Such females are in the "inter-batch" stage.

In 1999, the difference between PSFH and PSFV appeared sooner than in 1998. This suggests that the spawning period started earlier in 1999 than in 1998. The histological procedure increased the accuracy of the visual procedure by a maximum of 29%. However, this percentage has to be taken with caution due to the relative experience of the observer. Furthermore, it corresponds only to one sampling season. Further identical samples drawn from future spawning seasons would improve the accuracy of the conclusions. Nevertheless, it can be stated that applying only gross visual procedures to spawning stage determination of cod underestimates the quantity of spawning fish at a particular date and therefore, underestimates the length of time of the peak spawning period.

Chapter 4. Cod Reproductive Cycle in Northern Placentia Bay in 1998-1999 Relative to Length, Age, Weight of Fish and Water Temperature

4.1 Variation Due to Sites, Dates, and Sexes

4.1.1 Water Temperature Results

The average temperatures of the water column, 10 meters off the ocean bottom, measured at the four sites over 1998-1999, are presented in Fig. 4.1 and Appendix D. Due to a mechanical defect of the Seabird, no measurements could be taken over the months of July to September. Even if the homogeneity of the residuals was not met (Fig. 4.2: Presence of cone shapes), the p-values were reliable as the sample size was large (n=50) (Table 4.1) (Crawley, 1993). The results indicated a significant difference in temperatures between dates but not between sites. The data collected in each site were therefore grouped together (Fig. 4.3). During the spring of 1998, temperatures were close to zero with a few temperatures between –1 and 0°C. By the end of May, temperatures started to rise and the highest temperature (7°C) was observed in the second half of October. Temperatures then declined over the winter months. In 1999, however, the lowest temperatures were not observed going below 0°C, and the warming of the water began earlier (March), compared to 1998 (May).

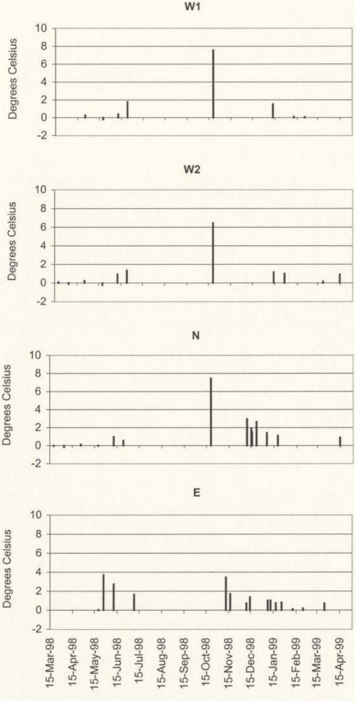


Fig. 4.1. Average (bottom 10 meters) temperatures measured at the four sites during 1998-1999.

Table. 4.1. Results of the average (bottom 10 meters) water temperatures variability among sites and dates (ANOVA, GLM).

Y= Average bottom 10 meters temperatures X= Site and date

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SITE	3	2.49077	0.83026	1.55	0.2322
DATE	11	132.68518	12.06229	22.46	0.0001
SITE*DATE	15	10.06282	0.67085	1.25	0.3129
Error	21	11.27989	0.53714		
Corrected Total	50	154.59555			

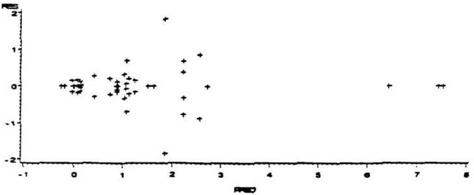


Fig.4.2. Residuals versus predicted values for a two-way Anova applied on the temperatures among sites and dates during 1998-1999.

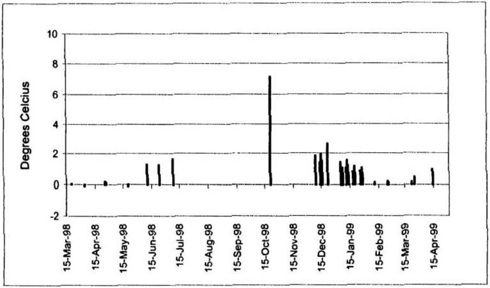


Fig.4.3. Average (bottom 10 meters) temperatures in northern Placentia Bay over 1998-1999.

4.1.2. Maturity Stages Results

The proportions of maturity stages of female and male cod sampled in the four sites are shown in Fig. 4.4 to 4.7. The detailed data is presented in Appendix E. A description of the spawning times is summarised in Table 4.2, with emphasis on the beginning and end time of the presence of spawning fish (date of the first and last appearance of spawning fish), and also on the peak spawning period (dates when more than 50% of the fish were spawning). In 1998, sampling started in the third week of March for two of the four sites, and by this time, spawning females were already present. Fish in the "spent" stage in March could be spent from the previous year and may skip spawning in the current year. It is not known what percentage of fish skip spawning in any particular year. However, sampling experience suggests that the numbers are low (Pers.Comm. DFO Commercial Sampling Section), and for this reason their presence would not have major consequences on the results of maturity stage proportions. It is not known if spawning cod were already present at site E before the 15th of May, as no samples were taken prior to this date. However, when comparing with the other 3 sites where spawning fish appeared in the second half of March, it is very probable that spawning cod in site E were present before mid May. The peak spawning period for females was observed over approximately 2 ½ months, with little variation between sites. In contrast to the females, males had a shorter peak spawning period, spread over 1½ months and which started, for the earliest, one month later (mid June) than the females' peak spawning time (mid May). The males' peak

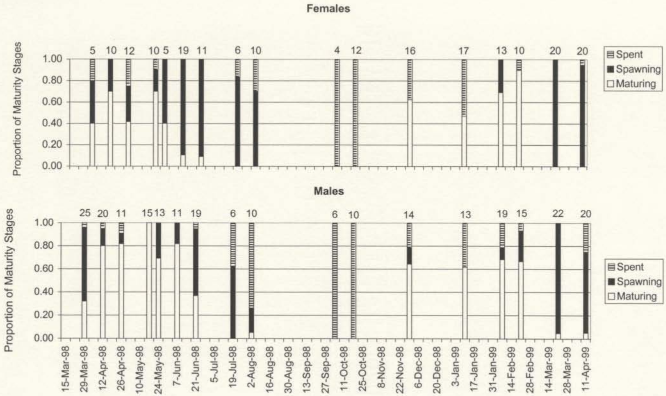


Fig. 4.4. Maturity stages of cod sampled at site W1 during 1998 -1999. The number on top of each bar represent the sample size.

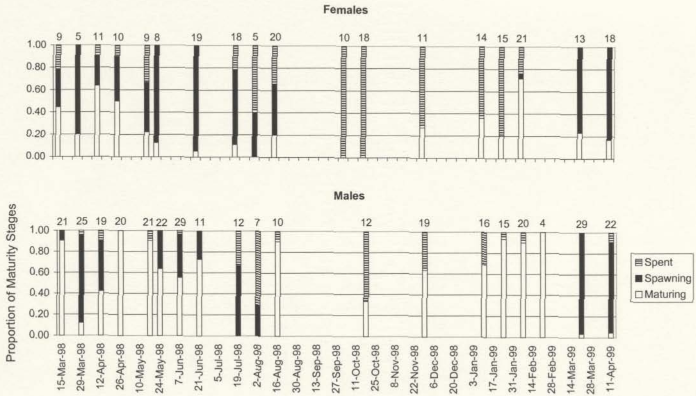


Fig. 4.5. Maturity stages of cod sampled at site W2 during 1998 -1999. The numbers on top of each bar represent the sample size.

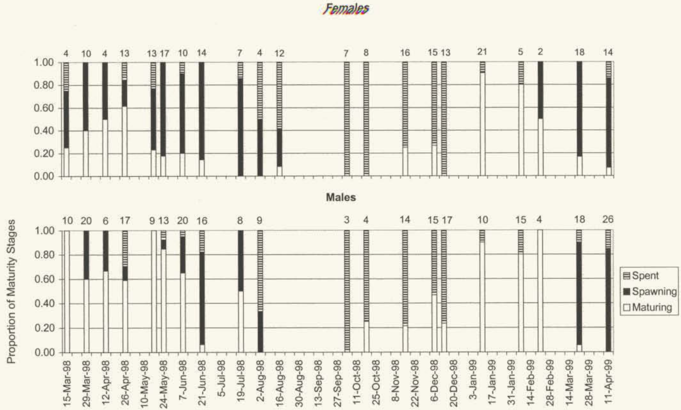


Fig. 4.6. Maturity stages of cod sampled at site N during 1998 -1999. The number on top of each bar represent the sample size.

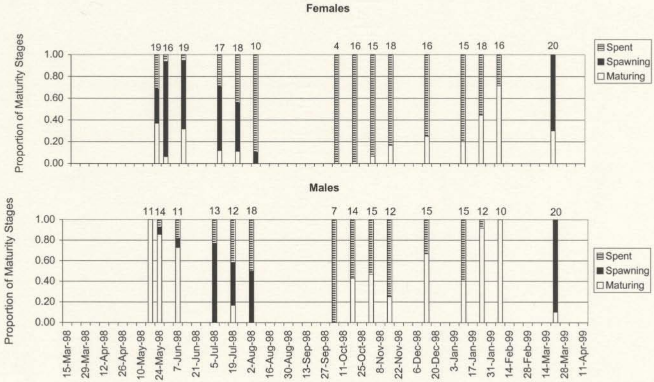


Fig. 4.7. Maturity stages of cod sampled at site E during 1998 -1999. The number on top of each bar represent the sample size.

Table 4.2. Spawning times at the four sites during 1998 and 1999.

		Female		Male	
		1998	1999	1998	1999
W1	Begin Presence of Spawning Fish	Mid Mar.	Begin Feb.	Mid Mar.	Begin Mar.
	Spawning Peak or Begin of Spawning Peak	End May to end Jul.	Mid Mar.	July	Mid Mar.
	End Presence of Spawning Fish	End Aug.		Mid Aug.	
W2	Begin Presence of Spawning Fish	End Mar.	Begin Feb.	End Mar.	Begin Feb.
	Spawning Peak or Begin of Spawning Peak	End May to begin Aug.	Mid Mar.	Mid Jun. to end Jul.	Mid Mar.
	End Presence of Spawning Fish	Mid Aug.		Mid. Aug.	
N	Begin Presence of Spawning Fish	Mid Mar.	Mid Feb.	End Mar.	Begin Mar.
	Spawning Peak or Begin of Spawning Peak	End May to begin Aug.	Mid Mar.	Mid Jun. to mid Jul.	Mid Mar.
	End Presence of Spawning Fish	Mid Aug.		Begin Aug.	
E	Begin Presence of Spawning Fish	Mid May	Begin Mar.	End May	Begin Mar.
	Spawning Peak or Begin of Spawning Peak	End May to mid Jul.	Mid Mar.	End Jun. to begin Aug.	Mid Mar.
	End Presence of Spawning Fish	Begin Aug.		Mid Aug.	

spawning time variability between sites seemed also more pronounced. Finally, spawning fish were observed until the end of August, with only a two week difference among the four sites. In 1999, spawning fish were observed as early as the beginning of February. However, spawning fish appeared a little later in site E, compared to the other three sites. A consistency in the timing of the beginning of the peak spawning period was observed among sites and sexes. All these observations suggest that there is little variation for spawning times between the four sampling sites. To test this hypothesis, a 3-way weighted ANOVA was applied to the maturity stage proportions. The results of this analysis are presented in Table 4.3. The proportions of ripening, spawning and spent female and male cod was not significantly different between the four sites but was significantly different between dates. For maturing and spent fish, the residuals were not homogeneous (Fig.4.8, 4.9), but the p-values from the F-distribution were reliable as the sample size was large (n=146). The female and male data for the four sites, representing the maturity stage timing of the cod sampled in the entire head of the bay are shown in Fig.4.10. The timing of spawning is summarised in Table 4.4. In 1999, the females' peak spawning time started 2 months earlier than in 1998. However, 1998 was distinctive with an early, short peak spawning period at the end of March, followed by a longer peak spawning time from the end of May to the end of July. Males showed also the same pattern for 1998, but their second peak spawning period spread only over 1½ months (from the second half of June

Table 4.3. Results of maturing (a), spawning (b), and spent (c) stage proportions variability among sites, dates, and sexes (weighted ANOVA, GLM) over 1998-1999.

(a) Y= Maturing stage proportions X= Sites, dates, and sex

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SITE	3	0.0803972	0.0267991	0.49	0.6873
DATE	12	7.0371015	0.5864251	10.81	0.0001
SEX	1	0.9747552	0.9747552	17.97	0.0001
SITE*DATE	31	1.5096205	0.0486974	0.90	0.6225
DATE*SEX	12	1.0629497	0.0885791	1.63	0.0978
SITE*SEX	3	0.1075837	0.0358612	0.66	0.5782
Error	84	4.556028	0.054238		
Corrected Total	146	16.354671			

(b) Y= Spawning stage proportions X= Site, date and sex

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SITE	3	0.109781	0.036594	1.06	0.3692
DATE	12	10.132411	0.844368	24.54	0.0001
SEX	1	0.297175	0.297175	8.64	0.0043
SITE*DATE	31	0.505085	0.016293	0.47	0.9894
DATE*SEX	12	0.996354	0.083029	2.41	0.0975
SITE*SEX	3	0.044298	0.014766	0.43	0.7327
Error	84	2.890841	0.034415		
Corrected Total	146	16.139333			

(c) Y= Spent stage proportions X= Dates, sites, and sex.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SITE	3	0.220535	0.073512	2.41	0.0725
DATE	12	10.550722	0.879227	28.84	0.0001
SEX	1	0.195505	0.195505	6.41	0.0132
SITE*DATE	31	1.313354	0.042366	1.39	0.1201
DATE*SEX	12	0.443723	0.036977	1.21	0.2880
SITE*SEX	3	0.235653	0.078551	2.58	0.0592
Error	84	2.560635	0.030484		
Corrected Total	146	17.468372			

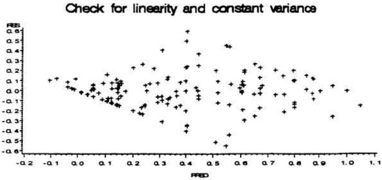


Fig. 4.8.Residuals versus predicted values for a three-way weighted Anova applied on the proportion of spent fish among sites, dates, and sexes.

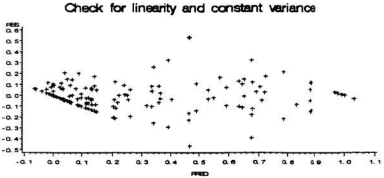


Fig. 4.9. Residuals versus predicted values for a three-way weighted Anova applied on the proportion of maturing fish among sites, dates, and sexes.

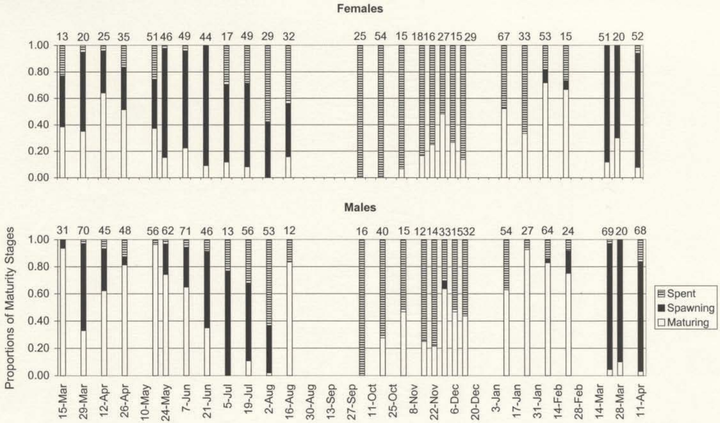


Fig. 4.10. Maturity stages of cod sampled in the head of Placentia Bay during 1998-1999. The number on top of each bar represent the sample size

Table 4.4. Spawning times for the head of Placentia Bay over 1998-1999.

	Female		Male	
	1998	1999	1998	1999
Begin presence of spawning fish	Mid Mar.	Begin Feb.	Mid Mar.	Begin Feb.
Spawning peak or begin of spawning peak	End Mar. and end May to end Jul.	Mid Mar.	End Mar. and end of Jun. to end of Jul.	Mid Mar.
End presence of spawning fish	Mid Aug.		Mid Aug.	

to the end of July). Their peak spawning time occurred also two months earlier in 1999 compared to 1998.

4.1.3 Length, Age, and Weights Results

The number of female and male cod of different lengths, sampled at the four sites are shown in Appendix F. A 4-way ANOVA applied to the length proportions showed no significant difference of length among sites and among sexes (respectively F=0.01, DF=3, n=1259, p=0.998 and F=0.01 DF=1, n=1501, p=0.937) and showed also no significant difference between dates (F=0.0, DF=12, n=1501, p=1.00). The p-values were reliable as the residuals were normal, homogeneous, and independent. The length data from male and female in the four sites was therefore pooled together (Fig.4.11). Most of the fish sampled, ranged between 55 and 85cm and the modal class was obtained for the 61 to 85 cm category. Large fish (more than 75 cm) were mostly present from March to April 1998 and in even higher percentages from January to April 1999.

In sites W1, N, and E, age 6 fish were the most abundant (Appendix G), unlike in site W2, where 7 year old fish were the most frequently observed. A consistency among sexes in each site seemed also to be the case: the most frequent age for males and females was 6 at site W1, N, and E. The most frequent age for males and females was 7 at site W2. Again, a statistical test was applied to the age proportions. The results show that the age proportions were not significantly different among sites and sexes (respectively F=0.00,3, n=1703,

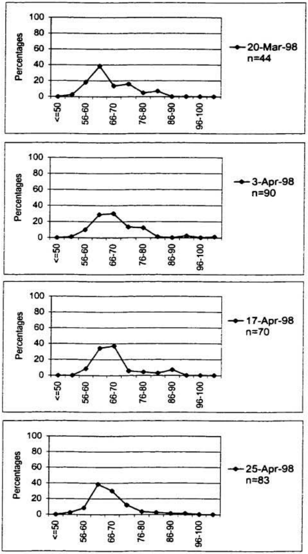


Fig. 4.11. Percentages of cod of different lengths sampled in the head of Placentia Bay in 1998-1999.

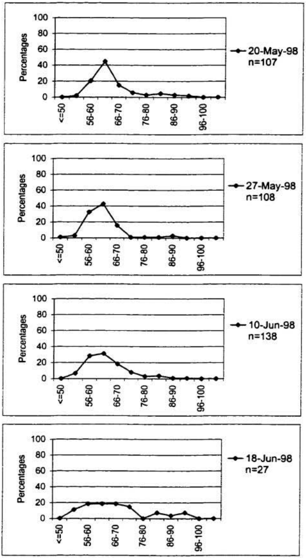


Fig. 4.11 (continued). Percentages of cod of different lengths sampled in the head of Placentia Bay in 1998-1999.

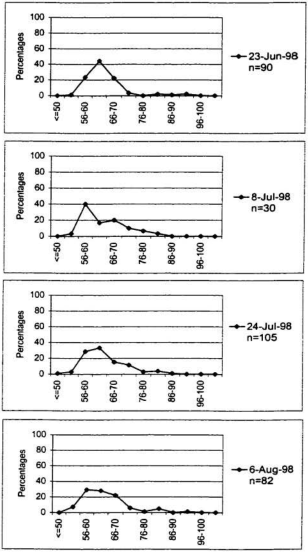


Fig. 4.11 (continued). Percentages of cod of different lengths sampled in the head of Placentia Bay in 1998-1999.

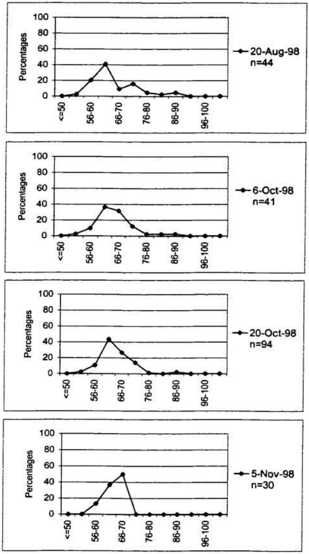


Fig. 4.11 (continued). Percentages of cod of different lengths sampled in the head of Placentia Bay in 1998-1999.

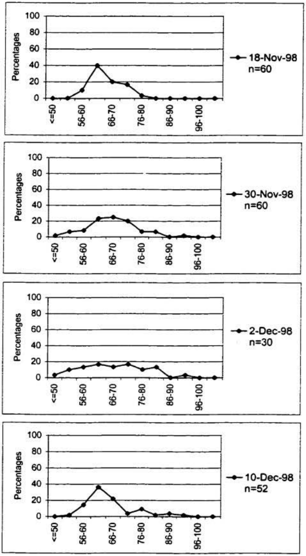


Fig. 4.11 (continued). Percentages of cod of different lengths sampled in the head of Placentia Bay in 1998-1999.

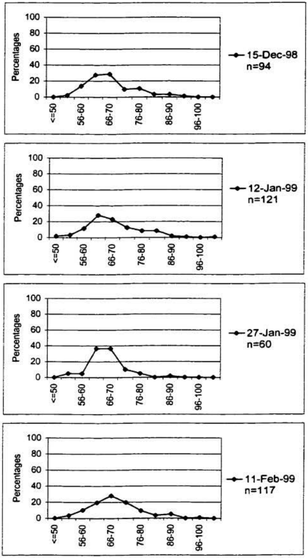


Fig. 4.11 (continued). Percentages of cod of different lengths sampled in the head of Placentia Bay in 1998-1999.

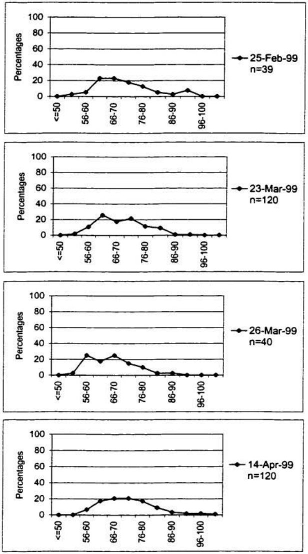


Fig. 4.11 (continued). Percentages of cod of different lengths sampled in the head of Placentia Bay in 1998-1999.

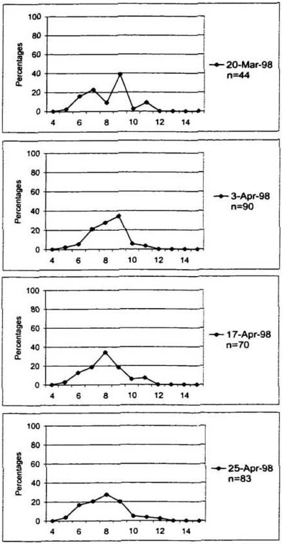


Fig. 4.12. Percentages of cod of different ages sampled in the head of Placentia Bay in 1998-1999.

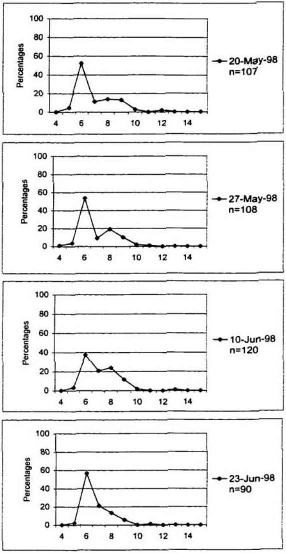


Fig. 4.12 (continued). Percentages of cod of different ages sampled in the head of Placentia Bay in 1998-1999.

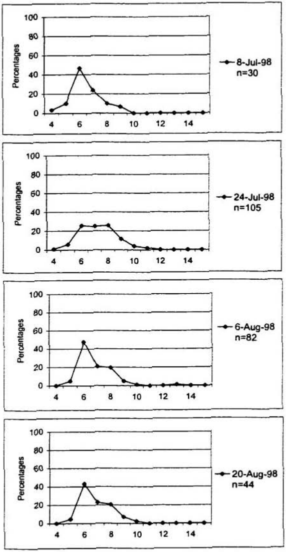


Fig. 4.12 (continued). Percentages of cod of different ages sampled in the head of Placentia Bay in 1998-1999.

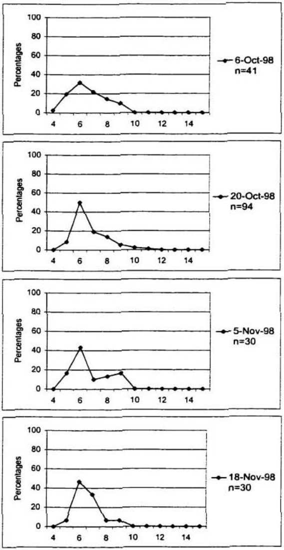


Fig. 4.12 (continued). Percentages of cod of different ages sampled in the head of Placentia Bay in 1998-1999.

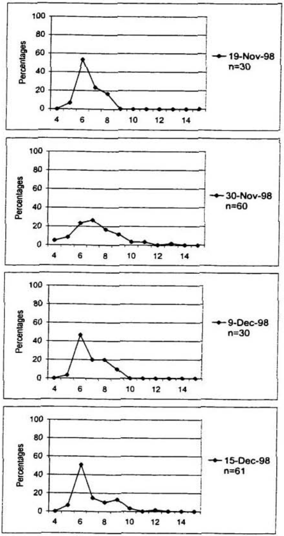


Fig. 4.12 (continued). Percentages of cod of different ages sampled in the head of Placentia Bay in 1998-1999.

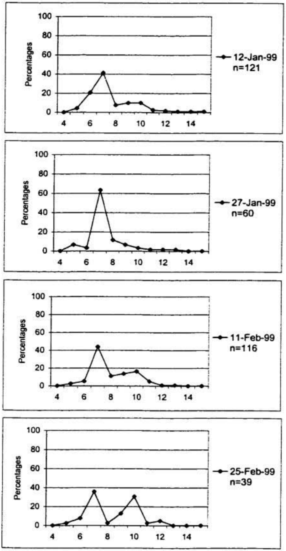


Fig. 4.12 (continued). Percentages of cod of different ages sampled in the head of Placentia Bay in 1998-1999.

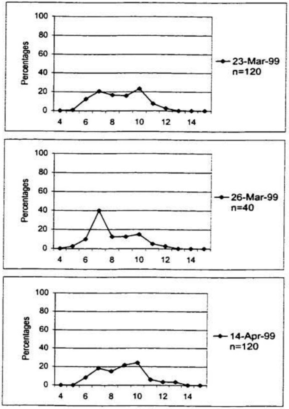


Fig. 4.12 (continued). Percentages of cod of different ages sampled in the head of Placentia Bay in 1998-1999.

p=1.00 and F=0.00,12, n=1703, p=0.999), with homogeneous, independent and normal residuals. Therefore, data between sexes and between sites were grouped together (Fig.4.12). Most of the sampled fish were between 5 and 10 years old, and the mode corresponded to 6-year-old fish. Old fish (more than 9 years old) were mostly present from March to April 1998 and in higher percentages from January to April 1999.

Average Fulton's condition factors with their 95% confidence intervals for the females and males collected in the four sites throughout 1998-1999 are presented in Fig. 4.13, 4.14 and Appendix H. Through a 3-way weighted ANOVA (Table 4.5), differences between condition factors were seen significantly different among dates but not among sites or sexes. The residuals being homogeneous, normal, and independent, the p-values of the F-distribution were reliable. Data were pooled and presented in one graph which represented the condition of cod for the entire head of the bay over 1998-1999 (Fig.4.15). During the months of April to mid-August 1998, the condition of the fish rose slightly between 0.7 and 0.8. Through the following months until the end of November, their condition increased to a value between 0.8 and 0.9. Finally, by the end of November, condition started to decline and reached a low value of 0.7 over the winter months 1998-1999.

Fig.4.16, 4.17, and Appendix I, show the average Gonado Somatic Indexes (GSI) with their 95% confidence intervals for the females and males collected in the four sites during 1998-1999. The graphs suggest that there is a

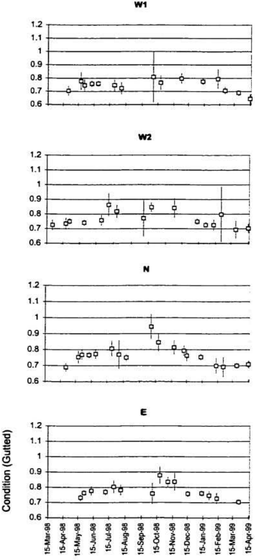


Fig. 4.13. Average Fulton's condition factor (gutted) for female cod sampled at the four sites during 1998-1999. Error bars are upper and lower 95% confidence intervals.

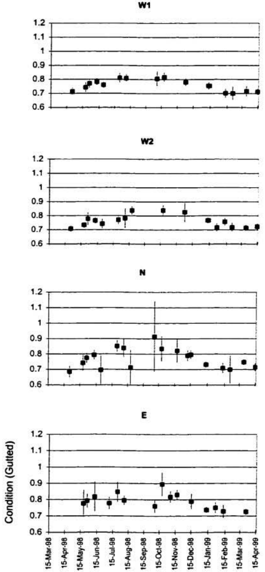


Fig. 4.14. Average Fulton's condition factor (gutted) for male cod sampled at the four sites during 1998-1999. Error bars are upper and lower 95% confidence intervals.

Table 4.5. Results of Fulton's condition factor variability among sites, dates, and sexes (weighted ANOVA, GLM).

Y= Fulton's condition factors X= Sites, dates, and sex

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SITE	3	0.0039176	0.0013059	1.25	0.2994
DATE	11	0.1890420	0.0171856	16.41	0.0001
SEX	1	0.0028005	0.0028005	2.67	0.1065
SITE*DATE	29	0.0406713	0.0014025	1.34	0.1615
DATE*SEX	11	0.0080611	0.0007328	0.70	0.7343
SITE*SEX	3	0.0009515	0.0003172	0.30	0.8232
Error	69	0.0722510	0.0010471		
Corrected Total	127	0.3395181			

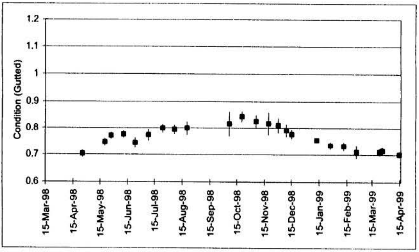


Fig. 4.15. Average Fulton's condition factor (gutted) for the cod sampled in the head of Placentia Bay during 1998-1999. Error bars are upper and lower 95% confidence intervals.

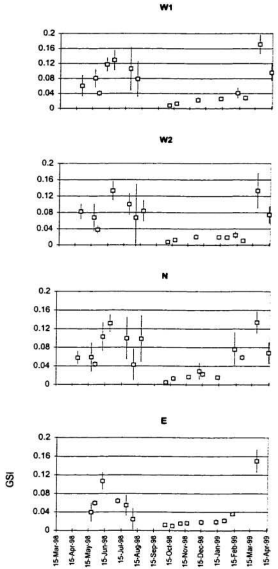


Fig. 4.16. Average Gonado Somatic Index (GSI) for female cod sampled at the four sites in 1998-1999. Error bars are upper and lower 95% confidence intervals.

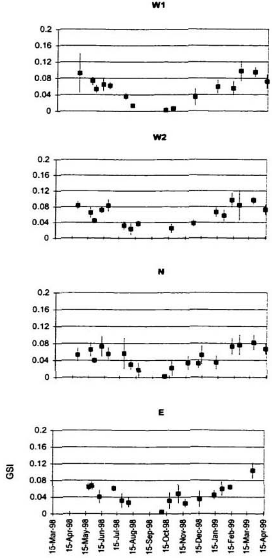
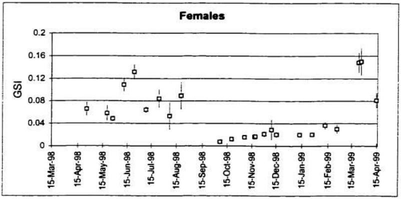


Fig. 4.17. Average Gonado Somatic Index (GSI) for male cod sampled at the four sites in 1998-1999. Error bars are upper and lower 95% confidence intervals.

difference of GSI among dates, sexes but not among sites. This was confirmed from a 3-way ANOVA (respectively F=44.68,11, n=127, p=0.0001; F=5.2,1, n=127, p=0.0256 and F= 2.66,3 n=127, p=0.0551), which p-values were reliable as the residuals were normal, independent, and homogeneous. Consequently, the GSI from each site were grouped together but kept distinctive among sexes (Fig. 4.18). By mid-May 1998, the GSI of both males and females decreased to a limit of 0.05. During the next 3 weeks, the female cod had their GSI multiplied by 3 (from 0.045 to 0.14) while males had their GSI only multiplied by 1.5 (from 0.04 to 0.07). By June, both sexes GSI declined until the end of August. However, for females, this decline was not regular, with small increasing peaks during the decline phase. In the second half of October 1998, the males' GSI was seen to rise again and reached a peak of 0.10 by the second half of March 1999. Contrary to this, females' GSI stayed low over most of the winter months and started to rise only at the start of February, and attained a peak of 0.15, also in the second half of March 1999. During the next 2 weeks, the GSI of both sexes decreased substantially.

4.2. Discussion

There were no significant differences between the four chosen sites for the biological and physical variables examined. These results imply that a consistent and regular sample of fish from only one site in the head of the bay would be representative of the cod's biology and of the temperature conditions in northern



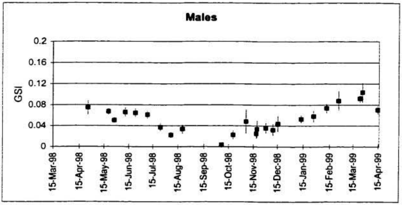


Fig. 4.18. Average Gonado Somatic Index (GSI) for the cod sampled in the head of Placen Bay in 1998-1999. Error bars are upper and lower 95% confidence intervals.

Placentia Bay. It appears that extensive movement and mixing of water resulted in similar temperature profiles throughout the head of the bay, and this could explain why there were no significant differences between sites.

From the maturity staging procedures, females' 1998 second peak spawning period extended from the end of May to the end of July. During this period, the GSI was seen to increase to reach its highest value at the end of June, and then decline. Hence, in the first half of this peak spawning period, most of the females' gonads were in the process of hydration and very few batches of eggs were yet released. Furthermore, the end of June seemed to represent the transition to an egg liberation phase, continuing until the end of August. The peak spawning period for males based on maturity staging procedures was found between the end of June to the end of July. This was confirmed by males' GSI decrease from mid-July to mid-August. Milt liberation was therefore precisely timed with the liberation of eggs. May and June 1998 were also seen to coincide with the start of rise in water temperature. Hence, liberation of females' gametes, followed by males' gametes seemed to be correlated to temperature. The irregularity in the decline of females' GSI between the end of June to the end of August could suggest the movement of females from different areas of origin and therefore with gonads in different stages of maturity. Maturing of male gonads seemed to take more time than for females', as the males' GSI increased regularly over the winter months, which was not the case for the females, who had their GSI commence increasing at the beginning of 1999. This was confirmed by the maturity staging procedures, which showed earlier maturation of a higher proportion of males compared to females.

Close to 0°C water temperatures in the beginning of 1999 did not seemed to stop the maturing of males' gonads. Temperatures started to rise in the second half of March 1999 and at the same time, GSI of females increased considerably, due to the presence of hydrated eggs in spawning females. The early increase in water temperatures in 1999 compared to 1998 could be the cause of the early spawning period observed in 1999. This confirms the previous hypothesis that the hydration and release of cod gametes is correlated to water temperature.

Cod condition was positively correlated with temperature, and negatively correlated with spawning. The temporal profile for cod condition matched that for temperature, while the temporal profile for spawning moved inversely with the temporal profile for condition. The influence of water temperature and high-energy use during the spawning season, on the condition of fish, is commonly cited in scientific literature (Chambers and Waiwood, 1996).

It was observed that most of the fish sampled were between 55 and 85 cm and between 5 and 10 years of age. This is related to the selectivity of the fishing gear (Gillnet 5.5-in mesh). Smaller fish would pass through the net without being caught while very large fish would be too big to pass through the mesh. In the range between 55 and 85 cm and 5 to 10 years, large fish were present from March to April 1998 and from January to April 1999. These times coincide with the first half of the spawning period and this could suggest that larger fish spawn earlier than small ones. However, without sampling smaller fish from the same area and time, this suggestion remains speculative.

Chapter 5. Cod Reproduction Cycle in Northern Placentia Bay over 1995-1999 in Relation to Length, Age, Weight of Fish and Water Temperature

5.1 Variation among Years

5.1.1 Water Temperature Results

The average temperatures of the water column in the 10 meters off the ocean bottom, measured in the three areas over 1995-1999 are presented in Fig. 5.1 to 5.3. Few data were collected during 1996 and 1997 due to the timing of the Sentinel Survey. For the temperatures obtained in each year, apart from the 1996 data which was too scarce to be used in a statistical test, a two-way ANOVA was applied on the temperatures among areas (Table 5.1). The results showed no significant differences between the three areas. The p-values were reliable as the residuals were homogeneous, normal and independent. The data for the three areas was then pooled (Fig. 5.4). The warming up of the water started by the second half of May in 1995 and 1997, in the second half of April for 1998, and already in the first half of April in 1999. Hence, if I exclude the 1996 data for which no samples were collected during the spring-summer seasons, the warming up of the water occurred earlier from 1995 to 1999. This observation has been corroborated by inshore fishers (Davis, Pers. Comm.).

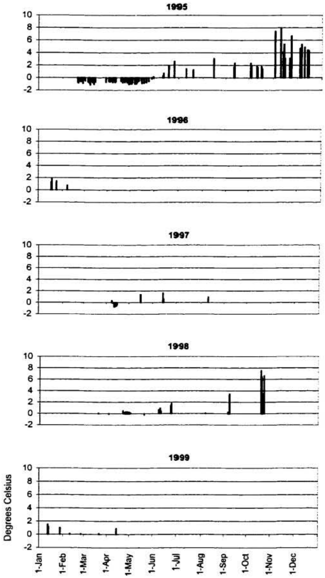


Fig. 5.1. Average bottom (10 meters) temperatures (degrees Celsius) measured at area W during 1995-1999.

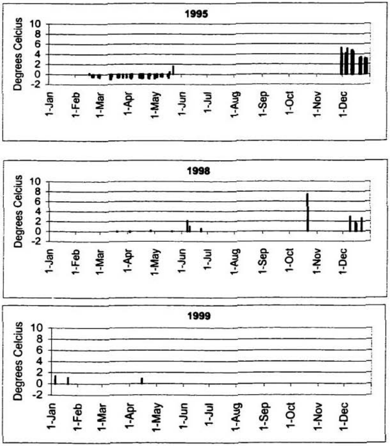


Fig. 5.2. Average Bottom 10 Meters Temperatures Measured at Area N During 1995-1999.

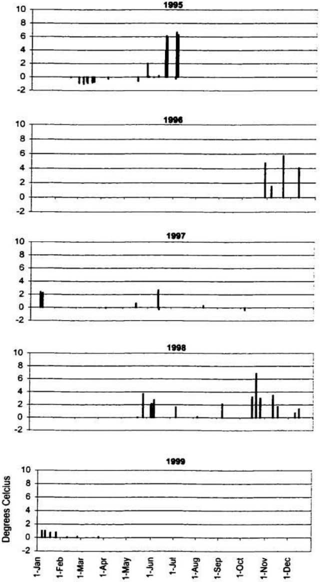


Fig. 5.3. Average bottom 10 meters temperatures measured at area E during 1995-1999.

Table 5.1. Results of the average bottom (10 meters) temperature variability among areas and dates (ANOVA, GLM), during the years 1995 to 1999.

Y= Average bottom 10 meters temperatures in 1995 X= Area and date

Source	DF	Type III SS	Mean Square	F Value	Pr > F
AREA	2	2.57307	1.28654	1.29	0.2787
DATE	10	606.20327	60.62033	60.82	0.0001
AREA*DATE	10	16.64572	1.66457	1.67	0.0951
Error	123	122.59195	0.99668		
Corrected Total	145	748.01402			

Y= Average bottom 10 meters temperatures in 1997 X= Area and date

Source	DF	Type III SS	Mean Square	F Value	Pr > F
AREA	2	0.0166243	0.0083121	0.01	0.9893
DATE	5	9.7771530	1.9554306	2.52	0.1079
AREA*DATE	3	0.3436270	0.1145423	0.15	0.9285
Error	9	6.977970	0.775330		
Corrected Total	19	22.084549			

Y= Average bottom 10 meters temperatures in 1998 X= Area and date

Source	DF	Type III SS	Mean Square	F Value	Pr > F
AREA	2	0.97456	0.48728	0.41	0.6659
DATE	9	132.75228	14.75025	12.46	0.0001
AREA*DATE	9	17.68696	1.96522	1.66	0.137
Error	34	40.26100	1.18415		
Corrected Total	54	228.89216			

Y= Average bottom 10 meters temperatures in 1999 X= Area and date

Source	DF	Type III SS	Mean Square	F Value	Pr > F
AREA	2	0.0545690	0.0272845	0.87	0.4561
DATE	3	2.8136882	0.9378961	29.81	0.0001
AREA*DATE	3	0.1102552	0.0367517	1.17	0.3804
Error	8	0.2516647	0.0314581		
Corrected Total	16	3.8485752			

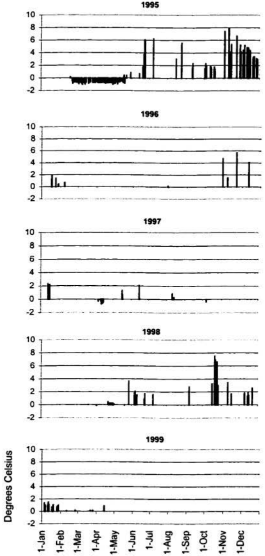


Fig. 5.4. Average bottom (10 meters) water temperatures (degrees Celsius) measured in the head of Placentia Bay during the years 1995 to 1999.

5.1.2. Maturity Stages Results

The proportions of maturity stages of female and male cod sampled in the head of the bay over the years 1995 to 1999 are shown in Fig. 5.5 and 5.6. Again, few data were collected during 1996-1997. The description of temporal spawning cycles over the years was applied separately on each sex: for females (Fig. 5.5), the first appearance of spawning fish was observed in the beginning of March in 1995, mid-February in 1996, mid-March in 1998 and mid-February in 1999. For 1995 and 1998, these dates should be viewed cautiously since no data were collected prior to them. Concerning the peak spawning times (dates when more of 50% of the fish were spawning), 1995 and 1998 were distinctive from the other years, with the presence of two peak spawning times: in the second half of March and mid-July for 1995, and in the beginning of April and May to July for 1998. The peak spawning period in 1996 seemed to have occurred prior to the month of July as most of the females were already spent by the 11th of July. The peak spawning season in 1999 occurred early: mid-March. The fall and winter months of all years were characterised by the presence of spent and maturing females.

For male cod (Fig. 5.6), spawning fish was also first observed in the beginning of March in 1995. Again, for 1995 and 1998, these times need to be viewed with caution as no sampling was done prior to these dates. In 1996 however, spawning males appeared two weeks earlier than spawning females. For the peak spawning times, 1995 and 1998 were distinctive by the presence of several peak spawning periods: second half of March, second half of May, and

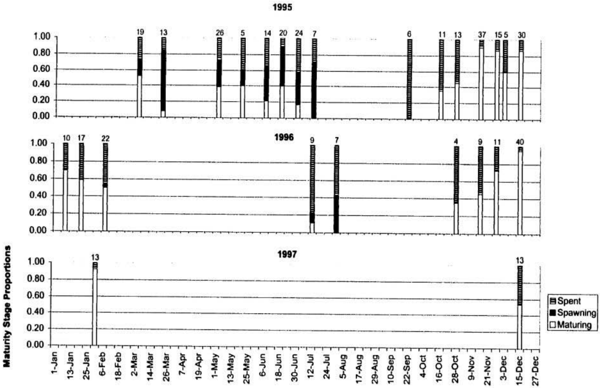


Fig. 5.5. Maturity stages of female cod sampled in the head of Placentia Bay during 1995-1999. The number on top of each bar represent the sample size.

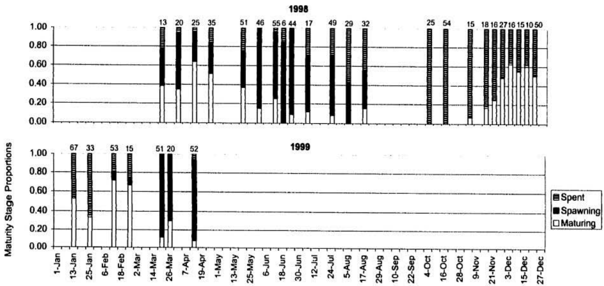


Fig. 5.5 (continued). Maturity stages of female cod sampled in the head of Placentia Bay during 1995-1999. The number on top of each bar represent the sample size.

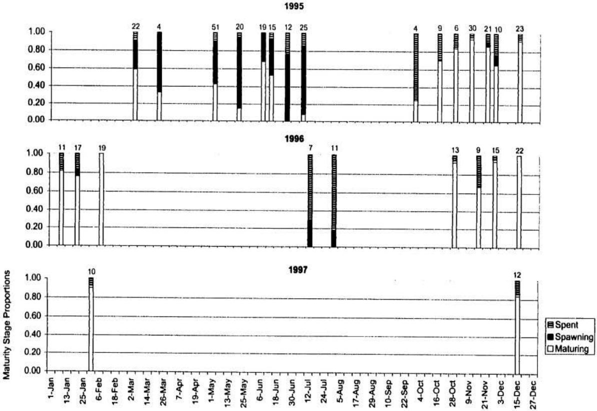


Fig. 5.6. Maturity stages of male cod sampled in the head of Placentia Bay during 1995-1999. The number on top of each bar represent the sample size.

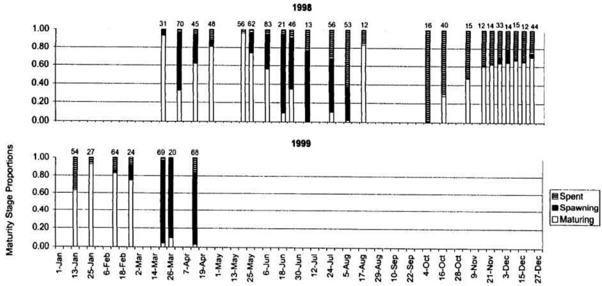


Fig. 5.6 (continued). Maturity stages of male cod sampled in the head of Placentia Bay during 1995-1999. The number on top of each bar represent the sample size.

June-July for 1995, and beginning of April and June-July for 1998. Male peak spawning time in 1996 seemed also to have taken place prior to July as most of the males were spent by this time. As for females, males from 1999 had also an early peak spawning time, but in contrast to females, fall and winter were not restricted to the presence of spent and maturing males. Indeed, few spawning males were also observed during those seasons.

5.1.3. Length, Age, and Weights Results

Percentages of cod of different lengths sampled in the years 1995 to 1999 are presented in Fig. 5.7 to 5.11. For all years, most of the sampled fish ranged between 55 and 85cm and most frequent fish lengths were obtained for the 61 to 70 cm category. In 1995 to 1997 large fish (more than 75 cm) were not restricted to the spawning season (spring-summer) but were also observed during fall and winter season.

For each year, most of the sampled fish were between 5 and 10 years old (Fig. 5.12 to 5.14 and Fig. 4.12). The mode was observed for 7 year old fish in 1995, 7 and 6 year old fish in 1996, 6 year old fish in 1998, and 8 year old fish in 1999. In 1995 to 1997 old fish (more than 9 year old) were not restricted to the spawning season (spring-summer) but were also observed during fall and winter season.

No significantly difference of Fulton's condition factor over time was observed between males and females (Fig. 5.15, 5.16). For all years, the condition

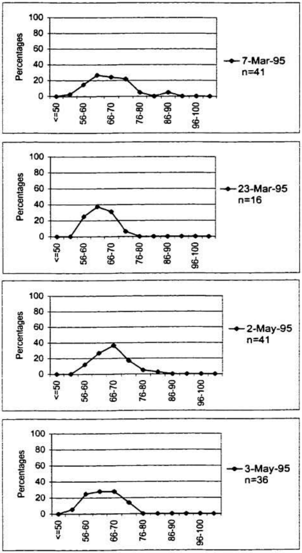


Fig. 5.7. Percentages of cod of different lengths sampled in the head of Placentia Bay in 1995.

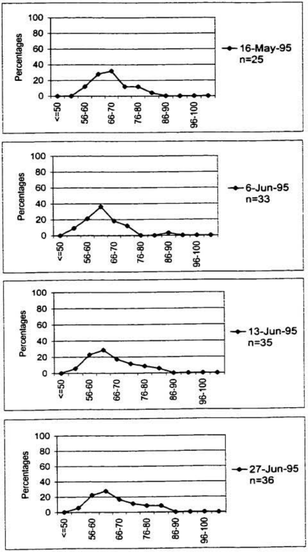


Fig. 5.7 (continued). Percentages of cod of different lengths sampled in the head of Placentia Bay in 1995.

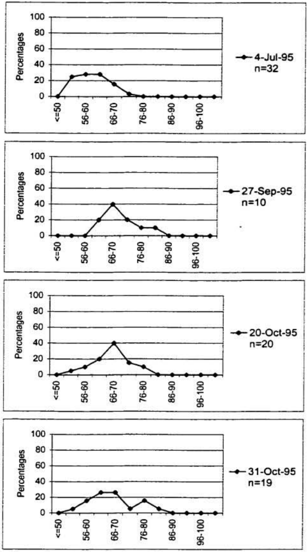


Fig. 5.7 (continued). Percentages of cod of different lengths sampled in the head of Placentia Bay in 1995.

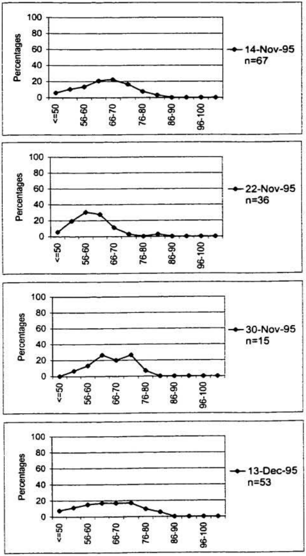


Fig. 5.7 (continued). Percentages of cod of different lengths sampled in the head of Placentia Bay in 1995.

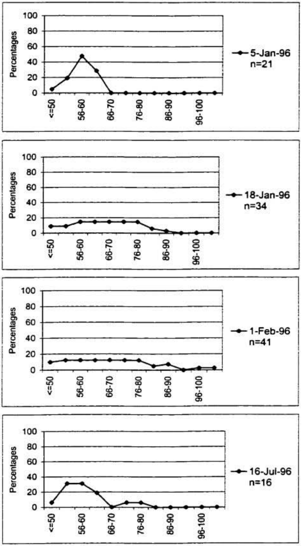


Fig. 5.8. Percentages of cod of different lengths sampled in the head of Placentia Bay in 1996.

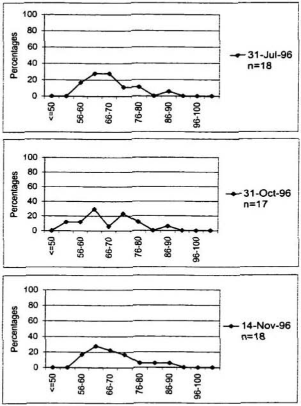
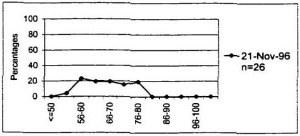


Fig. 5.8 (continued). Percentages of cod of different lengths sampled in the head of Placentia Bay in 1996.



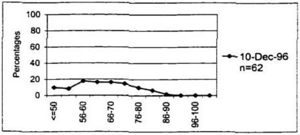


Fig. 5.8 (continued). Percentages of cod of different lengths sampled in the head of Placentia Bay in 1996.

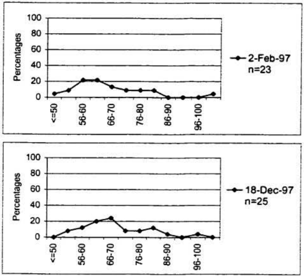


Fig. 5.9. Percentages of cod of different lengths sampled in the head of Placentia Bay in 1997.

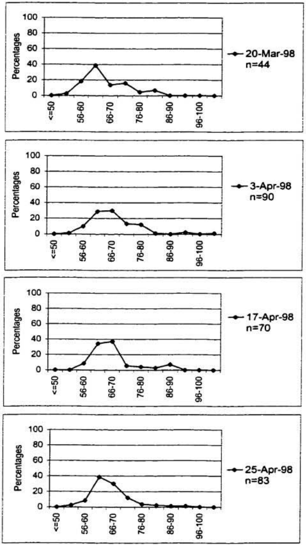


Fig. 5.10. Percentages of cod of different lengths sampled in the head of Placentia Bay in 1998.

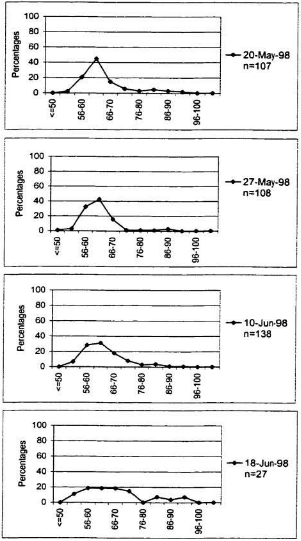


Fig. 5.10 (continued). Percentages of cod of different lengths sampled in the head of Placentia Bay in 1998.

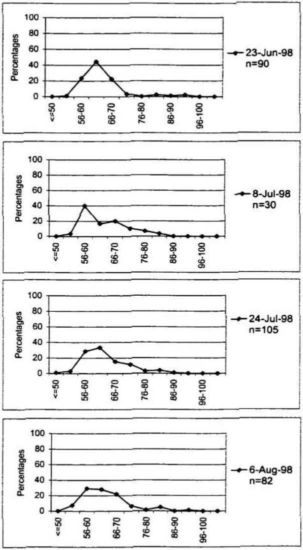


Fig. 5.10 (continued). Percentages of cod of different lengths sampled in the head of Placentia Bay in 1998.

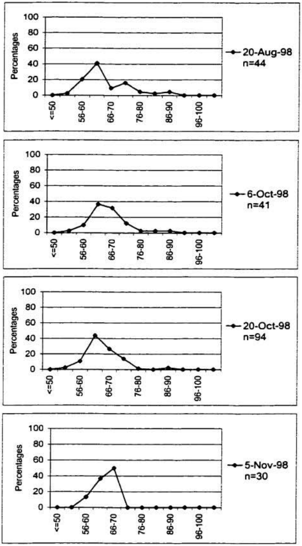


Fig. 5.10 (continued). Percentages of cod of different lengths sampled in the head of Placentia Bay in 1998.

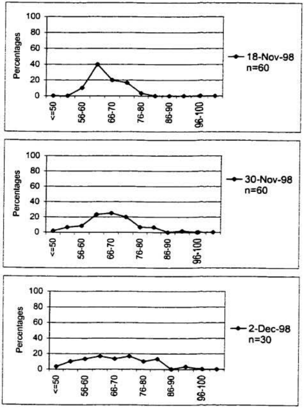


Fig. 5.10 (continued). Percentages of cod of different lengths sampled in the head of Placentia Bay in 1998.

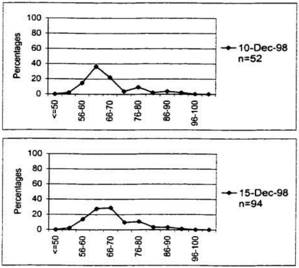
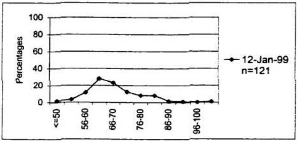
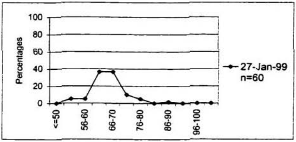


Fig. 5.10 (continued). Percentages of cod of different lengths sampled in the head of Placentia Bay in 1998.





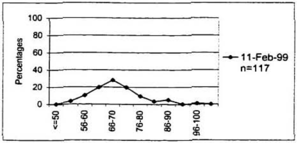


Fig. 5.11. Percentages of cod of different lengths sampled in the head of Placentia Bay in 1999.

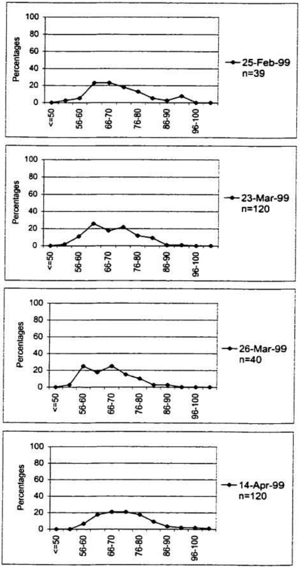


Fig. 5.11 (continued). Percentages of cod of different lengths sampled in the head of Placentia Bay in 1999.

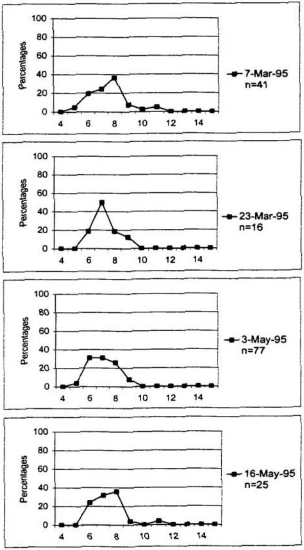


Fig. 5.12. Percentages of cod of different ages sampled in the head of Placentia Bay in 1995.

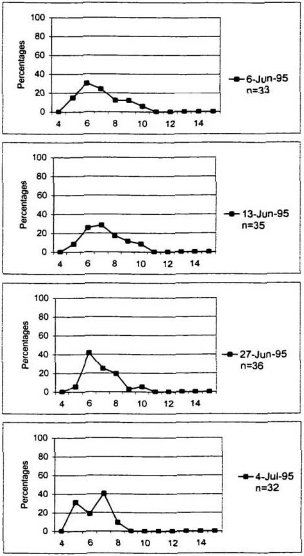


Fig. 5.12 (continued). Percentages of cod of different ages sampled in the head of Placentia Bay in 1995.

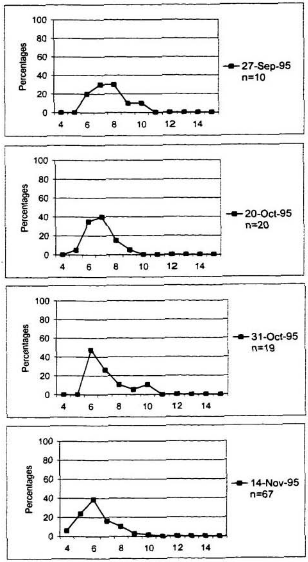


Fig. 5.12 (continued). Percentages of cod of different ages sampled in the head of Placentia Bay in 1995.

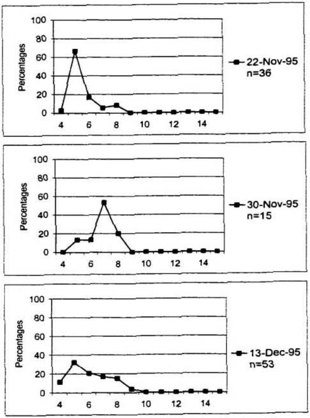


Fig. 5.12 (continued). Percentages of cod of different ages sampled in the head of Placentia Bay in 1995.

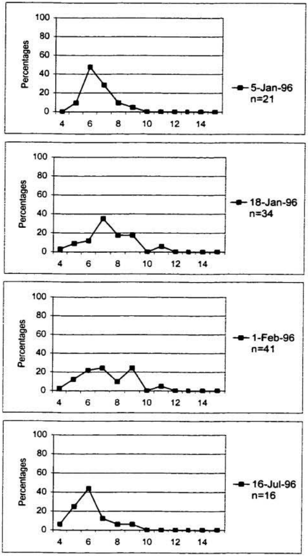


Fig. 5.13. Percentages of cod of different ages sampled in the head of Placentia Bay in 1996.

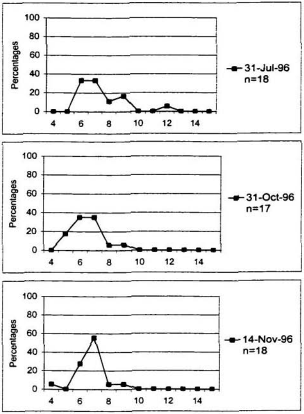
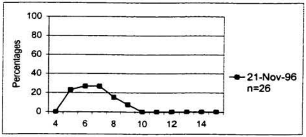


Fig. 5.13 (continued). Percentages of cod of different ages sampled in the head of Placentia Bay in 1996.



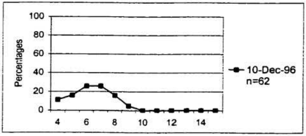


Fig. 5.13 (continued). Percentages of cod of different ages sampled in the head of Placentia Bay in 1996.

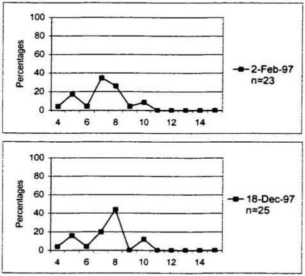


Fig. 5.14. Percentages of cod of different ages sampled in the head of Placentia Bay in 1997.

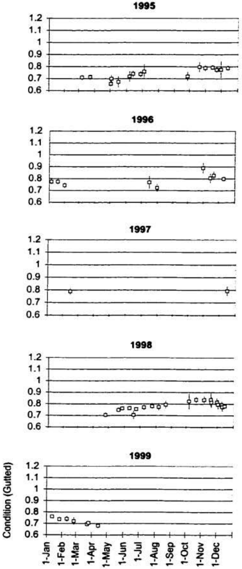


Fig. 5.15.Average Fulton's condition factor (gutted) for the female cod sampled in the head of the bay over 1995-1999. Error bar are upper and lower 95% confidence intervals.

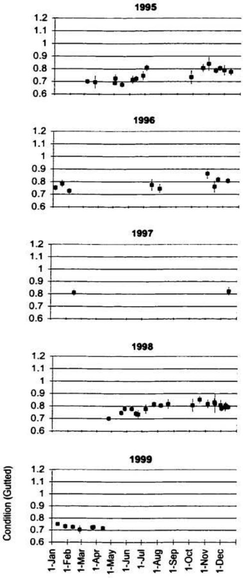


Fig. 5.16. Average Fulton's condition factor (gutted) for the male cod sampled in the head of bay over 1995-1999. Error bar are upper and lower 95% confidence intervals.

of cod ranged between 0.6 and 0.9. Condition was seen to decrease over the winter month, increase over the summer month, and attain high values over the fall season. Fish sampled in 1998 had a one month earlier increase in condition (beginning of May) than the fish sampled in 1995 (beginning of June). For the three years where sampling took place over the fall, the condition of fish was at its' highest values over October and in the beginning of November. In 1995, females had a lower condition than in 1996 and 1998.

Fig. 5.17, 5.18, show the average Gonado Somatic Indexes (GSI) with their 95% confidence intervals for the females and males collected in the head of the bay over 1995-1999. The distribution of the variables were symmetrical around the mean values computed. Therefore, the confidence limits were computed by using either a normal or t-distribution as appropriate, rather than via bootstrap methods. In 1995, females had two GSI peaks: one in the second half of March and the other during the month of June. In 1996, females showed a peak of GSI in early August, but this value was to consider carefully as its' confidence interval was large. The GSI peak for females in 1998 was observed by the end of June, while in 1999 it was observed as early as the end of March. For males, GSI were at their highest value in March, April 1995; May, June 1998; and March, April 1999. In contrast to females, males' GSI increased substantially over the winter months.

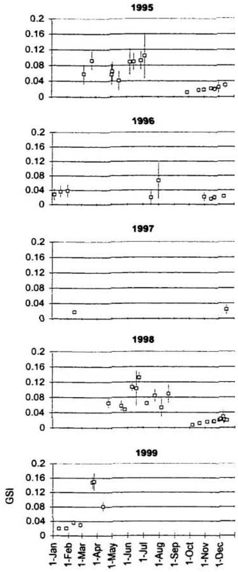


Fig. 5.17 Average Gonado Somatic Index (GSI) for female cod sampled in the head of the bay over the years 1995-1999. Error bars are upper and lower 95% confidence intervals.

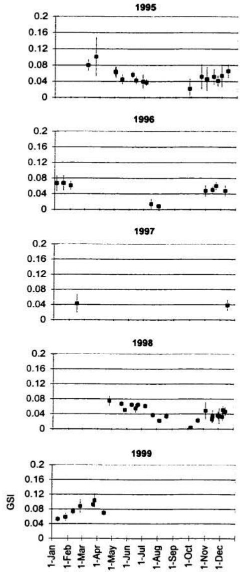


Fig. 5.18. Average Gonado Somatic Index (GSI) for male cod sampled in the head of the bay over the years 1995-1999. Error bars are upper and lower 95% confidence intervals.

5.2 Discussion

An increase in GSI would give an image of the maturation of the cod gonad. Maturation of male gonad seemed to happen earlier and over a longer period than females'. Indeed, GSI of females stayed low over the winter month, in contrast with males' GSI which were increasing significantly during these months. If the spawning times deducted from maturity staging procedures gave a broader image of the temporal spawning cycle, GSI, on the other hand, were giving a precise time of the liberation of gametes through the period of decrease which followed their peaks. GSI thus confirms visual maturity staging procedures, but they seem also more accurate in the timing of the liberation of gametes.

From the females' GSI and maturity staging results, the peak spawning time in 1995 occurred by the second half of June to the month of July. By this time the temperatures of the water were multiplied by three (2 to 6 Celcius degrees). In 1998 and 1999, the period of temperature increase coincided exactly with the peak spawning period. Hence, the liberation of female cod gametes seemed to be correlated with the water temperature. For males however, water temperatures did not seemed to be an essential factor for the liberation of milt. Indeed from both GSI and maturity staging graphs for all sampled years, the males were observed to have peak spawning periods during times when the water temperature was low. Temperature would therefore not be an important factor to the liberation of male cod gametes. Moreover, water temperatures at the end of the year were much higher in 1995, than in 1996 and 1998. From the maturity stage, these periods correspond to gonad maturation. The females' gonad maturation seemed to be affected by this temperature difference. Indeed, the proportion of maturing females was proportional to the level of temperature. This was very distinct in 1998, when GSI increase was related to low water temperatures. Again, males were observed to be less affected by the low temperatures than females. The maturation of male gonads took place with the same intensity even through the low temperatures of the late winter months.

The temporal profile of the cod condition was again seen proportional to the water temperature, and inversely proportional to spawning. This was the case in all five years (1995-1999). It supports the accepted notion that water temperature and high-energy use during the spawning season have a negative impact on the condition of fish (Chambers and Waiwood, 1996).

For all years, it was observed that most of the fish sampled were between 55 and 85 cm, and between 5 and 10 years old. This confirms the statement that the size and age of fish caught depend on the mesh size of the gillnet used. In this range of fish between 55 and 85 cm, and 5 to 10 years, the appearance of large fish was not restricted to the early spawning periods, for the samples taken from 1995 to 1997. This could be due to the fact that the samples collected by the Department of Fisheries and Ocean were not always randomly chosen, but were sometimes selected to have an equal proportion of fish from each length. It has been previously stated that the presence of large fish in the beginning of the spawning period in 1998 and 1999, could partly suggest an early spawning of large fish compared to small ones. During previous years (1995 to 1997), this hypothesis could not be supported as large fish were not restricted to early spawning periods.

Chapter 6. Comparison of Spawning Seasons to Catch Rates

6.1 Fishing Effort and CPUE Results over 1995-1999

In 1995, fishing effort was intense over the months from February to July and September to December (Fig. 6.1, 6.2). CPUE was highest from the end of October to the end of December and also a few over the months of May and June (Fig. 6.3, 6.4). For 1996, most of the fishing effort took place in January, November and December, while the relative CPUE was only high in November, and decreased over January and December. In 1997, a similar pattern was observed for both fishing effort and CPUE. Intense fishing effort took place over the months of May and June, but few fish were caught. CPUE over 1998-1999 was not only calculated from the number of fish caught, but from the weight of fish caught. For this reason, the results of CPUE calculated from weights are presented separately (Fig. 6.5). In 1998, the fishing effort was of medium intensity from March to October, and of less intensity over the winter months. However, CPUE was high over the winter months, beginning of April, and during the month of June. During 1999, the fishing effort was mostly applied from January to March, but CPUE was high only in the end of January.

Almost no difference was observed between the fishing effort conducted in the fixed locations and the fishing efforts conducted in the free locations. No significant differences were found among the average CPUE obtained through each fishing strategy (Table 6.1). The residuals were homogeneous, independent

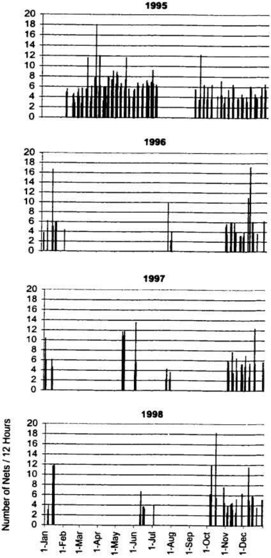


Fig. 6.1. Fishing effort in the head of Placentia Bay for fixed site locations during the years 1995-1998.

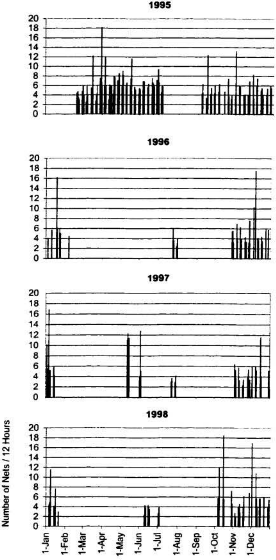


Fig. 6.2. Fishing effort in the head of Placentia Bay for free site locations during the years 1995-1998.

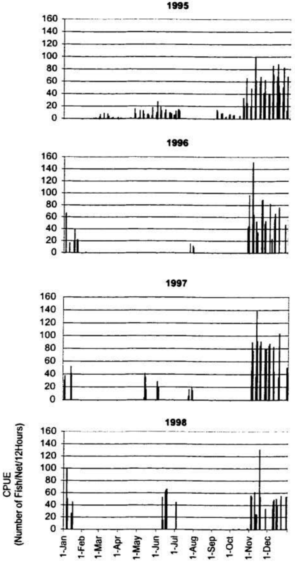


Fig.6.3 Catch Per Unit Effort (CPUE) in the head of Placentia Bay (obtained througl the number of fish caught) for fixed site locations during the years 1995-1998.

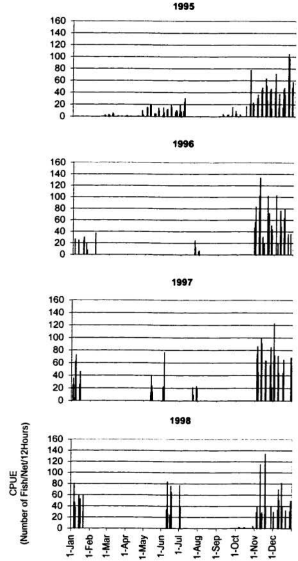


Fig. 6.4 Catch Per Unit Effort (CPUE) in the head of Placentia Bay (obtained throug the number of fish caught) for free site locations during the years 1995-1998.

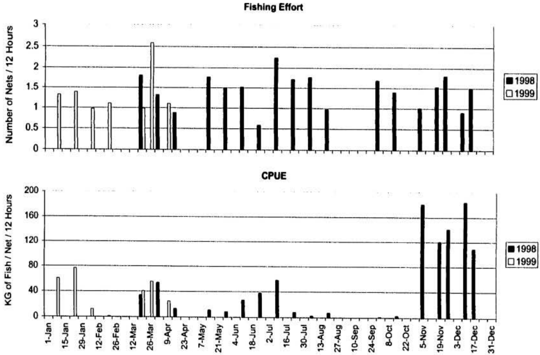


Fig. 6.5 Fishing effort and Catch Per Unit Effort (CPUE) (obtained through the weight of fish caught in gillnets 5$^{1/2}$ mesh), for the head of Placentia Bay, during 1998-1999, in fixed fishing locations.

Table 6.1. Results of average CPUE variability among the two different fishing strategies, and among dates (ANOVA, GLM), during 1995-1998.

Y= CPUE during 1995 X= Date and Fishing Method during 1995

Source	DF	Type III SS	Mean Square	F Value	Pr > F
METHOD	1	358.011	358.011	2.55	0.1113
DATE	9	92756.062	10306.229	73.49	0.0001
METHOD*DATE	9	2403.730	267.081	1.90	0.0516
Error	258	36180.556	140.235		
Corrected Total	277	130634.210			

Y= CPUE during 1996 X= Date and Fishing Method during 1996

Source	DF	Type III SS	Mean Square	F Value	Pr > F
METHOD	1	13.667	13.667	0.02	0.8938
DATE	5	25034.055	5006.811	6.58	0.0001
METHOD*DATE	5	1495.241	299.048	0.39	0.8517
Error	64	48673.872	760.529		
Corrected Total	75	74639.795			

Y= CPUE during 1997 X= Date and Fishing Method during 1997

Source	DF	Type III SS	Mean Square	F Value	Pr > F
METHOD	1	196.084	196.084	0.36	0.5478
DATE	5	45131.994	9026.399	16.74	0.0001
METHOD*DATE	5	2505.606	501.121	0.93	0.4653
Error	101	54457.928	539.187		
Corrected Total	112	104605.710			

Y= CPUE during 1998 X= Date and Fishing Method during 1998

Source	DF	Type III SS	Mean Square	F Value	Pr > F
METHOD	1	315.037	315.037	0.54	0.4654
DATE	5	20652.065	4130.413	7.04	0.0001
METHOD*DATE	5	552.411	110.482	0.19	0.966
Error	93	54532.953	586.376		
Corrected Total	104	76155.784			

and normal, therefore the p-values were reliable. Moreover, graphs showing the pattern between the CPUE obtained through the two fishing strategies were created to enable observation of extreme fluctuations in values. For all years, a general pattern was observed for the deviations from 1:1 relation between fixed and free CPUE (Fig. 6.6, 6.7). In 1995, the frequency of fishing containing less than 35 CPUE was much higher for free than fixed fishing procedures. However, catches over 35 CPUE were more frequent for fixed fishing locations. In 1996, catches below 30 CPUE were more abundant for the free fishing methods. Catches between 30 and 60 CPUE were equally frequent between the two fishing strategies, but CPUE over 60 were higher for fixed fishing locations. An identical pattern was observed in 1997. In 1998, CPUE below 25 were in much higher abundance through the free fishing strategy than CPUE obtained through the fixed fishing strategy. CPUE between 25 and 75 were equally distributed among the two fishing strategies. These results indicated that small to medium numbers of fish were mostly caught in free locations, while large numbers of fish were mostly caught in fixed locations.

6.2. Discussion

For all 5 years, cod CPUE was reported to be high over the winter months (November, December, January), and lower from May to July. Indeed, when fishing effort took place over the spring (March-April) and fall (September-October) seasons, few catches were reported during those periods

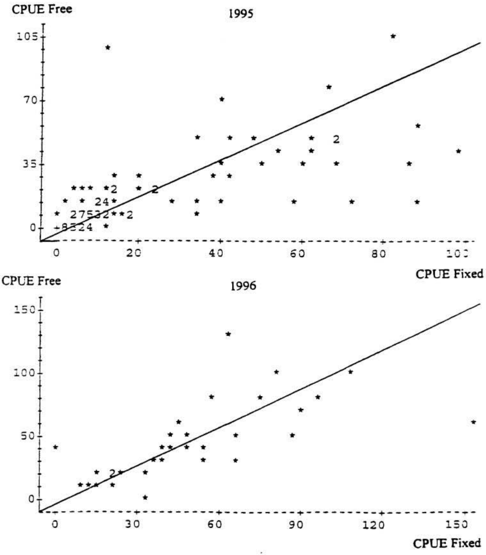


Fig. 6.6. Correlation between CPUE of free and fixed fishing locations over 1995-1997.

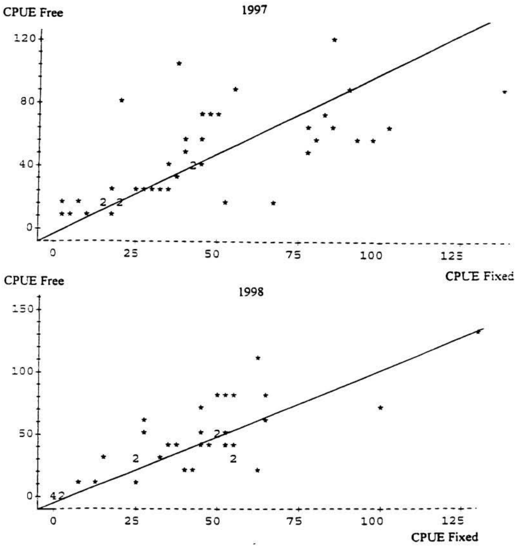


Fig. 6.7. Correlation between CPUE of free and fixed fishing locations over 1997-1998

The lack of fish caught in the nets could be due to the lack of movement of the fish or simply to the absence of fish.

No fish movement could be a consequence of low water temperature. In this case, the fish could be minimising movement during the period of cold temperatures and therefore, reducing energy loss. This could happen during the spring seasons, when the temperatures were observed to be at their lowest values. A second factor which could explain the absence of fish movement could be the feeding season. Indeed, cod are known to feed intensely on capelin over the summer (Lilly, 1987). In the fall, with prey species in reduced abundance, the cod may decrease their movement as an energy conservation strategy. Their condition would therefore increase significantly over this period, which was indeed observed. This would enable them to have high energy reserves available for the next spawning season. To sum up, if CPUE reflected the movement of the cod, the low water temperatures could explain the lack of movement during the spring; the few catches during the summer (June-July) could be the consequence of the movement due to the spawning season, and to the feeding season; and the reduced catch rate during the late summer and early fall period (August-September) could be due to the absence of movement during the post-feeding period.

Over the late fall (October) and early winter month (November, December), temperatures were found to be at their highest values, as were the CPUE. Compared to the summer (July to August), the movement of the fish seemed much higher during the winter months. No spawning was taking place over the winter months but the high catch rates could be due to the movement of cod associated with a return migration to their offshore over-wintering grounds.

In summary, CPUE obtained from gillnets could represent the degree of fish aggregation as well as its' movement. This suggests that cod would be mostly in motion and abundant in the head of the bay over the winter months.

The peak spawning periods in 1995, were found to be at the end of March and during the months of May to July. During these times, the CPUE was seen to increase but not to high values relative to the fall and winter period. This suggests that the cod were moving but their abundance in the bay may have been low. In 1998, peak spawning periods were observed in the beginning of April and over the months of May to July. Again, during those times, the CPUE was seen to increase but not to high values. This is consistent with the hypothesis that during those times, the cod were possibly moving but their overall abundance in the bay was low.

The positive correlation observed between "free" and "fixed" CPUE suggested a similarity of cod's CPUE variation among the different parts of the head of Placentia Bay. Moreover, fishermen seemed to catch low and medium numbers of fish by choosing the fishing location, and large numbers of fish when constrained to a constant fishing location. Therefore, free choice in fishing locations may not seem to increase the amount of fish caught.

Chapter 7. Summary and Conclusions

Accurate estimates of spawning periods have significant implications for fisheries managers. When stocks are at relatively low levels, management strategies which would enhance the rate of stock building would seem desirable. Science tools which therefore augment the information available to fisheries managers can only be beneficial in their decision making process. The work presented in this thesis included a year round analysis of sexual maturity and catch rates of cod in Placentia Bay. The results, which among other things, indicate at least bimodal peaks in annual spawning cycles, could be useful for managers in supporting decisions as to when fisheries should be opened and closed.

The application of a histological procedure enhanced the accuracy of classification of spawning stage in female cod by up to 29.7%. However, this high percentage should be viewed cautiously, due to the relative experience of the observer and to the fact that the experiment was conducted over two spawning seasons. Regardless, applying only visual procedures to spawning stage determination of cod would underestimate the quantity of spawning fish observed at a particular date and consequently, underestimate the duration of the peak spawning period.

In 1995, the cod in the head of Placentia Bay were found to have two peak spawning periods: a short, initial one at the end of March followed by a second, longer one in June-July. In 1996, because of a lack of data, the peak spawning time was presumed to have occurred prior to the month of July when data collection commenced. During 1998, two peak spawning times were again observed: a short one at the beginning of April and a longer one over June-July. In contrast with the previous years, 1999 was distinctive with a high intensity-spawning period in March and April. In general, spawning fish were present as early as March and as late as August. These spawning times observed during 1995-1999 were consistent with the findings of Neilsen (1895), and Fitzpatrick and Miller (1979) that spawning of cod in Placentia Bay took place during May, June, August and September. My results suggest that the annual spawning of cod in northern Placentia Bay is not restricted to one peak spawning period but can spread over at least two peak spawning periods of different length. Peak spawning time of males was observed to be shorter than the peak spawning time of females, but precisely timed with the liberation of females' eggs. The use of Gonado Somatic Indexes (GSI) was found to be a more precise method to determine the periods of gametes liberation.

The study partly confirmed Brander's (1993) and Kjesbu's (1994) suggestions, that water temperature was one of the principal factor associated with the variation of peak spawning times over years. Indeed, the females' gonad maturation over the winter months and periods of hydration and egg release were closely related to water temperature. However, it seemed that a difference existed between males and females: maturation of male gonads was less affected by low temperature than female gonads. Moreover, the warming-up of the water did not seem to be a primary factor to the liberation of milt. Kjesbu (1993) stated that the rate of gonad development is highly dependent on ambient water temperature, but did not make any distinction between sexes. Water temperature was also described to have an effect on the condition of cod. An unusual year of cold water temperatures could therefore have both a direct and indirect effect on the timing of the peak spawning period: a direct effect on the rate of gonad development and an indirect effect through the low energy available for spawning when the fish are in poor condition.

Hutchings and Myers (1993) observed that in Newfoundland and Labrador, younger cod start spawning earlier than older cod, which in turn complete spawning later in the season than younger ones. During this study in Placentia Bay, large fish appeared to spawn earlier than small ones. However, this finding must be treated with caution, as the study took place only over two seasons (1998-1999) and, the use of a constant relatively large size of mesh in the gillnets did not permit a random sample of all sizes of fish. Determining possible temporal spawning variability among large and small fish would require the use of a non-selective gear but also a more specific study comparing the beginning of spawning between large and small fish. Because of the selectivity of the gear used, my results did also not show any change in the age composition of the northern Placentia Bay cod among years, which could have played a role in the spawning time variability.

No significant differences were found for biological and physical variables collected in the four different fishing sites. This implies that a repeated study in the same area would only require regular samples from one site to be representative of the entire north of the bay. This result suggests also that if some cod migrate to Placentia Bay from different areas of origin or from different "stocks", this would have no major consequence on the spawning phenology of the Placentia Bay population.

Fishermen involved in the Sentinel program did not seem to catch more fish when selecting their fishing locations, as would be expected. Indeed, it would be logical to expect that by using their own knowledge of fishing areas, their catch rates would increase. It has been suggested that sentinel fishers were attempting in some cases to map the areal extent of aggregations of fish rather than maximising catch rates (Davis, Pers. Comm.). This hypothesis could be further studied by applying the same two fishing strategies during the commercial fishery.

The Catch Per Unit Effort (CPUE) values obtained from gillnets were thought to be able to give a representative image of the movement and relative abundance of fish. The cod were moving during the spawning and feeding periods (summer), but not over the spring and fall seasons. While the abundance of cod seemed to increase during the spawning period, the quantity of fish rose significantly over the winter months, probably due to the high water temperatures specific to fall months. The abundance of fish during the spawning period, compared to the winter months, seemed therefore not to be important. Hence, an intense fishery during the spawning period could have dramatic consequences on the annual recruitment of the stock. On the other hand, a fishery open during the winter months would enable economically viable catch rates while having less effect on the cod's recruitment. For the years analysed in this study, the latest peak spawning period lasted until the month of July. Unusual cold water temperatures over a long period could delay the peak spawning time possibly past the month of July. Closures to fishing between the months of March to July could have a positive impacts on the cod population growth in NAFO Subdivision 3Ps by allowing as much of the year's egg production as possible to enter the water.

Determining peak spawning times with accuracy would require the use of histological procedure in the determination of the maturity stage of cod. This would be greatly facilitated by applying it only to one sampling site (which would be representative of the entire head of the bay), and only to female cod (which are more reliable than males). Furthermore, improving studies which relate water temperature to spawning, and which analyse temporal spawning between small and large cod could, over long term, enable the prediction of spawning times.

In closing, this thesis provides new data on cod aggregations in Placentia Bay Newfoundland. This information provides improved analytical tools for resource assessment (increased precision in maturity studies), and new data on temperature impacts on the timing of spawning. This information can be applied to decision making by fisheries managers and possibly improve the overall management of the Subdivision 3Ps cod stock.

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Appendix A. Sample of fishermen's questionnaire form used to choose appropriate locations for the four sampling sites.

Fishermen Questionnaire

Goal: consistent sampling of Atlantic cod over one year (March 1998 to April 1999), in Northern Placentia Bay.

- Do you have some knowledge of the location of the spawning areas in Placentia Bay?
- Which months correspond to the beginning of the spawning season?
- Which months correspond to the end of the spawning season?
- Which months correspond to the peak spawning time?
- Are these times changing from year to year?
- If yes, is this difference important?
- In the last three years, what was the size of the spawning fish?
- Have you already seen some cod eggs in the water?
- If yes, when and where have you located them?
- Have you already seen some juveniles 0+?
- If yes, when and where have you encountered them?

Appendix B. Description of groundfish maturity stages used in the Newfoundland and Labrador regions.

Male	Female
Immature: Testes narrow and translucent, vasa deferentia very narrow and thin walled.	**Immature:** Ovary small, grey to pink in colour; membrane thin and translucent; eggs not visible to the naked eye.
Spent L: Vasa deferentia wide and opaque, sometimes with residual milt from spawning in previous year; outer edges of testes not pinkish or greyish as in maturing fish; spent in previous (L=last) year.	**Spent L:** Ovary thick-walled with no new eggs visible to the naked eye; spent in the previous (L-last) year.
Mat P: Testes relatively thick compared with immature, with outer edges pink or grey in early stage and white in later stage; early in the year some testes may show evidence of spawning in a previous year but the edges of the testes indicate recovery; maturing to spawn in present (P) year, i.e. year of capture.	**Mat A-P:** Eggs visible to naked eye in ovary itself; all eggs opaque; maturing to spawn in present year. **Mat B-P:** Opaque and clear eggs present with less than 50% of the volume being clear eggs; maturing to spawn in th present (P) year. **Mat C-P:** 50% or more of the volume are clear eggs; this stage also includes the ripe condition where the ovarian content is almost liquid with clear eggs; to spawn or spawning in the present (P) year.
Partly Spent P: Some milt extruded in present year, but residual milt in testes and vasa deferentia.	**Partly Spent P:** Ovary not full as in Mat C-P; some eggs extruded but many clear eggs remaining.
Spent P: Spawning completed in present year; recovery not sufficiently advanced for outer edges of testes to be pinkish or greyish in colour.	**Spent P:** Spawning completed in present year but possibly a few clear eggs remaining; no new opaque eggs visible to the naked eye.
Spent P Mat N. Spawning completed in present year; outer edges of testes pink or grey or even becoming white in preparation for spawning in the next (N) year; this stage becomes Mat P in January of the next year.	**Spent P Mat N:** Spawning completed in present year, and new opaque eggs, for spawning in the next (N) year, visible to the naked eye; this stage becomes Mat A-P in January of the next year. **Mat A-N:** No evidence of previous spawning; but new opaque eggs, for spawning in the next (N) year, visible to the naked eye; this stage becomes Mat A-P in January of the next year.
Mat N: Testes developing from immature stage for spawning in the next (N) year; testes becoming thick, being pinkor grey early in this stage and gradually whitening; this stage becomes Mat P in January of the next year.	

Appendix C. Detail of the number of female spawning stages obtained through histological and visual procedures for the four sites during 1998 and 1999.

			Histological procedures			Visual procedures		
Site	Date	N	Maturing	Spawning	Spent	Maturing	Spawning	Spent
W1	3-Apr-98	5	2	2	1	2	2	1
	17-Apr-98	10	7	3	0	7	3	0
	25-Apr-98	12	5	4	3	8	1	3
	20-May-98	10	7	2	1	8	1	1
	27-May-98	5	2	3	0	3	2	0
	10-Jun-98	19	2	17	0	3	16	0
	23-Jun-98	11	1	10	0	2	9	0
	24-Jul-98	6	0	5	1	0	5	1
	6-Aug-98	10	0	7	3	0	7	3
	6-Oct-98	4	0	0	4	0	0	4
	20-Oct-98	12	0	0	12	0	0	12
	30-Nov-98	16	10	0	6	10	0	6
	12-Jan-99	17	8	0	9	7	0	10
	11-Feb-99	13	9	4	0	9	4	0
	25-Feb-99	10	9	0	1	9	0	1
	23-Mar-99	20	0	20	0	1	19	0
	14-Apr-99	20	0	19	1	2	17	1
W2	20-Mar-98	9	4	3	2	4	3	2
	3-Apr-98	5	1	4	0	1	4	0
	17-Apr-98	11	7	3	1	7	3	1
	25-Apr-98	10	5	4	1	8	1	1
	20-May-98	9	2	4	3	4	2	3
	27-May-98	8	1	7	0	4	4	0
	23-Jun-98	19	1	18	0	2	17	0
	24-Jul-98	18	2	12	4	2	12	4
	6-Aug-98	5	0	2	3	0	2	3
	20-Aug-98	20	4	9	7	4	9	7
	6-Oct-98	10	0	0	10	0	0	10
	20-Oct-98	18	0	0	18	0	0	18
	30-Nov-98	11	3	0	8	3	0	8
	12-Jan-99	14	5	0	9	5	0	9
	27-Jan-99	15	3	0	12	3	0	12
	11-Feb-99	21	15	1	5	15	1	5
	23-Mar-99	13	3	10	0	4	9	0
	14-Apr-99	18	3	15	0	7	10	1

Appendix C (continued). Detail of the number of female spawning stages obtained through histological and visual procedures for the four sites during 1998 and 1999.

			Histological procedures			Visual procedures		
Site	Date	N	Maturing	Spawning	Spent	Maturing	Spawning	Spent
N	20-Mar-98	4	1	2	1	1	2	1
	3-Apr-98	10	4	6	0	4	6	0
	17-Apr-98	4	2	2	0	2	2	0
	25-Apr-98	13	8	3	2	10	1	2
	20-May-98	13	3	7	3	6	4	3
	27-May-98	17	3	14	0	6	11	0
	10-Jun-98	10	2	7	1	2	7	1
	23-Jun-98	14	2	12	0	3	11	0
	24-Jul-98	7	0	6	1	0	6	1
	6-Aug-98	4	0	2	2	0	2	2
	20-Aug-98	12	1	4	7	1	4	7
	6-Oct-98	7	0	0	7	0	0	7
	20-Oct-98	8	0	0	8	0	0	8
	19-Nov-98	16	4	0	12	4	0	12
	9-Dec-98	15	4	0	11	1	0	14
	15-Dec-98	13	0	0	13	0	0	13
	12-Jan-99	21	19	0	2	19	0	2
	11-Feb-99	5	4	0	1	4	0	1
	25-Feb-99	2	1	1	0	1	1	0
	23-Mar-99	18	3	15	0	7	11	0
	14-Apr-99	14	1	11	2	4	8	2
E	20-May-98	19	7	6	6	16	2	1
	27-May-98	16	1	14	1	8	7	1
	10-Jun-98	19	6	12	1	6	12	1
	8-Jul-98	17	2	10	5	3	9	5
	24-Jul-98	18	2	8	8	2	8	8
	6-Aug-98	10	0	1	9	0	1	9
	6-Oct-98	4	0	0	4	0	0	4
	20-Oct-98	16	0	0	16	0	0	16
	5-Nov-98	15	1	0	14	1	0	14
	18-Nov-98	18	3	0	15	3	0	15
	15-Dec-98	16	4	0	12	4	0	12
	12-Jan-99	15	3	0	12	3	0	12
	27-Jan-99	18	8	0	10	8	0	10
	11-Feb-99	14	10	0	4	10	0	4
	26-Mar-99	20	6	14	0	8	12	0

Appendix D. Temperatures in Celsius degrees obtained in the four sites during 1998-1999.

Site	Date	Temperatures
W1	3-Apr-98	0.003
	25-Apr-98	0.265
	20-May-98	-0.184
	10-Jun-98	0.404
	23-Jun-98	1.785
	21-Oct-98	7.549
	12-Jan-99	1.522
	10-Feb-99	0.117
	25-Feb-99	0.091
W2	20-Mar-98	0.097
	3-Apr-98	-0.101
	25-Apr-98	0.100
	25-Apr-98	0.246
	20-May-98	-0.242
	10-Jun-98	0.933
	23-Jun-98	1.346
	21-Oct-98	6.441
	13-Jan-99	1.148
	28-Jan-99	1.015
	22-Mar-99	0.158
	14-Apr-99	0.918

Site	Date	Temperatures
N	20-Mar-98	-0.015
	3-Apr-98	-0.174
	26-Apr-98	0.133
	20-May-98	0.015
	10-Jun-98	0.983
	23-Jun-98	0.552
	21-Oct-98	7.445
	9-Dec-98	2.940
	15-Dec-98	1.938
	16-Dec-98	1.491
	22-Dec-98	2.639
	5-Jan-99	1.410
	20-Jan-99	1.104
	14-Apr-99	0.893
E	20-May-98	0.039
	27-May-98	3.703
	10-Jun-98	2.739
	8-Jul-98	1.638
	11-Nov-98	3.461
	17-Nov-98	1.725
	9-Dec-98	0.734
	14-Dec-98	1.377
	7-Jan-99	1.022
	11-Jan-99	1.030
	18-Jan-99	0.748
	26-Jan-99	0.807
	10-Feb-99	0.112
	24-Feb-99	0.189
	25-Mar-99	0.715
	25-Mar-99	0.153

Appendix E. Detail of the proportion of fish in each maturity stage obtained in the four sites during 1998-1999.

		Females				Males			
Site	Date	N	Maturing	Spawning	Spent	N	Maturing	Spawning	Spent
W1	3-Apr-98	5	2	2	1	25	8	16	1
	17-Apr-98	10	7	3	0	20	16	3	1
	25-Apr-98	12	5	4	3	11	9	1	1
	20-May-98	10	7	2	1	15	15	0	0
	27-May-98	5	2	3	0	13	9	4	0
	10-Jun-98	19	2	17	0	11	9	2	0
	23-Jun-98	11	1	10	0	19	7	11	1
	24-Jul-98	6	0	5	1	24	0	15	9
	6-Aug-98	10	0	7	3	19	1	4	14
	6-Oct-98	4	0	0	4	6	0	0	6
	20-Oct-98	12	0	0	12	10	0	0	10
	30-Nov-98	16	10	0	6	14	9	2	3
	12-Jan-99	17	8	0	9	13	8	0	5
	11-Feb-99	13	9	4	0	19	13	2	4
	25-Feb-99	10	9	0	1	15	10	4	1
	23-Mar-99	20	0	20	0	22	1	21	0
	14-Apr-99	20	0	19	1	20	1	14	5
W2	20-Mar-98	9	4	3	2	21	19	2	0
	3-Apr-98	5	1	4	0	25	3	21	1
	17-Apr-98	11	7	3	1	19	8	9	2
	25-Apr-98	10	5	4	1	20	20	0	0
	20-May-98	9	2	4	3	21	19	0	2
	27-May-98	8	1	7	0	22	14	8	0
	10-Jun-98	1	1	0	0	29	16	12	1
	23-Jun-98	19	1	18	0	11	8	3	0
	24-Jul-98	18	2	12	4	12	0	8	4
	6-Aug-98	5	0	2	3	7	0	2	5
	20-Aug-98	20	4	9	7	10	9	0	1
	6-Oct-98	10	0	0	10	4	1	0	3
	20-Oct-98	18	0	0	18	12	4	0	8
	30-Nov-98	11	3	0	8	19	12	0	7
	12-Jan-99	14	5	0	9	16	11	0	5
	27-Jan-99	15	3	0	12	15	14	0	1
	11-Feb-99	21	15	1	5	20	18	0	2
	25-Feb-99	2	0	0	2	4	4	0	0
	23-Mar-99	13	3	10	0	29	1	28	0
	14-Apr-99	18	3	15	0	22	1	19	2

Appendix E (continued). Detail of the proportion of fish in each maturity stage obtained in the four sites during 1998-1999.

		Females				Males			
Site	Date	N	Maturing	Spawning	Spent	N	Maturing	Spawning	Spent
N	20-Mar-98	4	1	2	1	10	10	0	0
	3-Apr-98	10	4	6	0	20	12	8	0
	17-Apr-98	4	2	2	0	6	4	2	0
	25-Apr-98	13	8	3	2	17	10	2	5
	20-May-98	13	3	7	3	9	9	0	0
	27-May-98	17	3	14	0	13	11	1	1
	10-Jun-98	10	2	7	1	20	13	6	1
	23-Jun-98	14	2	12	0	16	1	12	3
	24-Jul-98	7	0	6	1	8	4	4	0
	6-Aug-98	4	0	2	2	9	0	3	6
	20-Aug-98	12	1	4	7	2	1	0	1
	6-Oct-98	7	0	0	7	3	0	0	3
	20-Oct-98	8	0	0	8	4	1	0	3
	19-Nov-98	16	4	0	12	14	3	0	11
	9-Dec-98	15	4	0	11	15	7	0	8
	15-Dec-98	13	0	0	13	17	4	0	13
	12-Jan-99	21	19	0	2	10	9	0	1
	11-Feb-99	5	4	0	1	15	12	0	3
	25-Feb-99	2	1	1	0	4	4	0	0
	23-Mar-99	18	3	15	0	18	1	15	2
	14-Apr-99	14	1	11	2	26	0	22	4
E	20-May-98	19	7	6	6	11	11	0	0
	27-May-98	16	1	14	1	14	12	1	1
	10-Jun-98	19	6	12	1	11	8	1	2
	8-Jul-98	17	2	10	5	13	0	10	3
	24-Jul-98	18	2	8	8	12	2	5	5
	6-Aug-98	10	0	1	9	18	0	9	9
	6-Oct-98	4	0	0	4	7	0	0	7
	20-Oct-98	16	0	0	16	14	6	0	8
	5-Nov-98	15	1	0	14	15	7	0	8
	18-Nov-98	18	3	0	15	12	3	0	9
	15-Dec-98	16	4	0	12	15	10	0	5
	12-Jan-99	15	3	0	12	15	6	0	9
	27-Jan-99	18	8	0	10	12	11	0	1
	11-Feb-99	14	10	0	4	10	10	0	0
	25-Feb-99	1	0	0	1	1	0	0	1
	26-Mar-99	20	6	14	0	20	2	18	0

Appendix F. Details of the number of fish per length groups collected in the four sites over 1998-1999.

				Group Length (cm)											
Site	Date	N	Sex	<= 50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	86-90	91-95	96-100	>=101
W1	3-Apr-98	5	F	0	1	0	2	1	0	0	0	0	0	0	1
	17-Apr-98	10	F	0	0	1	3	2	1	0	1	2	0	0	0
	25-Apr-98	12	F	0	1	0	4	4	2	1	0	0	0	0	0
	20-May-98	10	F	0	1	4	2	2	1	0	0	0	0	0	0
	27-May-98	5	F	0	0	3	2	0	0	0	0	0	0	0	0
	10-Jun-98	19	F	0	0	4	3	6	2	2	1	0	1	0	0
	23-Jun-98	11	F	0	1	3	3	2	1	0	1	0	0	0	0
	24-Jul-98	6	F	0	0	3	0	2	1	0	0	0	0	0	0
	6-Aug-98	10	F	0	1	1	3	3	2	0	0	0	0	0	0
	6-Oct-98	4	F	0	1	0	1	2	0	0	0	0	0	0	0
	20-Oct-98	12	F	0	0	1	7	1	2	1	0	0	0	0	0
	30-Nov-98	16	F	0	1	0	3	2	4	3	2	0	1	0	0
	12-Jan-99	17	F	0	0	0	3	5	2	2	4	1	0	0	0
	11-Feb-99	13	F	0	0	0	0	4	3	1	3	2	0	0	0
	25-Feb-99	10	F	0	0	0	1	4	3	1	0	0	1	0	0
	23-Mar-99	20	F	0	0	4	6	3	4	2	1	0	0	0	0
	14-Apr-99	20	F	0	0	1	3	4	5	2	2	2	0	0	1
	3-Apr-98	25	M	0	0	2	8	8	3	3	1	0	0	0	0
	17-Apr-98	20	M	0	0	3	10	4	2	0	0	1	0	0	0
	25-Apr-98	11	M	0	0	2	7	1	1	0	0	0	0	0	0
	20-May-98	15	M	0	1	1	9	1	1	0	1	1	0	0	0
	27-May-98	13	M	0	0	4	6	3	0	0	0	0	0	0	0
	10-Jun-98	11	M	0	0	4	6	0	0	0	1	0	0	0	0
	23-Jun-98	19	M	0	0	5	10	3	0	0	1	0	0	0	0
	24-Jul-98	24	M	0	0	5	10	3	4	0	1	1	0	0	0
	6-Aug-98	19	M	0	1	3	10	4	0	0	0	0	1	0	0
	6-Oct-98	6	M	0	0	0	3	0	2	1	0	0	0	0	0
	20-Oct-98	10	M	0	1	0	8	1	0	0	0	0	0	0	0
	30-Nov-98	14	M	1	2	4	2	2	1	0	2	0	0	0	0
	12-Jan-99	13	M	0	1	1	4	3	3	0	1	0	0	0	0
	11-Feb-99	19	M	0	0	1	5	2	3	5	1	2	0	0	0
	25-Feb-99	15	M	0	0	2	3	2	4	1	1	0	2	0	0
	23-Mar-99	22	M	0	0	1	6	3	9	2	1	0	0	0	0
	14-Apr-99	20	M	0	0	0	4	1	5	5	2	1	2	0	0

Appendix F(continued). Details of the number of fish per length groups collected in the four sites over 1998-1999.

Site	Date	N	Sex	Group Length (cm)											
				<= 50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	86-90	91-95	96-100	>=101
W2	20-Mar-98	9	F	0	0	2	2	1	1	1	2	0	0	0	0
	3-Apr-98	5	F	0	0	2	0	1	0	2	0	0	0	0	0
	17-Apr-98	11	F	0	0	1	3	5	0	1	1	0	0	0	0
	25-Apr-98	10	F	0	1	2	5	0	0	1	0	0	1	0	0
	20-May-98	9	F	0	0	0	2	1	1	3	1	0	1	0	0
	27-May-98	8	F	0	1	3	2	1	0	0	0	1	0	0	0
	23-Jun-98	19	F	0	0	4	10	4	0	0	0	1	0	0	0
	24-Jul-98	18	F	0	0	10	3	3	2	0	0	0	0	0	0
	6-Aug-98	5	F	0	0	2	2	1	0	0	0	0	0	0	0
	20-Aug-98	20	F	0	1	5	8	2	2	1	0	1	0	0	0
	6-Oct-98	10	F	0	0	2	4	3	1	0	0	0	0	0	0
	20-Oct-98	18	F	0	0	3	8	3	4	0	0	0	0	0	0
	30-Nov-98	11	F	0	0	0	5	3	3	0	0	0	0	0	0
	12-Jan-99	14	F	0	0	0	3	2	2	4	1	0	1	0	1
	27-Jan-99	15	F	0	0	0	9	5	1	0	0	0	0	0	0
	11-Feb-99	21	F	0	0	3	6	8	1	3	0	0	0	0	0
	23-Mar-99	13	F	0	1	1	0	4	1	2	4	0	0	0	0
	14-Apr-99	18	F	0	0	1	1	4	1	7	2	1	0	1	0
	20-Mar-98	21	M	0	1	2	8	4	4	1	1	0	0	0	0
	3-Apr-98	25	M	0	0	1	7	9	5	2	0	0	1	0	0
	17-Apr-98	19	M	0	0	1	8	9	0	1	0	0	0	0	0
	25-Apr-98	20	M	0	0	2	6	7	3	1	0	1	0	0	0
	20-May-98	21	M	0	0	5	9	5	1	0	0	1	0	0	0
	27-May-98	22	M	0	2	4	12	3	0	0	0	1	0	0	0
	10-Jun-98	29	M	0	1	7	10	4	4	1	2	0	0	0	0
	23-Jun-98	11	M	0	0	1	6	2	1	0	0	0	1	0	0
	24-Jul-98	12	M	0	0	0	8	2	2	0	0	0	0	0	0
	6-Aug-98	7	M	0	1	1	1	2	2	0	0	0	0	0	0
	20-Aug-98	10	M	0	0	4	4	0	0	1	0	1	0	0	0
	20-Oct-98	12	M	0	1	2	4	3	1	0	0	1	0	0	0
	30-Nov-98	19	M	0	1	1	4	8	4	1	0	0	0	0	0
	12-Jan-99	16	M	0	0	1	4	7	2	1	1	0	0	0	0
	27-Jan-99	15	M	0	0	2	5	6	2	0	0	0	0	0	0
	11-Feb-99	20	M	0	0	4	2	8	1	2	0	2	0	1	0
	25-Feb-99	4	M	0	0	0	2	1	0	0	1	0	0	0	0
	23-Mar-99	29	M	0	0	1	7	6	9	4	1	1	0	0	0
	14-Apr-99	22	M	0	0	1	5	6	5	3	2	0	0	0	0

Appendix F(continued). Details of the number of fish per length groups collected in the four sites over 1998-1999.

Site	Date	N	Sex	Group Length (cm)											
				<= 50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	86-90	91-95	96-100	>=101
N	20-Mar-98	4	F	0	0	1	1	1	1	0	0	0	0	0	0
	3-Apr-98	10	F	0	0	1	2	3	1	2	0	0	1	0	0
	17-Apr-98	4	F	0	0	0	0	2	0	0	0	2	0	0	0
	25-Apr-98	13	F	0	0	0	2	7	2	0	2	0	0	0	0
	20-May-98	13	F	0	0	3	5	2	0	0	2	0	1	0	0
	27-May-98	17	F	1	0	5	7	2	0	1	1	0	0	0	0
	10-Jun-98	10	F	0	1	3	3	2	0	1	0	0	0	0	0
	23-Jun-98	14	F	0	0	6	5	3	0	0	0	0	0	0	0
	24-Jul-98	7	F	1	0	2	1	0	1	1	1	0	0	0	0
	6-Aug-98	4	F	0	1	0	2	0	0	0	1	0	0	0	0
	20-Aug-98	12	F	0	0	0	6	1	4	0	1	0	0	0	0
	6-Oct-98	7	F	0	0	0	2	5	0	0	0	0	0	0	0
	20-Oct-98	8	F	0	0	1	3	2	2	0	0	0	0	0	0
	19-Nov-98	16	F	0	0	2	3	6	5	0	0	0	0	0	0
	9-Dec-98	15	F	0	0	4	8	3	0	0	0	0	0	0	0
	15-Dec-98	13	F	0	0	2	5	3	0	2	1	0	0	0	0
	12-Jan-99	21	F	0	2	4	4	5	1	2	2	1	0	0	0
	11-Feb-99	5	F	0	0	1	0	2	2	0	0	0	0	0	0
	25-Feb-99	2	F	0	0	0	1	0	0	1	0	0	0	0	0
	23-Mar-99	18	F	0	1	3	5	1	2	2	4	0	0	0	0
	14-Apr-99	14	F	0	0	2	2	1	6	2	1	0	0	0	0
	20-Mar-98	10	M	0	0	3	6	0	1	0	0	0	0	0	0
	3-Apr-98	20	M	0	0	3	7	5	3	2	0	0	0	0	0
	17-Apr-98	6	M	0	0	0	0	4	1	1	0	0	0	0	0
	25-Apr-98	17	M	0	0	1	8	6	2	0	0	0	0	0	0
	20-May-98	9	M	0	0	4	3	1	0	0	1	0	0	0	0
	27-May-98	13	M	0	0	4	7	0	1	0	0	1	0	0	0
	10-Jun-98	20	M	0	4	4	5	4	2	0	0	1	0	0	0
	23-Jun-98	16	M	0	0	2	6	6	1	0	0	0	1	0	0
	24-Jul-98	8	M	0	2	3	1	0	1	0	1	0	0	0	0
	6-Aug-98	9	M	0	1	3	1	2	1	0	1	0	0	0	0
	6-Oct-98	3	M	0	0	0	1	1	1	0	0	0	0	0	0
	20-Oct-98	4	M	0	0	0	2	1	0	0	0	1	0	0	0
	19-Nov-98	14	M	0	0	1	5	6	2	0	0	0	0	0	0
	9-Dec-98	15	M	0	0	2	7	4	1	1	0	0	0	0	0
	15-Dec-98	17	M	0	0	0	7	7	2	1	0	0	0	0	0
	12-Jan-99	10	M	1	1	1	1	0	4	1	1	0	0	0	0
	11-Feb-99	15	M	0	4	3	0	2	6	0	0	0	0	0	0
	25-Feb-99	4	M	0	1	0	1	1	0	0	0	1	0	0	0
	23-Mar-99	18	M	0	0	3	7	4	1	2	0	0	1	0	0
	14-Apr-99	26	M	0	0	3	6	9	3	2	2	0	0	1	0

Appendix F(continued). Details of the number of fish per length groups collected in the four sites over 1998-1999.

Site	Date	N	Sex	Group Length (cm)											
				<= 50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	86-90	91-95	96-100	>=101
E	20-May-98	19	F	0	0	0	15	2	1	0	0	1	0	0	0
	27-May-98	16	F	0	0	5	7	4	0	0	0	0	0	0	0
	10-Jun-98	19	F	0	0	10	6	2	1	0	0	0	0	0	0
	8-Jul-98	17	F	0	1	8	1	3	2	2	0	0	0	0	0
	24-Jul-98	18	F	0	0	3	7	5	1	1	1	0	0	0	0
	6-Aug-98	10	F	0	0	7	1	1	0	0	1	0	0	0	0
	6-Oct-98	4	F	0	0	0	1	1	0	0	1	1	0	0	0
	20-Oct-98	16	F	0	0	0	6	9	1	0	0	0	0	0	0
	5-Nov-98	15	F	0	0	1	8	6	0	0	0	0	0	0	0
	18-Nov-98	18	F	0	0	1	8	5	3	1	0	0	0	0	0
	15-Dec-98	16	F	0	0	2	4	9	0	1	0	0	0	0	0
	12-Jan-99	15	F	0	0	1	9	4	1	0	0	0	0	0	0
	27-Jan-99	18	F	0	2	0	3	9	2	1	0	1	0	0	0
	11-Feb-99	14	F	0	0	0	4	7	3	0	0	0	0	0	0
	26-Mar-99	20	F	0	1	6	2	5	4	0	1	1	0	0	0
	20-May-98	11	M	0	0	5	3	2	1	0	0	0	0	0	0
	27-May-98	14	M	0	0	7	3	4	0	0	0	0	0	0	0
	10-Jun-98	11	M	0	2	2	4	3	0	0	0	0	0	0	0
	8-Jul-98	13	M	0	0	4	4	3	1	0	1	0	0	0	0
	24-Jul-98	12	M	0	1	4	5	1	0	1	0	0	0	0	0
	6-Aug-98	18	M	0	1	7	3	5	0	1	1	0	0	0	0
	6-Oct-98	7	M	0	0	2	3	1	1	0	0	0	0	0	0
	20-Oct-98	14	M	0	0	3	3	5	3	0	0	0	0	0	0
	5-Nov-98	15	M	0	0	3	3	9	0	0	0	0	0	0	0
	18-Nov-98	12	M	0	0	2	8	1	0	1	0	0	0	0	0
	15-Dec-98	15	M	0	0	4	5	3	2	1	0	0	0	0	0
	12-Jan-99	15	M	1	0	6	6	2	0	0	0	0	0	0	0
	27-Jan-99	12	M	0	1	1	5	2	1	2	0	0	0	0	0
	11-Feb-99	10	M	0	0	0	6	0	4	0	0	0	0	0	0
	26-Mar-99	20	M	0	0	4	5	5	2	4	0	0	0	0	0

Appendix G. Details of the number of fish per age collected in the four sites over 1998-1999.

Site	Date	N	Sex	Ages 4	5	6	7	8	9	10	11	12	13	14	15
W1	3-Apr-98	5	F	0	1	1	0	1	1	0	1	0	0	0	0
	17-Apr-98	10	F	0	0	2	1	4	2	1	0	0	0	0	0
	25-Apr-98	12	F	0	0	2	4	3	2	0	0	1	0	0	0
	20-May-98	10	F	0	0	8	1	0	1	0	0	0	0	0	0
	27-May-98	5	F	0	0	5	0	0	0	0	0	0	0	0	0
	10-Jun-98	19	F	0	0	2	5	7	4	1	0	0	0	0	0
	23-Jun-98	11	F	0	0	7	3	0	0	0	1	0	0	0	0
	24-Jul-98	6	F	0	0	3	2	1	0	0	0	0	0	0	0
	6-Aug-98	10	F	0	0	5	3	2	0	0	0	0	0	0	0
	6-Oct-98	4	F	0	2	1	0	1	0	0	0	0	0	0	0
	20-Oct-98	12	F	0	1	6	1	3	1	0	0	0	0	0	0
	30-Nov-98	16	F	1	1	1	4	3	4	1	1	0	0	0	0
	12-Jan-99	17	F	0	0	3	3	2	3	3	1	2	0	0	0
	11-Feb-99	13	F	0	0	0	2	0	4	6	1	0	0	0	0
	25-Feb-99	10	F	0	0	0	7	0	2	1	0	0	0	0	0
	23-Mar-99	20	F	0	0	1	6	6	1	4	1	1	0	0	0
	14-Apr-99	20	F	0	0	3	1	5	3	4	4	0	0	0	0
	3-Apr-98	25	M	0	0	1	4	8	10	2	0	0	0	0	0
	17-Apr-98	20	M	0	0	2	3	9	6	0	0	0	0	0	0
	25-Apr-98	11	M	0	0	4	2	4	1	0	0	0	0	0	0
	20-May-98	15	M	0	1	4	2	5	2	0	0	1	0	0	0
	27-May-98	13	M	0	0	7	1	5	0	0	0	0	0	0	0
	10-Jun-98	11	M	0	0	4	3	2	2	0	0	0	0	0	0
	23-Jun-98	19	M	0	0	12	3	2	2	0	0	0	0	0	0
	24-Jul-98	24	M	0	3	1	6	6	6	2	0	0	0	0	0
	6-Aug-98	19	M	0	1	11	3	3	1	0	0	0	0	0	0
	6-Oct-98	6	M	0	1	2	3	0	0	0	0	0	0	0	0
	20-Oct-98	10	M	0	1	4	3	1	0	0	1	0	0	0	0
	30-Nov-98	14	M	1	2	4	3	1	1	0	1	0	1	0	0
	12-Jan-99	13	M	0	1	4	4	0	2	1	0	0	1	0	0
	11-Feb-99	19	M	0	1	2	6	2	1	2	4	0	1	0	0
	25-Feb-99	15	M	0	0	1	3	0	2	6	1	2	0	0	0
	23-Mar-99	22	M	0	0	1	5	4	4	5	3	0	0	0	0
	14-Apr-99	20	M	0	0	1	2	1	1	9	1	3	2	0	0

Appendix G (continued). Details of the number of fish per age collected in the four sites over 1998-1999.

Site	Date	N	Sex	Ages 4	5	6	7	8	9	10	11	12	13	14	15
W2	20-Mar-98	9	F	0	0	0	4	2	3	0	0	0	0	0	0
	3-Apr-98	5	F	0	0	0	2	1	1	0	1	0	0	0	0
	17-Apr-98	11	F	0	0	3	1	5	0	1	1	0	0	0	0
	25-Apr-98	10	F	0	2	2	3	1	0	1	1	0	0	0	0
	20-May-98	9	F	0	0	2	1	1	2	3	0	0	0	0	0
	27-May-98	8	F	0	0	2	1	4	1	0	0	0	0	0	0
	23-Jun-98	19	F	0	0	13	2	2	2	0	0	0	0	0	0
	24-Jul-98	18	F	0	2	5	5	5	1	0	0	0	0	0	0
	6-Aug-98	5	F	0	0	2	2	1	0	0	0	0	0	0	0
	20-Aug-98	20	F	0	1	11	3	3	2	0	0	0	0	0	0
	6-Oct-98	10	F	1	3	2	1	2	1	0	0	0	0	0	0
	20-Oct-98	18	F	0	0	10	2	1	3	2	0	0	0	0	0
	30-Nov-98	11	F	0	0	5	4	2	0	0	0	0	0	0	0
	12-Jan-99	14	F	0	0	0	9	0	0	3	0	0	0	1	1
	27-Jan-99	15	F	0	0	1	11	3	0	0	0	0	0	0	0
	11-Feb-99	21	F	1	2	1	13	1	2	1	0	0	0	0	0
	23-Mar-99	13	F	0	0	1	2	3	2	3	1	1	0	0	0
	14-Apr-99	18	F	0	0	1	2	4	4	5	0	0	2	0	0
	20-Mar-98	21	M	0	0	3	5	1	9	1	2	0	0	0	0
	3-Apr-98	25	M	0	0	1	4	5	13	2	0	0	0	0	0
	17-Apr-98	19	M	0	2	2	5	3	5	1	1	0	0	0	0
	25-Apr-98	20	M	0	0	5	2	3	7	2	0	1	0	0	0
	20-May-98	21	M	0	0	13	2	3	2	0	0	1	0	0	0
	27-May-98	22	M	0	1	10	2	3	5	1	0	0	0	0	0
	10-Jun-98	29	M	0	1	8	4	10	5	0	0	0	1	0	0
	23-Jun-98	11	M	0	0	4	2	4	1	0	0	0	0	0	0
	24-Jul-98	12	M	0	0	5	3	2	1	0	1	0	0	0	0
	6-Aug-98	7	M	0	0	3	1	3	0	0	0	0	0	0	0
	20-Aug-98	10	M	0	1	1	5	2	0	1	0	0	0	0	0
	20-Oct-98	12	M	0	1	4	3	4	0	0	0	0	0	0	0
	30-Nov-98	19	M	1	2	4	5	4	2	1	0	0	0	0	0
	12-Jan-99	16	M	0	0	0	8	2	3	3	0	0	0	0	0
	27-Jan-99	15	M	0	0	0	10	2	2	1	0	0	0	0	0
	11-Feb-99	20	M	0	0	3	8	3	2	2	1	1	0	0	0
	25-Feb-99	4	M	0	0	1	1	0	0	2	0	0	0	0	0
	23-Mar-99	29	M	0	0	2	4	4	6	10	2	1	0	0	0
	14-Apr-99	22	M	0	0	1	5	3	6	7	0	0	0	0	0

Appendix G (continued). Details of the number of fish per age collected in the four sites over 1998-1999.

				Ages											
Site	Date	N	Sex	4	5	6	7	8	9	10	11	12	13	14	15
N	20-Mar-98	4	F	0	0	1	1	0	1	0	1	0	0	0	0
	3-Apr-98	10	F	0	0	1	4	2	3	0	0	0	0	0	0
	17-Apr-98	4	F	0	0	0	2	0	0	0	2	0	0	0	0
	25-Apr-98	13	F	0	0	1	3	6	1	1	1	0	0	0	0
	20-May-98	13	F	0	1	5	4	1	2	0	0	0	0	0	0
	27-May-98	17	F	1	2	6	2	2	3	1	0	0	0	0	0
	10-Jun-98	10	F	0	1	5	2	2	0	0	0	0	0	0	0
	23-Jun-98	14	F	0	2	8	4	0	0	0	0	0	0	0	0
	24-Jul-98	7	F	1	0	1	1	2	1	1	0	0	0	0	0
	6-Aug-98	4	F	0	0	1	1	1	1	0	0	0	0	0	0
	20-Aug-98	12	F	0	0	7	1	3	1	0	0	0	0	0	0
	6-Oct-98	7	F	0	1	4	1	1	0	0	0	0	0	0	0
	20-Oct-98	8	F	0	4	4	0	0	0	0	0	0	0	0	0
	19-Nov-98	16	F	0	1	8	3	4	0	0	0	0	0	0	0
	9-Dec-98	15	F	0	1	7	3	4	0	0	0	0	0	0	0
	15-Dec-98	13	F	0	0	7	3	1	1	1	0	0	0	0	0
	12-Jan-99	21	F	0	1	5	8	4	2	1	0	0	0	0	0
	11-Feb-99	5	F	0	0	0	3	0	1	1	0	0	0	0	0
	25-Feb-99	2	F	0	1	0	0	0	0	1	0	0	0	0	0
	23-Mar-99	18	F	0	1	4	3	2	4	3	1	0	0	0	0
	14-Apr-99	14	F	0	0	0	3	4	4	2	1	0	0	0	0
	20-Mar-98	10	M	0	1	3	0	1	4	0	1	0	0	0	0
	3-Apr-98	20	M	0	1	1	5	8	3	1	1	0	0	0	0
	17-Apr-98	6	M	0	0	0	1	3	0	1	1	0	0	0	0
	25-Apr-98	17	M	0	1	0	3	6	6	0	1	0	0	0	0
	20-May-98	9	M	0	2	2	1	1	3	0	0	0	0	0	0
	27-May-98	13	M	0	0	8	1	2	1	0	1	0	0	0	0
	10-Jun-98	20	M	0	2	9	2	4	2	1	0	0	0	0	0
	23-Jun-98	16	M	0	0	7	5	4	0	0	0	0	0	0	0
	24-Jul-98	8	M	0	1	3	2	2	0	0	0	0	0	0	0
	6-Aug-98	9	M	0	0	2	3	2	1	0	0	0	1	0	0
	6-Oct-98	3	M	0	0	2	1	0	0	0	0	0	0	0	0
	20-Oct-98	4	M	0	1	2	1	0	0	0	0	0	0	0	0
	19-Nov-98	14	M	0	1	8	4	1	0	0	0	0	0	0	0
	9-Dec-98	15	M	0	0	7	3	2	3	0	0	0	0	0	0
	15-Dec-98	17	M	0	2	8	1	2	3	1	0	0	0	0	0
	12-Jan-99	10	M	0	1	2	3	1	1	0	2	0	0	0	0
	11-Feb-99	15	M	0	0	0	9	0	3	3	0	0	0	0	0
	25-Feb-99	4	M	0	0	1	1	0	1	1	0	0	0	0	0
	23-Mar-99	18	M	0	0	6	5	1	2	3	1	0	0	0	0
	14-Apr-99	26	M	0	0	4	9	1	8	2	1	1	0	0	0

Appendix G (continued). Details of the number of fish per age collected in the four sites over 1998-1999.

				Ages											
Site	Date	N	Sex	4	5	6	7	8	9	10	11	12	13	14	15
E	20-May-98	19	F	0	1	15	0	2	1	0	0	0	0	0	0
	27-May-98	16	F	0	0	11	1	3	1	0	0	0	0	0	0
	10-Jun-98	19	F	0	0	13	5	1	0	0	0	0	0	0	0
	8-Jul-98	17	F	0	0	9	6	1	1	0	0	0	0	0	0
	24-Jul-98	18	F	0	0	5	4	6	2	0	1	0	0	0	0
	6-Aug-98	10	F	0	2	5	1	1	1	0	0	0	0	0	0
	6-Oct-98	4	F	0	0	1	1	1	1	0	0	0	0	0	0
	20-Oct-98	16	F	0	0	10	5	1	0	0	0	0	0	0	0
	5-Nov-98	15	F	0	1	9	1	2	2	0	0	0	0	0	0
	18-Nov-98	18	F	0	2	7	8	0	1	0	0	0	0	0	0
	15-Dec-98	16	F	0	0	10	2	2	2	0	0	0	0	0	0
	12-Jan-99	15	F	0	1	7	7	0	0	0	0	0	0	0	0
	27-Jan-99	18	F	0	2	1	11	2	1	0	1	0	0	0	0
	11-Feb-99	14	F	0	0	0	7	4	3	0	0	0	0	0	0
	26-Mar-99	20	F	0	1	4	5	2	3	4	1	0	0	0	0
	20-May-98	11	M	0	0	7	1	2	1	0	0	0	0	0	0
	27-May-98	14	M	0	1	9	2	2	0	0	0	0	0	0	0
	10-Jun-98	11	M	0	0	4	4	2	1	0	0	0	0	0	0
	8-Jul-98	13	M	1	3	5	1	2	1	0	0	0	0	0	0
	24-Jul-98	12	M	0	0	4	3	3	1	1	0	0	0	0	0
	6-Aug-98	18	M	0	1	10	3	3	0	1	0	0	0	0	0
	6-Oct-98	7	M	0	1	1	2	1	2	0	0	0	0	0	0
	20-Oct-98	14	M	0	0	7	3	3	1	0	0	0	0	0	0
	5-Nov-98	15	M	0	4	4	2	2	3	0	0	0	0	0	0
	18-Nov-98	12	M	0	0	7	2	2	1	0	0	0	0	0	0
	15-Dec-98	15	M	0	2	6	3	1	2	0	0	1	0	0	0
	12-Jan-99	15	M	0	1	4	8	0	1	1	0	0	0	0	0
	27-Jan-99	12	M	0	2	0	6	0	1	1	0	1	1	0	0
	11-Feb-99	10	M	0	0	0	3	3	0	4	0	0	0	0	0
	26-Mar-99	20	M	0	0	0	11	3	2	2	1	1	0	0	0

Appendix H. Average Fulton's gutted Condition Factors (FCF) with their 95% confidence intervals for the cod sampled in the four sites during 1998-1999.

Females					Males				
		95% Confidence interval					95% Confidence interval		
Site	Date	Uper Limit	Lower Limit	FCF	Site	Date	Uper Limit	Lower Limit	FCF
W1	25-Apr-98	0.741	0.668	0.704	W1	25-Apr-98	0.741	0.687	0.714
	20-May-98	0.845	0.711	0.778		20-May-98	0.778	0.710	0.744
	27-May-98	0.792	0.698	0.745		27-May-98	0.803	0.741	0.772
	10-Jun-98	0.783	0.731	0.757		10-Jun-98	0.808	0.758	0.783
	23-Jun-98	0.780	0.737	0.758		23-Jun-98	0.784	0.738	0.761
	24-Jul-98	0.793	0.700	0.746		24-Jul-98	0.846	0.777	0.812
	6-Aug-98	0.772	0.676	0.724		6-Aug-98	0.836	0.783	0.809
	6-Oct-98	1.000	0.617	0.809		6-Oct-98	0.858	0.753	0.805
	20-Oct-98	0.819	0.710	0.765		20-Oct-98	0.850	0.785	0.817
	30-Nov-98	0.836	0.758	0.797		30-Nov-98	0.808	0.755	0.781
	12-Jan-99	0.799	0.750	0.775		12-Jan-99	0.781	0.728	0.754
	11-Feb-99	0.870	0.719	0.794		11-Feb-99	0.733	0.670	0.701
	25-Feb-99	0.734	0.678	0.706		25-Feb-99	0.748	0.652	0.700
	23-Mar-99	0.717	0.663	0.690		23-Mar-99	0.754	0.678	0.716
	14-Apr-99	0.677	0.611	0.644		14-Apr-99	0.731	0.693	0.712
W2	25-Apr-98	0.762	0.688	0.725	W2	25-Apr-98	0.734	0.683	0.708
	20-May-98	0.775	0.695	0.735		20-May-98	0.754	0.716	0.735
	27-May-98	0.772	0.729	0.751		27-May-98	0.824	0.733	0.779
	23-Jun-98	0.762	0.720	0.741		10-Jun-98	0.790	0.741	0.765
	24-Jul-98	0.795	0.722	0.758		23-Jun-98	0.776	0.711	0.743
	6-Aug-98	0.943	0.785	0.864		24-Jul-98	0.801	0.740	0.771
	20-Aug-98	0.864	0.774	0.819		6-Aug-98	0.852	0.712	0.782
	6-Oct-98	0.898	0.644	0.771		20-Aug-98	0.868	0.808	0.838
	20-Oct-98	0.879	0.814	0.846		20-Oct-98	0.875	0.804	0.839
	30-Nov-98	0.909	0.773	0.841		30-Nov-98	0.897	0.756	0.827
	12-Jan-99	0.773	0.726	0.749		12-Jan-99	0.788	0.747	0.768
	27-Jan-99	0.743	0.709	0.726		27-Jan-99	0.746	0.687	0.717
	11-Feb-99	0.763	0.688	0.725		11-Feb-99	0.786	0.731	0.758
	25-Feb-99	0.987	0.608	0.798		25-Feb-99	0.750	0.686	0.718
	23-Mar-99	0.755	0.630	0.693		23-Mar-99	0.736	0.691	0.714
	14-Apr-99	0.733	0.671	0.702		14-Apr-99	0.742	0.705	0.724

Appendix H (continued). Average Fulton's gutted Condition Factors (FCF) with their 95% confidence intervals for the cod sampled in the four sites during 1998-1999.

	Females					Males			
		95% Confidence interval					95% Confidence interval		
Site	Date	Uper Limit	Lower Limit	FCF	Site	Date	Uper Limit	Lower Limit	FCF
N	25-Apr-98	0.716	0.662	0.689	N	25-Apr-98	0.723	0.649	0.686
	20-May-98	0.794	0.714	0.754		20-May-98	0.795	0.691	0.743
	27-May-98	0.799	0.738	0.769		27-May-98	0.807	0.742	0.775
	10-Jun-98	0.788	0.744	0.766		10-Jun-98	0.824	0.764	0.794
	23-Jun-98	0.804	0.743	0.774		23-Jun-98	0.790	0.603	0.697
	24-Jul-98	0.856	0.759	0.808		24-Jul-98	0.890	0.813	0.852
	6-Aug-98	0.860	0.680	0.770		6-Aug-98	0.898	0.781	0.840
	20-Aug-98	0.773	0.727	0.750		20-Aug-98	0.826	0.601	0.714
	6-Oct-98	1.022	0.865	0.943		6-Oct-98	1.142	0.686	0.914
	20-Oct-98	0.903	0.788	0.845		20-Oct-98	0.916	0.753	0.835
	19-Nov-98	0.859	0.769	0.814		19-Nov-98	0.899	0.745	0.822
	9-Dec-98	0.825	0.761	0.793		9-Dec-98	0.826	0.756	0.791
	15-Dec-98	0.797	0.728	0.763		15-Dec-98	0.824	0.768	0.796
	12-Jan-99	0.776	0.731	0.754		12-Jan-99	0.754	0.710	0.732
	11-Feb-99	0.750	0.649	0.699		11-Feb-99	0.742	0.677	0.709
	25-Feb-99	0.755	0.629	0.692		25-Feb-99	0.789	0.609	0.699
	23-Mar-99	0.722	0.677	0.700		23-Mar-99	0.768	0.727	0.748
	14-Apr-99	0.731	0.685	0.708		14-Apr-99	0.740	0.690	0.715
E	20-May-98	0.757	0.709	0.733	E	20-May-98	0.858	0.694	0.776
	27-May-98	0.782	0.745	0.763		27-May-98	0.835	0.750	0.792
	10-Jun-98	0.809	0.747	0.778		10-Jun-98	0.910	0.724	0.817
	8-Jul-98	0.795	0.746	0.770		8-Jul-98	0.817	0.741	0.779
	24-Jul-98	0.847	0.761	0.804		24-Jul-98	0.909	0.786	0.848
	6-Aug-98	0.816	0.747	0.782		6-Aug-98	0.824	0.767	0.796
	6-Oct-98	0.829	0.688	0.758		6-Oct-98	0.802	0.720	0.761
	20-Oct-98	0.936	0.821	0.878		20-Oct-98	0.967	0.823	0.895
	5-Nov-98	0.868	0.803	0.835		5-Nov-98	0.852	0.782	0.817
	18-Nov-98	0.894	0.779	0.836		18-Nov-98	0.861	0.799	0.830
	15-Dec-98	0.779	0.736	0.758		15-Dec-98	0.835	0.743	0.789
	12-Jan-99	0.779	0.743	0.761		12-Jan-99	0.757	0.718	0.737
	27-Jan-99	0.775	0.718	0.747		27-Jan-99	0.782	0.719	0.750
	11-Feb-99	0.765	0.689	0.727		11-Feb-99	0.769	0.688	0.728
	26-Mar-99	0.723	0.687	0.705		26-Mar-99	0.745	0.707	0.726

Appendix I. Average Gonado Somatic Indexes (GSI) with their 95% confidence intervals for the cod sampled in the four sites over 1998-1999.

Females					Males				
		95% Confidence interval					95% Confidence interval		
Site	Date	Uper Limit	Lower Limit	GSI	Site	Date	Uper Limit	Lower Limit	GSI
W1	25-Apr-98	0.089	0.032	0.060	W1	25-Apr-98	0.140	0.045	0.093
	20-May-98	0.106	0.056	0.081		20-May-98	0.085	0.063	0.074
	27-May-98	0.049	0.033	0.041		27-May-98	0.064	0.044	0.054
	10-Jun-98	0.136	0.099	0.117		10-Jun-98	0.081	0.049	0.065
	23-Jun-98	0.156	0.102	0.129		23-Jun-98	0.071	0.053	0.062
	24-Jul-98	0.165	0.047	0.106		24-Jul-98	0.045	0.027	0.036
	6-Aug-98	0.126	0.031	0.079		6-Aug-98	0.018	0.008	0.013
	6-Oct-98	0.010	0.005	0.008		6-Oct-98	0.003	0.001	0.002
	20-Oct-98	0.017	0.009	0.013		20-Oct-98	0.009	0.004	0.007
	30-Nov-98	0.030	0.015	0.023		30-Nov-98	0.055	0.013	0.034
	12-Jan-99	0.032	0.020	0.026		12-Jan-99	0.077	0.042	0.059
	11-Feb-99	0.055	0.027	0.041		11-Feb-99	0.073	0.038	0.055
	25-Feb-99	0.034	0.022	0.028		25-Feb-99	0.123	0.073	0.098
	23-Mar-99	0.197	0.145	0.171		23-Mar-99	0.107	0.083	0.095
	14-Apr-99	0.118	0.074	0.096		14-Apr-99	0.089	0.055	0.072
W2	25-Apr-98	0.101	0.064	0.082	W2	25-Apr-98	0.094	0.073	0.083
	20-May-98	0.102	0.034	0.068		20-May-98	0.079	0.051	0.065
	27-May-98	0.048	0.028	0.038		27-May-98	0.050	0.039	0.044
	23-Jun-98	0.157	0.110	0.133		10-Jun-98	0.081	0.063	0.072
	24-Jul-98	0.127	0.074	0.100		23-Jun-98	0.099	0.067	0.083
	6-Aug-98	0.150	-0.015	0.067		24-Jul-98	0.043	0.022	0.032
	20-Aug-98	0.110	0.058	0.084		6-Aug-98	0.039	0.008	0.023
	6-Oct-98	0.009	0.006	0.007		20-Aug-98	0.046	0.029	0.037
	20-Oct-98	0.016	0.010	0.013		20-Oct-98	0.037	0.013	0.025
	30-Nov-98	0.027	0.013	0.020		30-Nov-98	0.046	0.028	0.037
	12-Jan-99	0.025	0.014	0.019		12-Jan-99	0.079	0.054	0.066
	27-Jan-99	0.024	0.014	0.019		27-Jan-99	0.072	0.042	0.057
	11-Feb-99	0.033	0.016	0.024		11-Feb-99	0.115	0.078	0.097
	25-Feb-99	0.013	0.008	0.011		25-Feb-99	0.122	0.046	0.084
	23-Mar-99	0.177	0.090	0.133		23-Mar-99	0.106	0.087	0.096
	14-Apr-99	0.095	0.054	0.074		14-Apr-99	0.085	0.060	0.072

Appendix I (continued). Average Gonado Somatic Indexes (GSI) with their 95% confidence intervals for the cod sampled in the four sites over 1998-1999.

		Females					Males		
		95% Confidence interval					95% Confidence interval		
Site	Date	Uper Limit	Lower Limit	GSI	Site	Date	Uper Limit	Lower Limit	GSI
N	25-Apr-98	0.073	0.043	0.058	N	25-Apr-98	0.069	0.037	0.053
	20-May-98	0.091	0.028	0.059		20-May-98	0.082	0.049	0.066
	27-May-98	0.051	0.037	0.044		27-May-98	0.047	0.033	0.040
	10-Jun-98	0.134	0.072	0.103		10-Jun-98	0.097	0.049	0.073
	23-Jun-98	0.150	0.113	0.132		23-Jun-98	0.070	0.040	0.055
	24-Jul-98	0.145	0.054	0.099		24-Jul-98	0.093	0.020	0.056
	6-Aug-98	0.077	0.009	0.043		6-Aug-98	0.043	0.018	0.030
	20-Aug-98	0.149	0.048	0.098		20-Aug-98	0.035	0.000	0.017
	6-Oct-98	0.007	0.003	0.005		6-Oct-98	0.004	0.001	0.002
	20-Oct-98	0.019	0.008	0.013		20-Oct-98	0.042	0.003	0.022
	19-Nov-98	0.020	0.014	0.017		19-Nov-98	0.050	0.017	0.034
	9-Dec-98	0.047	0.011	0.029		9-Dec-98	0.044	0.021	0.032
	15-Dec-98	0.029	0.017	0.023		15-Dec-98	0.074	0.030	0.052
	12-Jan-99	0.020	0.012	0.016		12-Jan-99	0.051	0.019	0.035
	11-Feb-99	0.113	0.039	0.076		11-Feb-99	0.092	0.054	0.073
	25-Feb-99	0.065	0.052	0.059		25-Feb-99	0.100	0.053	0.076
	23-Mar-99	0.158	0.110	0.134		23-Mar-99	0.100	0.064	0.082
	14-Apr-99	0.091	0.045	0.068		14-Apr-99	0.080	0.055	0.067
E	20-May-98	0.061	0.019	0.040	E	20-May-98	0.073	0.055	0.064
	27-May-98	0.065	0.054	0.060		27-May-98	0.077	0.058	0.067
	10-Jun-98	0.125	0.088	0.107		10-Jun-98	0.057	0.025	0.041
	8-Jul-98	0.070	0.058	0.064		8-Jul-98	0.069	0.054	0.061
	24-Jul-98	0.077	0.032	0.055		24-Jul-98	0.049	0.014	0.032
	6-Aug-98	0.048	0.000	0.024		6-Aug-98	0.039	0.016	0.027
	6-Oct-98	0.016	0.008	0.012		6-Oct-98	0.007	0.002	0.005
	20-Oct-98	0.012	0.008	0.010		20-Oct-98	0.051	0.011	0.031
	5-Nov-98	0.019	0.012	0.015		5-Nov-98	0.072	0.025	0.048
	18-Nov-98	0.020	0.013	0.016		18-Nov-98	0.035	0.015	0.025
	15-Dec-98	0.025	0.012	0.018		15-Dec-98	0.055	0.015	0.035
	12-Jan-99	0.026	0.012	0.019		12-Jan-99	0.056	0.035	0.045
	27-Jan-99	0.026	0.017	0.022		27-Jan-99	0.077	0.043	0.060
	11-Feb-99	0.040	0.033	0.036		11-Feb-99	0.066	0.062	0.064
	26-Mar-99	0.174	0.126	0.150		26-Mar-99	0.123	0.085	0.104