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Age of Sexual Maturation and Recruitment in Pacific Herring

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Abstract

Percent at age data from the commercial herring roe fishery in northern BC indicate that herring are fully recruited at age 4. In general, there are more age 4 fish in the catch than age 3, 5, or older ages. Percent at age data are taken as evidence that in most assessment areas, a substantial part of the age 3 cohort is immature and not fully recruited to the spawning population. This is represented in the annual BC herring assessments in an age-structured model as the age-specific parameter lambda (λ) that represents the age-specific vulnerability to fishing gear. There is, however, other evidence that most age 3 fish are sexually maturing. We present 3 types of evidence. (1) Ovarian histology: analyses of maturing ovaries taken from samples collected from several years and areas in the winter months indicates that virtually all age 3 females had vitellogenic oocytes, a condition found only in sexually maturing females. (2) Gonad weights: since 1982, gonads have been weighed as part of the routine herring sample analyses. When ovary weights exceed 5% of total body weight (defined as a gonosomatic index or 'GSI' > 5) sexual maturation has started. We then show that virtually all age 3 fish collected in the late winter and spring have a GSI of 5, or greater. (3) The Hjort Maturity scale: this index is recorded for all fish, but the results have not been presented in previous analyses. Using this scale, any fish with a Hjort index of 4 or greater is sexually mature. All age 3 herring, collected in the late winter or later, have a Hjort Index of 4 or more. Therefore, there is an apparent contradiction between the area-specific percent at age data, which indicate incomplete recruitment of age 3 herring, and the observation most that age 3 are maturing. There are two mutually exclusive hypotheses to explain this contradiction (1) the 'age 3 immature hypothesis' and (2) the 'sample bias hypothesis'. The present stock assessment models assume the 'age 3 immature hypothesis' - that there are many immature age 3 herring that do not reside with the main herring stock and are not available for capture. The alternative 'sample bias' assumes that most age 3 fish are mature, but their frequency in the samples of catches is under-represented. There is no direct evidence to support the 'age 3 immature hypothesis'. If such evidence existed, it would consist of samples that consist mainly of sexually immature age 3 fish. In our reviews of the historical biological sampling data, we have not found such samples. Such fish have not been encountered during winter surveys of herring. On the other hand, there is evidence that samples from fishery catches may not be fully representative of the spawning populations. There are differences in the mean age of spawning fished when compared among different 'Statistical Areas', within each of the 'stock assessment areas'. In some areas and years, the duration of the sampling period often is shorter than the duration of the spawning period. Younger fish tend to spawn later so could be under-represented in samples. Therefore, there are data to support the 'sample bias hypothesis'. In general, however, we conclude that the potential for sample bias may not fully explain the differences between the percent at age data and observed age at maturity. We suggest a new hypothesis: that there are episodic migrations of younger but mature herring from southern to northern areas. The consequence is that the observed percent at age data are valid, because the older age groups are augmented from southern mature migrants, not late maturing fish. This migration hypothesis concurs with a recent review and analyses of tagging data and would support the general validity both of the percent at age data and our observations about the age of sexual maturation. Of the competing hypotheses on this issue, the hypothesis of episodic migrations is the most parsimonious and precautionary.

Résumé

Le pourcentage selon l'âge des individus capturés par la pêche commerciale du hareng, pour les œufs, effectuée dans le nord de la Colombie-Britannique montre que les harengs sont pleinement recrutés à l'âge 4. De façon générale, on retrouve plus de poissons d'âge 4 dans les captures que de poissons d'âge 3, 5 ou plus. Le pourcentage selon l'âge indique que, dans la plupart des zones d'évaluation, une partie appréciable de la cohorte d'âge 3 est immature et non pleinement recrutée à la population de géniteurs. Cela est représenté dans les évaluations annuelles du hareng de la C.-B. par un modèle structuré par âges où lambda (λ) est le paramètre spécifique à l'âge de la vulnérabilité aux engins de pêche spécifique à l'âge. D'autres indices montrent que la plupart des poissons d'âge 3 sont en maturation sexuelle. Nous présentons trois types de ces indices : 1) histologie ovarienne – l'analyse des ovaires en maturation obtenus d'échantillons prélevés en hiver au cours de diverses années et dans des zones différentes montrent que pratiquement toutes les femelles d'âge 3 présentaient des oocytes vitellogènes, que l'on ne retrouve que chez les femelles en maturation sexuelle ; 2) poids des gonades – depuis 1982, le poids des gonades est déterminé de façon routinière au moment de l'analyse des échantillons. Lorsque le poids des ovaires est supérieur à 5 % du poids corporel total (défini comme l'indice gonosomatique ou IGS > 5) la maturation a débuté. Nous démontrons ensuite que pratiquement tous les poissons d'âge 3 récoltés à la fin de l'hiver et au printemps ont un IGS de 5 ou plus ; 3) l'échelle de maturité Hjort – cet indice est noté pour tous les poissons, mais les résultats n'ont pas été présentés dans le cadre des analyses antérieures. Selon cette échelle, tout poisson présentant un indice Hjort de 4 ou plus est sexuellement mature. Tous les harengs d'âge 3 prélevés à la fin de l'hiver ou plus tard présentaient un indice Hjort d'au moins 4. Par conséquent, il y a donc contradiction apparente entre le pourcentage selon l'âge spécifique à la zone, qui indique un recrutement incomplet des harengs d'âge 3, et l'observation selon laquelle la plupart des poissons d'âge 3 sont en maturation. Deux hypothèses mutuellement exclusives expliquent cette contradiction : 1) l'hypothèse des poissons d'âge 3 immatures et 2) l'hypothèse du biais d'échantillonnage. Les modèles actuels d'évaluation des stocks sont fondés sur l'hypothèse des poissons immatures à l'âge 3, c'est-à-dire qu'il existe un grand nombre de harengs d'âge 3 immatures qui ne sont pas présents au sein du principal stock et qui ne sont pas disponibles à la capture. L'autre hypothèse, celle du « biais d'échantillonnage », suppose que la plupart des poissons d'âge 3 sont matures mais que leur fréquence au sein des échantillons des captures est sous-représentée. Il n'y a aucune observation directe à l'appui de « l'hypothèse des poissons d'âge 3 immatures ». Dans le cas contraire, il y aurait des échantillons surtout composés de poissons immatures d'âge 3. Les auteurs n'ont pu trouver aucun échantillon de ce genre après examen des données d'échantillonnage biologique de la période antérieure. De tels poissons n'ont pas été décelés au moment des relevés d'hiver. Par ailleurs, il apparaît que les échantillons provenant des captures pourraient ne pas être totalement représentatifs des populations de géniteurs. Il existe des écarts de l'âge moyen au moment du frai des poissons pêchés lorsque l'on compare les « zones statistiques » au sein de chacune des zones « d'évaluation des stocks ». Dans certaines zones et au cours de certaines années, la période d'échantillonnage est souvent plus courte que celle du frai. Les plus jeunes poissons tendent à frayer plus tard de sorte qu'ils pourraient être sous-représentés au sein des échantillons. Par conséquent, il existe des données à l'appui de « l'hypothèse du biais d'échantillonnage ». Mais de façon générale, il a été conclu qu'un tel biais d'échantillonnage ne pouvait expliquer totalement les écarts entre les données de pourcentage selon l'âge et l'âge à maturité observé. Une nouvelle hypothèse est donc proposée : il y aurait des

migrations épisodiques de poissons plus jeunes, mais matures, du sud vers le nord. Il en découle que les données de pourcentage selon l'âge observé est valable car les groupes de poissons plus âgés se voient augmentés de poissons matures en provenance du sud, et non de poissons à maturation retardée. Cette hypothèse d'une migration est en accord avec les résultats d'analyses récentes et d'un examen de données de marquage et semble donc confirmer la validité générale tant des données du pourcentage selon l'âge que nos observations relatives à l'âge de la maturation sexuelle. Des hypothèses possibles, celle de migrations épisodiques apparaît comme la plus réservée et la plus prudente.

Introduction

This paper presents evidence to support the contention that most Pacific herring mature sexually at age 3 in all major assessment areas of British Columbia. Following the aging conventions in assessment documents, age 3 is synonymous with 'age 2+' or an age of 36 months at the time of first spawning. Therefore most of the fish we call age 3 in this paper have been captured 0-6 months prior to spawning and are 30-36 months of age. We do not, however, suggest that age 3 is necessarily the age of 'recruitment'. Instead, our purpose is to point out that if herring are not fully 'recruited' at age 3, the explanation may not be that many age 3 fish are sexually immature, as is stated in recent assessment documents (Schweigert *et al*. 1998). There may be other explanations, perhaps associated with sampling bias, or differential movement of herring among areas. In general, 'recruitment' is defined as the 'addition of new fish to the vulnerable population by growth from among smaller size classes' (Ricker 1958). Based on percent at age data, the age when herring are fully recruited in northern assessment areas is age 4, or later. Therefore there is an apparent contradiction between the age of recruitment, as seen in the percent at age data and the age of sexual maturity, which is virtually complete at age 3, as we show in this paper.

The contradiction between percent at age data and maturation data can be expressed as two mutually exclusive hypotheses which we call: (1) the 'age 3 immature hypothesis' and (2) the 'sample bias hypothesis'. The present stock assessment models assume the 'age 3 immature hypothesis': that there are many immature age 3 herring that do not reside with the main herring stock, and are not available for capture. The alternative 'sample bias hypothesis' assumes that age 3 fish are indeed mature, but that their frequency in the samples of catches is under-represented. In this paper we discuss these hypotheses but we point out that a full review of sampling bias is beyond the scope of this paper. The tentative conclusion from our results, however, is that the samples used to monitor the fishery may not be fully representative of the spawning population.

The paper is organized according to 3 main topics: (1) percent at age data, (2) analyses of sexual maturity and (3) a brief analyses of some temporal and spatial factors associated with the samples of spawning fish. Within the section on analyses of sexual maturity, we present 2 different approaches in support of the contention that age 3 herring mature sexually. (i) The first approach is based microscopic analyses of the size composition of developing eggs (oocytes) in ovaries as criteria of maturation. We distinguished between immature, non-vitellogenic oocytes (non-yolky) and maturing vitellogenic as criteria of maturation in herring taken in near-shore and offshore locations, in the fall months. The results indicate that most herring in northern British Columbia matured sexually at age 3. This approach is limited to females,

and is representative of only a few years in a few coastal areas. (ii) The second approach uses catch sampling data to support an analysis of gonad weights in conjunction with the Hjort maturity index. Analyses using a minimum gonad weight (5% of total body weight) as a criterion of maturity can be extended back to 1982. An analyses based only on the Hjort index, using 3 maturation stages (4 – 7) as criteria of maturity both in males and females, also can be extended back to the 1970's in all assessment areas. In the final section of the paper we examine some factors that could result in an age-specific bias in the samples collected during the spawning season.

In the Discussion we point out that there is no direct evidence to support the 'age 3 immature hypothesis'. Further, we suggest that this hypothesis may not be 'precautionary' or risk-averse, because it assumes that herring biomass exists (i.e. the alleged immature age 3 herring) without any confirmatory evidence. On the other hand, there is ample evidence of a *potential* for bias during the collection of samples during the spawning season, but in general, any deficiencies in the annual sampling may not account for the apparent discrepancy between the age of maturity and the percent at age data. Instead we suggest a new hypothesis based on episodic movement of young but mature herring from the south to the north. There is evidence that such movements occur (Hay *et al*. 1999). If so, such episodic migrations could account for the observed percent at age data and not contradict our observations about the age of maturity. The 'episodic-migration' hypothesis is only a suggestion, however, and the main topic of this paper is the age of sexual maturity. We conclude with a discussion of the implication of the results and make some recommendations concerned with the stock assessment and management implications of the results presented in this paper.

Methods and Materials

Databases: catch sampling and herring spawn

Two databases were used for these analyses: (1) the herring spawn database that has been described and used in previous analyses of variation in spawning (Hay and Kronlund 1987, Hay and McCarter 1998) and (2) the catch sampling database that has been used for annual stock assessments (Schweigert et al. 1998). The catch sampling database expands each year with the addition of new samples. Several hundred herring samples of about 100 fish each are collected before, during and after the fishery. These samples are routinely analyzed for length, weight, gonad weight (since the early 1980's), a Hjort maturity index (Hourston and Miller 1980, Hay 1985), and age. The herring catch sampling database used in this report was in the form of a Microsoft Access© file that had 1,384,436 records from 1946-1996. Age determination is made from scales. A fish at age '3' is defined as a fish that is approximately 36 months of age during the spawning season. By convention, the same fish would be called age 3 (or in its third year, or age 2+) after its second birthday. Therefore,herring at age 3 in the winter months (October-December) represent the same cohort as herring at age 3 during the following spawning season.

Percent at age data

The catch sampling database was used to estimate the age composition of herring for each of the 5 main stock assessment areas: (1) Queen Charlotte Islands (QCI), (2) the Prince Rupert District (PRD), the

Central Coast (CC) the Strait of Georgia (SOG), and the West Coast of Vancouver Island (WCVI) (Fig. 1). In these analyses we distinguished between samples collected between 4 different periods: (i) the pre-spawning and spawning period, from January – April, (ii) the summer feeding period from May until September, (iii) the over-wintering period, between October and December. For some analyses we present data from Statistical Areas 3-5 within the PRD (Fig. 2)

Maturity analyses

(i) Histological analyses of ovaries

In the early 1980's samples from offshore and inshore areas in the PRD, CC, WCVI and SOG were collected by mid-water trawl and seine vessels. In all years and locations, small (<2 gms) sections of fresh ovary were removed from the fish and placed in individually marked vials and stored in 10% buffered formal saline (40 g sodium phosphate monobasic plus 65 g sodium phosphate dibasic plus 90 g sodium chloride per L of fresh water). The size and age (from scales) was recorded for each specimen. In 1982, fish samples were randomly selected from catches. In 1983, samples were not random. First, fish were sorted by length into 10-mm classes ranging from 150 mm to 250 mm, with 10 females from each 10-mm size class. In the laboratory, we measured total length (mm) and took 3 scales for age determination from each specimen. Ovary sections were removed and placed in jars containing Bouin's Fixative (75 mls saturated picric acid: 25 mls formal: glacial acetic acid). The ovaries were stored in the Bouin's fixative for at least 3-4 days. During this period the individual eggs (or oocytes), which are generally not distinguishable to the naked eye, hardened. Subsequent sectioning and crushing the ovaries dispersed the individual eggs into a shallow petri dish. Using an ocular micrometer on a dissecting microscope, 10 oocytes were measured from each female. Generally two size classes of oocytes were present: a large group composed of 'vitellogenic' or maturing oocytes and a small size group consisting only of non-vitellogenic or immature (or resting) oocytes. From previous work we determined that oocytes > 170 μm are vitellogenic (Hay *et al.* 1987). Usually the distinction between maturing and non-maturing eggs was immediately apparent, and when there were two obvious size classes of eggs, the diameters were measured from the largest size group. When the distinction was not apparent, we measured the eggs at random. This allowed an estimate of the progress of the maturation process according to oocyte size.

(ii) Analyses by GSI and the Hjort Maturity Index analyses

For all these analyses subsets of the catch sampling database were extracted and imported into Minitab© statistical software. A geo-referenced data file was linked to the resultant maturity data, which permitted geographic grouping by stock assessment region.

Since 1982, gonads have been weighed as part of the routine herring sample analyses although some gonad weights were included in some samples from 1972-1974. When ovary weights exceed 5% of total body weight (defined as a gonosomatic index or 'GSI' > 5) sexual maturation has started. This criterion is based on results of Hay and Outram (1981) and (Hay 1985) that showed that the GSI begins to increase in the fall, but that it is size dependent: bigger fish have slightly higher GSI's. Samples collected in

August and September have low mean GSI values, of 2 or 3. After October, the GSI starts to increase. For the present study we used a GSI of 5 as a criterion of sexual maturation.

The Hjort Maturity scale defines stages 3 as a 'developing gonad' although the least developed of stage 3 may be hard to differentiate from an immature fish. (See Appendix Table 1 for full definitions). Stage 4 represents a gonad where sexual maturation has clearly started. Stage 4 (developing), 5 (sexually ripe), 6 (spawning or running gametes) and 7 (recently spent) are all stages that reflect sexual maturation. We used Hjort stages of 4-7 as the criterion for sexual maturation for all samples. For each area, we calculated the percentage of herring at each Hjort maturity stage.

Three separate analyses are shown, based on the Hjort and GSI criteria. All analyses are confined to the PRD and QCI assessment areas, as these are the two assessment areas where recruitment appears to be incomplete at age 3. A combined Hjort-GSI analyses considered females with a GSI of less than 5 percent *and* with a maturity scale of between 0 and 4 (pre-spawning maturity stages) to be *not* maturing. All other fish were considered to be maturing that season or in a spent or recovering condition.

(a) Hjort maturity analysis: estimated the percent mature by age based only on the Hjort maturity index on pooled samples from 1983-1997 for PRD and QCI.
(b) GSI analysis: estimated the percent mature by age based only on the GSI (>5) on pooled samples from 1983-1997 for PRD and QCI.
(c) Hjort and GSI time series estimated the percent mature by age and year, for females only, for (a) the North coast (combined PRD, QCI and CC) and the South coast (combined SOG and WCVI). Maturity was based on a combined criteria of the Hjort index (stages 4-7) and GSI (>5).

During our analysesof data for this working paper, we encountered a small but important procedural problem in the recording of gonad weight data. During the analyses of samples in the laboratory, some herring ovaries are not weighed because they were considered too small to obtain accurate or meaningful weights so their weight are left blank. This is a procedural error in the catch-sampling data collection, because in effect, such ovaries are indeed assessed and their weights were assigned to a category that was lower than the resolution of the balance. They are not 'blanks' or missing, as is indicated in the records. These gonad weights should have been designated with a small nominal weight, or with a 'zero' weight to distinguish them from samples where no ovary weights were taken. For the present analyses, we applied a correction, using a crosstab query, to determine, by sample. By convention, within the analyses of individual samples (usually 100 fish each) gonad weights were recorded for either (i) all fish in the samples or (ii) no fish. Therefore, in those samples where some gonad weights were weight and some were not, blank gonad weights represent gonads whose weight (i.e. < 1 gm) were too small to register on a balance. Therefore, for all samples where some gonad weights had been recorded, we converted 'missing weights' in samples to a zero weight. In effect, this conversion, relative to the stated objectives of this paper, is conservative, because the inclusion of 'zero' weights, will have the effect of adding more decreasing GSI estimates. We caution, however, that for any future analysis of gonad weights, this correction must be applied.

Potential for sample bias

If the samples of the catches do not represent the whole spawning population, or are taken disproportionately in time of space, then there may be a potential for bias in the samples. To examine the

potential for this we first examined the percent at age data within the PRD and QCI assessment areas for individual years to determine the consistency of the pattern with time. Then we compared the age composition from statistical areas from within assessment areas. If herring of different ages tend to spawn in some areas preferentially, then a concentration of samples from one area could give a mis-leading result. Finally, on a subset of the data, we examined the temporal pattern of sampling relative to the timing of spawning, to determine how the sampling was distributed in time.

Results and Discussion

Percent at age data

The percent at age data for each of the 5 major assessment areas are shown in Fig. 3a-e. Within each figure we distinguish between fish captured during 3 periods: (i) January-April (ii); May-September and (iii) October-December. In general, the percent at age data in the fall over-wintering period (October-December) match those of the pre-spawning period (January-April). The percent at age data show that age 3 appears to be the most frequent age class in the WCVI and SOG assessment areas. In the PRD and QCI areas, however, age 4 appears to be the most frequent age class, but the CC is intermediate, with age 4 fish being the most frequent during the spawning period and age 3 during the fall. In general, the percent at age data for the PRD and QCI areas indicate that some age 3 fish are not represented in these samples. What these composite percent at age data do not show, however, is that in many years the numbers of age 3 fish dominate the catches (this can be verified by reference to age frequency data in Appendix Tables 2-3 which show the percentage and numbers at age, from 1950 to 1997 for the CC and PRD). Therefore, the percent at age data shown in Fig. 3 do not represent a static condition because in over half of the years the frequency of age 3 fish exceed that of age 4 or older fish.

Analyses of Maturity

(i) Histological analyses of ovaries

The criterion of maturation based on a presence of oocytes >170 µm, was simple to implement. Using this criterion, there were almost no cases where the classification of a fish into a 'mature' or 'immature' class was uncertain. If vitellogenic oocytes were present, they were usually abundant. Oocyte diameters were assessed from a total of 729 fish in September, 1982 and 475 in November, 1983 (Tables 1-2). The distribution of oocyte diameters from these samples (Fig. 4a-b) shows the distinction between non-vitellogenic and vitellogenic oocytes. The maximal size range was much greater in the November samples, showing that the fall period (Sept.- Nov.) is a period of rapid oocyte growth. The age-specific maturity ogive (the proportion of females maturing in age class) based on oocyte diameter shows that most age 3 fish were maturing (Fig. 5a-b) both in September, 1982 and November, 1983. The proportion is higher in November samples because the oocyte size distinction was not as clear in the earlier September samples, so some fish that might have been maturing were incorrectly classified as immature. Similarly, the size-specific maturity ogive (the proportion of females maturing in each 5 mm size group) shows a gradually

increasing proportion of mature fish at lengths beginning at 150 mm, with nearly all fish maturing (>90%) at sizes > 200 mm (Figs. 6a-b). The age-specific ogives indicate that by November, about 95% of age 3 fish and all fish age 4 and greater were maturing. The size-specific ogives for the same fish indicate that about 80-90% of fish between from 16-18 cm are maturing, and virtually all fish > 18 cm are maturing.

Temporal changes in egg diameters

A year-round study of herring ovary histology from SOG tracked annual changes in oocyte diameter (Hay and Outram 1981, Hay 1985). During July and August, developing (vitellogenic) eggs could not be distinguished from the resting or non-vitellogenic. Beginning in September there was a clear separation of the two size groups in most individuals. After September, the vitellogenic oocytes increased rapidly in size to a mean of about 700µ in March. This physiological process is described in detail by Gillis *et al*. (1990a, 1990b). Prior to release in spawning, the oocytes increase in size by taking in water. When released they are about 1.0-1.2 mm in diameter. Based on this analysis, early summer is too early to distinguish between maturing and non-maturing ovaries based on oocyte diameter. By September, two groups of egg sizes were clearly separable, with the maximum diameter of the resting oocytes staying around 150 µ or less. Therefore, diameters >170µ would be indicative of a maturing female. These size ranges were confirmed in later studies of egg development from offshore samples (Hay *et al*. 1987) where 50 egg measurements were made at random from histological sections of ovaries from about 35 females. There were two size classes in September, 1980: small oocytes (30 to 150 microns) and a larger size group ranging from about 150 to 500 microns. In November, 1980 the smaller group remained but the larger group increased its upper range to 700 µ. Therefore, developing oocytes grew rapidly while resting eggs stayed at approximately the same size.

(ii) The Hjort Index and GSI analysis

(a) Hjort stage analyses: 1983-1997

PRD: Based on the analysis of 40,888 females and 40,817 males, collected by all types of fishing gear over all seasons, the proportion of age 3 females at Hjort stages 4-7 is 93.94% and the proportion for males is 97.61% (Table 3). The estimated proportion of immature individuals of unknown sex is much higher (>84%) but there are relatively few individuals (547), less than 0.7% of the total numbered samples.
QCI: Based on the analysis of 61,952 females and 57,144 males, collected by all types of fishing gear over all seasons, the proportion of age 3 females at Hjort stages 4-7 is 98.72% and the proportion for males is 99.25% (Table 4). The estimated proportion of immature individuals of unknown sex is much higher (>92%) but there are relatively few individuals (687), less than 0.6% of the total numbered samples.

(b) GSI analyses: 1983-1997

PRD: Based on the analysis of 39,072 females and 38,944 males, collected by all types of fishing gear over all seasons, the proportion of age 3 females with a GSI > 5 is 97.76% and the proportion for males is 97.32% (Table 5a-b). There were only 10 individuals of unknown sex.

QCI: Based on the analysis of 61,042 females and 56,166 males, collected by all types of fishing gear over all seasons, the proportion of age 3 females with a GSI > 5 is 99.5% and the proportion for males is 99.24% (Table 6a-b). There were only 16 individuals of unknown sex.

The explanation for the small difference in total numbers, between the Hjort and GSI analyses is that some of the samples were collected during the summer months when gonads were small and sexes could not necessarily be identified. For some samples, fish had an estimate of the Hjort maturity index, but no gonad weight. Therefore, no GSI could be calculated. This explains the slightly lower numbers sampled for GSI analysis as compared to the Hjort analysis.

(c) Combined GSI and Hjort time series analysis for female maturity

In nearly all years the proportion of age 3 females defined as maturing is about 95% or higher, both for the combined northcoast (Table 7a) and southcoast areas (Table 7b). The numbers of individual females examined for each year are shown in Tables 8a and 8b. Note that this analysis extends back to 1972, although data for a few years are missing. There is an apparent exception in the years 1980 and 1981, in both coastal areas, where the rates appear lower. These lower maturation rates, however, apply to *all* age groups (not just age 3) and we believe that they represent an error in the database, for gonad weights, for these two years, and perhaps some of 1979. For all age groups in these years, the recorded gonad weight is very low, and we suspect that these are erroneous, perhaps something other than gonad weights. Specifically, it appears that for most samples, the data recorded as 'gonad weight' is really something else, because all other data appears normal, including the Hjort maturity index. We attempted to resolve this error by examining the original paper records, but this has proved to be an enormous task, as they are stored in the archives. We did examine the archive material corresponding to these years (1980 and 1981) and found most of the data sheets, but the data we found had no recorded gonad weights. In the database, the samples with the abnormally low gonad weights contained both sample numbers (including 'internal samples numbers') which could not be matched with the paper records. The resolution of this problem will require a complete search of the archived data, but this will require a substantial effort. In fact, this effort is underway, in support of related work, but the results will not be available in time to resolve this question for this report. Instead, we use this opportunity to point out this problem as a notice to any future users of this aspect of the database – and indeed, in case anyone should care to attempt to reproduce these results. For the purposes of this report, we advise readers that the estimated maturity rates at age apply to all years except 1980 and 1981.

The maturity rate of age 3 females was 97.8% (n = 29,384) for north coast samples and 94.6% (n = 51,797) for south coast samples. An important point to note is the *lower* maturity rates of the younger, age 2 (or 24 months) fish, with maturity rates of 76.3% in the north and 82.6% in the south. Although these estimates seem high, they also show that there are a number of immature age 2 fish captured in the samples. Therefore, if the 'age 3 immature hypothesis' were correct, then should we not expect to see at least *some* immature age 3 herring – or least more than the 2% estimated in Table 3.

Potential for sample bias

(i) Sampling times versus spawning times

In general, the sample collection precedes spawning (Table 9). This is especially true for the period from 1951 to 1965, during the reduction fishing era. During the roe fishery, the collection of samples occurs mainly in March, but in general, much of the spawn occurs in April, and some in May. In some years, however, the collection of samples matches that of spawning quite closely, especially since 1988. Therefore, even if some of the sampling ended before spawning, it is probable that some of the last spawning fish would be vulnerable to the nets. In the years of the reduction fishery, nearly all of the catches were taken prior to spawning. Even then, however, there were years with relatively low numbers of age 3 herring in the catches (Taylor, 1964). Therefore, although there may be some differences between the times of catches and the times of spawning, this may not provide a full or satisfactory explanation for the differences between the maturity data (indicating nearly complete sexual maturity of age 3 fish) and the percent at age data that indicate incomplete recruitment of age 3 fish.

(ii) Area-specific differences in size and age

Another possibility is that size and age composition may differ among areas within the northern assessment areas. This is confirmed by a comparison (ANOVA) of sizes among the 3 Statistical Areas in the PRD. Comparisons are made by single years (from 1992-1996) and all years pooled (1947-1997) in Appendix Table 4. All comparisons show highly significant differences among Statistical Areas . For these comparisons, we limited the data to those collected by purse seiners during the months from January to (the end of) May. This reduces the potential size-selective effect of gillnets. Similar comparisons of age composition were made using Chi-square analyses (Appendix Table 6) using data from 1983 to 1997, and 5 individual years (1992-1996). All comparisons show highly significant differences in age composition among areas (Appendix Table 5). Therefore, it is possible that there may some segregation by size, or age among spawning areas. The likelihood that this occurs is seen in Table 10, which contrasts the annual percentage of age 3 and age 4 fish, by year from 1950 to 1997, among Statistical Areas 3-5. In some years there are substantial differences between these relative frequencies, with much higher frequencies of age 4 fish than age 3 fish. In other years, the reverse occurs. The purpose of these analyses, however, is not to describe these temporal or area-specific variations in size or age. Rather, we only want to point out that geographic variation in the size and age structure of herring may result in some sampling error, so it seems probable that samples from a fishery may not represent the population at large. This is not necessarily surprising or profound. It would not be a surprise if there were some form of lateral stratification of herring by size or age on the spawning grounds. Vertical stratification of size in schools is well known. Further, the later spawning of smaller younger herring has been established in several studies (Hay 1985). With respect to the purposes of this paper, however, if non-random sampling occurs in the PRD, it may also be a concern for other areas of the BC coast. Therefore, the kinds of variation that we see in the PRD probably may not be unique and therefore does not necessarily provide a basis for resolving the discrepancies between the percent at age data and the maturity data.

Synopsis: a review of the results in the context of herring life history

It is well known that there are distinct schools of herring juveniles in all areas of the BC coast (Hourston 1957). At some point juveniles grow and join the sexual mature population - and for most fish, this occurs around the third year of life. Some individuals must join the adult stock in the fall of their third year of life, when they are approximately 30 months of age. Other fish may join later, after spawning and after March of their third year of life when they are about 36 months of age. To our knowledge, there have been no documented examples of immature age 3 herring taken during the late maturation period. Therefore, based on the evidence presented in this paper we conclude that nearly all herring mature by age 3. The only basis for assuming the 'age 3 immature hypothesis' is the structure of the northern catch composition or percent at age data – specifically that the proportions of age 3 fish is lower than that of older age groups. This observation, however, is not evidence of the 'age 3 immature hypothesis'. Rather it is an observation that generated the hypothesis – and we are not aware of any evidence that supports this hypothesis. By this assertion, we do not mean to imply that the structure of the percent at age data for northern assessment areas are incorrect. On the contrary, the patterns seen in Fig. 3 were recognized over 30 years ago (Taylor 1964). We do point out, however, that the composite percent at age data based on many years of data would change if examined by individual years. For most years, the frequency of age 3 fish exceeds that of older groups.

We briefly reviewed some data to examine the potential for systematic bias in catch sampling in the PRD assessment area. While there is evidence that the samples may not be fully representative of the spawning populations at large, we found nothing to indicate that these would result in a systemic sampling bias that would affect the PRD region differently than other regions.

There are other potential explanations for this apparent under-representation of age 3 fish, but these apply equally to all parts of the BC coast, not just the northern regions. For instance, the roe-fishery, is size selective. This is known for gillnets (Hay et al. 1986) but it also may occur with purse seines. Selectivity in favour of larger, older fish, could occur because these are the most desirable for the fishery but such selection would occur throughout the coast and not just in the northern assessment areas. Also, there is evidence of spatial and temporal segregation between older, repeat spawning herring and 'recruits' spawning for the first time. We know that late-spawning herring usually are smaller (Hay 1985). It follows that the spawning times and even spawning locations may vary, as a function of the size and age of spawning herring. While there is some evidence that this occurs in the PRD, the trend of later spawning of smaller fish occurs throughout the coast. Therefore, spatial and temporal segregation of spawning groups does not provide a satisfactory explanation for both the percent at age data and the observations on the age of recruitment.

A review of the hypotheses and explanations

There is another explanation for this issue however, that invokes a hypothesis of episodic movements of herring among different areas of the coast, and specifically a tendency for young herring to move north. This suggestion is based on the observation that there are periods when there is a movement or migration of tagged herring from the Central coast (and other areas) to the PRD. There also are years

when there are movements of herring among other areas, particularly from Johnstone Strait to the CC. Such episodic migration would provide a satisfactory answer to the puzzle or contradiction between the age composition data in catches (sometimes low frequency of age 3 fish) and the age-of-maturity analyses (most age 3 fish are mature) that is the subject of this paper. The movement of young fish to the north would periodically inflate the frequency of age 4 and older herring in the PRD and QCI regions, resulting in the catch composition patterns shown in Fig. 3. Probably such movements would be episodic, so that during years when few fish moved north, the tendency for high frequencies of age 3 spawning fish would occur – and we see that age 3 fish exceed the numbers of age 4 fish in over half of the years in the data set. Such movements eliminate the necessity for the assumption that there are large groups of immature herring, mainly of age 3, that are not vulnerable to the fishing gear. This 'age 3 immature hypothesis' has no supporting evidence. No samples showing high frequency of immature fish exist in the database. There is no corroboration of this assumption in the scientific literature on Pacific herring. The suggestion that relatively large abundance of immature fish could elude fishing gear is untenable when viewed in the context of the collapse of herring stocks in the 1960's. During that time, few herring escaped the fishery, mature or otherwise. Therefore, if there were large bodies of immature herring, it is inconceivable that they would not be taken frequently.

For the purposes of argument, if we were to suppose that there were large numbers of immature age 3 herring somewhere, then why would we not see even a *few* in the samples, especially when we routinely see a varying frequency of immature ***age 2*** herring? Why would more immature age 2 herring be vulnerable to fishing gear and not the older, larger cohort of age 3 herring? The answer, we suggest, is that there are no large concentrations of immature age 3 herring.

Assumptions about the age of recruitment and risk-averse management

There is an important question about the assumption of the 'age 3 immature hypothesis' as it is applied in the assessment models. That is, is the effect of the assumption in 'age 3 immature hypothesis' pre-cautionary and risk-averse? We suggest that it is neither. The assumption demands that there is a biomass of immature fish that is not encountered by the fishery and this assumed biomass could be substantial, given the vulnerability coefficients or lambda (λ) values in the annual reports. These suggest that perhaps more than 50% of the age 3 cohort, as well as large parts of older cohorts are unavailable for capture. The assumption of 'invulnerability' *per se* is not be a problem unless it is also assumed that these invulnerable fish do not spawn – because they are immature. If so, we suggest this assumption is wrong and will lead to misleading (inflated?) biomass estimates. If so, the assumption of the 'age 3 immature hypothesis' is neither precautionary nor risk-averse.

Recommendations

(1.) Annual herring assessments should not assume that age 3 herring are sexually immature. This also applies to the assumptions about partial maturity of other cohorts, particularly ages 4 and 5. The suggestion that this assumption be changed, however, does not necessarily argue that all cohorts are equally vulnerable to fishing gear, only that nearly all herring of age 3 and older are sexually mature.

(2.) Annual assessments should consider the possibility that there could be periods of episodic migrations among different assessment regions, particularly in the form of period movements of younger fish from the CC and to the PRD.

References

Gillis, D.J., B.A. McKeown, and D.E. Hay. 1990a. Ultrastructural observations on the ovary and eggs, and the development of egg adhesion in Pacific herring *(Clupea harengus pallasi*). Can. J. Fish. Aquat. Sci. 47: 1495-1504.

Gillis, D.J., B.A. McKeown, and D.E. Hay. 1990b. Physiological and histological aspects of late oocyte provisioning, ovulation, and fertilization in Pacific herring *(Clupea harengus pallasi*). Can. J. Fish. Aquat. Sci. 47: 1505-1512.

Hay, D. E. 1985. Reproductive biology of Pacific herring (*Clupea harengus pallasi*). Can. J. Fish. Aquat. Sci.42(Supplement 1):111-126.

Hay, D.E., Cooke, K.D. and C.V. Gissing. 1986. Experimental studies of Pacific herring gillnets. Fish. Res. 4:191-211.

Hay, D.E. and A.R. Kronlund. 1987. Factors affecting the distribution, abundance, and measurement of Pacific herring (*Clupea harengus pallasi*) spawn. Can. J. Fish. Aquat. Sci.44: 1181-1194.

Hay, D.E. and P.B. McCarter. 1998. Distribution and timing of herring spawning in British Columbia. Canadian Stock Assessment Secretariat Research Document 99/14. 44pp

Hay, D.E. and Outram, D.N. 1981. Assessing and monitoring maturity and gonad development in Pacific herring. Can. Tech. Rep. Fish. Aquat. Sci. 998: 31 p.

Hay, D.E., D.N. Outram, B.A. McKeown, and M. Hurlburt. 1987. Ovarian development and oocyte diameter as maturation criteria in Pacific herring (*Clupea harengus pallasi*). Can. J. Fish. Aquat. Sci. 44: 1496-1502.

Hay, D.E. , P.B. McCarter and K. Daniel. Pacific herring tagging from 1936-1992: a re-evaluation of homing based on additional data. 1999. Canadian Stock Assessment Secretariat Research Document 99/176.

Hourston, A.S. 1957. Investigation of the juvenile herring stocks in the Strait of Georgia region, 1956. Fisheries Research Board of Canada, Biological Station, Nanaimo, B.C. MS. Report No. BQ118: 59 p.

Hourston, A,S, and D.C. Miller. 1980. Procedures for sampling herring at the Pacific Biological Station. Can. MS Rep. Fish. Aquat. Sci. 1554: 23p.

Ricker, W.E. 1958. Handbook of computations for biological statistics of fish populations. Bull. 119. Fish. Res. Bd. Canada. 300p.

Schweigert et al. 1998. Stock assessments for British Columbia herring in 1998 and forecasts of the potential catch in 1999. Canadian Stock Assessment Secretariat Research Document 99/21.

Taylor, F.H.C., 1964. Life history and present status of British Columbia herring stocks. Bull. Fish. Res. Bd. Canada 143. 81 p.

Table 1. Maturity by age. Maturity samples from all locations sampled in September 1982, pooled for this analysis. Total numbers are less than those of Table 2 because some fish that were measured for length could not be aged.

Age	Immature	Mature	Total	Percent Mature
2	68	17	85	25.0
3	24	198	222	89.2
4	11	126	137	92.0
5	4	55	59	93.2
6	4	118	122	96.7
7	3	24	27	88.8
8	2	30	32	93.7
9	1	12	13	91.9
10	3	29	32	91.4
Total	120	609	729	83.5

Table 2. Maturation by age (percentage in italics) of 475 herring collected from Georgia Strait and the North coast in November, 1983.

Age	Immature	Mature	Total	Percent Mature
2	77	43	120	35.8
3	10	164	174	94.3
4	0	76	76	100.0
5	0	27	27	100.0
6	0	14	14	100.0
7	0	43	43	100.0
8	0	11	11	100.0
9	0	11	11	100.0
All	87	369	476	80.8

Table 3. Percentage by age for each Hjort maturity stage for the **PRD** assessment area. The numbers show all fish taken by all fishing gears for all months for the years 1983 to 1996. Most of the samples were collected in March and April. Stage '0' was used infrequently and is equivalent to stage 1. For each sex, the total percentage of immature fish is shown as stages 1-3, above the line. The total percentage of age 3 fish is shown in bold underlined Italics, between ages 3 and 4. The total numbers of individuals included in each category in shown in bold Italics in row 'n'. The proportion of individuals in category 8 was very low, and ignored for the purposes of this analysis. All ages of 10 and above were pooled as age 10.

Age

Females

Hjort	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**All**
0	--	--	--	--	--	--	--	--	--	--	--
1	87.50	27.69	0.12	--	0.01	--	--	--	--	--	0.52
2	12.50	36.44	1.09	0.82	0.74	0.43	0.56	0.45	0.85	1.00	1.35
3	--	5.74	4.83	4.39	4.64	3.54	3.96	3.89	5.19	8.36	4.36
			6.04								
4	--	7.03	16.04	14.46	11.10	10.18	7.08	5.66	4.95	4.35	11.68
5	--	20.09	71.22	75.35	78.77	79.08	83.25	84.49	83.94	79.26	76.45
6	--	2.30	5.40	4.23	3.90	5.17	3.55	3.13	3.14	4.35	4.40
7	--	0.72	1.27	0.72	0.83	1.58	1.57	2.37	1.81	2.68	1.22
8	--	--	0.02	0.02	0.01	0.03	0.02	--	0.12	--	0.02
All	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
n	***8***	***697***	***8050***	***8561***	***8414***	***7915***	***4137***	***1979***	***828***	***299***	***40888***

Males

Hjort	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**All**
0	--	--	--	--	--	0.01	--	--	--	0.28	0.00
1	50.00	15.53	0.09	0.02	0.03	0.01	--	--	--	--	0.32
2	16.67	16.76	0.57	0.50	0.90	0.69	0.78	0.61	1.35	1.94	0.99
3	--	5.99	1.70	1.94	2.25	1.81	2.06	2.57	3.11	9.17	2.13
			2.36								
4	--	11.85	14.43	10.12	9.29	7.61	5.35	4.82	8.18	9.44	9.60
5	33.33	38.83	61.46	67.97	64.66	61.90	58.47	58.09	56.11	7.50	62.26
6	--	9.54	19.28	18.32	21.85	26.00	31.15	30.73	28.16	35.83	22.83
7	--	1.50	2.43	1.08	1.01	1.96	2.15	2.99	3.11	5.83	1.83
8	--	--	0.03	0.05	0.01	--	0.05	0.19	--	--	0.03
All	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
n	***6***	***734***	***8585***	***8421***	***7743***	***7636***	***4228***	***2138***	***966***	***360***	***40817***

SEX UNKNOWN

Hjort	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**All**
0	24.55	25.59	36.84	36.36	25.00	--	--	--	--	--	26.14
1	75.45	59.37	7.89	18.18	50.00	--	--	25.00	--	--	57.77
2	--	13.72	36.84	27.27	--	--	--	--	--	--	12.61
3	--	0.79	2.63	9.09	--	--	--	25.00	--	--	1.10
			84.20								
4	--	--	--	--	--	--	--	--	--	--	--
5	--	--	2.63	9.09	--	--	100.00	50.00	--	--	0.91
6	--	--	--	--	--	--	--	--	--	--	--
7	--	0.53	13.16	--	25.00	--	--	--	--	--	1.46
8	--	--	--	--	--	--	--	--	--	--	--

All	100.00	100.00	100.00	100.00	100.00	--	100.00	100.00	--	--	100.00
n	***110***	***379***	***38***	***11***	***4***	***0***	***1***	***4***	***0***	***0***	***547***

Table 4. Percentage by age for each Hjort maturity stage for the **QCI** assessment area. The numbers show all fish taken by all fishing gears for all months for the years 1983 to 1996. Most of the samples were collected in March and April. Stage '0' was used infrequently and is equivalent to stage 1. For each sex, the total percentage of immature fish is shown as stages 1-3, above the line. The total percentage of immature age 3 fish is shown in bold Italics, with an asterisk, between ages 3 and 4. The total numbers of individuals included in each category in shown in bold Italics in row 'n'. The proportion of individuals in category 8 was very low, and ignored for the purposes of this analysis. All ages of 10 and above were pooled as age 10.

Age

Females

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**All**
Hjort											
0	--	--	--	--	--	--	0.02	--	--	--	0.00
1	--	0.46	0.02	0.01	0.01	0.02	--	--	--	--	0.02
2	100.00	14.61	0.30	0.02	0.03	--	0.02	--	--	--	0.38
3	--	2.94	0.73	0.40	0.38	0.37	0.44	0.40	0.72	1.40	0.53
			***1.05**								
4	--	27.82	26.02	23.25	18.16	13.10	11.73	11.55	17.23	12.73	18.89
5	--	46.37	66.87	70.86	77.25	78.53	81.64	82.55	76.50	77.48	74.21
6	--	5.80	5.14	4.91	3.56	7.06	4.40	3.80	3.66	4.34	4.96
7	--	1.78	0.68	0.49	0.59	0.93	1.74	1.56	1.83	4.06	0.92
8	--	0.23	0.23	0.06	0.03	--	0.03	0.14	0.07	--	0.08
All	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
n	***3***	***1294***	***12442***	***12595***	***11797***	***11433***	***6617***	***3524***	***1532***	***715***	***61952***

Males

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**All**
Hjort											
0	--	--	0.01	--	0.01	0.01	0.05	--	0.07	--	0.01
1	--	0.10	--	--	--	--	--	0.03	--	--	0.01
2	50.00	6.76	0.17	0.04	0.01	--	--	--	--	--	0.27
3	--	1.03	0.42	0.12	0.04	0.05	0.08	0.06	0.14	--	0.18
			***0.60**								
4	--	21.94	16.82	12.75	11.07	5.36	4.01	5.84	11.60	11.50	10.91
5	50.00	55.34	67.06	69.82	68.16	67.01	64.67	68.29	64.86	58.67	67.07
6	--	12.08	14.41	16.58	20.06	26.61	29.56	23.76	21.94	27.17	20.45
7	--	2.58	0.97	0.67	0.63	0.92	1.59	1.93	1.39	2.50	1.04
8	--	0.15	0.15	0.03	0.03	0.03	0.03	0.09	--	0.17	0.06
All	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
n	***2***	***1937***	***11917***	***11285***	***10369***	***10171***	***6153***	***3270***	***1440***	***600***	***57144***

Sex Unknown

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**All**
Hjort											
0	18.75	16.67	17.19	76.19	33.33	36.36	--	50.00	50.00	33.33	19.21
1	60.94	41.47	20.31	4.76	33.33	9.09	20.00	--	50.00	33.33	39.16
2	20.31	39.48	54.69	4.76	16.67	18.18	20.00	--	--	--	36.83

3	--	0.60	--	--	16.67	--	--	--	--	--	0.58
			92.09								
4	--	0.60	--	--	--	18.18	--	--	--	--	0.73
5	--	--	--	4.76	--	18.18	30.00	50.00	--	--	1.02
6	--	--	--	--	--	--	10.00	--	--	--	0.15
7	--	1.19	4.69	9.52	--	--	20.00	--	--	33.33	2.04
8	--	--	3.12	--	--	--	--	--	--	--	0.29
All	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
n	***64***	***504***	***64***	***21***	***6***	***11***	***10***	***2***	***2***	***3***	***687***

Table 5a. **PRD females: GSI by age**. The percentage by age for each GSI stage for the **PRD** assessment area. The numbers show all fish taken by all fishing gears for all months for the years 1983 to 1996. Most of the samples were collected in March and April. The total percentage of mature fish is shown as a GSI>5 below the line. The total percentage of immature age 3 fish is shown in bold underlined Italics, between ages 3 and 4. The total numbers of individuals included in each category is shown in bold Italics in row 'n'. All ages of 10 and above were pooled as age 10.

	AGE										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**All**
GSI											
1	--	--	0.36	0.25	0.10	0.18	0.20	0.47	0.38	1.09	0.24
2	--	2.01	0.63	0.30	0.27	0.73	0.75	1.57	1.28	1.09	0.59
3	--	4.82	0.49	0.49	0.44	0.68	0.60	0.89	1.15	1.82	0.60
4	--	4.42	0.53	0.60	0.42	0.43	0.38	0.57	0.26	2.55	0.52
5	--	3.21	0.67	0.65	0.49	0.44	0.45	0.21	0.89	1.45	0.57
			***2.68**								
6	--	1.61	0.47	0.64	0.55	0.31	0.40	0.16	0.38	--	0.47
7	--	1.20	0.44	0.42	0.57	0.23	0.35	0.10	0.64	--	0.40
8	--	1.61	0.32	0.31	0.53	0.33	0.20	0.42	0.38	0.36	0.37
9	--	1.20	0.26	0.28	0.36	0.22	0.35	0.16	0.26	--	0.28
10	--	1.20	0.16	0.24	0.23	0.23	0.23	0.37	0.13	--	0.23
11	--	2.41	0.21	0.23	0.16	0.25	0.18	0.10	0.13	--	0.21
12	--	0.80	0.40	0.11	0.21	0.16	0.25	0.16	--	--	0.21
13	--	2.41	0.44	0.20	0.10	0.16	0.13	0.10	0.38	--	0.22
14	--	2.81	0.57	0.17	0.10	0.20	0.30	0.21	0.38	--	0.27
15	--	3.21	0.62	0.23	0.21	0.20	0.18	0.10	0.26	0.36	0.30
16	--	1.20	1.20	0.34	0.18	0.26	0.25	0.10	--	--	0.44
17	--	1.61	1.55	0.55	0.39	0.30	0.35	0.57	0.13	--	0.64
18	--	4.02	2.00	0.99	0.53	0.39	0.65	0.63	0.26	1.09	0.93
19	--	4.82	3.09	1.43	0.90	0.81	0.78	0.52	0.77	1.45	1.42
20	--	6.02	4.33	2.18	1.07	1.03	1.00	0.84	1.15	1.09	1.96
21	--	8.43	5.33	3.33	2.16	1.45	1.35	1.36	1.28	1.45	2.79
22	--	6.83	7.21	4.24	2.69	2.41	1.93	2.19	2.04	1.09	3.76
23	--	7.23	8.47	6.54	3.61	3.66	3.01	3.08	3.19	2.55	5.12
24	--	6.43	10.56	7.79	5.65	4.52	4.74	4.70	3.95	3.27	6.67
25	--	6.43	10.46	9.00	6.56	6.04	6.17	5.64	5.74	6.18	7.64
26	--	2.81	10.17	10.46	8.07	8.11	7.07	6.53	7.78	5.82	8.77
27	--	3.21	8.99	10.52	9.24	9.13	9.18	8.20	8.04	11.27	9.33
28	--	3.21	7.03	10.48	11.23	10.56	12.34	10.82	10.20	8.73	10.11
29	--	1.20	5.39	9.10	10.84	11.48	11.58	10.29	8.42	13.09	9.47
30	--	0.80	3.19	6.78	9.89	10.31	9.78	11.34	10.59	9.82	8.00
31	--	1.20	2.18	4.65	8.25	8.89	8.48	10.24	10.08	8.73	6.52
32	--	0.80	1.00	3.02	6.18	6.59	6.67	7.11	6.38	5.82	4.62
33	--	--	0.69	1.87	3.54	4.01	4.26	4.49	5.74	5.45	2.87
34	--	0.40	0.32	0.87	2.30	2.98	3.16	2.61	3.32	2.55	1.85
35	--	--	0.17	0.37	1.16	1.51	1.18	1.25	2.55	0.36	0.89
36	--	--	0.04	0.20	0.44	0.59	0.55	1.25	1.15	0.73	0.40
37	--	--	0.03	0.13	0.28	0.12	0.28	0.47	0.38	0.73	0.18
38	--	--	0.01	0.01	0.05	0.09	0.25	0.05	--	--	0.06
39	--	0.40	0.01	0.01	0.02	0.03	0.05	0.10	--	--	0.03
40	--	--	--	0.02	0.01	0.01	--	--	--	--	0.01
All	--	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
n	***0***	***249***	***7735***	***8309***	***8137***	***7681***	***3988***	***1914***	***784***	***275***	***39072***

Table 5b. **PRD males: GSI by age**. The percentage by age for each GSI stage for the **PRD** assessment area. The numbers show all fish taken by all fishing gears for all months for the years 1983 to 1996. Most of the samples were collected in March and April. The total percentage of mature fish is shown as a GSI>5 below the line. The total percentage of immature age 3 fish is shown in bold underlined Italics, between ages 3 and 4. The total numbers of individuals included in each category in shown in bold Italics in row 'n'. All ages of 10 and above were pooled as age 10.

	AGE										
GSI	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**All**
1	--	--	0.48	0.23	0.16	0.39	0.42	0.34	0.66	1.84	0.35
2	--	1.26	0.97	0.28	0.27	0.43	0.62	0.98	0.87	2.15	0.57
3	--	1.68	0.34	0.25	0.33	0.38	0.25	0.39	0.55	2.76	0.36
4	--	1.05	0.22	0.22	0.18	0.34	0.27	0.49	0.44	2.15	0.29
5	--	1.47	0.23	0.22	0.22	0.31	0.30	0.44	0.22	0.92	0.28
			****2.24***								
6	--	1.68	0.24	0.27	0.20	0.26	0.42	0.39	0.44	1.53	0.30
7	--	2.94	0.46	0.32	0.11	0.34	0.32	0.34	0.55	0.92	0.36
8	--	1.47	0.52	0.53	0.35	0.31	0.30	0.20	0.66	1.23	0.43
9	--	3.98	0.58	0.39	0.41	0.26	0.54	0.29	0.55	1.23	0.48
10	--	5.66	1.05	0.66	0.33	0.43	0.40	0.78	0.98	0.92	0.69
11	50.00	8.39	1.61	0.70	0.54	0.54	0.57	0.68	0.98	1.23	0.93
12	50.00	8.60	2.23	1.13	0.81	0.69	1.24	0.83	1.53	1.23	1.32
13	--	11.53	5.14	2.04	1.23	0.96	1.39	0.83	0.98	0.61	2.29
14	--	9.22	7.03	2.97	1.84	1.82	1.46	1.47	1.53	1.53	3.19
15	--	11.53	10.31	5.34	3.19	2.34	2.85	1.91	3.06	2.76	4.98
16	--	10.27	12.54	7.44	4.62	3.64	3.27	4.06	2.84	3.99	6.56
17	--	6.50	12.26	9.12	7.16	5.65	6.01	4.60	5.03	5.83	8.04
18	--	5.45	12.27	12.26	9.06	7.77	6.81	7.19	6.45	3.07	9.68
19	--	3.35	10.61	12.19	11.48	9.55	9.93	7.49	6.34	6.75	10.45
20	--	2.10	7.66	13.20	11.54	11.23	10.32	10.32	8.52	7.98	10.60
21	--	1.05	5.59	9.97	12.15	11.43	11.46	10.27	8.63	9.20	9.75
22	--	0.42	3.47	7.92	10.51	11.38	10.57	11.64	11.04	7.36	8.57
23	--	--	1.90	5.63	8.65	9.75	9.88	9.30	10.05	9.82	6.89
24	--	--	1.09	3.13	5.94	7.69	7.52	9.49	7.98	7.36	4.99
25	--	0.42	0.55	1.69	4.11	5.36	5.00	6.41	8.85	6.44	3.38
26	--	--	0.22	0.95	2.14	2.99	3.56	3.82	4.48	2.76	1.91
27	--	--	0.12	0.49	1.23	1.89	2.03	2.20	2.40	4.29	1.14
28	--	--	0.13	0.21	0.62	0.99	1.16	1.32	1.75	--	0.61
29	--	--	0.08	0.11	0.28	0.43	0.62	0.59	0.77	1.23	0.30
30	--	--	0.04	0.07	0.18	0.23	0.22	0.49	0.33	0.61	0.16
31	--	--	--	0.02	0.09	0.14	0.17	0.24	0.22	--	0.08
32	--	--	0.02	0.05	0.01	0.01	0.05	0.05	--	--	0.03
33	--	--	--	--	0.03	0.05	--	0.10	0.11	--	0.02
34	--	--	0.01	--	--	--	0.02	--	0.11	--	0.01
35	--	--	--	--	0.01	--	--	--	0.11	--	0.01
36	--	--	--	--	0.01	--	--	--	--	--	0.00
37	--	--	--	--	--	--	0.02	0.05	--	--	0.01
38	--	--	--	--	--	--	0.02	--	--	--	0.00
39	--	--	--	--	--	--	--	--	--	0.31	0.00
40	--	--	0.01	--	--	--	--	--	--	--	0.00
All	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
N	***2***	***477***	***8253***	***8147***	***7376***	***7364***	***4040***	***2044***	***915***	***326***	***38944***

Table 6a. **QCI Females: GSI by age**. The percentage by age for each GSI stage for the **QCI** assessment area. The numbers show all fish taken by all fishing gears for all months for the years 1983 to 1996. Most of the samples were collected in March and April. For each sex, the total percentage of mature fish is shown as a GSI>5 below the line. The total percentage of immature age 3 fish is shown in bold underlined Italics, between ages 3 and 4. The total numbers of individuals included in each category is shown in bold Italics in row 'n'. All ages of 10 and above were pooled as age 10.

	AGE										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**All**
GSI											
1	--	0.09	0.06	0.09	0.06	0.08	0.15	0.26	0.86	0.29	0.11
2	--	0.74	0.14	0.11	0.18	0.12	0.38	0.40	0.33	1.30	0.21
3	--	1.11	0.15	0.06	0.06	0.08	0.15	0.06	0.20	0.72	0.12
4	--	0.65	0.06	0.06	0.03	0.07	0.08	0.17	0.13	0.14	0.08
5	--	--	0.09	0.10	0.03	0.04	0.03	0.06	0.07	0.29	0.06
			0.42								
6	--	0.56	0.20	0.06	0.10	0.04	0.06	0.12	0.07	0.43	0.11
7	--	0.56	0.13	0.14	0.09	0.07	0.12	0.14	0.46	0.43	0.13
8	--	0.28	0.13	0.09	0.07	0.08	0.15	0.09	0.20	0.58	0.11
9	--	0.74	0.11	0.11	0.05	0.07	0.20	0.14	0.20	0.14	0.12
10	--	0.83	0.22	0.08	0.06	0.09	0.17	0.03	0.13	0.14	0.13
11	--	1.85	0.15	0.10	0.09	0.12	0.09	0.12	0.13	0.14	0.14
12	--	0.93	0.17	0.13	0.14	0.10	0.09	0.06	0.13	--	0.14
13	--	2.13	0.32	0.17	0.09	0.10	0.11	0.09	0.13	0.43	0.19
14	--	1.94	0.51	0.18	0.18	0.11	0.11	0.06	0.26	0.29	0.25
15	--	3.70	0.81	0.23	0.09	0.15	0.17	0.20	0.07	0.29	0.36
16	--	4.53	1.33	0.42	0.19	0.16	0.23	0.23	0.13	0.14	0.54
17	--	5.27	2.11	0.69	0.35	0.38	0.25	0.40	0.26	0.14	0.85
18	--	5.09	2.92	1.26	0.58	0.49	0.38	0.55	0.79	0.43	1.24
19	--	8.42	3.64	1.62	0.99	0.50	0.81	0.55	0.79	0.58	1.64
20	--	6.20	5.11	2.47	1.34	1.04	0.83	0.72	0.60	0.43	2.24
21	--	7.31	6.03	3.62	2.16	1.39	1.49	1.16	1.85	1.30	3.04
22	--	8.51	7.11	4.84	2.85	2.25	1.89	1.53	1.99	1.59	3.89
23	--	8.97	7.20	5.72	4.18	3.39	2.44	2.75	3.84	3.62	4.76
24	--	7.40	8.15	7.15	5.25	4.09	3.87	3.84	4.24	3.19	5.77
25	--	6.94	9.42	7.82	6.46	5.30	4.60	5.23	5.83	3.48	6.81
26	--	4.63	9.00	8.80	7.03	5.84	5.74	5.75	6.23	5.94	7.29
27	--	4.35	8.48	8.83	7.92	7.30	6.80	6.82	7.42	7.54	7.84
28	--	2.96	7.96	9.84	9.52	8.42	8.47	8.03	8.28	8.70	8.72
29	--	1.57	6.35	9.45	9.59	9.32	9.40	10.35	8.21	9.42	8.71
30	--	0.56	4.81	8.47	10.03	10.53	10.26	9.91	9.34	10.43	8.59
31	--	0.56	2.90	6.60	9.53	10.64	10.71	11.04	8.21	9.57	7.82
32	--	0.28	1.97	4.38	7.00	8.96	9.04	9.80	8.15	8.12	6.11
33	--	0.19	1.12	2.80	5.65	7.03	7.23	7.46	7.55	8.12	4.66
34	--	0.09	0.66	1.84	3.60	5.06	5.98	5.20	6.49	5.07	3.29
35	--	0.09	0.22	0.87	2.19	3.27	3.31	3.41	2.52	3.91	1.90
36	--	--	0.14	0.52	1.09	1.73	2.45	1.79	1.72	1.74	1.09
37	--	--	0.07	0.18	0.64	0.88	0.98	0.81	1.26	0.58	0.53
38	--	--	0.07	0.07	0.38	0.49	0.52	0.32	0.60	0.14	0.28
39	--	--	0.01	0.02	0.11	0.20	0.25	0.23	0.33	--	0.11
40	--	--	--	0.02	0.06	0.01	0.02	0.12	--	--	0.02
All	--	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
n	***0***	***1081***	***12293***	***12524***	***11701***	***11264***	***6519***	***3460***	***1510***	***690***	***61042***

Table 6b. **QCI Males: GSI by age**. The percentage by age for each GSI stage for the **QCI** assessment area. The numbers show all fish taken by all fishing gears for all months for the years 1983 to 1996. Most of the samples were collected in March and April. For each sex, the total percentage of mature fish is shown as a GSI>5 below the line. The total percentage of immature age 3 fish is shown in bold underlined Italics, between ages 3 and 4. The total numbers of individuals included in each category is shown in bold Italics in row 'n'. All ages of 10 and above were pooled as age 10.

	AGE										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**All**
GSI											
1	--	--	0.14	0.13	0.08	0.03	0.15	0.16	0.28	--	0.11
2	--	1.24	0.32	0.21	0.08	0.17	0.18	0.22	0.14	0.69	0.24
3	--	0.51	0.12	0.09	0.05	0.09	0.08	0.25	0.14	0.17	0.11
4	--	0.17	0.08	0.05	0.04	0.08	0.03	0.22	--	--	0.07
5	--	0.45	0.10	0.05	0.02	0.02	0.08	0.09	0.14	0.17	0.07
			0.76								
6	--	0.39	0.11	0.05	0.04	0.02	0.15	0.06	0.14	0.34	0.08
7	--	0.79	0.15	0.06	0.07	0.08	0.18	0.22	--	--	0.13
8	--	1.13	0.19	0.05	0.07	0.05	0.17	0.31	0.35	0.17	0.15
9	--	1.63	0.20	0.07	0.11	0.08	0.21	0.22	0.14	--	0.18
10	100.00	3.21	0.51	0.19	0.12	0.26	0.17	0.19	0.35	0.52	0.36
11	--	3.89	0.95	0.29	0.29	0.28	0.31	0.22	0.28	0.34	0.54
12	--	6.37	1.55	0.38	0.23	0.38	0.55	0.50	0.78	0.69	0.83
13	--	10.65	3.31	1.00	0.53	0.66	0.63	0.50	0.49	1.03	1.56
14	--	11.39	5.13	2.12	1.02	0.94	0.84	0.91	1.13	1.38	2.39
15	--	13.19	8.42	3.58	1.59	1.41	1.32	1.62	1.62	1.89	3.73
16	--	11.89	11.10	5.83	2.99	2.37	2.03	1.56	2.12	1.38	5.20
17	--	10.26	11.31	8.46	5.30	3.94	3.65	3.09	3.46	3.10	6.73
18	--	7.84	12.34	11.28	7.47	5.19	5.62	4.34	4.59	4.48	8.37
19	--	6.37	11.56	12.74	9.28	7.96	7.24	6.96	8.33	3.96	9.69
20	--	4.45	10.72	12.27	10.82	10.28	9.25	8.90	9.68	9.64	10.47
21	--	1.80	8.00	11.47	11.83	10.80	11.00	10.40	11.51	10.84	10.27
22	--	0.79	5.63	9.64	11.38	11.24	11.19	12.59	10.03	9.81	9.47
23	--	1.07	3.44	7.91	10.46	11.41	12.44	11.56	10.81	12.39	8.66
24	--	0.17	2.29	5.13	8.46	10.48	9.27	9.65	9.96	9.47	6.80
25	--	0.17	1.25	3.05	6.89	7.63	8.13	8.15	8.33	7.92	5.12
26	--	0.06	0.46	1.76	4.72	5.98	5.50	6.28	6.29	6.20	3.54
27	--	0.11	0.32	1.06	2.85	3.54	4.26	4.40	3.95	4.65	2.29
28	--	--	0.14	0.54	1.73	2.23	2.69	3.06	1.98	2.41	1.39
29	--	--	0.06	0.20	0.68	1.25	1.12	1.53	1.27	3.27	0.67
30	--	--	0.03	0.19	0.45	0.62	0.88	1.12	1.13	1.03	0.43
31	--	--	0.02	0.05	0.23	0.29	0.33	0.34	0.21	1.55	0.18
32	--	--	0.02	0.04	0.09	0.11	0.20	0.28	0.07	0.17	0.09
33	--	--	0.01	0.02	0.03	0.04	0.03	0.03	0.14	--	0.03
34	--	--	--	0.03	0.02	0.06	0.02	0.03	--	--	0.02
35	--	--	--	--	--	--	0.03	--	0.07	--	0.01
36	--	--	--	--	--	0.02	0.02	--	--	0.17	0.01
37	--	--	--	--	--	--	0.02	0.03	--	--	0.00
38	--	--	--	--	--	0.01	--	--	--	0.17	0.00
39	--	--	--	--	--	--	--	--	0.07	--	0.00
40	--	--	--	--	--	--	0.02	--	--	--	0.00
All	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
n	***1***	***1774***	***11769***	***11176***	***10221***	***9974***	***6052***	***3202***	***1416***	***581***	***56166***

Table 7a. Hjort and GSI analyses of **North coast females** showing the proportion of each age group sexually maturing each from 1972-97. North coast samples are from the PRD, QCI and CC Assessment Areas. We believe that there is an undocumented database error in the ovary weights for all herring collected from 1979 to 1981. Data for these years are shown in Italics.

	AGE							
	1	**2**	**3**	**4**	**5**	**6**	**7+**	**All**
YEAR								
1972	--	1.0000	0.9980	0.9983	0.9973	1.0000	1.0000	0.9981
1973	--	1.0000	0.9911	1.0000	0.9983	1.0000	1.0000	0.9964
1974	--	0.9500	0.9728	0.9930	0.9891	0.9978	0.9960	0.9894
1975	--	--	--	--	--	--	--	--
1976	--	--	--	--	--	--	--	--
1977	--	--	--	--	--	--	--	--
1978	--	--	--	--	--	--	--	--
1979	--	--	--	--	--	--	--	--
1980	--	*0.7273*	*0.8032*	*0.1888*	*0.3481*	*0.2366*	*0.2105*	*0.5061*
1981	*0.0000*	*0.6826*	*0.7907*	*0.9502*	*0.9415*	*0.9352*	*0.9143*	*0.9121*
1982	--	0.6552	0.9962	1.0000	0.9998	1.0000	0.9967	0.9944
1983	--	0.4567	0.9677	0.9969	0.9958	0.9992	0.9987	0.9790
1984	0.0000	0.9888	0.9932	0.9910	0.9971	1.0000	0.9994	0.9970
1985	0.0000	0.3491	0.9692	0.9838	0.9440	0.9441	0.9755	0.9505
1986	--	0.7302	0.9872	0.9983	0.9991	0.9975	0.9992	0.9926
1987	--	0.7665	0.9387	0.9149	0.9857	0.9865	0.9731	0.9586
1988	--	0.8663	0.9953	0.9974	1.0000	1.0000	0.9985	0.9942
1989	--	0.7476	0.9945	0.9996	1.0000	0.9971	0.9987	0.9957
1990	--	0.6275	0.9838	0.9993	0.9967	0.9938	0.9921	0.9935
1991	0.0000	0.7128	0.9879	0.9859	0.9955	0.9963	0.9888	0.9875
1992	--	0.8596	0.9966	0.9988	1.0000	1.0000	0.9987	0.9964
1993	--	0.8299	0.9796	0.9955	0.9678	0.9545	0.9921	0.9854
1994	--	0.8681	0.9884	0.9814	0.9986	1.0000	0.9983	0.9948
1995	0.0000	0.9384	0.9972	0.9973	0.9989	0.9995	0.9987	0.9976
1996	1.0000	0.9703	0.9972	1.0000	1.0000	1.0000	1.0000	0.9966
1997	--	0.8800	0.9951	0.9994	0.9973	1.0000	0.9992	0.9927
All	**0.0833**	**0.7635**	**0.9786**	**0.9781**	**0.9912**	**0.9907**	**0.9871**	**0.9801**

Table 7b. Hjort and GSI analysis of **South coast females** showing the proportion of each age group sexually maturing each year from 1972-97. South coast samples are from the WCVI and SOG Assessment Areas. We believe that there is an undocumented database error in the ovary weights for all herring collected from 1979 to 1981. Data for these years are shown in Italics.

	AGE							
	1	2	3	4	5	6	7+	All
YEAR								
1972	--	0.8906	0.8919	0.9634	0.9670	0.9811	0.9886	0.9412
1973	--	1.0000	0.9718	0.9765	0.9907	0.9947	0.9915	0.9825
1974	--	0.9036	0.9415	0.9665	0.9855	0.9886	1.0000	0.9636
1975	--	--	--	--	--	--	--	--
1976	--	--	--	--	--	--	--	--
1977	--	--	--	--	--	--	--	--
1978	--	--	--	--	--	--	--	--
1979	--	*0.2500*	*0.4242*	*0.3500*	*0.3421*	*0.3871*	*0.5000*	*0.3819*
1980	--	*0.3911*	*0.4741*	*0.5491*	*0.6038*	*0.5591*	*0.4851*	*0.5024*
1981	--	*0.6346*	*0.7880*	*0.9262*	*0.9672*	*0.9226*	*0.9406*	*0.8286*
1982	--	0.8320	0.9923	0.9987	1.0000	1.0000	1.0000	0.9918
1983	--	0.9595	0.9934	0.9971	0.9994	0.9993	0.9974	0.9958
1984	0.0000	0.9455	0.9938	1.0000	0.9988	0.9953	1.0000	0.9901
1985	--	0.9093	0.9950	0.9992	1.0000	1.0000	1.0000	0.9759
1986	--	0.6456	0.9588	0.9689	0.9809	0.9809	0.9860	0.9324
1987	--	0.9095	0.8786	0.9770	0.9692	0.9511	0.9883	0.9422
1988	--	0.6660	0.9676	0.8455	0.9700	0.9523	0.9349	0.9314
1989	0.6000	0.8243	0.9136	0.9861	0.8381	0.9562	0.9021	0.9408
1990	--	0.7029	0.9559	0.9071	0.9830	0.8734	0.9745	0.9455
1991	1.0000	0.9232	0.9240	0.9819	0.9835	0.9976	0.9980	0.9688
1992	--	0.7197	0.9823	0.9611	0.9952	0.9928	1.0000	0.9747
1993	--	0.9450	0.9750	0.9938	0.9811	0.9982	1.0000	0.9840
1994	--	0.6762	0.9622	0.9709	0.9959	0.9897	0.9983	0.9680
1995	--	0.6918	0.8096	0.9703	0.9782	0.9920	0.9944	0.9316
1996	0.0476	0.9118	0.9751	0.9888	0.9958	0.9943	0.9974	0.9747
1997	1.0000	0.7727	0.9895	0.9972	0.9982	0.9968	1.0000	0.9792
All	**0.2424**	**0.8260**	**0.9461**	**0.9676**	**0.9767**	**0.9763**	**0.9820**	**0.9530**

Table 8a. Numbers of female herring used in Tables 7a for **North coast female** Hjort and GSI analyses.

	AGE							
	1	**2**	**3**	**4**	**5**	**6**	**7+**	**All**
1972	0	33	495	590	745	168	124	2155
1973	0	7	901	431	606	411	111	2467
1974	0	20	514	1143	552	456	251	2936
1975	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0
1980	0	99	879	519	135	131	209	1972
1981	1	167	387	2027	205	108	210	3105
1982	0	87	789	381	4395	261	307	6220
1983	0	300	804	1908	714	5162	765	9653
1984	1	178	1478	663	1025	1057	3482	7884
1985	7	275	1624	2217	982	1002	3222	9329
1986	0	189	941	2313	3237	803	2573	10056
1987	0	257	2056	940	1745	2151	1674	8823
1988	0	172	3814	1532	529	771	1305	8123
1989	0	103	906	4808	1213	341	771	8142
1990	0	51	986	1379	6618	1442	1133	11609
1991	1	195	1980	778	1326	4846	1697	10823
1992	0	114	3807	1612	470	657	2996	9656
1993	0	147	786	5538	1740	440	2405	11056
1994	0	91	1035	969	4886	1629	1165	9775
1995	1	146	727	1470	949	4098	1490	8881
1996	1	472	1801	350	654	399	1863	5540
1997	0	275	2674	1799	371	414	1192	6725
All	**12**	**3378**	**29384**	**33367**	**33097**	**26747**	**28945**	**154930**

Table 8b. Numbers of female herring used in Tables 7b for **South coast female** Hjort and GSI analyses.

	AGE							
	1	**2**	**3**	**4**	**5**	**6**	**7+**	**All**
1972	0	192	1721	2130	1271	265	88	5667
1973	0	15	1027	1147	1188	562	117	4056
1974	0	166	1230	1015	692	525	164	3792
1975	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0
1979	0	8	33	20	38	31	14	144
1980	0	271	983	499	260	186	134	2333
1981	0	364	1113	650	183	168	101	2579
1982	0	244	1813	1575	2014	421	924	6991
1983	0	247	2569	2415	1685	1357	784	9057
1984	3	807	2264	1498	810	645	538	6565
1985	0	1720	3027	1270	578	307	240	7142
1986	0	666	3396	1737	470	157	143	6569
1987	0	829	2462	3178	1951	511	343	9274
1988	0	515	5037	1489	1634	859	384	9918
1989	5	535	1598	4528	902	753	439	8760
1990	0	350	3081	1270	3173	474	588	8936
1991	3	651	1935	2266	909	2045	494	8303
1992	0	289	3791	1132	1259	414	1050	7935
1993	0	582	2238	2762	583	565	602	7332
1994	0	315	2431	2333	2453	583	591	8706
1995	0	490	1570	2495	1652	1499	714	8420
1996	21	1259	3332	1339	1670	878	1146	9645
1997	1	550	5146	1434	541	627	645	8944
All	**33**	**11065**	**51797**	**38182**	**25916**	**13832**	**10243**	**151068**

Table 9. Distribution of samples, by year and month relative to the distribution of spawning in the same periods in the Prince Rupert District. The spawn index is described in Hay and McCarter (1998). Discrepancies between the monthly proportion of samples and the spawn index indicate the samples may have been taken either early or late relative to spawning. Sampling was completed before spawn completion for most years. Since the 1990's however, the differences are smaller.

	Percent of sampled fish						Percent of Spawn Index				
	Jan	Feb	March	April	May	All	March	April	May	June	All
Year											
1951	94.69	5.31	--	--	--	100.0	65.00	35.00	--	--	100.0
1952	100.00	--	--	--	--	100.0	5.00	95.00	--	--	100.0
1953	69.45	30.55	--	--	--	100.0	25.00	75.00	--	--	100.0
1954	100.00	--	--	--	--	100.0	68.97	27.59	3.45	--	100.0
1955	91.48	8.52	--	--	--	100.0	51.85	48.15	--	--	100.0
1956	69.66	26.77	3.57	--	--	100.0	12.90	87.10	--	--	100.0
1957	19.97	47.53	32.50	--	--	100.0	--	93.33	6.67	--	100.0
1958	100.00	--	--	--	--	100.0	61.54	38.46	--	--	100.0
1959	27.01	69.60	3.39	--	--	100.0	10.00	90.00	--	--	100.0
1960	44.12	55.88	--	--	--	100.0	5.00	95.00	--	--	100.0
1961	44.85	45.05	10.10	--	--	100.0	21.43	78.57	--	--	100.0
1962	39.16	50.31	10.53	--	--	100.0	24.24	75.76	--	--	100.0
1963	30.25	43.57	26.19	--	--	100.0	9.52	90.48	--	--	100.0
1964	41.96	35.93	22.11	--	--	100.0	25.71	74.29	--	--	100.0
1965	44.29	53.46	2.25	--	--	100.0					100.0
1971	36.36	63.64	--	--	--	100.0	3.12	87.50	9.37	--	100.0
1972	--	--	100.00	--	--	100.0	--	70.97	16.13	12.90	100.0
1973	--	--	84.06	15.94	--	100.0	--	78.57	21.43	--	100.0
1974	--	--	64.36	35.64	--	100.0	45.83	29.17	25.00	--	100.0
1975	2.58	25.01	72.41	--	--	100.0	--	95.12	2.44	2.44	100.0
1976	--	--	100.00	--	--	100.0	--	87.74	12.26	--	100.0
1977	25.28	--	74.72	--	--	100.0	20.66	46.28	22.31	10.74	100.0
1978	5.96	--	29.52	46.33	18.19	100.0	28.75	43.75	18.75	8.75	100.0
1979	--	--	100.00	--	--	100.0	31.03	58.62	10.34	--	100.0
1980	--	--	82.86	17.14	--	100.0	30.77	65.38	3.85	--	100.0
1981	--	--	72.32	27.68	--	100.0	59.02	39.34	1.64	--	100.0
1982	--	--	100.00	--	--	100.0	67.09	32.91	--	--	100.0
1983	--	--	79.99	20.01	--	100.0	43.48	53.04	3.48	--	100.0
1984	--	--	95.11	4.89	--	100.0	38.54	55.73	5.73	--	100.0
1985	--	--	80.51	19.49	--	100.0	62.71	37.29	--	--	100.0
1986	--	--	43.06	56.94	--	100.0	0.47	98.59	0.94	--	100.0
1987	--	--	78.08	21.92	--	100.0	50.29	48.55	1.16	--	100.0
1988	--	--	38.21	61.79	--	100.0	11.76	88.24	--	--	100.0
1989	--	--	51.33	48.67	--	100.0	18.75	81.25	--	--	100.0
1990	--	--	64.52	35.48	--	100.0	78.57	21.43	--	--	100.0
1991	--	--	69.49	30.51	--	100.0	29.73	70.27	--	--	100.0
1992	--	--	100.00	--	--	100.0	64.71	35.29	--	--	100.0
1993	--	--	73.06	26.94	--	100.0	46.15	53.85	--	-	100.0
1994	--	--	52.50	47.50	--	100.0	27.27	72.73	--	-	100.0
1995	--	--	57.89	42.11	--	100.0	55.56	44.44	--	-	100.0
1996	--	--	94.12	5.88	--	100.0	39.13	60.87	--	-	100.0
1997	--	--	62.86	37.14	--	100.0	3.85	96.15	--	-	100.0

Table 10. Comparison of the frequency of age 3 and 4 herring among Statistical Areas 3-5, from years 1950-1997 within the Prince Rupert District. Years with large discrepancies are indicated in bold.

	Stat. Area 3		Stat. Area 4		Stat. Area 5	
Year	**Age 3**	**Age 4**	**Age 3**	**Age 4**	**Age 3**	**Age 4**
1950	--	--	--	--	18.96	57.83
1951	--	--	--	--	10.95	39.97
1952	--	--	--	--	13.03	33.43
1953	--	--	34.99	22.84	22.92	31.81
1954	--	--	47.88	19.11	--	--
1955	--	--	**51.84**	**11.04**	**4.86**	**70.29**
1956	--	--	57.79	10.46	17.94	9.71
1957	30.30	--	**10.81**	**41.43**	**23.19**	**37.46**
1958	**52.27**	**29.55**	**17.29**	**9.02**	**61.67**	**16.25**
1959	17.03	4.96	19.45	31.02	27.58	45.16
1960	58.89	--	38.15	14.00	--	--
1961	**25.00**	**58.33**	**47.70**	**16.24**	**47.25**	**9.89**
1962	17.04	27.41	23.54	33.02	22.34	13.60
1963	**25.36**	**20.85**	**52.33**	**14.43**	**35.93**	**18.43**
1964	24.14	22.60	66.45	9.28	40.28	29.86
1965	12.35	40.59	13.06	64.04	8.39	35.41
1971	**54.40**	**14.40**	**48.88**	**26.82**	**15.11**	**58.99**
1972	1.29	22.62	--	--	10.15	12.31
1973	33.00	4.39	47.71	7.84	--	--
1974	3.70	42.59	25.31	57.99	1.69	44.07
1975	9.32	22.46	10.31	10.01	11.56	24.84
1976	--	1.54	5.36	7.14	0.85	8.09
1977	20.25	4.14	18.98	22.97	6.32	11.78
1978	1.98	17.39	11.63	26.91	9.08	17.52
1979	27.47	10.26	33.13	13.25	35.71	8.50
1980	**74.47**	**9.43**	**60.65**	**7.22**	**24.97**	**39.90**
1981	16.17	73.53	6.18	85.04	9.95	53.51
1982	27.35	7.67	--	--	11.64	6.75
1983	26.23	17.22	7.11	14.06	20.58	15.58
1984	34.93	19.26	17.13	9.66	30.93	12.55
1985	8.39	63.43	5.44	39.34	8.43	32.14
1986	17.86	8.42	4.07	5.50	12.72	10.13
1987	32.57	11.73	19.44	6.28	35.88	13.13
1988	16.86	37.69	5.42	17.40	34.42	35.01
1989	21.53	25.17	17.85	22.54	19.36	41.84
1990	10.41	27.13	10.01	17.56	19.79	20.36
1991	35.80	6.58	19.55	7.21	47.66	11.00
1992	**11.99**	**32.21**	**17.29**	**43.19**	**45.39**	**28.49**
1993	15.23	22.92	10.66	17.06	6.22	54.12
1994	7.30	17.04	5.48	14.55	3.44	10.49
1995	23.58	13.21	9.69	5.03	12.91	5.40
1996	17.34	5.17	46.48	9.90	66.69	7.36
1997	--	--	10.90	48.99	37.14	40.98
All	**22.41**	**21.58**	**23.12**	**22.00**	**20.93**	**29.08**

Appendix Table 1. The Hjort maturity Scale for Pacific herring (from Hay, 1985).

Stage	***State of Maturity***	***Gonad Appearance***	***Description***	***Approximate Timing***
1	*Undeveloped*	*Thread-shaped*	*Virgin herring with small gonads, less than 2 mm broad. Accurate macroscopic determination of sex is not usually possible*	*Year-round for young herring, usually less than 150 mm in standard length*
2	*Starting*	*Ribbon-shaped*	*Gonads increased in breadth to 3-5 mm. Sex determination possible. Testes reddish grey colored and knife-shaped; ovaries reddish wine colored and rounder*	*Late spring and early summer*
3	*Developing*	*Tube-like*	*Gonads thickened, increased in breadth (5-15 mm) and elongated, but do not extend full length of body cavity. Ovaries red to reddish orange with granular appearance; testes reddish grey with smooth texture*	*Late summer and early fall*
4	*Maturing*	*Prominent*	*Gonads extend full length of body cavity. Ovaries reddish orange to yellow; eggs distinguishable, opaque, variable in size, and separable. Testes mostly grey and will ooze sperm when sliced. Blood vessels clearly visible in the ovary and testes walls*	*Late fall and early winter (slightly earlier in males than in females)*
5	*Mature*	*Bulging*	*No blood vessels visible in gonad walls. Ovaries gold-yellow; eggs transparent and uniform in size. Eggs can be exuded under pressure and are adhesive. Testes milk-white; milt will flow under pressure*	*Early winter for males, late winter for females*
6	*Ripe*	*Running*	*Eggs transparent. Eggs and sperm flow easily without external pressure*	*A few days prior to spawning (usually in late winter or early spring)*
7	*Spent*	*Baggy*	*Gonads slack. Ovaries may contain a few residual eggs. Testes limp and bloodshot*	*Early spring for the first few weeks following spawning*
8	*Recovering*	*Compressed*	*Gonads wine-colored and usually longer and thicker than in stage 2. Blood vessels prominent. This stage passes into stage 3, but may resemble stage 2 in the process*	*Late spring and early summer*

Appendix Table 2a. The percentage at age for samples from the Central Coast. Ages of 8 and greater were pooled as age 8. The years in which age 3 herring frequency exceeds the age 4 are indicated in bold font. The samples represent all fishing gears.

Age in years

Year	1	2	3	4	5	6	7	8	All
1950	0.17	6.53	28.82	47.17	11.35	4.79	1.10	0.06	100.00
1951	0.18	6.94	28.92	47.38	10.39	4.92	1.25	0.04	100.00
1952	1.11	5.12	19.85	29.75	37.71	4.45	1.52	0.50	100.00
1953	0.36	8.49	**51.62**	18.86	14.47	5.31	0.66	0.22	100.00
1954	0.33	7.62	34.50	48.71	6.70	1.86	0.25	0.02	100.00
1955	0.07	15.47	12.86	36.12	32.68	2.48	0.29	0.04	100.00
1956	0.02	31.26	27.31	6.31	32.23	2.54	0.31	0.02	100.00
1957	0.02	23.92	**45.76**	14.25	6.15	8.88	0.90	0.13	100.00
1958	0.35	7.38	**55.21**	28.67	5.51	1.53	1.10	0.24	100.00
1959	0.02	21.13	**34.93**	33.21	8.27	1.39	0.62	0.43	100.00
1960	0.24	61.49	**23.61**	6.26	6.16	1.91	0.20	0.15	100.00
1961	--	20.75	**40.71**	9.78	20.04	7.81	0.71	0.19	100.00
1962	--	24.18	**46.86**	16.96	2.53	7.31	2.06	0.09	100.00
1963	--	9.64	**44.72**	37.12	4.77	2.04	1.53	0.19	100.00
1964	--	11.58	**46.08**	27.25	10.94	2.96	0.89	0.30	100.00
1965	0.07	5.41	29.73	34.14	18.85	7.75	2.63	1.42	100.00
1971	0.05	22.92	**35.14**	30.01	7.74	3.25	0.69	0.20	100.00
1972	0.23	4.00	24.55	25.72	31.77	8.38	4.31	1.05	100.00
1973	--	0.97	**39.52**	19.59	19.59	15.64	3.27	1.41	100.00
1974	--	1.76	15.36	34.39	21.90	16.22	7.85	2.52	100.00
1975	0.26	1.08	30.61	25.38	28.42	9.58	3.70	0.98	100.00
1976	--	2.22	8.37	35.19	24.28	20.52	6.72	2.71	100.00
1977	--	0.59	15.66	20.68	32.12	18.57	9.27	3.10	100.00
1978	--	0.12	**15.10**	12.46	24.12	29.66	13.84	4.69	100.00
1979	1.32	19.30	**23.25**	9.21	22.81	13.60	8.77	1.75	100.00
1980	0.04	5.80	**59.33**	9.25	9.31	6.40	5.48	4.38	100.00
1981	0.01	4.71	11.64	54.99	10.80	8.98	5.18	3.68	100.00
1982	--	1.41	**12.14**	9.51	63.56	5.57	5.07	2.73	100.00
1983	--	0.40	5.34	13.33	11.30	60.35	4.99	4.30	100.00
1984	0.01	3.68	6.21	9.00	17.38	16.32	43.73	3.68	100.00
1985	--	2.15	**30.24**	7.13	8.57	14.45	14.24	23.22	100.00
1986	--	4.54	13.57	36.25	10.25	6.94	8.05	20.40	100.00
1987	--	8.09	**18.57**	12.87	32.31	6.40	4.81	16.96	100.00
1988	--	2.75	**60.88**	11.08	7.45	8.03	3.02	6.79	100.00
1989	--	1.16	5.04	69.30	11.30	5.22	4.34	3.65	100.00
1990	--	1.63	5.27	5.24	69.79	8.48	4.41	5.18	100.00
1991	0.06	3.03	**16.94**	6.26	6.98	54.84	6.78	5.11	100.00
1992	--	2.12	**50.98**	10.95	3.14	4.42	23.80	4.59	100.00
1993	--	3.31	6.37	61.52	10.09	2.36	2.89	13.47	100.00
1994	--	0.97	**17.30**	7.93	55.12	8.54	2.42	7.72	100.00
1995	0.55	1.00	5.57	21.59	9.30	49.03	6.83	6.12	100.00
1996	0.01	12.89	**18.01**	5.67	16.75	7.31	30.71	8.65	100.00
1997	--	2.23	**52.84**	15.76	3.97	7.48	5.12	12.60	100.00
All	***0.11***	***6.90***	***25.67***	***23.57***	***18.95***	***12.86***	***6.75***	***5.19***	***100.00***

Appendix Table 2b. The numbers at age for samples from the Central Coast. Ages of 8 and greater were pooled as age 8. The years in which the numbers of age 3 herring exceed the number for age 4 are indicated in bold font. The samples represent all fishing gears.

Age in years

Year	1	2	3	4	5	6	7	8	All
1950	6	225	993	1625	391	165	38	2	3445
1951	5	189	788	1291	283	134	34	1	2725
1952	58	267	1035	1551	1966	232	79	26	5214
1953	23	537	**3265**	1193	915	336	42	14	6325
1954	18	421	1906	2691	370	103	14	1	5524
1955	3	705	586	1646	1489	113	13	2	4557
1956	1	1723	**1505**	348	1776	140	17	1	5511
1957	2	2481	**4747**	1478	638	921	93	13	10373
1958	22	462	**3456**	1795	345	96	69	15	6260
1959	1	1186	**1960**	1864	464	78	35	24	5612
1960	5	1258	**483**	128	126	39	4	3	2046
1961	0	959	**1881**	452	926	361	33	9	4621
1962	0	258	**500**	181	27	78	22	1	1067
1963	0	208	**965**	801	103	44	33	4	2158
1964	0	235	**935**	553	222	60	18	6	2029
1965	2	152	836	960	530	218	74	40	2812
1971	1	465	**713**	609	157	66	14	4	2029
1972	6	103	633	663	819	216	111	27	2578
1973	0	20	811	402	402	321	67	29	2052
1974	0	55	481	1077	686	508	246	79	3132
1975	27	113	**3216**	2666	2985	1006	389	103	10505
1976	0	180	680	2859	1973	1667	546	220	8125
1977	0	19	505	667	1036	599	299	100	3225
1978	0	3	373	308	596	733	342	116	2471
1979	3	44	53	21	52	31	20	4	228
1980	2	295	**3020**	471	474	326	279	223	5090
1981	1	389	961	4542	892	742	428	304	8259
1982	0	71	**610**	478	3194	280	255	137	5025
1983	0	29	390	974	826	4411	365	314	7309
1984	1	274	463	671	1295	1216	3259	274	7453
1985	0	149	**2095**	494	594	1001	987	1609	6929
1986	0	332	992	2649	749	507	588	1491	7308
1987	0	518	**1189**	824	2069	410	308	1086	6404
1988	0	199	**4412**	803	540	582	219	492	7247
1989	0	80	348	4789	781	361	300	252	6911
1990	0	134	433	430	5729	696	362	425	8209
1991	5	244	**1365**	504	562	4418	546	412	8056
1992	0	182	**4378**	940	270	380	2044	394	8588
1993	0	323	621	6001	984	230	282	1314	9755
1994	0	93	**1651**	757	5261	815	231	737	9545
1995	62	112	623	2415	1041	5486	764	685	11188
1996	1	888	**1241**	391	1154	504	2116	596	6891
1997	0	178	**4222**	1259	317	598	409	1007	7990
All	**255**	**16758**	**62320**	**57221**	**46009**	**31228**	**16394**	**12596**	**242781**

Appendix Table 3a. The percentage at age for samples from the Prince Rupert District. Ages of 8 and greater were pooled as age 8. The years in which the numbers of age 3 herring exceed the number for age 4 are indicated in bold font. The samples represent all fishing gears.

Age in years

Year	1	2	3	4	5	6	7	8	All
1950	0.03	5.19	18.96	57.83	10.05	5.42	2.27	0.26	100.00
1951	0.09	4.42	10.95	39.97	36.69	5.80	1.63	0.45	100.00
1952	--	3.54	13.03	33.43	42.26	6.53	1.03	0.17	100.00
1953	--	0.65	**28.06**	27.99	26.07	14.63	2.11	0.49	100.00
1954	--	8.88	**47.88**	19.11	13.51	6.76	3.28	0.58	100.00
1955	--	5.35	15.37	57.04	16.54	4.53	0.82	0.34	100.00
1956	--	19.83	**50.03**	10.32	16.33	2.75	0.57	0.17	100.00
1957	--	8.50	17.63	38.52	18.80	14.11	2.02	0.42	100.00
1958	--	30.18	**39.45**	13.82	6.36	7.82	1.64	0.73	100.00
1959	--	23.65	22.07	33.37	10.09	6.51	2.86	1.45	100.00
1960	--	36.31	**38.68**	13.65	7.61	2.45	0.85	0.45	100.00
1961	--	5.88	**47.51**	16.39	20.71	6.01	2.38	1.12	100.00
1962	--	34.39	22.72	25.04	8.65	6.05	2.20	0.94	100.00
1963	--	15.00	**37.78**	17.93	20.22	5.73	2.69	0.64	100.00
1964	--	5.04	**41.10**	23.51	12.31	11.94	4.53	1.56	100.00
1965	--	4.00	10.70	46.14	12.40	11.09	10.99	4.68	100.00
1971	2.54	9.10	**44.44**	28.65	8.57	4.55	1.47	0.67	100.00
1972	--	--	5.32	17.93	64.43	5.88	3.78	2.66	100.00
1973	--	3.89	**35.37**	4.95	27.58	23.05	3.26	1.89	100.00
1974	--	0.14	15.49	51.22	9.37	19.02	4.21	0.54	100.00
1975	0.88	4.77	10.56	20.09	38.86	10.69	9.32	4.82	100.00
1976	--	--	1.09	7.51	32.32	46.73	7.99	4.36	100.00
1977	--	0.48	13.90	12.57	21.43	30.05	14.21	7.36	100.00
1978	--	1.34	8.73	18.48	18.79	19.75	18.38	14.53	100.00
1979	--	1.67	**34.68**	8.99	21.74	10.89	13.33	8.72	100.00
1980	--	1.40	29.56	36.80	9.00	8.73	7.82	6.70	100.00
1981	0.01	1.01	10.37	58.28	16.96	5.81	3.91	3.65	100.00
1982	--	6.21	18.39	7.14	63.66	2.73	1.30	0.56	100.00
1983	--	8.00	**22.03**	16.27	5.86	40.79	4.89	2.16	100.00
1984	--	2.62	**28.62**	13.36	13.07	15.02	24.87	2.43	100.00
1985	1.74	7.36	7.76	37.18	15.42	9.22	10.51	10.81	100.00
1986	--	1.41	**11.15**	8.42	47.74	12.43	5.95	12.89	100.00
1987	--	0.61	**28.28**	9.96	7.08	35.11	8.73	10.24	100.00
1988	--	0.77	25.53	32.13	6.42	12.25	16.09	6.82	100.00
1989	--	0.67	19.22	32.41	27.37	6.10	7.07	7.16	100.00
1990	--	0.86	16.14	20.41	27.25	22.25	5.28	7.81	100.00
1991	--	2.92	**36.96**	9.07	13.30	18.15	13.09	6.51	100.00
1992	--	0.59	32.55	32.59	7.10	8.55	9.97	8.64	100.00
1993	--	0.26	8.95	38.15	32.04	5.48	6.48	8.65	100.00
1994	--	0.68	4.32	12.09	45.05	25.42	5.12	7.32	100.00
1995	0.06	2.70	**12.87**	5.88	12.32	41.73	19.48	4.97	100.00
1996	--	0.93	**54.91**	8.14	3.34	7.86	15.07	9.75	100.00
1997	--	1.09	18.36	46.71	8.77	4.81	8.09	12.16	100.00
All	**0.11**	**5.05**	**21.76**	**26.02**	**19.66**	**14.25**	**7.62**	**5.54**	**100.00**

Appendix Table 3b. The numbers at age for samples from the Prince Rupert District. Ages of 8 and greater were pooled as age 8. The years in which the numbers of age 3 herring exceed the number for age 4 are indicated in bold font. The samples represent all fishing gears.

Age in years

Year	1	2	3	4	5	6	7	8	All
1950	1	183	668	2038	354	191	80	9	3524
1951	4	206	510	1862	1709	270	76	21	4658
1952	0	103	379	972	1229	190	30	5	2908
1953	0	20	**863**	861	802	450	65	15	3076
1954	0	46	**248**	99	70	35	17	3	518
1955	0	78	224	831	241	66	12	5	1457
1956	0	346	**873**	180	285	48	10	3	1745
1957	0	408	846	1848	902	677	97	20	4798
1958	0	166	**217**	76	35	43	9	4	550
1959	0	1090	1017	1538	465	300	132	67	4609
1960	0	1288	**1372**	484	270	87	30	16	3547
1961	0	178	**1438**	496	627	182	72	34	3027
1962	0	875	578	637	220	154	56	24	2544
1963	0	563	**1418**	673	759	215	101	24	3753
1964	0	149	**1215**	695	364	353	134	46	2956
1965	0	113	302	1302	350	313	310	132	2822
1971	19	68	**332**	214	64	34	11	5	747
1972	0	0	38	128	460	42	27	19	714
1973	0	37	**336**	47	262	219	31	18	950
1974	0	1	114	377	69	140	31	4	736
1975	32	173	383	729	1410	388	338	175	3628
1976	0	0	9	62	267	386	66	36	826
1977	0	14	**408**	369	629	882	417	216	2935
1978	0	39	254	538	547	575	535	423	2911
1979	0	43	**895**	232	561	281	344	225	2581
1980	0	150	3176	3955	967	938	840	720	10746
1981	1	79	815	4580	1333	457	307	287	7859
1982	0	100	**296**	115	1025	44	21	9	1610
1983	0	455	**1253**	925	333	2320	278	123	5687
1984	0	109	**1191**	556	544	625	1035	101	4161
1985	121	511	539	2582	1071	640	730	751	6945
1986	0	99	**783**	591	3352	873	418	905	7021
1987	0	44	**2044**	720	512	2538	631	740	7229
1988	0	42	1396	1757	351	670	880	373	5469
1989	0	29	832	1403	1185	264	306	310	4329
1990	0	51	953	1205	1609	1314	312	461	5905
1991	0	163	**2061**	506	742	1012	730	363	5577
1992	0	32	1770	1772	386	465	542	470	5437
1993	0	13	446	1902	1597	273	323	431	4985
1994	0	52	328	918	3422	1931	389	556	7596
1995	3	143	**681**	311	652	2209	1031	263	5293
1996	0	30	**1774**	263	108	254	487	315	3231
1997	0	37	622	1582	297	163	274	412	3387
All	**181**	**8326**	**35897**	**42931**	**32437**	**23511**	**12565**	**9139**	**164987**

Appendix Table 4. Oneway Analysis of Variance (modified output from Minitab©) and associated plots for the comparisons of length among 3 Statistical Areas (3, 4 and 5) within the PRD Region Assessment area. Comparisons are made for age and length for 6 time periods: for all years from 1946 to 1997 and for each of 5 years from 1992 to 1996.

1. All Years (1946-1997)

```
Source     DF        SS        MS        F        P
STATAREA    2    505463    252731   533.67    0.000
Error   1E+05  57467896       474
Total   1E+05  57973358

                                  Individual 95% CIs For Mean
                                  Based on Pooled StDev
Level       N      Mean     StDev  ----+---------+---------+---------+--
3       21653    193.84     25.07                        (-*-)
4       29541    190.15     22.59 (-*)
5       70159    195.08     20.25                                 (-*)
                                  ----+---------+---------+---------+--
Pooled StDev =    21.76            190.5     192.0     193.5     195.0
```

2. 1996

```
Source     DF        SS        MS        F        P
STATAREA    2      8900      4450    13.38    0.000
Error    2797    930642       333
Total    2799    939542

                                  Individual 95% CIs For Mean
                                  Based on Pooled StDev
Level       N      Mean     StDev  ---------+---------+---------+-------
3         100    186.33     20.12                (--------*--------)
4         900    177.63     19.42  (--*--)
5        1800    180.30     17.51         (-*-)
                                  ---------+---------+---------+-------
Pooled StDev =    18.24              180.0     184.0     188.0
```

3. 1995

```
Source     DF        SS        MS        F        P
STATAREA    2      5703      2852     9.36    0.000
Error    4697   1431213       305
Total    4699   1436916

                                  Individual 95% CIs For Mean
                                  Based on Pooled StDev
Level       N      Mean     StDev  -----+---------+---------+---------+-
3         400    191.77     16.49             (----------*----------)
4         500    189.93     17.15   (---------*---------)
5        3800    193.35     17.59                                 (---*---)
                                  -----+---------+---------+---------+-
Pooled StDev =    17.46             189.0     190.5     192.0     193.5
```

Appendix Table 4 Continued

4. 1994

```
Source     DF        SS        MS        F        P
STATAREA    2     29788     14894    86.90    0.000
Error    6997   1199305       171
Total    6999   1229093

                                 Individual 95% CIs For Mean
                                 Based on Pooled StDev
Level       N      Mean     StDev  ------+---------+---------+---------+
3         700    189.89     15.37   (---*----)
4         800    191.15     14.34         (----*---)
5        5500    195.54     12.58                                 (-*)
                                 ------+---------+---------+---------+
Pooled StDev =    13.09               190.0     192.0     194.0     196.0
```

5. 1993

```
Source     DF        SS        MS        F        P
STATAREA    2     13327      6664    36.14    0.000
Error    4293    791650       184
Total    4295    804977

                                 Individual 95% CIs For Mean
                                 Based on Pooled StDev
Level       N      Mean     StDev  --+---------+---------+---------+----
3         798    189.71     13.62  (------*-----)
4         798    190.00     14.84    (------*-----)
5        2700    193.50     13.17                              (--*--)
                                 --+---------+---------+---------+----
Pooled StDev =    13.58          189.0     190.5     192.0     193.5
```

6. 1992

```
Source     DF        SS        MS        F        P
STATAREA    2      8123      4061    13.65    0.000
Error    4497   1338004       298
Total    4499   1346126

                                 Individual 95% CIs For Mean
                                 Based on Pooled StDev
Level       N      Mean     StDev  ---------+---------+---------+-------
3         500    183.76     14.62  (-------*------)
4         900    187.20     16.11                    (-----*-----)
5        3100    188.08     17.95                           (--*--)
                                 ---------+---------+---------+-------
Pooled StDev =    17.25               184.0     186.0     188.0
```

Appendix Table 5. Comparison of age frequency data among 3 statistical areas within the PRD Region Assessment area. Only samples collected in March and April are included. To eliminate small cell sizes, ages from 8 and above are pooled as age 8 and ages 0 and 1 were removed from the analyses. Table (a) shows the Chi-square analyses for all years from 1983-1997, and Tables (B-F) show 5 individual years from 1992 to 1996. There are significant differences ($p<0.05$) for all comparisons. For each combination of age and statistical area, we show the percent frequency (**bold**), observed number of fish at age and expected number (*italics*). The results of the Chi-square test (in the form of edited Minitab© output) are shown in bold Italics.

(a) Years 1983-1997

AGE	STATAREA			
	3	**4**	**5**	**All**
2	**4.26**	**0.46**	**1.41**	**1.61**
	554	106	592	1252
	209.21	*368.01*	*674.78*	*1252.00*
3	**20.18**	**13.93**	**24.20**	**20.51**
	2626	3188	10159	15973
	2669.14	*4695.05*	*8608.81*	*15973.00*
4	**22.08**	**18.81**	**21.67**	**20.90**
	2873	4306	9094	16273
	2719.27	*4783.23*	*8770.50*	*16273.00*
5	**18.47**	**18.98**	**20.21**	**19.56**
	2404	4344	8481	15229
	2544.82	*4476.36*	*8207.83*	*15229.00*
6	**19.86**	**21.73**	**17.66**	**19.23**
	2585	4975	7414	14974
	2502.20	*4401.40*	*8070.39*	*14974.00*
7	**8.96**	**14.46**	**8.37**	**10.26**
	1166	3311	3512	7989
	1334.99	*2348.26*	*4305.75*	*7989.00*
8	**6.19**	**11.62**	**6.48**	**7.94**
	805	2660	2719	6184
	1033.37	*1817.70*	*3332.93*	*6184.00*
All	**100.00**	**100.00**	**100.00**	**100.00**
	13013	22890	41971	77874
	13013.00	*22890.00*	*41971.00*	*77874.00*

Chi-Square = 2864.688, DF = 12, P-Value = 0.000

Appendix Table 5 (Continued).

(B) Year 1992

AGE	STATAREA			
	3	**4**	**5**	**All**
3	**12.04**	**17.39**	**46.44**	**32.73**
	124	217	1370	1711
	337.09	*408.44*	*965.46*	*1711.00*
4	**32.33**	**43.43**	**28.37**	**32.75**
	333	542	837	1712
	337.29	*408.68*	*966.03*	*1712.00*
5	**6.02**	**7.21**	**6.44**	**6.54**
	62	90	190	342
	67.38	*81.64*	*192.98*	*342.00*
6	**15.05**	**11.30**	**5.56**	**8.80**
	155	141	164	460
	90.63	*109.81*	*259.56*	*460.00*
7	**15.83**	**10.82**	**8.03**	**10.23**
	163	135	237	535
	105.40	*127.71*	*301.88*	*535.00*
8	**18.74**	**9.86**	**5.15**	**8.95**
	193	123	152	468
	92.20	*111.72*	*264.08*	*468.00*
All	**100.00**	**100.00**	**100.00**	**100.00**
	1030	1248	2950	5228
	1030.00	*1248.00*	*2950.00*	*5228.00*

Chi-Square = 750.552, DF = 10, P-Value = 0.000

(C) Year 1993

AGE	STATAREA			
	3	**4**	**5**	**All**
3	**15.27**	**10.68**	**6.35**	**9.13**
	117	160	160	437
	69.97	*136.84*	*230.19*	*437.00*
4	**22.98**	**17.09**	**56.15**	**38.61**
	176	256	1415	1847
	295.74	*578.35*	*972.92*	*1847.00*
5	**48.30**	**39.92**	**21.98**	**31.81**
	370	598	554	1522
	243.70	*476.58*	*801.72*	*1522.00*
6	**3.39**	**6.88**	**4.17**	**4.89**
	26	103	105	234
	37.47	*73.27*	*123.26*	*234.00*
7	**4.83**	**11.28**	**4.44**	**6.65**
	37	169	112	318
	50.92	*99.57*	*167.51*	*318.00*
8	**5.22**	**14.15**	**6.90**	**8.90**
	40	212	174	426
	68.21	**133.39**	**224.40**	**426.00**
All	**100.00**	**100.00**	**100.00**	**100.00**
	766	1498	2520	4784
	766.0	1498.00	2520.00	4784.0

Chi-Square = 817.077, DF = 10, P-Value = 0.000

Appendix Table 5 (Continued).

(D) Year 1994

AGE **STATAREA**

	3	4	5	All
3	**7.40**	**5.51**	**3.46**	**4.35**
	75	73	180	328
	44.09	*57.57*	*226.35*	*328.00*
4	**17.26**	**14.65**	**10.55**	**12.17**
	175	194	549	918
	123.39	*161.11*	*633.50*	*918.00*
5	**24.75**	**23.26**	**54.99**	**45.36**
	251	308	2863	3422
	459.96	*600.57*	*2361.47*	*3422.00*
6	**33.53**	**40.48**	**20.27**	**25.60**
	340	536	1055	1931
	259.55	*338.90*	*1332.55*	*1931.00*
7	**6.90**	**6.12**	**4.57**	**5.16**
	70	81	238	389
	52.29	*68.27*	*268.44*	*389.00*
8	**10.16**	**9.97**	**6.17**	**7.37**
	103	132	321	556
	74.73	*97.58*	*383.69*	*556.00*
All	**100.00**	**100.00**	**100.00**	**100.00**
	1014	1324	5206	7544
	1014.00	*1324.00*	*5206.00*	*7544.00*

Chi-Square = 661.132, DF = 10, P-Value = 0.000

(E) Year 1995

AGE **STATAREA**

	3	4	5	All
3	**23.64**	**9.72**	**13.44**	**13.23**
	91	131	459	681
	50.94	*178.35*	*451.71*	*681.00*
4	**13.25**	**5.04**	**5.62**	**6.04**
	51	68	192	311
	23.26	*81.45*	*206.29*	*311.00*
5	**22.08**	**16.62**	**10.05**	**12.67**
	85	224	343	652
	48.77	*170.76*	*432.47*	*652.00*
6	**15.06**	**28.86**	**51.61**	**42.92**
	58	389	1762	2209
	165.24	*578.54*	*1465.23*	*2209.00*
7	**22.08**	**33.83**	**14.35**	**20.03**
	85	456	490	1031
	77.12	*270.02*	*683.86*	*1031.00*
8	**3.90**	**5.93**	**4.92**	**5.11**
	15	80	168	263
	19.67	*68.88*	*174.45*	*263.00*
All	**100.00**	**100.00**	**100.00**	**100.00**
	385	1348	3414	5147
	385.00	*1348.00*	*3414.00*	*5147.00*

Chi-Square = 521.303, DF = 10, P-Value = 0.000

Appendix Table 5 (Continued).

(F) Year 1996

AGE	STATAREA			
	3	**4**	**5**	**All**
3	**17.34**	**46.67**	**67.66**	**55.42**
	47	568	1159	1774
	150.19	*674.46*	*949.35*	*1774.00*
4	**5.17**	**9.94**	**7.47**	**8.22**
	14	121	128	263
	22.27	*99.99*	*140.74*	*263.00*
5	**4.43**	**4.77**	**2.22**	**3.37**
	12	58	38	108
	9.14	*41.06*	*57.80*	*108.00*
6	**21.40**	**11.26**	**3.44**	**7.94**
	58	137	59	254
	21.50	*96.57*	*135.93*	*254.00*
7	**26.57**	**14.30**	**14.07**	**15.21**
	72	174	241	487
	41.23	*185.15*	*260.62*	*487.00*
8	**25.09**	**13.06**	**5.14**	**9.84**
	68	159	88	315
	26.67	*119.76*	*168.57*	*315.00*
All	**100.00**	**100.00**	**100.00**	**100.00**
	271	1217	1713	3201
	271.00	*1217.00*	*1713.00*	*3201.00*

Chi-Square = 420.239, DF = 10, P-Value = 0.000