CHAPTER 3
ANALYSIS AND ASSESSMENT MADE ON THE STOCKS

3.1 Methods and Data Source employed in the Study

The study employed in the analysis and assessment of seven target fish species was conducted through the "Cohort Analysis" aiming at clarifying the current status of the stocks, for which the selection of 7 target species (Thiof, Pagre, Thiekem, Otolithe, Machoiron, Sole, Sompatt) had been made through the discussion with CRODT (at the beginning of this Report). Outline of the information and data source employed in the study, as well as the parameters estimated through preparatory data processing was summarized in the appended Table 3-1 [Synopses of Biological and Population Parameters estimated for Stock Assessment Purpose on Seven Target Stocks.].

The "cohort" referred to here means "the group of fish born in the same year". Such a group of fish is called as the "specific year-class" in the science of population dynamics. The "Cohort Analysis" is the science to clarify the state of stocks analyzing the annual change in the number of fish for each of year-classes at its [Initial Stage], (the status before reduction by natural and fishing mortality is made).

It is the same concept, therefore, to estimate the age-composition of the stocks at its [Initial Stage]. The information on age and growth pattern, relationship between body-length and body-weight, length-composition of commercial catch are therefore indispensable data to pursue the task.

3.1.1 Age Determination and Growth Parameters

The otolith, which is embedded in the inner ears in skull of fish, is generally used as aging material for growth analysis. However, it is necessary to spend a laborious time for processing to prepare for aging samples, while the number of species to be investigated is seven which is too many to be dealt within the allowable time and manpower. Under these circumstances, scale sample of fish was adopted as an alternative aging material, and each of seven species was allocated to employ aging either by otolith or by scale, then the two research personnel of the project had shared in aging works, one with otolith and the other with scale to save time and laborious works. Thus the three components of parameters (L_∞, k, t_0) of "von Bertalanffy's Growth Equation ($L_{(t)} = L_\infty$_[1-exp(-k_(t- t_0))])" had been estimated by a specifically developed FORTRAN Program being based on the data on aging results. Further more, for "Otolithe", *Pseudotolithus senegalensis*, the aging materials of both otolith and scale were collected from the same sample fish, then the assessment results obtained separately from each aging material was examined for the verification purpose.

Sample fishes of target species collected either from the catch of research vessel, ITAF DEME, or from purchased fish at fish markets, were firstly measured their body length (total or fork length) and wet weight by individual specimen, secondly opened their belly to investigate their sex and maturity, and thirdly collected their pair of otoliths and/or a few scales (in case of “Machoiron”, otoliths and the first dorsal spine instead of scales which is non existed).

The scale samples collected were mounted in a pair of slide glasses after washing and cleaning to investigate their ages by a stereomicroscope. A photomicrograph was taken for imagery of each scale samples prepared, the data on photomicrographs were transferred onto the computer storage, the transferred data were printed out by a laser-printer on a sheet of paper, then measured *radii of annuli* on the printed sheets.

The otolith samples collected were stored with individual label, then firstly mounted in a resin block, secondly cut it into a very thin slice by a otolith-cutter together with surrounding resin. The thin sliced otoliths were then investigated their ages by a stereomicroscope, finally the *radii of annuli* were measured by the imagery itself. The characteristics of the otolith by each species are specified as follows:

(1) “Machoiron”, *Arius heudelotii* (cf. Figure 3-2, a)

It is bearing a unique form with “hook-shape”. Since scale does not existe and there is very hard bone covered its head, it had been so far generally very difficult to collect otoliths from the inner ears. Under these circumstances, the imagery appeared on the cross section of the first dorsal spine had usually been selected as aging material of “Machoiron” in the past studies. However, in this particular study, an easy otolith collection method has been found by applying a steel saw on its head to cut. The otoliths of “Machoiron” are relatively large size bearing better readability on the imagery of *annuli* rather than those on spines, which had made the investigation on growth pattern much easier.

(2) “Brotula”, Brotula barbata (cf. Figure 3-2, b)

The shape of otolith is a peculiar type with a prolonged figure. Although its circular formation were of concentric circles (which might be daily marks) and could be rather clearly recognized, the contrast between their transparent and opaque zones were generally apt to be weak, which had been finally resulted in difficulties in determining their ages.

(3) “Sole”, *Cynoglossus senegalensis* (cf. Figure 3-2, c)

The shape of otolith is of an ellipse type nearly round. It is relatively thick, however, very difficult in preparing sliced sample due to fragile texture when polishing is applied. Also difficult in identifying ages due to weak contrast in transparent and opaque zones which needs the lengthy time to clarify.

(4) “Thiof”, *Epinephelus aeneus* (cf. Figure 3-2, d)

The shape of otolith is of an ellipse in orthodox type. The contrast in transparent and opaque zones is very weak resulting in spending lengthy time to identify their ages.

(5) “Thiekem”, *Galeoides decadactylus* (cf. Figure 3-2, e)

Although the shape of otolith is of an ellipse in orthodox type, it is very thin and fragile in texture, which resulted in very difficult to prepare sliced sample for aging. Also age reading is extremely difficult due to the weakness in contrast in transparent and opaque zones, for which almost no identifiable *annuli* observed.

(6) “Sompatt”, *Pomadasys jubelini* (cf. Figure 3-2, f)

The shape of otolith is of an ellipse in orthodox type. The identification of *annuli* in outer part (older ages) is rather easy to be recognized, however, is very difficult in inner part (younger stage within 1-2 years old) due to faint appearance of year rings, especially when cutting position is slightly deviated in older fish samples. It was necessary to employ careful cutting for those otoliths when preparing sliced samples.

(7) “Otolithe”, *Pseudotolithus senegalensis* (cf. Figure 3-2, g)

The shape of otolith is of square type with a peculiar feature. The decision on cutting angle was most difficult to make due to the sophisticated deformation in shape of this particular species, and very thick too. In preparation of slicing material was needed lengthy time, however, reading *annuli* was fairly easy when polished well the sliced surface of the sample with careful handling.

(8) Rouget, *Pseudupeneus prayensis* (cf. Figure 3-2, h)

The shape of otolith is of round type, and very small (about 2-3 mm) with very fragile texture especially when dried. It was unable to investigate the otolith further in detail with enough samples because the most of otolith samples had been broken during the storage and processing. It may be necessary to preserve the samples in alcoholic solutions. It was concluded, taken as a whole, that otolith was not suitable for aging material of this particular species.

(9) “Pagre”, *Sparus caeruleostictus* (cf. Figure 3-2, i)

The shape of otolith is of an ellipse in orthodox type. The characteristic of the otolith of this species was, like that of “Sompatt”, very difficult in inner part with faint identifiable nature in *annuli* while relatively clear features in outer part.

After the over-all procedure had been established with regard to the allocation of aging materials to the seven target species, and after the consultation with CRODT, it was agreed to make the general rule to manage, as; (1) “Machoiron”, which was identified to be fairly easy to employ otolith, would be selected as a training material for technology transfer on aging technique to counterparts (C/P) utilizing as many sample specimens as possible collected over one year (cf. Figure 3-3), (2) “Sompatt” and “Otolithe” would be dealt with otolith sample for about 10 large (older) specimens for each, from which the data on past growth record were obtained from the radius on *annuli* on otolith (cf. Figure 3-3), converting them into body lengths, then the parameters on growth formulae would be estimated, (3) the other four species (“Thiof”, “Pagre”, “Thiekem”, “Sole”) would be aged by scale samples and processed onto growth studies (cf. Figure 3-1). In addition, for “Otolithe” a special study was made, from which double sampling of both otolith and scale from the same sample fish were made to investigate for verification purpose on the consistency of assessment results derived from both aging materials.

All the estimated parameters on growth (L_∞, k, t_0) for the seven target species, thus obtained, are listed in the Column of “Growth” in the Table 3-1 [Synopses of Biological and Population Parameters estimated for Stock Assessment Purpose on Seven Target Stocks.], together with the kind of aging material and the number of sample specimens employed.

3.1.2 Relationship between Body Length and Body Weight, and Length Composition of Commercial Catch

The data on “Length-Weight Relationship” had been cited mostly from the past study made by CRODT, while the data lacking in the CRODT’s references had been estimated by the survey team and supplemented.

The original data on length composition of sample fish was entirely provided by the CRODT for the duration of fifteen years (1985-1999). The length composition of commercial catch was firstly estimated being based on these information and catch statistics of commercial catch, which was finally converted into the age composition of commercial catch by a “FORTRAN Program” and became the precious original data to be employed in the “Cohort Analysis”.

3.1.3 Commercial Catch Statistics

The catch statistics by each of seven target species compiled by CRODT for 33 years (1971-2003) was employed, for which the reference is given in Table 3-2 [CRODT Provided Catch Statistics of Target Species by Fisheries in Senegalese Waters for 1971-2003.]. Although the original format of the statistics was tabulated by species and by fisheries (artisanal, industrial, and foreign fisheries), the total amount of annual catch was applied here summing up all the fisheries type in the light of the purpose, analyzing by "Cohort Analysis".

3.1.4 "Cohort Analysis" on Initial Stock Numbers of Cohorts

(1) Age Composition of Commercial Catch

Estimating the age composition of commercial catch is essential task to perform the "Cohort Analysis". The age composition was estimated based on the combination of the results of growth studies (section 3.1.11 in this paper) and the length composition of commercial catch. That is, supposing the theory on "normal distribution nature of length composition by age" proposed by Tanaka (1956) be basic role, firstly establishes the "mid-point values" of theoretical lengths by age as the standard calculating measure. Dividing the distribution of length composition by the "mid-point values", the sum of frequencies existed between the neighboring two "mid-points" would represent the number of fish in respective relevant age. The two length compositions distributed beyond and before the "mid-point" would be offset in each other. The age composition of a given length composition could therefore have been approximately estimated. Under these "Working Hypothesis", the two "FORTRAN Programs" was developed for a personal computer to work out for the task, which were named "CH-Growth" and "CH-Comp" respectively.

(2) Processing of "Cohort Analysis"

The calculation procedure employed in the "Cohort Analysis" was traditional one, following so-called "Back-Calculation" (or "Count Backward Calculation"). Namely, the initial stock number ($N_{(i, t)}$) in a given year (t) for a given age (i) is estimated through estimating the fishing mortality coefficient (F) at one age younger in previous year ($F_{(i-1, t-1)}$) against the catch number in relevant tense of time ($C_{(i-1, t-1)}$). The estimation of the fishing mortality coefficient ($F_{(i-1, t-1)}$) was made through iterative calculation on the "Discriminating Function" from its initial value of tentatively given ($F_{(Tent)}$) against the initial stock number of current year ($N_{(i, t)}$) and the catch at one age younger in previous year ($C_{(i-1, t-1)}$). Once ($F_{(i-1, t-1)}$) is estimated the "Initial Stock Numbers" at one age younger in previous year ($N_{(i-1, t-1)}$) is instantly estimated. Thus all the components in the "Cohort Matrix" is completed through the "Count Backward Method". A "FORTRAN Program" named "CH-Cohort" was applied to perform the task, which was specifically developed to fulfill the task by a personal computer.

(3) Natural Mortality Coefficient (M) and Terminal Fishing Mortality Coefficient (TF)

The next important parameters to be employed in the "Cohort Analysis" are the "Natural Mortality Coefficient (M)" and the "Terminal Fishing Mortality Coefficient (TF)".

As of the "Natural Mortality Coefficient (M)", the information reported already in the past is none except for the case of "Thiof" (M=0.2). For the other target species, it was estimated being the "Thiof's" case (M=0.2) be as standard, the value by guess made arbitrarily by the research personnel had been given taking the information on the length-infinity (L_{∞}), growth coefficient (k), presumable maximal age, and anticipated stock abundance into account. Thus estimated results is listed in the Table 3-1 [Synopses of Biological and Population Parameters estimated for Stock Assessment Purpose on Seven Target Stocks.]. The values of (M) for all the target species varied in a large range of 0.20-0.40.

For the "Terminal Fishing Mortality Coefficient (TF)", (i) firstly choose the two successive ages from the estimated age composition of the catch as older as possible, (ii) secondly apparent rates of annual survival ($S_{(t)}$) are estimated for the selected 2 years data, (iii) thirdly the "Total Mortality Coefficient (Z)" is estimated from the mean value of ($S_{(t)}$) by the formula [$Z = -\ln(S)$], (iv) fourthly the "Terminal Fishing Mortality Coefficient" is decided by [TF = Z-M]. The estimated "Terminal Fishing Mortality Coefficient (TF)" for seven target species is listed in the Table 3-1 [Synopses of Biological and Population Parameters estimated for Stock Assessment Purpose on Seven Target Stocks.]. The value of TF for each stock is then consistently applied to the respective "Terminal Catch ($C_{(T, t)}$)" by age, (the catch number at oldest age), which had finally come out of the annual "Terminal Initial Stock Number ($N_{(T, t)}$)" (at oldest age) of each of target species. Thus all the indispensable components of "Cohort Analysis" (Age Composition of Commercial Catch, M, TF) was prepared for the seven target species.

(4) Age at Maturity

The information on the stage of sexual maturity gives a basis on an effective consideration on reproductive aspects when stock assessment is made by the results of "Cohort Analysis". Unfortunately however, this type of information had also been scarcely available in the past literature with the exception of "Thiof". The information on other target species is therefore supplemented arbitrarily by the research personnel, judging from the change in growth pattern of the features of aging materials. The estimated ages at each of maturity stage ("Immature", "Semi-Mature", "Full-Mature") in each of target species is summarized in the Table 3-1 [Synopses of Biological and Population Parameters estimated for Stock Assessment Purpose on Seven Target Stocks.].

3.1.5 Investigation by Annual Change in Stock Biomass

Investigation on annual change in "Stock Biomass" is employed in this study, as an indicator of annual change in total biomass. The estimation of annual total biomass was made as follows;
(i) The mean body weight by age was applied to the estimated annual "Initial Stock Numbers" by age ($N_{(i, t)}$), then the biomass by age and by year ($BM_{(i, t)}$) could have been accordingly estimated, (ii) then the annual "Lump Sum Amount of Biomass ($BM_{(i)}$)" gives an index of annual total biomass, (iii) the ratio of the annual total catch in weight by year ($CW_{(i)}$) against total biomass ($BM_{(i)}$) of the same year could be regarded as a sort of "Outward Rate of Exploitation (ROE)" in weight, for which annual change in (ROE) in weight would give us an effective indices to assess the annual catch.

3.2 Result of Assessment of respective Stock

The assessment was made by evaluating annual changes in the "Initial Stock Numbers", (stock numbers before the reduction by natural mortality and by fishing had been made), for respective target stock.

The criteria for the assessment are;

- "Lump-Sum Amount of Annual Initial Stock Numbers by Age",
- "Total Stock Numbers by Stage of Maturity" (examined by "Immature", "Semi-mature", and "Full mature"),
- "Potential Harvest of Exploitable Stock Numbers" (estimated by maximal stock numbers during the survey period),
- "Annual Change in Indices of Biomass" in relation to the catch, and
- "Information on the Extension of Habitat" collected from other source.

3.2.1 "Thiof", Epinephelus aeneus

The results obtained through "Cohort Analysis" is given in the Table 3-3 [Thiof (aged by scale samples): Cohort Matrix, ($C_{(i, t)}$, $F_{(i, t)}$, $N_{(i, t)}$).] and Figure 3-4 [Cohort Analysis and Assessment, for Thiof aged by scale samples.].

The "Thiof's" [Lump-Sum Amount of Initial Stock Numbers] had been continuously declined from about 14 million individuals in 1885 down to about 5.4 millions in 1996-1997. Although the total number afterwards showed an increasing tendency, this was an outward appearance due to the increase in "Immature" fishes of ages at 1-3, especially the fish at age-1, but not an indication of recovery of entire stock size which had drastically declined so far. The reasons for this were, firstly the intensive fishing for smaller and younger fish had occurred due to the scarcity of larger and older fish in the stock, secondly the sample size of fish measured at field survey site had decreased greatly owing to the lack of enough funds and unfavorable reaction of marketer in recent years. As a results, the component of smaller fish was biased towards greater in the length composition of sample fish, resulting in a great increase in younger fishes of ages 1-3 in the age composition of commercial catch, which had made eventually the total stock number be greater in those ages. The second factor mentioned above may affect seriously the reliability and represent-ability of sample data to be used in stock assessment in the future. The annual change in sample size measured at survey site is given in the Table 3-4 [Thiof: Annual change in number of sample-fish measured at landing site.].

Table 3-4 Thiof: Annual Change in Number of Sample-Fish measured at Landing Site

(Individual numbers)

Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Number of Fish measured	11,061	9,013	13,951	12,336	6,020	4,108	2,935	4,364	3,946	3,461	2,377	2,150	899	350	325

It should be well aware of that such a man made distortion on age composition would be involved in the other stocks' data too. It is necessary therefore, that a re-building of survey system at measuring site should be made in the future to improve the reliability and represent-ability of sample data. Under these circumstances, the change in "Immature" fish and the [Lump Sum Amount of Initial Stock Numbers] observed on "Thiof" after 1997 was neglected from the examination on stock assessment.

The change in "Initial Stock Size" of "Semi-Mature" fish (Age 4-5) and "Mature" fish (Age 6-12) for entire period (1985-1999) had consistently shown a continuous decline. This decline accorded well with the extrapolated declining tendency observed during the period 1985-1996 as was shown in the Figure 3-4 [Cohort Analysis and Assessment, for Thiof aged by scale samples.]. The magnitude of decline was fortunately not so drastic, however, they had reduced in 1999 to about 27% in "Semi-Mature" fish and to about 30 % in "Mature" fish when compared with the original level. In addition to these continuous declines, there has been no sign of recovery observed at all in spawning parental stock size including reserved stock ("Semi-Mature" stock). Such a symptom indicated an unhealthy and unsafe status regarding the reproduction of the stock, it indicates rather the existence of a serious risk on further decline in the future. The reduction by large catch of more than 2,000 tons starting 1982 must already had been an over-exploitation from the above mentioned point of view. Especially, an extra-ordinary large annual catches of more than 4,000 tons made during four years from the 1984 to 1987 had obviously been excesses in catch, which must have accelerated the worsening state of stock. Judging from the no sign of recovery detected, the abundance of "Thiof" stock would surely be further declined in the future.

The increase in Age 1-3 fishes after 1997 is concluded to be outwardly appeared man made effects, judging from the process employed in the decline in spawning parental fish as was mentioned already, since there is no assurance on outburst of strong year-classes as recruitment from such a depleted spawning stock.

The next examination to be made here are the estimation of the amount of [Potential Harvest] and past history on fishing against it as well as the prediction for future. The [Lump Sum Amount of Annual Initial Stock Numbers] by age would give a yardstick on the size of exploitable stock size. In case of "Thiof", the highest value was 14,254,000 individuals in 1985 when the survey was started. The stock had been exploited with considerably high fishing intensity since even before 1985, which had been recorded as continuous annual catches of some 1,000-2,500 tons during past ten years from 1974 to 1983. The amount of [Potential Harvest] of the stock was therefore considered, far beyond the level in 1985. However, it may not be larger than one digit over, and since this study have to be made focusing at the state of stock at beginning of this particular survey, the [Potential Harvest] of "Thiof" was estimated to be 15 million individuals, slightly above of the value observed in 1985.

The potential harvest of 15 million individuals is the smallest among the seven target species (cf. Table 3-20 [Comparison of estimated Potential Harvest, Recent Catch Level, and Rate of Exploitation by Stock.]). The estimated [Rate of Exploitation: C/N] of "Thiof" in recent years against the estimated [Potential Harvest] were in a range of 0.027-0.040 against the catches of 400-600 thousand individuals, which (equivalent to about 3-4 %) were considerably higher than the other target species. The higher [Rate of Exploitation] against the smaller [Potential Harvest] of "Thiof" indicated that the fishing had been made under strong reliability of fishermen on the stock being stimulated by high commercial value.

It should also be pointed out that the distribution range of "Thiof" is rather limited and very difficult to locate the fish and to catch, which may have been resulted in more devotion and concentration in fishing by fishermen. Such a stock is generally fragile, and easily devastated once the fishing intensity exceeds normal level.

Taken as a whole, the "Thiof" stock in Senegalese waters is [Strongly Over Exploited] and in a [Highly Dangerous] phase in its sustainability. There is no way other than reducing the quantity of catch by some way to remedy the current status and recover the reproductive potential (cf. Table 3-19 [Summary of Assessment by Stock identified through Findings obtained by Cohort Analysis.]).

3.2.2 “Pagre”, Sparus caeruleostictus

The results of “Cohort Analysis” of “Pagre” is given in the Table 3-5 [Pagre (aged by scale samples): Cohort Matrix, ($C_{(i, t)}$, $F_{(i, t)}$, $N_{(i, t)}$).] and the Figure 3-5 [Cohort Analysis and Assessment, for Pagre aged by scale samples.].

The estimated annual change in the [Lump-Sum Amount of Initial Stock Numbers] of “Pagre” had changed from about 350 million individuals at initial stage of the survey (1985-1987) down to about 200 million individuals during 1995-1996 in accordance with the increased catch, which was a decline of about 57 % from the beginning. The total stock number increased thereafter to about 400 millions exceeding the level at beginning, however, this was not an indication of recovery of the stock but an outward phenomenon. The reason for this phenomenon had, as was similarly observed in the case of “Thiof”, been caused mainly by the reduction in sample size of length measurement and as well as the bias towards smaller sample fish. As the result, the component of younger “Immature” fishes, especially in Age-1 fish, had increased in the age composition of commercial catch in recent years. The improvement in the sampling system employed in the length measurement at field site should therefore be made as was already described in the “Thiof’s” section.

The annual change in sample size measured is given in the Table 3-6 [Pagre: Annual change in number of sample-fish measured at landing site.]. Under these circumstances, stock number of “Immature” fish (period 1-3) as well as that of the [Lump Sum Amount of Initial Stock Sizes] after 1997 was neglected from examination for stock assessment here.

Table 3-6 Pagre: Annual Change in Number of Sample-Fish measured at Landing Site

(Individual numbers)

Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Number of Fish measured	6,986	17,955	17,898	15,880	10,019	12,678	9,178	7,965	3,990	5,141	3,980	2,210	1,071	693	795

The large annual catches of some 5,000 tons for ten years during 1985-1994, (especially 6,000-8,000 tons during 1990-1992) had reduced the stock abundance for all maturity stages (“Immature”, “Semi-Mature” and “Mature”). However the magnitude of decline was not so drastic, i.e. it remained at about 70 % in “Immature” fish from the beginning, 57 % in “Semi-Mature” fish, and 79 % in “Mature” fish. On the contrary, “Immature” fish had increased by about 40 % during 1991-1994, despite continuation of large annual catches. This was favorably resulted in starting increase in “Semi-Mature” fish in1995 and continued for four years period, which resulted in the recovery of “Mature” fish with 2-3 years’ time lag. The abundance of “Mature” fish has reached nearly the level of beginning in 1998-1999 with about 50 million individuals.

Thus, though the “Pagre” stock had once declined slightly at the mid-stage of survey owing to the large annual catches of some 5,000-8,000 tons made during 1986-1987 and 1990-1994, the abundance of parental spawning stock had recovered thereafter and had been maintained at relatively favorable level in recent years. There is also no indication observed on the decline of total stock abundance in the near future. The stock remains at [Moderately Exploited] status, which is expected to maintain even in the future. However, it should be recommended firstly not to exceed more than 3,000 tons annual catch, secondly to continue careful monitoring on stock abundance. It can be said that the stock is in a [Highly Cautious] phase in this sense.

The major reasons for the stock remaining in such a favorable condition are, firstly its large [Potential Harvest], which was estimated to be about 400 million individuals at third largest among the stocks examined (cf. Table 3-20 [Comparison of estimated Potential Harvest, Recent Catch Level, and Rate of Exploitation by Stock.]). Although it cannot be said that the enormously large amount of catch could have been achieved only by the huge [Potential Harvest] is inhered in the stock, but it may be one of the important element of realization of large continuous catch. Namely, the estimated [Rate of Exploitation: C/N] of “Pagre” in recent years against [Potential Harvest] were at 0.013-0.023 with the level of annual catch of 6-9 million individuals, which is the second smallest among the stocks examined, showing the large tolerability of the stock against fishing.

The another elements which may have supported the tolerable nature of “Pagre” is in its wide distribution range and in less variations in catch-ability throughout the season, which gives favorable condition in catching anywhere and any season, and the probable huge range of spawning area may had favored to sustain the large catches. It is considered that those tolerable natures had been made massive and continuous catch be possible, and had even given the stock recovering potential to sustain the sock abundance. Even if there is no immediate risk on reproduction of the stock foreseen, the careful monitoring on stock abundance should be maintained in the future, as “Pagre” is one of the most popular and favorite fish to Senegalese people with relatively high commercial value (cf. Table 3-19 [Summary of Assessment by Stock identified through Findings obtained by Cohort Analysis.]).

3.2.3 “Thiekem”, Galeoides decadactylus

The results of “Cohort Analysis” of “Thiekem” are given in the Table 3-7 [Thiekem (aged by scale samples): Cohort Matrix, ($C_{(i, t)}$, $F_{(i, t)}$, $N_{(i, t)}$).] and the Figure 3-6 [Cohort Analysis and Assessment, for Thiekem aged by scale samples.].

The estimated annual change in the [Lump-Sum Amount of Initial Stock Numbers] of “Thiekem” stock had greatly decreased in accordance with the increase in the commercial catch from about 810 million individuals at initial stage of the survey (1985) down to about 122 million individuals in 1999, which was a decline to about 15 % from the beginning.

There had been no serious distortion to smaller and younger fish observed annually on the body-length composition collected at survey site, which were commonly observed on the data on “Thiof” and “Pagre”. However, the sample size measured had become smaller in most recent 3 years, for which improvement in over all survey system would be necessary as was so in the other stocks. The annual change in the sample size measured for length-composition is shown in the following table (Table 3-8 [Thiekem: Annual Change in Number of Sample-Fish measured at Landing Site.]).

Table 3-8 Thiekem: Annual Change in Number of Sample-Fish measured at Landing Site

(Individual numbers)

Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Number of Fish measured	1,259	1,688	1,977	3,640	3,080	4,517	2,528	2,723	2,231	1,719	2,205	1,433	1,065	938	1,464

“Thiekem” is originally the fish of small-size bearing small growth compared with larger fishes like “Thiof” or “Otolithe” (cf. theoretical maximum length ($L_{infinity}$) of “Thiekem” is 44.6 cm). Owing to this small size nature in adult fish, bias towards smaller fishes would hardly occur when sample fishes are collected. This type of species-specific characteristics may be favored to avoid inclusion of a bias. Under these circumstances, the examination here will be done with a single standard throughout the survey period, 1985-1999.

The fishing for “Thiekem” had been rapidly developed since 1972 with157 tons of catch, then 7-8 years later, the annual catch had reached at large amount of 3,000-5,000 tons for 15 years until 1994. The catch, since then, had continued at about 2,000-4,000 tons level in recent years. Owing to thus continuing strong fishing intensities the “Initial Stock Numbers” in each maturity stage had unilaterally continued to decline. The abundance of each stage in the most latest 1999 had became at 15 % for “Immature”, 10 % for “Semi-Mature” and 21 % for “Mature” fishes from their values at the beginning in 1985. There is no indication at all on stoppage of this declining tendency of “Semi-Mature” and “Mature” fishes in recent years. It is presumed therefore, that as long as the current fishing intensity continues, the abundance of overall “Thiekem” stock would surely keep decline further in the future, which may be resulted in difficulty maintaining current catch level in the near future, then the fishing itself would be shrunk. It is concluded, unfortunately, that the stock is now in a typical process of [Strongly Over-Exploited] stage. In conclusion, the current phase of the stock is considered to be in the [Very Dangerous] phase. An action to remedy the serious status should then be taken, in which the reduction in catch level at about 1,000-2,000 tons, would be most desirable for the time being aiming at recovery of stock abundance, especially of spawning parental stock.

The estimated [Potential Harvest] of "Thiekem" originally inherent in the stock is enormously large with 900 million individuals, which is ranked at the second largest among the 7 stocks (cf. Table 3-20 [Comparison of estimated Potential Harvest, Recent Catch Level, and Rate of Exploitation by Stock.]). The estimated [Rate of Exploitation (C/N)] of the catches against the [Potential Harvest] were, therefore, conspicuously small with about 0.007-0.012 which is the lowest level among 7 species together with "Sompatt" stock of newly exploited resources.

Why then the stock had reached at the [Strongly Over-Exploitation] stage with the [Very Dangerous] phase? The answer is that the accumulation of excess in catches, (over reduction of resources from biological point of view), over the years since 1979 had driven the stock into such a critical status. As a result, the [Rate of Exploitation] of "Thiekem" stock of the 6 million individuals catch in 1999 against the [Potential Harvest] of the same year (122 million) had jumped up to 0.045 (cf. Table 3-7 [Thiekem (aged by scale samples): Cohort Matrix, ($C_{(i, t)}$, $F_{(i, t)}$, $N_{(i, t)}$).]). This value far exceeds the other species' cases such as "Thiof", "Pagre" and "Sole" (cf. Table 3-20 [Comparison of estimated Potential Harvest, Recent Catch Level, and Rate of Exploitation by Stock.]).

The other characteristics inherent in the "Thiekem" stock are (1) its wide distribution range being supported by its originally large abundance, (2) its high density in fishing ground which had made the fishermen easy to fish. Those factors had made the stock to be highly vulnerable resources. The long years accumulation of such circumstances had surely driven the stock into current status and phase. There is no way other than reducing the amount of catch by some way for effective action to remedy from current status (cf. Table 3-19 [Summary of Assessment by Stock identified through Findings obtained by Cohort Analysis.]).

3.2.4 "Otolithe", Pseudotolithus senegalensis

The growth study of "Otolithe" was conducted through analyzing 12 specimens in total by both the otoliths and scales collected from the same sample fish. The results of age determination of them had shown a slight difference between the aging materials, otolith and scale, however, it had been finally made clear that the difference could be adjustable through the careful analysis on growth pattern. The stock assessment analysis by each of otolith and scale were, therefore, made separately as if they were an independent species, then the both of the assessment results had been verified whether any difference had been existed between the two. Since any difference was not existed between the two assessment results through the verification study, the result of the stock assessment made by otolith sample as aging material is, therefore, firstly examined here, then the results on a verification study between otolith and scale are secondly explained later under a separate heading.

In body-length composition data of “Otolithe” collected at the field survey site, a result of a bias or distortion to smaller/younger fish was recognized as were observed in the data on “Thiof” and “Page”. The annual change in number of measured fish showed some what smaller numbers in recent years (cf. Table 3-9 [Otolithe: Annual Change in Number of Sample-Fish measured at Landing Site.], however, the problems were shown more clearly in the size composition itself. The number of larger fish over 50 cm had gradually declined around 1990, and the medium size fish over 40 cm had started to vanish since around 1995. On the contrary, the component of frequency in smaller fish of 20-30 cm had rapidly increased since around 1997. There was no doubt on the fact that the fish size had become smaller in accordance with the sequence of time. However, precise judgment on whether this phenomenon had been caused by the problems involved in sampling system or by the changes in structure of stock itself had been very difficult to make from only recorded data on the number of fish measured.

Table 3-9 Otolithe: Annual Change in Number of Sample-Fish measured at Landing Site.

(Individual numbers)

Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Number of Fish measured	4,288	1,484	1,488	1,903	1,775	2,624	1,864	1,805	2,483	1,506	2,511	1,454	1,084	1,217	1,289

As is analyzed in the next section, it is really the fact that large changes had occurred in stock numbers and biomasses of “Otolithe” stock. The tendency on becoming smaller fish is presumably caused by both the problems in sampling system and the change in stock structure itself. The necessity in improvement in the sampling system in the length measurement at field site is therefore urged as was so in the other stocks. The assessment employed here was made on a single and an over-all criterion throughout the survey period, 1985-1999.

(1) The results of assessment by the data based on age determination by otoliths

Annual change in abundance of “Otolithe” stock shows highly complicated features with quite unique pattern from the other stocks. The results of “Cohort Analysis” of “Otolithe” aged by otolith is shown in the Table 3-10 [Otolithe, aged by otolith samples: Cohort Matrix, ($C_{(i, t)}$, $F_{(i, t)}$, $N_{(i, t)}$).] and the Figure 3-7 [Cohort Analysis and Assessment, for Otolithe aged by otolith samples.].

The estimated [Lump-Sum Amount of Initial Stock Numbers] of Otolithe stock had once increased to some extent from about 26 million individuals at initial stage of the survey (1985) in accordance with the rapid and drastic decline in the catch, and it declined again from its apex at the middle of survey (1990). Namely, it had declined drastically from the apex in accordance with the extremely large catch of 4,000-12,000 tons, which started 2 years later during 1992-1994, and the magnitude of its decline was the most precipitous. So as to evaluate the process employed in this drastic decline more clearly the comparison of the [Annual Initial Stock Numbers] by maturity stage for recent years with those at the years of apex (1990 and 1992) was made.

Firstly, the “Immature” fish had decreased from an apex of 59 million individuals in 1990 to 2.1 millions in 1999 which was only 3.9 % of the top, secondly, the “Semi-Mature” fish had decreased from 23.9 million individuals in1992 (top) to 2.7 millions in 1999 showing only 11.3 % of the top, thirdly, the “Mature” fish had decreased from 27.8 millions in 1992 (top) to 1.7 millions in 1999 showing only 6.1 % of the top, fourthly, the [Lump Sum Amount of Initial Stock Numbers] had decreased from 84 million individuals in 1990 (top) to 6.4 millions in1999 showing only 7.6 % of the top, thus the magnitude of decline had been disastrous in all categories. It should be noted here at the same time, that there has been no indication at all on the ceasing the decline of spawning parental stock of both the “Semi-Mature” and “Mature” fish stocks, which has been still continuing decline at very low level.

Estimated over-all strength of the cohorts of “Otolithe” in recent years remains at devastating level as described above. Particularly the continuation of decline in depleted spawning stock in recent five years should be taken as a grave warning on sustainability of the reproductive potential of the stock, for which some measures to remedy are needed. In conclusion, current status of “Otolithe” stock is considered to be at the [Most Heavily Exploited] status in the [Highly Dangerous] phase, for which some [Urgent Remedy Actions] are required.

The estimated [Potential Harvest] of “Otolithe” stock is originally not so large with about 90 million individuals. The amount of annual catches taken from such a stock for 10 years since 1976 had been excessively huge with more than 3,000 tons. The magnitude of excessiveness had been far greater, especially in 5 years period in the middle of the exploitation stage (1978-1982) with 5,000-9,000 tons level. It is concluded that such large reductions had been originally unreasonable human behavior.

When the [Rate of Exploitation (ROE)] of “Otolithe” stock is examined for the period of 1992-1994, in which the large catch of 32–10 million individuals had been achieved, against the original [Potential Harvest] of 90 million individuals, it has come out to be 0.356-0.144, which is extraordinary larger than that of the other stocks (cf. Table 3-20 [Comparison of estimated Potential Harvest, Recent Catch Level, and Rate of Exploitation by Stock.]). When the similar figures were applied to the latest 2 years (1998-1999), it comes out to be 0.467-0.333 (7-2 millions individuals against 15-6 millions), which shows similarly the extraordinary large ROE than the other stock. That is to say, the exploitation of the stock had been in greatly excess even through the examination made by the [Rate of Exploitation].

However, as already analyzed, the stock abundance had once recovered in response to the drastic decrease in catch down to less than 1,000 tons for 5 years during 1987-1991. Then the spawning stock size had increased from 10 million individuals to 30 millions within 5 years time during the same period, which gives us an encouraging result of successful experience. The stock in a depleted status would surely be recovered on the application of appropriate remedy action.

(2) Verification of assessment results between aging materials, Otolith and Scale

A trials on the verification of assessment results between the difference in aging materials, otolith and scale, were undertaken for the "Otolithe" stock. The otoliths and scales employed were simultaneously collected from the same sample fish. All of the examination procedure on growth study, estimation of age composition, processing of "Cohort Analysis" were done independently for each of the data prepared by otoliths and scales. The results of age determination made by otolith and scale samples are given in Table 3-11 [Otolithe: Aging results made by Otolith versus Scale samples].

Table 3-11 Otolithe: Aging results made by Otolith versus Scale samples, discrepancies recognized in the results obtained.

Identity of specimen	Sample specimen		Ages determined by each method		Difference in
	Specimen NO.	Body length (mm)	Scale reading	Otolith reading	Otolith reading
Otolithe:	1	595	11	9	-2
Pseudotolithus	2	605	10	10	0
senegalensis	3	620	12	11	-1
	4	600	10	10	0
Identification:	5	616	(11)	Otolith broken	Not applicable
SP-0409 -	6	530	10	8	-2
Specimen No.	7	580	11	11	0
Sample fish was purchased at wholesale fish market on 16 September 2004.	8	575	9	9	0
	9	560	8	8	0
	10	560	(11)	Otolith broken	Not applicable
	11	650	14	12	-2
	12	560	10	10	0
Number of fish agreed / Total number			6 / 10		0
Number of fish disagreed / Total number			4 / 10		-7
Average ages in disagreement of Otolith reading			-		-1.75

When compared the results of age determination obtained by otolith and scale, there was a tendency on one age younger in otolith reading than scale reading even though on the samples collected from the same fish. This is mainly due to the difficulty in identifying the first annulus in otolith reading. Generally speaking, the identification of the first ring causes on setting the t-zero

(t_0) at a plus zone or a negative zone with regard to growth parameters, which does not concern seriously with the substance of growth pattern itself. But it does affect on the number of ages to be counted, namely one age younger.

The estimated growth patterns and formulae by both otolith and scale are given in the Figure 3-8 [Otolithe: Comparison of Aging Results.]. The discrepancy between the otolith and scale is shown on the difference in t-zero, at in a plus zone (otolith) or in a negative zone (scale) as was explained above. If the difference in t-zero is examined in relation with the age at first maturity, it is a range of ages 3-5 (300-400 cm in length) in the case of otolith and ages 4-6 (same 300-400 cm in length), one age younger in otolith than those of scale. The body length at age-1 estimated by otolith sample appears too larger than those by scale when growth pattern is examined throughout life span, however, further study on this particular matter could be left in the future study to clarify. However, it is necessary to keep in mind that the age at first maturity is set one age younger in otolith reading than scale reading when proceed onto assessment work.

Being based on the examination made so far, estimated age compositions for both aging materials by a “Fortran Program” named “CH-Comp” are given on a comparative basis in the Figure 3-9 [Comparison of Age Composition estimated between aging by Otolith vs. Scale.] to compare and to verify the both results. In the “Figure” the results of both by the otolith and scale is illustrated together in parallel, upper and lower. Looking at the “Figure”, it is clearly shown that the no difference at all recognized between the both patterns of age composition, in which completely resemblant patterns are shown in each other. However, it should be noticed here that the scale of horizontal axis for otolith is shifted to rightward for one age, that is, one age younger in otolith sample. It was considered that the adjustment thus made have taken away completely the difference existed in age compositions between the otolith and scale. In conclusion, it can be considered that even in the employment of “Cohort Analysis”, the difference in age determination will have been completely taken away from the substance of assessment when the setting of the age at first maturity was appropriately made. With regard to the question on how one age younger maturation occurred in the otolith samples, there is no way other than waiting for future study in the matter of field of biology. Focal point in the adjustment procedure is not to swallow the results obtained, but to examine the results further in detail standing on the basis of ecology and biology.

Since it has assured that the “Cohort Analysis” could be made by the growth studies made either otolith or scale, the results of “Cohort Analysis” of “Otolithe” stock aged by scale is shown in the Table 3-12 [Otolithe, aged by scale samples: Cohort Matrix, (C(i, t), F(i, t), N(i, t)).] and the result of comparison obtained by otolith sample is in the Figure 3-12 [Comparison of Cohort Analyses between aging Materials, Otolith versus Scale Samples.]. It is obvious that both results show completely resemblance in each other, categories applied to the stage of maturity are different though, as was already explained before.

However there are slight differences existed between the both results, which are derived from the difference in [Terminal Fishing Mortality (TF)]. As each of original data for “Cohort Analysis” had been prepared independently, the absolute values of age composition had been therefore slightly different, which resulted in the difference in values of (TF) for each to be applied to the “Cohort Analysis”, 0.45 in otolith sample and 0.74 in scale sample. This is a merely computational problem, therefore, there is no difference at all on the substances to be evaluated by assessment made, because, the decision on assessment will be made by examining the annual change in “Initial Stock Numbers” of each maturity stages being based on the relative evaluation theory. The gaps in absolute values will not affect at all the assessment results. In conclusion, there is no difference involved between the both assessments made.

3.2.5 “Machoiron”, *Arius heudelotii*

The results of “Cohort Analysis” of “Thiekem” stock are given in the Table 3-13 [Machoiron aged by otolith samples: Cohort Matrix, ($C_{(i,\ t)}$, $F_{(i,\ t)}$, $N_{(i,\ t)}$).] and the Figure 3-11 [Cohort Analysis and Assessment, for Machoiron aged by otolith samples.].

The commercial fishing on the stock was rather new, for which substantial fishing had started in 1977 with about 1,000 tons catch. The fisheries had rapidly developed thereafter, and four years later the annual catch had reached at about 4,000 tons level and had lasted for 9 years with the annual catch of 5,000-6,000 tons level. The catch had been gradually decreased thereafter being accompanied by some fluctuations, and has been at 1,000-2,000 tons level in recent years.

There had been no extremely serious distortion towards smaller and younger fish observed on the body-length composition data collected at survey site, which was commonly observed on the data of “Thiof” and “Pagre”. There had been rather large decline in the number of fish measured at survey site in recent years (cf. Table 3-14 [Machoiron: Annual Change in Number of Sample-Fish measured at Landing Site.].

Table 3-14 Machoiron: Annual Change in Number of Sample-Fish measured at Landing Site

(Individual numbers)

Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Number of Fish measured	41	95	689	741	1,869	2,067	905	1,291	2,053	1,371	2,084	500	543	674	1,010

However, the fish larger than 60 cm had began to decrease in the catch since 1995, and the fish in middle-size of 50-60 cm began to decrease being accompanied by the rapid increase in the component of smaller fish of 25-40 cm since 1998. It is obvious that the body length composition of sample fish had become smaller in the latest 3 years as was seen "Thiof" and "Pagre". The reason for this phenomenon is not clear whether due to insufficient sampling scheme or by the change in stock structure itself. Probably both factors would have made the length composition of sample fish smaller, the improvement in sampling scheme is, therefore, needed in the future as was so in the other stocks.

The estimated [Lump-Sum Amount of Initial Stock Numbers] of "Machoiron" stock had decreased continuously from about 30 million individuals at the beginning stage of survey (1985) down to about 18 millions in 1991, which was the decline to about 60 % of the beginning. The cause of the decline must have been the excess in the catch of 4,000-8,000 tons made during 1978-1988. It had been remained at about 20 million individuals until 1997 under the annual catch around 2,000 tons. However, it had suddenly declined drastically owing to the huge catch of 6,000 tons made for 2 years during 1998-1999. It had been decreased down to 10 million individuals (31 % of beginning) in 1998, and further down to 2.4 millions (8.1 % of beginning) in 1999 reaching at the historical minimal level.

The next examination is on the change in spawning stock size to investigate in the change in on potential reproductive power. The initial stock number of "Mature" fish had been originally about 14 million individuals in 1985, but it had decreased in accordance with the continuation of large catches down to 4.2 million individuals (29.7 % of beginning) in 1992. The spawning stock size had remained at around the same level for 5 years since then, but largely declined again down to 2.5 million individuals (17 %) in 1998 in conjunction with the extraordinary large catches made during 1997-1998, more over, it had been further declined down to 0.7 million individuals (4.1 %) in 1999, which was the historical minimal record. The devastation in reproductive potential was thus destructively critical in recent years. Also there is no sign at all on recovery of reproductive potential.

Even if the examinations were made on annual changes in the estimated [Rate of Exploitation (C/N)] of the stock, there is no change in the situation clarified from the examination on annual change in spawning stock size. The estimated [Potential Harvest] of "Machoiron" of 30 million individuals in the beginning (1985) is originally not so large potential. It is the second smallest among the 7 stocks being followed only by "Thiof" (cf. Table 3-20 [Comparison of estimated Potential Harvest, Recent Catch Level, and Rate of Exploitation by Stock.]). The catch actually taken in 1985 was about 2 million individuals, then the [Rate of Exploitation] in that year was 0.067, which was second largest value surpassed only by "Thiof". The value of [Rate of Exploitation] of the stock had increased afterwards year-by-year accompanying some fluctuations. It had reached at remarkable high value of 0.236-0.243 when catch exceeded 7 million individuals during 1997-1998. Though the value against original [Potential Harvest] (30 million individuals) reduced in 1999 down to 0.040, due to the large shrink in the catch (down to 1.2 million individuals), it showed extremely large value of 0.500 against the [Lump Sum Amount of Initial Stock Numbers] of the same year (2.4 million individuals), which may be regarded the [Real-Time Potential Harvest] in 1999. It is an astonishingly large value, which meant the catch was equivalent to half of the current [Exploitable Stock Size] in the same year. Such exploitation must be obviously impossible to sustain.

The other important biological characteristics inherent in “Machoiron” stock to have to be taken into consideration are its limited habitat and low fecundity. The habitat is rather limited in the swamps in near shore area with muddy bottom structure for the former, and the size of egg is relatively large and the fecundity is accordingly small for the latter. The limited habitat implies the easy vulnerable nature on one hand, and the low fecundity implies small in spawning potential resulted in small recruitment on the other. The first factor easily causes intensive fishing, while the second factor is also easily causes depletion on reproductive potential once the intensive fishing exceed its optimal level on such a stock. The “Machoiron” stock can therefore be regarded as a fragile stock with these risks, for which the cautious fishing should have been planned at the beginning of their exploitation.

Taken as a whole, it has been summarized for “Machoiron” stock that though it had been exploited since late 1970s, the catch of some 4,000-5,000 tons made during the following 12 years were considered to have been over exploitation. The fishing intensity had not been reduced even in thereafter, and more than 2,000 tons catch were taken annually for more than 10 years. Those massive catch also considered in excess pursuing the depleted stock more, which resulted in further depletion in stock abundance. There is no sign detected on the recovery on spawning parental stock, the “Machoiron” stock would therefore further declined in the future.

In conclusion, the “Machoiron” stock is currently at the [Most Heavily Exploited] status and is in the most [Highly Dangerous] phase, for which some effective measure to remedy is urgently recommended. It would desirable for the time being that the annual catch be limited within the 1,000 tons level to enhance the recover of spawning parental stock.

3.2.6 “Sole”, Cynoglossus senegalensis

The results of “Cohort Analysis” of “Sole” stock are given in the Table 3-15 [Sole aged by scale samples: Cohort Matrix, ($C_{(i, t)}$, $F_{(i, t)}$, $N_{(i, t)}$).] and the Figure 3-12 [Cohort Analysis and Assessment, for Sole aged by scale samples.].

The fishing on “Sole” stock has a long history, in which the stock may have been utilized from long time before by artisanal fisheries since around the beginning of 1960s. According to the record of the official statistics established in1971 for the first time, the commercial catch of the stock had already existed with about 1,500 tons. The fishery had been expanded every year thereafter, and the commercial catch increased accordingly, however, the increase in the amount of total catch had remained in a small scale as the fishing were constrained within a coastal small scale fisheries. Nevertheless, total catch in1990 reached at 4,300 tons level with annual increment rate of 150 tons. These phenomena imply that the stock was holding a huge size with wide distribution range at high density, which might have given the fishermen a quite favorable condition for development of the fishery. When the large industrial fisheries had joined in "Sole" fishing in 1992, the total catch had then suddenly increased at 10,000 tons level thereafter. Although the intensive fishing with huge catch had ceased 5-6 years later, the steady increase in the total catch had continued even thereafter being supported by installation of higher fishing efficiency in small-middle class fishing boats. In recent years the catch had been leveled off at around 5,000 tons level (cf. Figure 3-12 [Cohort Analysis and Assessment, for Sole aged by scale samples.]).

The field survey on body length measurement of "Sole" had not been done for the beginning 4 years during 1985-1988 (cf. Table 3-16 ["Sole": Annual Change in Number of Sample-Fish measured at Landing Site.]).

Table 3-16 Sole: Annual Change in Number of Sample-Fish measured at Landing Site

(Individual numbers)

Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Number of Fish measured	No value	No value	No value	No value	663	707	344	3,417	8,309	384	589	365	209	106	191

The results of examinations on length composition in recent years show that firstly the composition of the larger fish more than 40 cm had began to decrease since around 1994, secondly the components of middle size fish of 35-45 cm had become extremely few, thirdly in contrast, the components of smaller fish of 25-35 cm had not changed so much in the entire component. However, as the number of samples measured became greatly small since 1997, bias on length composition towards smaller size might have occurred as were observed in "Thiof" and "Pagre". The improvement in sampling scheme is, therefore, needed in the future survey as was recommended so for the other stocks.

In this study, the processing for the estimation of age composition from length composition data was made utilizing the length composition data measured during 1989-1999 (excluding data of 1985-1988 as no observation), and the processing for "Cohort Analysis" made afterwards was conducted for entire survey duration (1985-1999) on the same standard (including the period of 1985-1988 when data on length composition had been lacking). Namely in "Cohort Analysis", on an assumption that the catch numbers ($C_{(i, t)}$) were zero (0) in all the years and ages during the period of 1985-1988, [Initial Stock Numbers] in all the year and ages was estimated with the application of normal procedure being based on the already estimated [Terminal Fishing Mortality] for entire period. Therefore, the Fishing Mortality

($F_{(i, t)}$) for all the years and ages had become zero (0) during 1985-1988, and estimated Initial Stock Numbers ($N_{(i, t)}$) had been somehow smaller, being under-estimated.

The estimated [Lump-Sum Amount of Initial Stock Numbers] of “Sole” stock had increased from about 900 million individuals in the beginning of 1985 to the top of about 1181 millions in 1988. It should be looked at this increased high level of the [Lump-Sum Amount of Initial Stock Numbers], nevertheless 1,000-4,000 tons annual catch had been achieved during the past 18 years. But afterwards, the total stock number had continuously declined in accordance with the further increase in the catch especially with the huge catches of 10,000-15,000 for 3 years during 1992-1994. It had become the historical minimal value of 197 million individuals in 1999, which was only the 16.7 % of the top in 1988. This decline had continued every year with rather drastic pace, but more noticeable after 1997, which might have been caused mainly by extraordinary large catch during 1992-1994, and by additional blow of large catches followed.

The next examination is on the change in spawning stock size to investigate in the change in potential reproductive power. The initial stock number of “Mature” fish had shown its peak at 126 million individuals in1992. It had been declining tendency thereafter similarly to that of total stock numbers, it reached at last the historical minimal of about 14 million individuals in 1999, which was only 11 % of the top in 1992. The current reproductive power of “Sole” has been destructively depleted and extremely low. Moreover, no sign at all has been detected on its recovery.

When examined by the record on annual change in the estimated [Rate of Exploitation (C/N)] of the “Sole” stock, there is no change in the situation observed from those clarified by stock numbers. The estimated original [Potential Harvest] of the “Sole” stock of 1,200 million individuals is the largest among the 7 target species (cf. Table 3-20 [Comparison of estimated Potential Harvest, Recent Catch Level, and Rate of Exploitation by Stock.]). It is extraordinarily large exceeding the second largest “Thiekem” which is about 90 million individuals. The catch actually taken at the beginning of the exploitation (1989) was about 21 million individuals, then the [Rate of Exploitation] in that year was 0.017 (cf. Table 3-15 [Sole aged by scale samples: Cohort Matrix, (C(i, t), F(i, t), N(i, t)).]. The value is, however, more than double fold of that for “Thiekem” (0.007) which is holding second largest [Potential Harvest] with 900 millions. The same value for the largest catch of 63 million individuals in 1994 was 0.053, which is equivalent to 4.5 times of that of “Thiekem” (0.012). Farther more, the [Total Catch Number] in the latest catch of 28 million individuals in 1999 became to be 0.141 against the estimated [Lump-Sum Amount of Initial Stock Numbers] of 197 millions in the same year. This value is nearly equivalent to the initial value of “Otolithe”, which was ranked at the most heavily exploited. Even when taking the huge [Potential Harvest] of “Sole” into account, the value in 1999 is considered to be fearfully large enough.

The conspicuous biological characteristics of “Sole” are its large [Potential Harvest] and wide distribution range with high density as was already mentioned. Such a stock could easily be over exploited when it is exposed to the intensive fishing of trawl fishery. It is quite natural that the stock of “Sole” has now been in overexploited status when considering its past history, in which in addition to the expose to fishing of 4,000-5,000 tons for more than two decades, further more, it had encountered extraordinary annual catch of 10,000-15,000 tons during the first half of 1990s.

In conclusion, the “Sole” stock is currently in a [Most Heavily Exploited] status and at [Highly Dangerous] phase, for which remedy action in someway is urgently required to take. Especially, the amount of annual allowable catch should be limited within 2,500 tons (about half of current catch) to recover the reproductive potential. That aside, the guidepost on limiting catch within 2,500 tons is the largest among the guideposts given to the all 5 stocks in danger, “Thiof”, “Thiekem”, “Otolithe”, “Machoiron” and “Sole”, which may have been favored by huge [Potential Harvest] of “Sole” stock.

3.2.7 “Sompatt”, Pomadasys jubelini

The results of “Cohort Analysis” of “Sompatt” stock are given in the Table 3-17 [Sompatt aged by otolith samples: Cohort Matrix, $_{(C(i,\ t)}$, $F_{(i,\ t)}$, $N_{(i,\ t)}$).] and the Figure 3-13 [Cohort Analysis and Assessment, for Sompatt aged by otolith samples.].

The history of commercial fishing for “Sompatt” is rather short. It was firstly reported the small amount of catch in 1972. The catch had been remained at very small amount for 9 years thereafter, but substantial fishing had been initiated when the catch of 326 tons was achieved in 1981. The fishing had remained at a small scale for 15 years thereafter with the annual catch of 200-1,000 tons level, it had been finally developed expanding its annual catch to 1,000-2,000 tons level in recent years (2002-2003), and entered into substantive fishing. Although the fishery had achieved suddenly the large catch of 5,600 tons in 1978, the background on this event had not yet been clear. In order to this unknown irregularity, the catch of this large quantity in 1978 was not taken into consideration when [Potential Harvest] of the stock was estimated, as is described later. Anyway, the commercial fishery for “Sompatt” stock had not been well developed even in recent years and is assumed to have remained at relatively low level (cf. Figure 3-13 [“Cohort Analysis and Assessment, for Sompatt” aged by otolith samples.]).

There had been no serious distortion detected towards smaller and younger fish on the body-length composition collected at survey site, which was commonly observed on the data of “Thiof” and “Pagre”. This may be due to the originally small body size nature of the fish for which serious bias is hardly occurred when sample fish are taken. However, as is seen in the following Table 3-18 [Sompatt: Annual Change in Number of Sample-Fish measured at Landing Site.], number of sample size became smaller in recent years. The pattern of the body length composition measured had might have been made flatten. The improvement in sampling scheme is, therefore, needed to ensure the represent-ability of sample fish in the future as was so in the other stocks.

Table 3-18 Sompatt: Annual Change in Number of Sample-Fish measured at Landing Site

(Individual numbers)

Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Number of Fish measured	3,375	2,029	1,852	2,160	1,808	2,486	1,155	1,639	1,542	787	1,956	838	443	537	726

The estimated [Lump-Sum Amount of Initial Stock Numbers] of "Sompatt" stock had increased rapidly from about 18 million individuals from the beginning in 1985 in accordance with the development of the fishery up to about 229 millions in 1994. It had somewhat decreased since then, and had leveled off at around 170 million individuals in recent years.

When examined the annual change of stock size by stage of sexual maturation, "Immature" fish had shown a remarkable increase from the beginning of 1985 to its apex in 1984. In accordance with this increase in "Immature" fish, the "Mature" fish had increased 3-5 years later with most remarkable increase during 1955-1998. The abundance of the spawning stock had reached its peak in 1998 with about 67 million individuals, and its recent level has been kept at 50-60 millions for which further increase may be expected. There is no fear, therefore, on the reproductive potential to decline in the future in "Sompatt" stock.

The estimated [Potential Harvest] of "Sompatt" stock is around 230 million individuals, which ranked at middle position among the 7 target species. The estimated [Rate of Exploitation (C/N)] of "Sompatt" stock had been kept in a range at 0.009-0.018 in recent years, which may presumably be kept at safely small level.

Thus, judging from the current status of fishing and the prospects on future reproduction power, as long as the current intention on fishing is maintained, there is no risk at all in the future abundance of "Sompatt" stock, even further increase in abundance and larger production would be expected. Taken as a whole, "Sompatt" stock still remains in a [Light and Moderately Exploited] status for which [Immediate Action for Conservation Measure] is not required. However, careful [Monitoring System] should be maintained.

3.3 Summary of Assessment

(1) Results of "Cohort Analysis"

The results obtained through "Cohort Analysis" are given in the Table 3-19 [Summary of Assessment by Stock identified through Findings obtained by "Cohort Analysis".]. Also the potentially exploitable stock numbers [Potential Harvest], together with the [Rate of Exploitation (C/N)] estimated by each of 7 target species are given in the Table 3-20 [Comparison of estimated Potential Harvest, Recent Catch Level, and Rate of Exploitation by Stock.]. The details of the discussion on each item have been already described in each of the respective articles in this paper.

Table 3-20 Comparison of estimated Potential Harvest, Recent Catch Level, and Rate of Exploitation by Stock

(Individual numbers)

Stock	Thiof	Pagre	Thiekem	Otolithe	Machoiron	Sole	Sompatt
Potential Harvest (N)	15,000,000	400,000,000	900,000,000	90,000,000	30,000,000	1,200,000,000	230,000,000
Level of Recent Catch (C)	400,000 - 600,000	6,000,000 - 9,000,000	6,000,000 - 11,000,000	32,000,000 - 13,000,000	2,000,000 - 7,000,000	20,000,000 - 65,000,000	2,000,000 - 4,000,000
Rate of Exploitation (C/N)	0.027-0.040	0.015-0.023	0.007-0.012	0.148-0.356	0.067-0.243	0.017-0.054	0.009-0.018

Remarks:

1) Reference should be made to the "Tables of Cohort Matrix" of respective stock for the values of "Potential Harvest" and "Level of Recent Catch".
2) For the "Level of Current Catch" of "Sompatt", an extraordinary large catch of about 5,600 metric tons was abruptly recorded which accounted for about 13,500 specimens, the value was then ignored as "Current Level".

In addition, a simplified summary results obtained has been also given in the following Table 3-21 [Digest of the Assessment made on the seven Target Species.].

Table 3-21 Digest of the Assessment made on the seven Target Species

No.	Target Species	Sate of Stocks	Phase in;	Immediate Action needed for Remedy (Guide post for the action)
1	Thiof *Epinephelus aeneus*	Heavily exploited	Cautious phase	Reduction in fishing intensity. (Annual catch, less than 500 tons)
2	Pagre *Sparus caeruleostictus*	Moderately exploited	Careful phase	No need for immediate actions. (Careful monitoring is essential.)
3	Thiekem *Galeoides decadactylus*	Heavily exploited	Cautious phase	Reduction in fishing intensity. (Annual catch, 1,000-2,000 tons)
4	Otolithe *Pseudotolithus senegalensis*	Most-Heavily exploited	Highly dangerous phase	Reduction in fishing intensity. **(Total ban of catching "Otolithe")**
5	Machoiron *Arius heudelotii*	Heavily exploited	Cautious phase	Reduction in fishing intensity. (Annual catch, less than 1,000 tons)
6	Sole *Cynoglossus senegalensis*	Heavily exploited	Cautious phase	Reduction in fishing intensity. (Annual catch, less than 2,500 tons)
7	Sompatt *Pomadasys jubelini*	Moderately exploited	Careful phase	No need for immediate actions. (Careful monitoring is essential.)

As was described in the above "Digest Table", the stock in the most dangerous status is the "Otolithe" amongst 7 stocks studied in this paper. "Machoiron" and "Thiof" are the next dangerous stocks following the worst. "Thiekem" and "Sole" are also in danger in respect of sustainable reproductive potential. The amount of allowable catches as guide post for depleted stocks have been given too in the table to be enforced urgently to recover the stocks from the depleted status and to ensure their sustainable level. They are variable in accordance with the grade of status and the magnitude of their [Potential Harvest]. Although a trial on a tentative moratorium was proposed for "Otolithe" stock owing to its seriousness, it may appears too much severe action to be taken. However, the fishermen had an experience on a similar event in the past, in which the "Otolithe" stock had recovered in response to decline in catch in 1980s. Enforcing regulatory measures is really sever and hard task, being aware of this well however, I dare proposing several regulatory measures to be taken for the four other stocks, which are believed to be the most direct and effective way to recover from the depletion.

For two stocks of "Page" and "Sompatt", no strong action required immediately. However, careful monitoring on stock abundance should be continued in the future too.

(2) Results of Investigation on Biomass Basis

By applying the [Age-Weight] relationships to the estimated [Initial Stock Sizes by Age ($N_{(i,\ t)}$)] which had been obtained through "Cohort Analysis", annual Biomass by Age ($BM_{(i,\ t)}$) had been estimated. The estimated [Lump Sum Amount of Annual Biomass ($BM_{(i, t)}$)] gives an index on the "Total Biomass by Year ($BM_{(i)}$)". The investigation was made comparing the annual $BM_{(i)}$ with the change in the commercial catch. Then an outward "Rate of Exploitation" in terms of biomass can be examined as an effective index for assessment. The estimated three components of indices "TBM: Total Biomass", "CCT: Commercial Catch" and "ORE: Outward Rate of Exploitation" for each of stocks by year have been given in the Table 3-22 [Annual Change in Biomass converted from Initial Stock Numbers and outward Rate of Exploitation.]. Also the annual change in those indices has been given in the Figure 3-14 [Annual Change in Biomass and Outward Rate of Exploitation for Seven Target Species.].

Those data at the beginning and ending time of the survey is given in the Table 3-23, while for "Otolithe", the beginning time was set at 1992 when biomass reached its apex, and for "Sole" at 1990 for the same reason. (cf. Table 3-23 [Annual Change in Biomass converted from Initial Stock Numbers and outward Rate of Exploitation.].

Table 3-23 Annual Change in Biomass converted from Initial Stock Numbers and outward Rate of Exploitation

No.	Stock	Estimating Items	Beginning 1985	Latest 1999	Rate of Decline
1	**Thiof**	Total Biomass	25,588	8,935	0.349
	Epinephelus aeneus	Commercila Catch	3,867	1,407	-
	Potential Biomass = 28,000 tons	Rate of Exploitation	0.151	0.158	-
2	**Pagre**	Total Biomass	34,126	34,673	1.106
	Sparus caeuleostictus	Commercila Catch	3,002	3,237	-
	Potential Biomass = 40,000 tons	Rate of Exploitation	0.088	0.093	-
3	**Thiekem**	Total Biomass	52,224	10,754	0.205
	Galeoides decadactylus	Commercila Catch	5,349	1,972	-
	Potential Biomass = 60,000 tons	Rate of Exploitation	0.102	0.183	-
4	**Otolithe_OT**	Total Biomass	20,697	1,570	0.076
	Pseudotolithus senegalensis	Commercila Catch	11,496	644	-
	Potential Biomass = 25,000 tons	Rate of Exploitation	0.555	0.410	-
5	**Machoiron**	Total Biomass	35,471	1,942	0.055
	Arius heudelotii	Commercila Catch	5,125	1,041	-
	Potential Biomass = 40,000 tons	Rate of Exploitation	0.144	0.536	-
6	**Sole**	Total Biomass	79,270	16,602	0.209
	Cynoglossus senegalensis	Commercila Catch	4,287	4,374	-
	Potential Biomass = 75,000 tons	Rate of Exploitation	0.054	0.263	-
7	**Sompatt**	Total Biomass	3,221	31,992	9.932
	Pomadasys jubelini	Commercila Catch	343	219	-
	Potential Biomass = 40,000 tons	Rate of Exploitation	0.106	0.007	-

Remarks:

The year of the maximum biomass at 1992 was chosen for "Beginning year" of "Otolithe", while so was the same for "Sole" (1990).

The rate in percent of the amount of biomass at the latest year (1999) comparing those at beginning were respectively; “Thiof” 35 %, “Pagre” 111 %, “Thiekem” 21 %, “Otolithe” 8 %, “Machoiron” 6 %, “Sole” 22 %, and “Sompatt” 993 %. The all values showed a large decline from the beginning with exception of “Pagre” and “Sompatt”. The two stocks in which biomass had increased, “Pagre” and “Sompatt” were the stocks of only moderately exploited ones for which no regulatory measure is required.

The stocks in which biomass had declined most were “Otolithe” and “Machoiron”. In “Otolithe” stock, nevertheless the biomass showed only 8 % level from the beginning, 644 tons catch had been taken in 1999 resulting in unreasonably high value in the [Rate of Exploitation] by weight-scale at 41 %. As was previously discussed, the status of “Otolithe” stock was so severe as to propose a tentative moratorium, and the reasonableness of the proposal would have been certified through the examination made here.

For the “Machoiron” stock (6 %), the situation is almost the same as the “Otolithe” stock. However, taking the recent catches of 5,766 and 6,696 tons in 1997 and 1998 into account, limitation of catch at 1,000 tons is proposed for the stock as the conservation measure.

For the “Thiof” stock (35 %), taking the decline in the spawning parental stock was also large (30%) into account, one third (500 tons) of the catch taken in 1999 (1,400 tons) is proposed to be the upper limit for the conservation measure.

For “Thiekem” and “Sole” stocks, the decline in biomasses was large (21 % and 22 %) as well as in spawning parental stock. However, taking the large [Potential Harvest], (900 millions and 1,200 million individuals in stock number, and 60,000 tons and 75,000 tons in biomass), into account, about half of the catch (1,000 tons) taken in 1999 (1,500 tons and 2,500 tons) is proposed to be the upper limit for the conservation measure.

Through the examination being based on the biomass estimates made in this section, the results obtained have been assured to be identical to the results obtained by “Initial Stock Numbers”.

3.4 Biomass Estimates of Clams

The estimation of biomass for two species of snails, (spiral shells, Gastropoda, “Cymbium” and “Murex” spp.), which had become to be harvested massively owing to increased commercial values by popularity in consumers in recent years, is included in this particular study. The statistical data compiled by CRODT was finally utilized to fulfill the task. The statistics on regional production compiled by DPM was also utilized as supplement to analyze the results further.

The trawl survey records, made by the CRODT's "R/V ITAF DEME" for twice, had shown only a small amount of catch taken. Since the catch records were considered to have covered only a small and minor portion of the distribution range of "Cymbium", the recode was excluded from this particular examination. On the other, although there had been a detailed survey study made on "Cymbium" fishing for a selected local fishery, it was also considered to have covered only a small portion of the distribution range of the stock in coastal area, then the study results was not incorporated in this particular examination. The data on the biological characteristics of the snails such as length, weight, growth, reproduction, etc. were almost nothing since the survey has not yet performed in such field, the information on biological aspects were completely excluded from the examination here.

The statistics employed in the examination were those compiled by CRODT and DPM, for which respective statistics have been given in the Table 3-24 [Catch Statistics of Clams, "Cymbium" spp. and "Murex" spp. provided by CRODT and DPM.] and Table 3-25 [Regional catches of "Cymbium" spp. and "Murex" spp. reported in DPM statistics, during the two years when high productions were achieved, and their average value and component ratio in the total.]. The former is the catch statistics of the two species for 1981-2003 compiled respectively by CRODT and DPM, while the latter is the Regional catch for selected 2 yeas when the massive catch had been taken compiled by DPM. The annual changes in the catch of these species are given in the Figure 3-15 [Annual Catch of "Cymbium" spp. estimated by CRODT and DPM.] and Figure 3-16 [Annual Catch of "Murex" spp. estimated by CRODT and DPM.] by compiled organization.

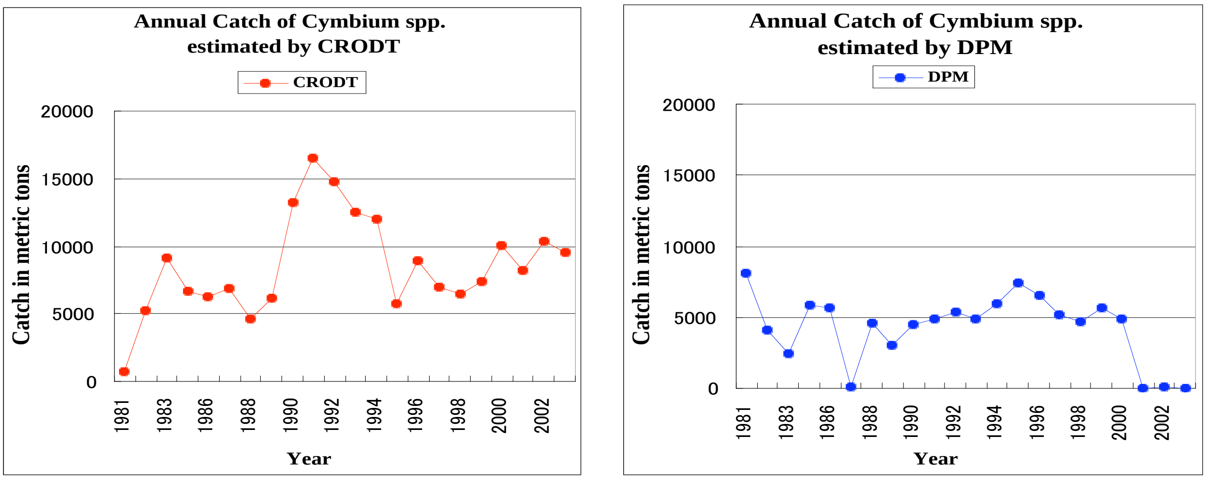


Figure 3-15 Annual Catch of Cymbium spp. estimated by CRODT and DPM

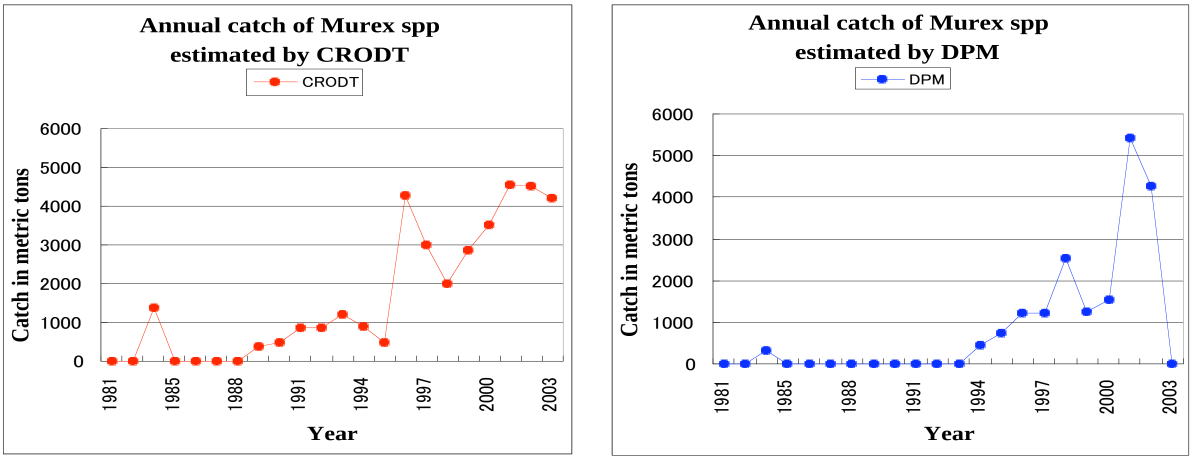


Figure 3-16 Annual Catch of Murex spp. estimated by CRODT and DPM

Taking a glance at those Figures, it is obvious that the history of both fisheries is very short, since 1990 for "Cymbium" and since 1996 for "Murex", the substantial full-scale exploitation had been achieved very soon. The statistics compiled by CRODT was chosen to use in the study since it was considered that the reliability was superior with higher catch record.

3.4.1 "Cymbium" spp. (Gastropoda, Volutidae)

When estimating the biomass of "Cymbium" the statistics during 1990-2003 was employed as it was considered that the fishery had entered nearly stable exploitation phase during the period after the examination on the Figure 3-15.

Among the several ways to estimate the biomass from catch data, the [Count Backward] method was applied here, in which the [Rate of Fishing (ROF)] will be firstly estimated then applied to the amount of catch. As [Rate of Fishing (ROF)] for "Cymbium", ROF = 0.6 was applied since the snail is presumed to have been caught by relatively intensive fishing by gillnet in local limited area.

The estimated results are given in Table 3-26 [Annual catch and estimated Biomass of "Cymbium" spp. during 1990-2003.] and Figure 3-17 [Annual change in estimated Biomass of "Cymbium" spp. during 1990-2003.].

Table 3-26 Annual catch and estimated Biomass of Cymbium spp. during 1990-2003

(Biomass = Annual Catch / ROF)

(metric tons)

Year	**Annual Catch Cymbium spp**	**Biomass Estimates (ROF = 0.6)**
1990	13,249	22,081
1991	16,499	27,498
1992	14,751	24,585
1993	12,536	20,893
1994	11,952	19,920
1995	5,759	9,598
1996	8,952	14,920
1997	6,961	11,601
1998	6,477	10,795
1999	7,379	12,298
2000	10,033	16,721
2001	8,173	13,621
2002	10,400	17,334
2003	9,535	15,892

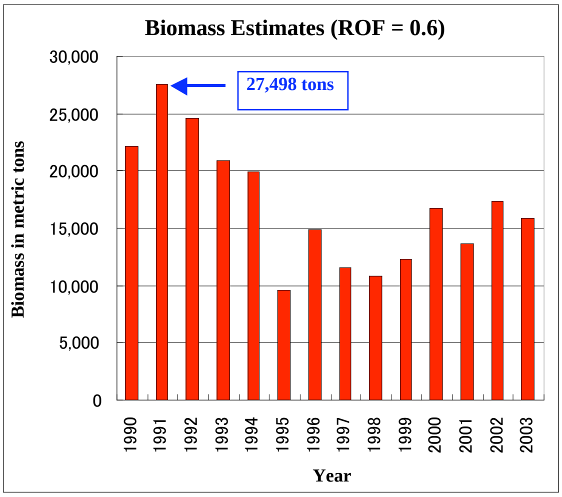


Figure 3-17 Annual change in estimated Biomass of Cymbium spp. during 1990-2003

The total amount of exploitable stock biomass of "Cymbium" is estimated to be 28,000 tons, being based on the maximum value estimated in 1991 (27,496 tons), for which actual catch was 16,499 tons.

The estimated total biomass could be allocated to each of region where actual catch were reported, being based on the Table 3-15 [Regional catches of "Cymbium" spp. and "Murex" spp. reported in DPM statistics], and the results shows the concentration of biomass in "Thies Region" as is given in the Table 3-27 [Estimated Biomass of "Cymbium" spp. allocated to each of Provinces.].

Table 3-27 Estimated Biomass of Symbium spp. allocated to each of Provinces

(metric tons)

Province / Items	**Provincial Ratio (%)**	**Biomass Estimates**
Fleuve/St-Luise	0.5	146
Louga	0.2	60
Thies	94.0	26,328
Cap Vert/Dakar	2.0	563
S. Saloum/F Kaolack	–	–
Fatick	1.8	507
Cazamance/Ziguinchor	1.4	397
TOTAL	100.0	28,000

3.4.2 "Murex" spp. (Gastropoda, Muricidae)

The estimation of the biomass of "Murex" was followed by the similar procedure employed in the "Cymbium". That is, the catch statistics for 8 years during 1996-2003 were employed, when the fishing were considered to have been reached at their full-scale exploitation after the examination of Figure 3-16. Also for the [Rate of Fishing (ROF)], the value of ROF = 0.6 is applied similarly to that of "Cymbium", and the biomass was estimated through the backward calculation. The discussion to some extent will be given later on this aspect together with that of "Cymbium".

The estimated results are given in the Table 3-28 [Annual catch and estimated Biomass of "Murex" spp. during 1996-2003.] and Figure 3-18 [Annual change in estimated Biomass of "Murex" spp. during 1996-2003.].

Table 3-28 Annual catch and estimated Biomass of Murex spp. during 1996-2003

(Biomass = Annual Catch /ROF)

(metric tons)

Year	Annual Catch Cymbium spp	Biomass Estimates (ROF = 0.6)
1996	4,274	7,124
1997	2,989	4,981
1998	1,999	3,332
1999	2,877	4,795
2000	3,517	5,861
2001	4,553	7,588
2002	4,531	7,551
2003	4,200	7,000

(Biomass = Annual Catch/ROF)

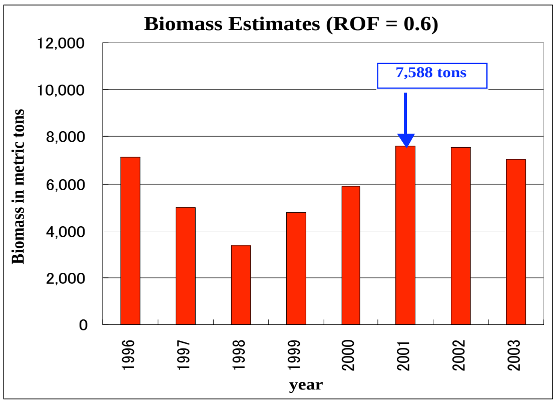


Figure 3-18 Annual change in estimated Biomass of Murex spp. during 1996-2003

The total amount of exploitable stock biomass of "Murex" is estimated to be 8,000 tons, being based on the maximum value estimated in 2001 (7,588 tons), for which actual catch was 4,553 tons.

The estimated total biomass could be allocated to each of regions where actual catch were reported, being based on the Table 3-15 [Regional catches of "Cymbium" spp. and "Murex" spp. reported in DPM statistics], and the results shows the concentration of biomass in "Thies Region" as is given in the Table 3-29 [Estimated Biomass of "Murex" spp. allocated to each of Provinces.]. However in the case of "Murex", the amount of allocated biomass to the Regions of Fatick and Casamance are relatively large than the case of "Cymbium", which may indicates the stronger dependency of the fishermen there on this stock.

Table 3-29 Estimated Biomass of Murex spp. allocated to each of Provinces

(metric tons)

Province / Items	Provincial Ratio (%)	Biomass Estimates
Fleuve/St-Luise	0.34	27
Louga	1.40	112
Thies	86.63	6,930
Cap Vert/Dakar	1.17	93
S. Saloum/F Kaolack	–	–
Fatick	6.29	503
Cazamance/Ziguinchor	4.17	334
TOTAL	100.00	8,000

3.4.3 Discussion on Biomass Estimates of Clams

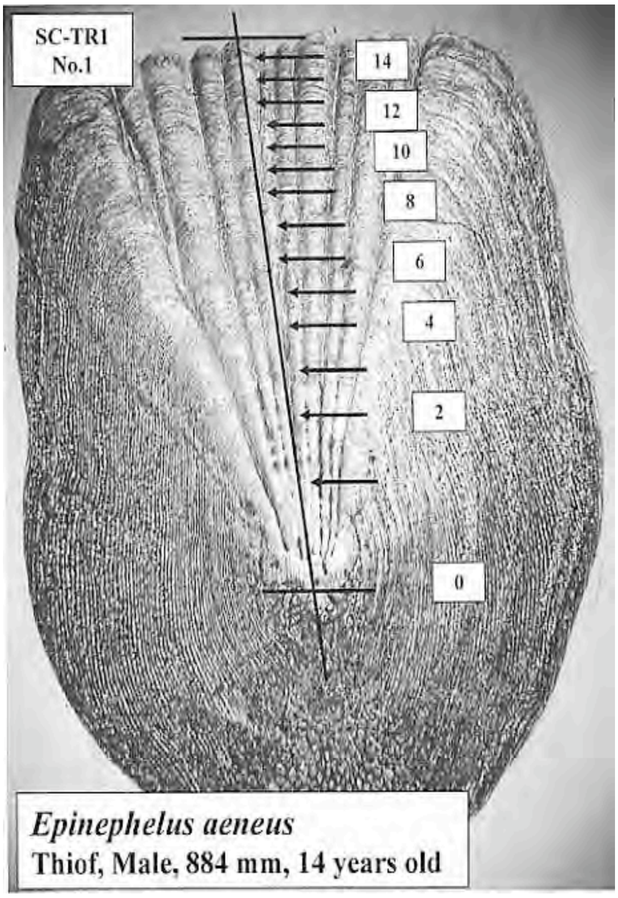
The biomasses of "Cymbium" and "Murex" are estimated 28,000 tons and 8,000 tons respectively. However, they were estimated by backward calculation on the assumption of the [Rate of Fishing: (ROF=0.6)]. They should be, therefore regarded as estimates at the first approximation.

It has been a general rule, when the amount of [Standing Stock Biomass] is to be estimated by means of trawl survey, the first approximation will be estimated on the basis of the [Rate of Fishing (ROF)], (Catch Rate in other words), is assumed to be [0.5] should there is no other effective method is available. This type of rule had been applied *mutatis mutandis* for the data obtained by "Gill Net Fishery". The value of [Rate of Fishing (ROF)] was set at ROF=0.6, which is larger than the standard value of 0.5 by 0.1, as the fishing had been intensified annually with increased catch to have been rather concentrated fishing performed. However, that value is also merely arbitrary, the estimated biomasses are, therefore no more than the values within accuracy at the first approximation.

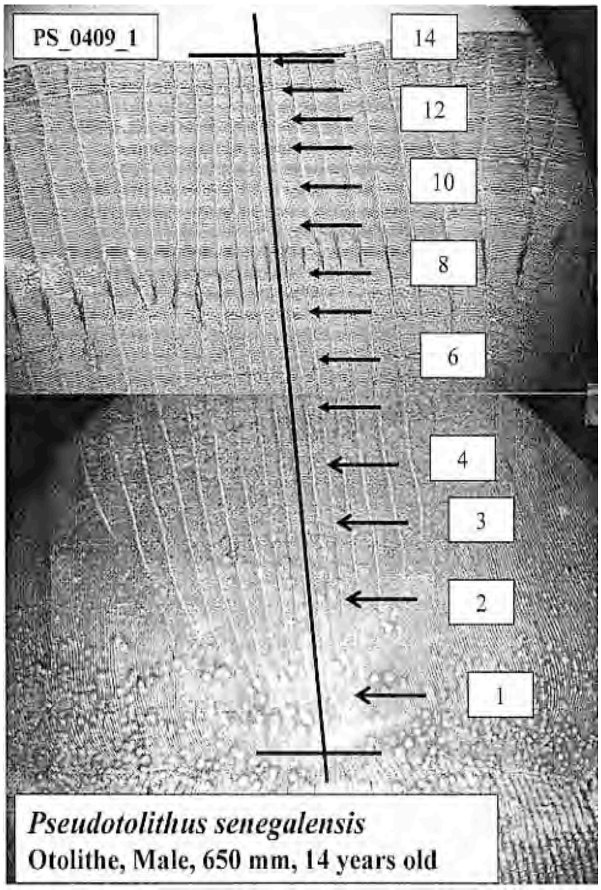
Increase in the accuracy of estimates is therefore required in the future. A study on quantitative verification in fishing mechanisms of the snails would be proposed to make to enhance the research for the time being. The description on physical characteristics of habitat of the two snail species concerned, including bottom material, sea bed topography and ocean current, etc. should firstly be specified as the snails are caught by bottom gillnet.

With regard to the fishing for "Cymbium", the catching of snail would mechanically be made through entangling its foot/tail portion but not round spiral shell itself when it is closed, since the structure and nature of bottom are presumed to be flat and muddy sand, for which the clarification be made in conjunction with the physical characteristics of habitat.

With regard to the fishing for "Murex", which inhabits on undulating rise-and fall sea-bottom with gravelly materials, the sophisticated structure inherent on its spiral shell need to be taken into account in addition to the function on catching mechanism of entangling its foot/tail portion as they may affect a great deal on entanglement of gill-net and eventually on the [Rate of Fishing (ROF)]. Because, on the surface of spiral shell, there are many elongated spines sequentially existed along the vertical varix, which may affect the catch-ability of "Murex" a great deal and act as an important factor on the value of [Rate of Fishing (ROF)]. Anyway, the information further more on fishing technology and bio-morphologic aspects should be collected and analyzed in the future so as to improve the accuracy in biomass estimates.



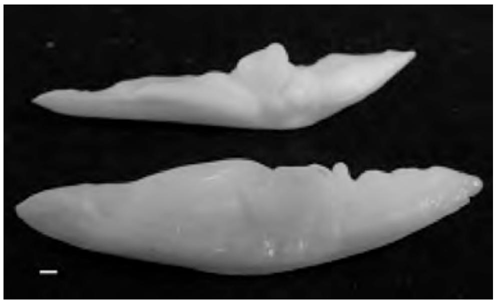
Whole scale is shown

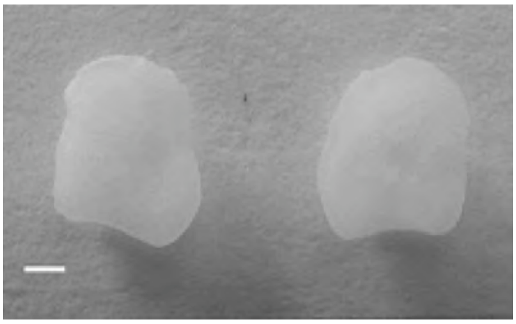


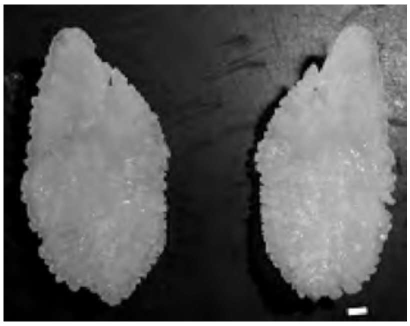
Two photos have been compiled into one to show the details of scale feature

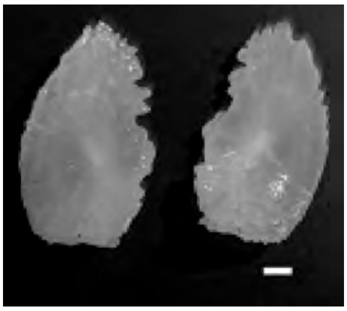
Figure 3-1 Schematic illustrations of scale reading for sample specimens of Thiof and Otolithe

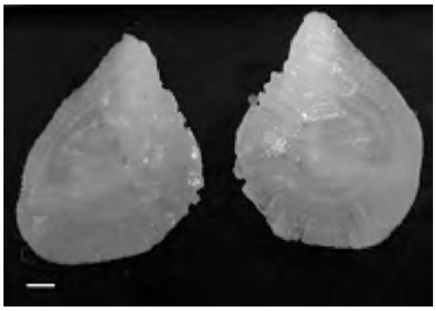

a. *Arius heudelotii*


b. *Brotula barbata*

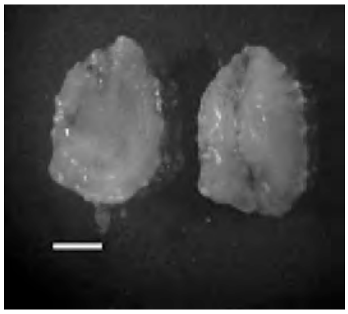

c. *Cynoglossus senegalensis*


d. *Epinephelus aeneus*


e. *Galeoides decadactylus*


f. *Pomadasys jubelini*


g. *Pseudotolithus senegalensis*


h. *Pseudupeneus prayensis*

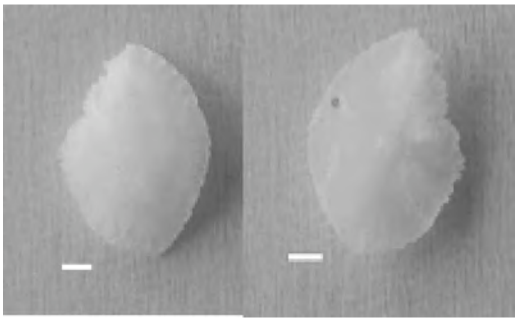
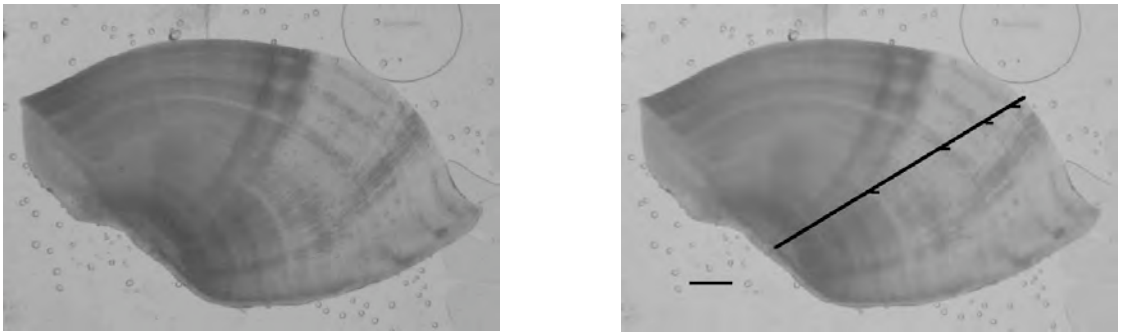
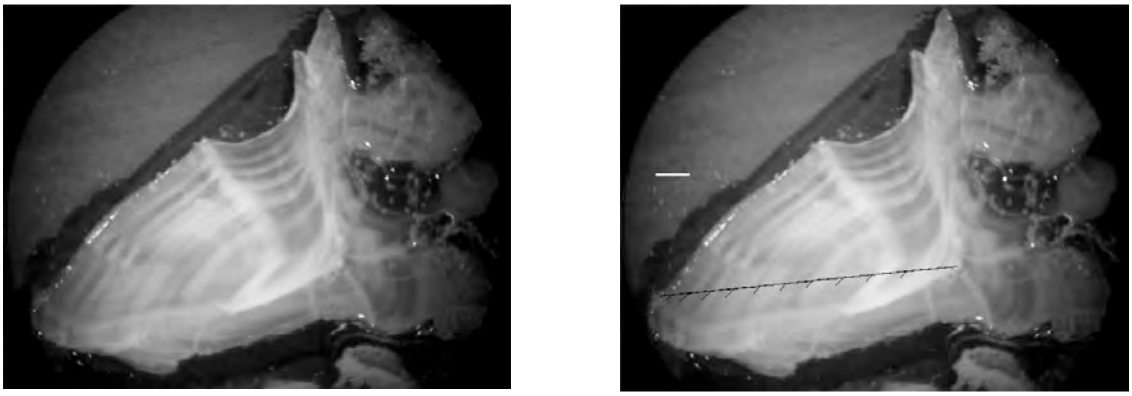

i. *Sparus caeruleostictus*

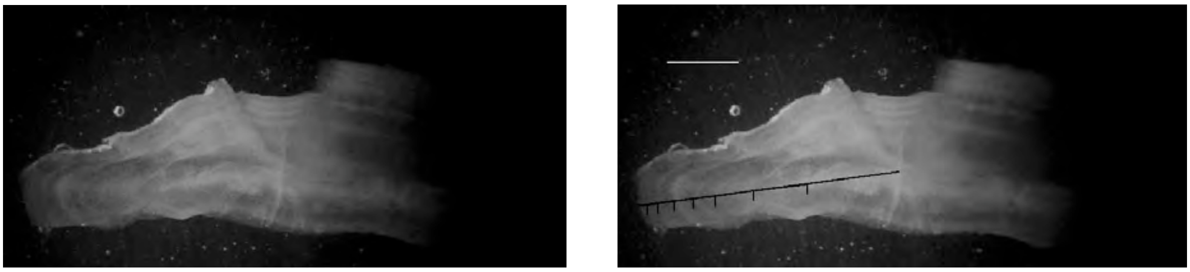
Figure 3-2 The typical forms and sizes of a pair of otoliths of the nine target species



a. Otolithe de *Arius heudelotii* (LF = 457mm, Pds = 1300g : 4 ans)

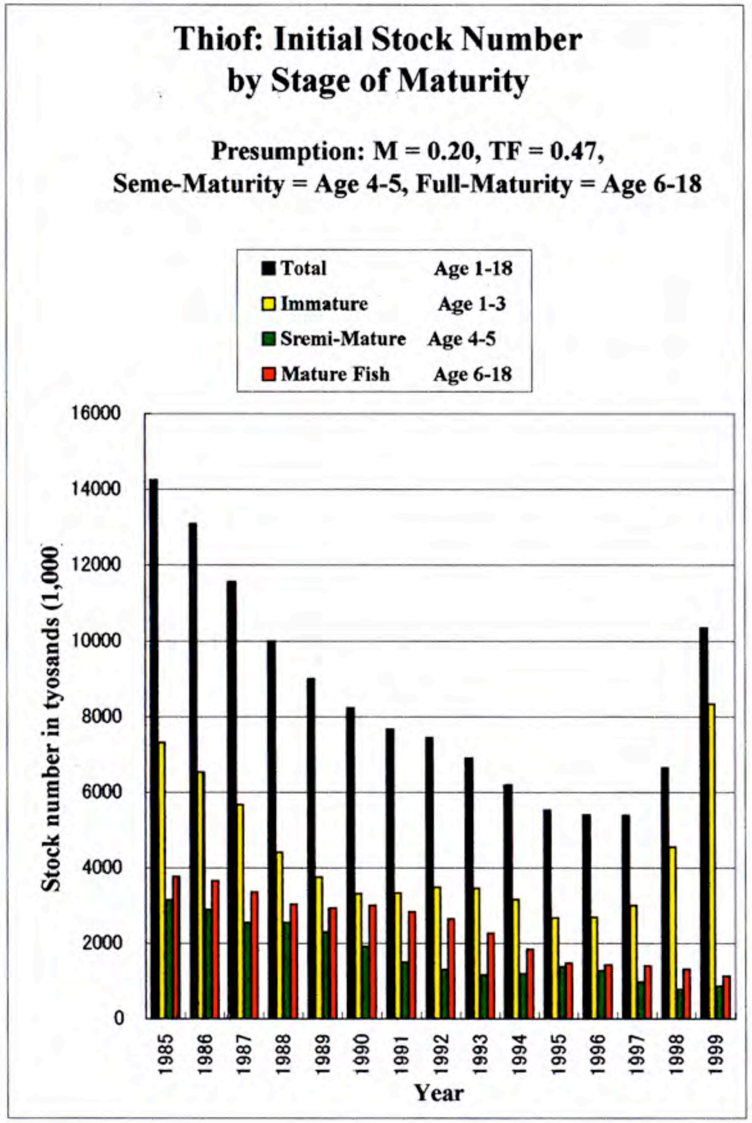


b. Otolithe de *Pseudotolithus senegalensis* (LT = 595mm, Pds = 1850g : 10ans)



c. Otolith de *Pomadasys jubelini* (LF = 282mm, Pds = 380g : 7ans)

Figure 3-3 Schematic illustrations of otolith reading by thin sliced otoliths samples for three target species employed



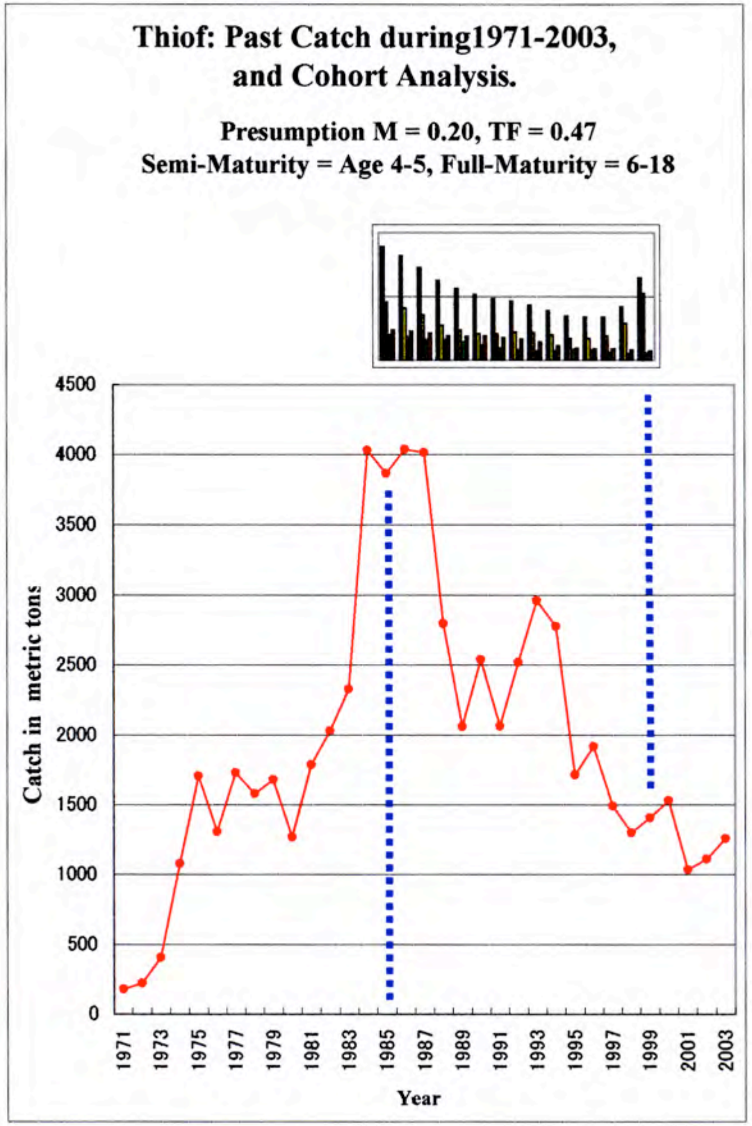
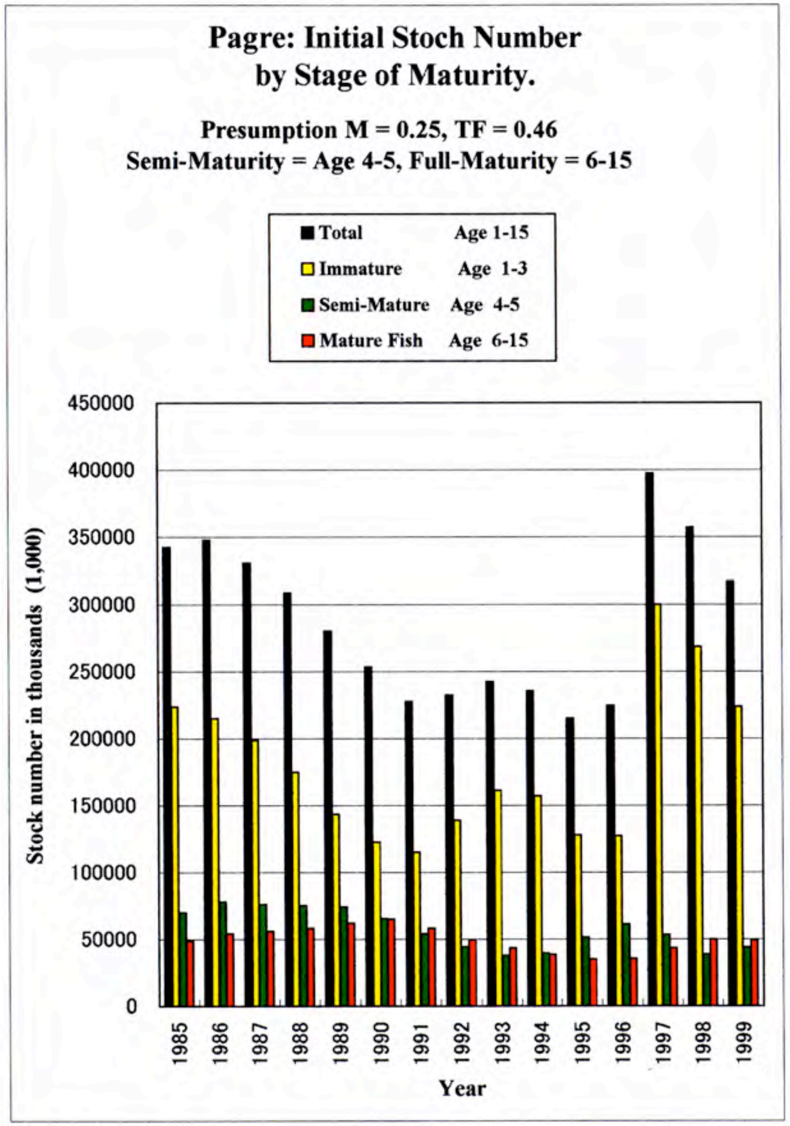


Figure 3-4 Thiof: The change in initial stock numbers by stage of maturity during 1985-1999, and the past commercial catch during 1971-2003



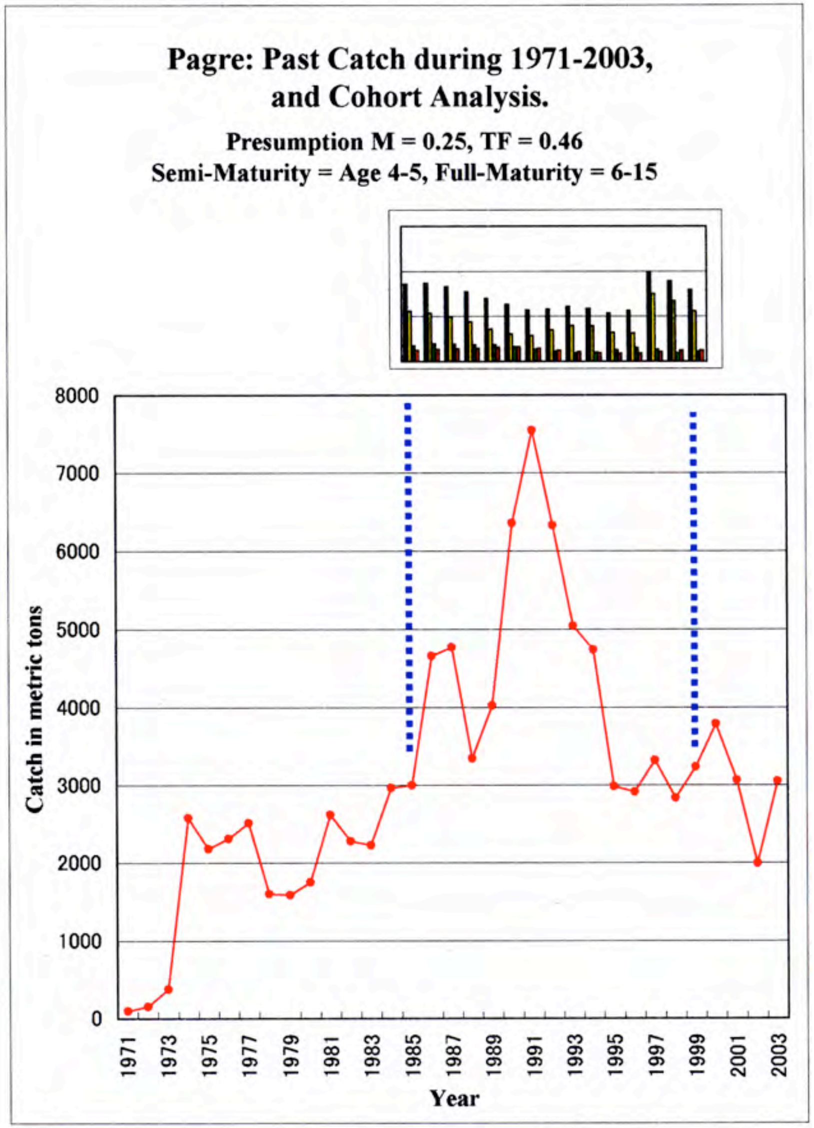
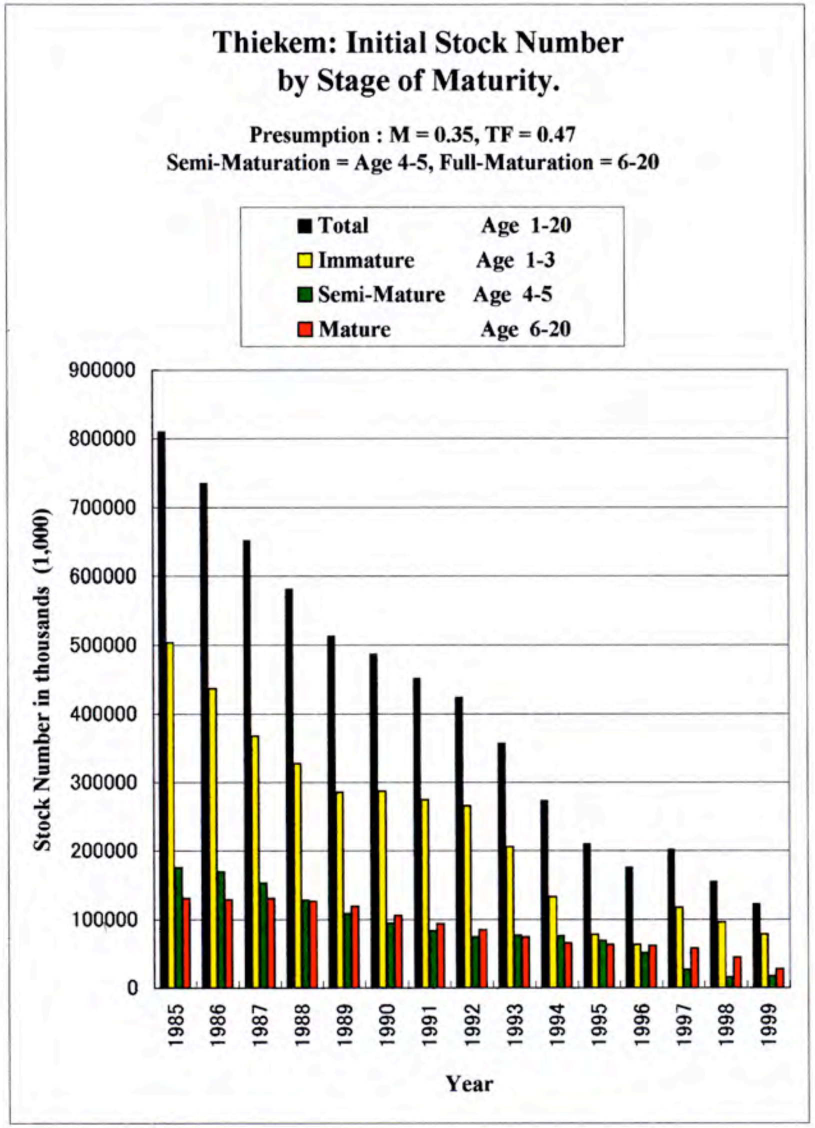


Figure 3-5 Pagre: The change in initial stock numbers by stage of maturity during 1985-1999, and the past commercial catch during 1971-2003



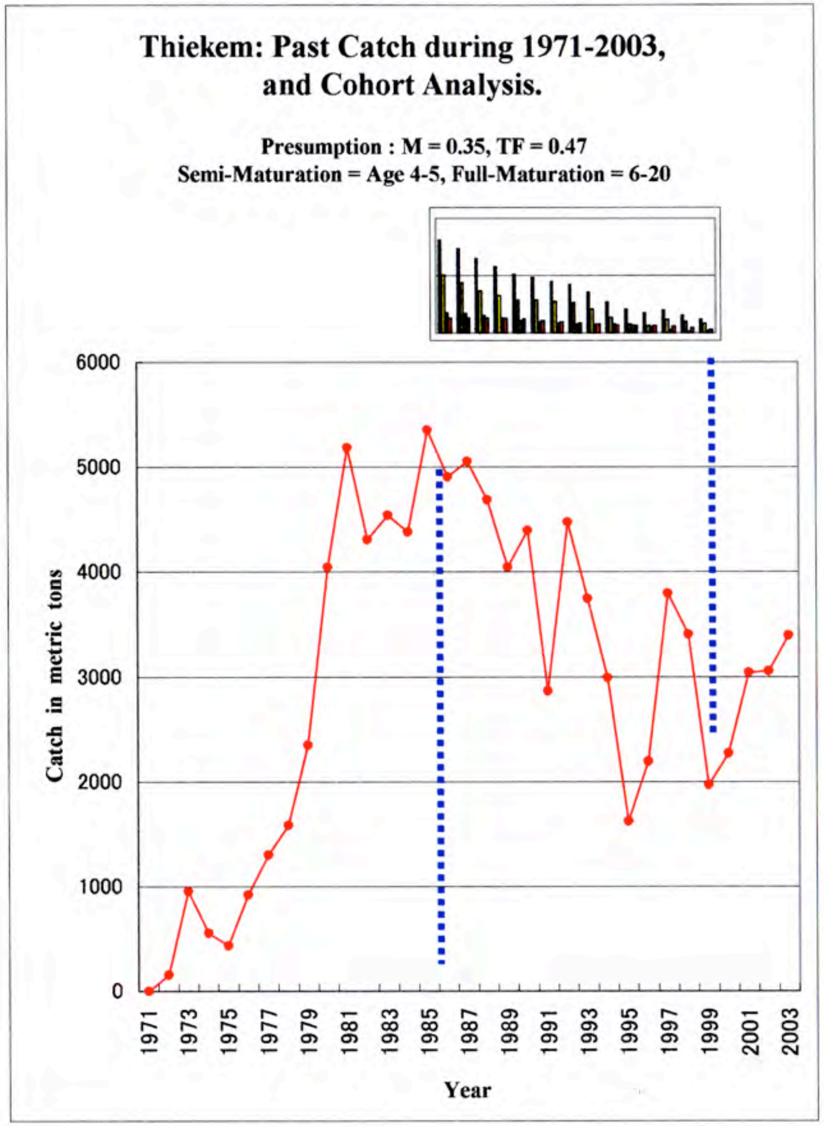
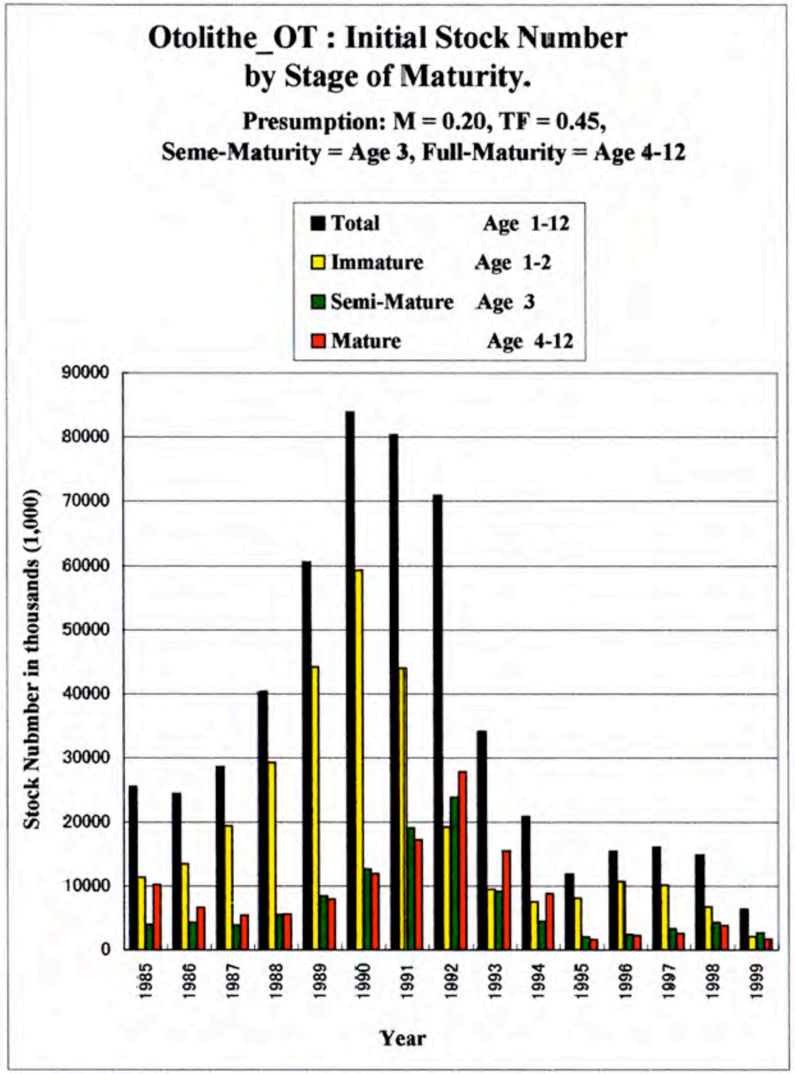


Figure 3-6 Thiekem: The change in initial stock numbers by stage of maturity during 1985-1999, and the past commercial catch during 1971-2003



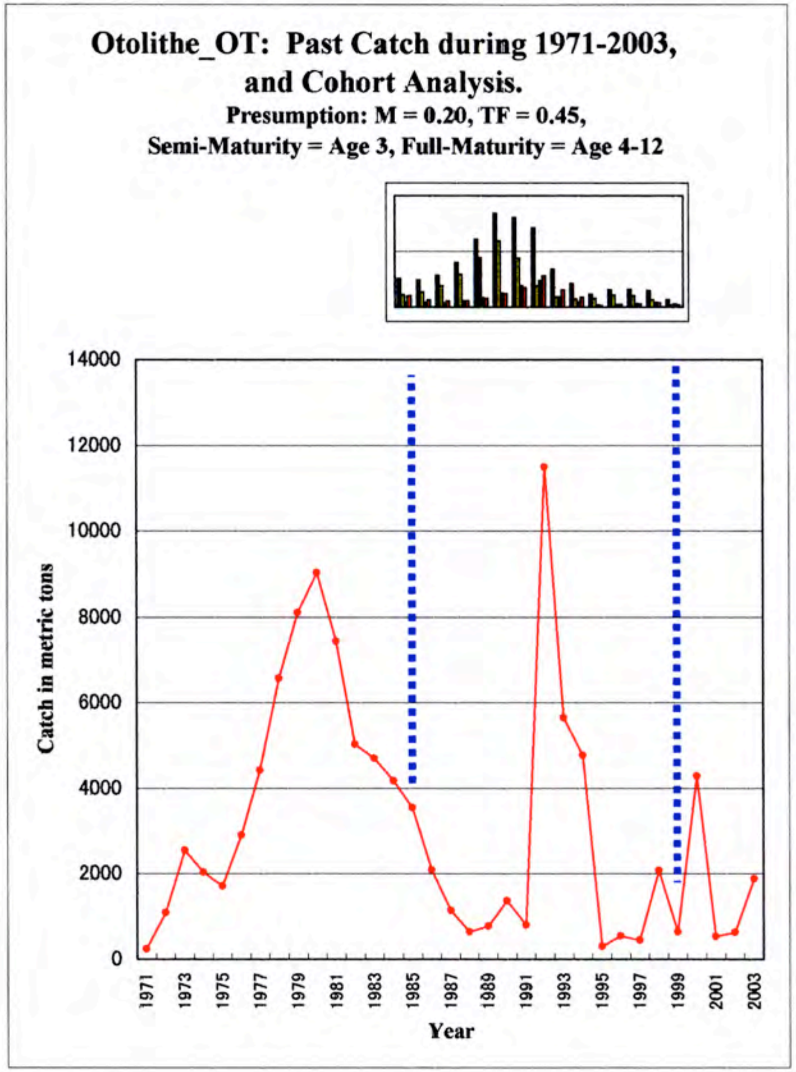


Figure 3-7 Otolithe_OT (aged by otolith): The change in initial stock numbers by stage of maturity during 1985-1999, and the past commercial catch during 1971-2003

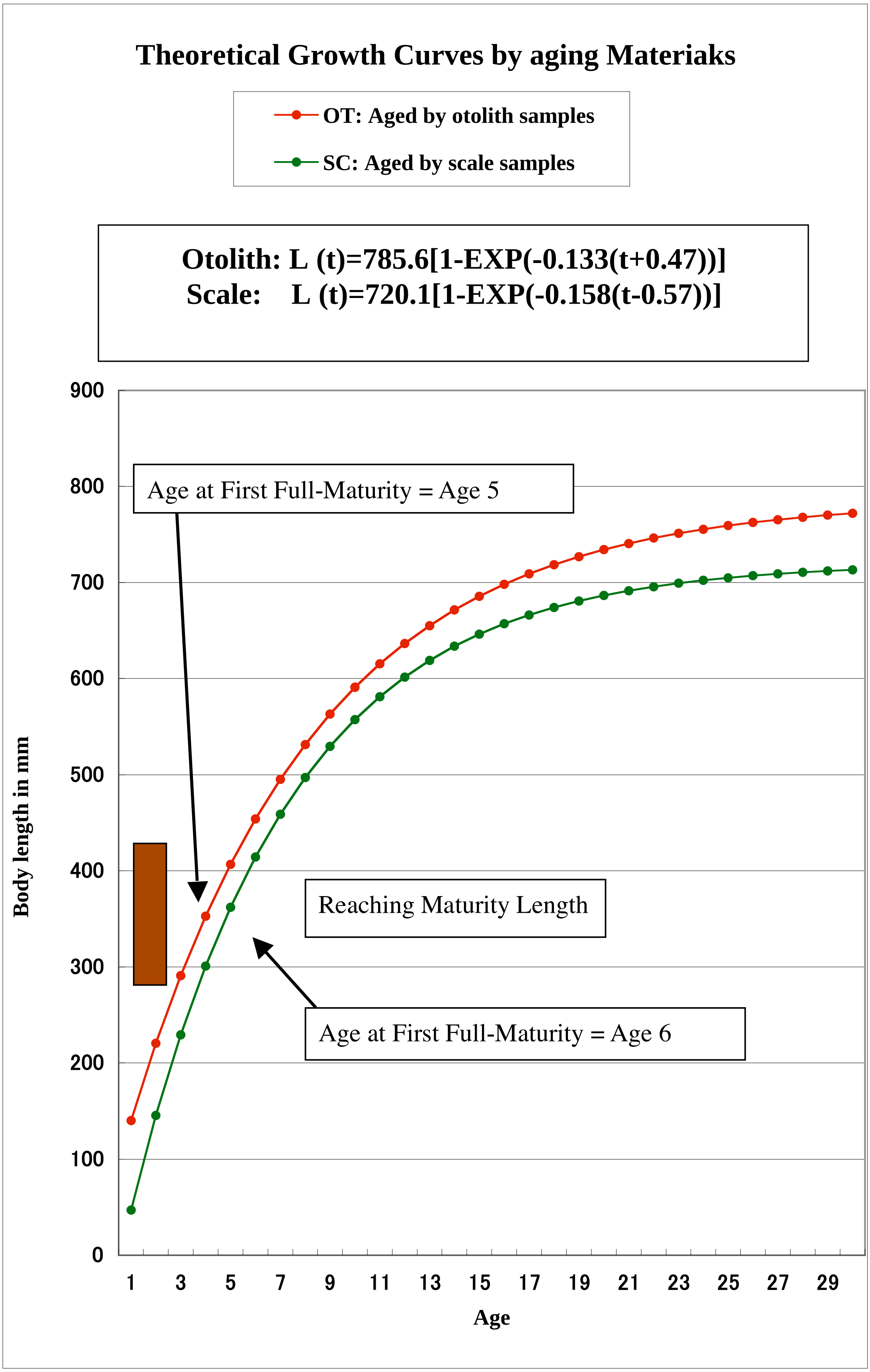


Figure 3-8 Otolithe: Comparison of aging results, discrepancies between aging materials, Otolith versus Scale samples

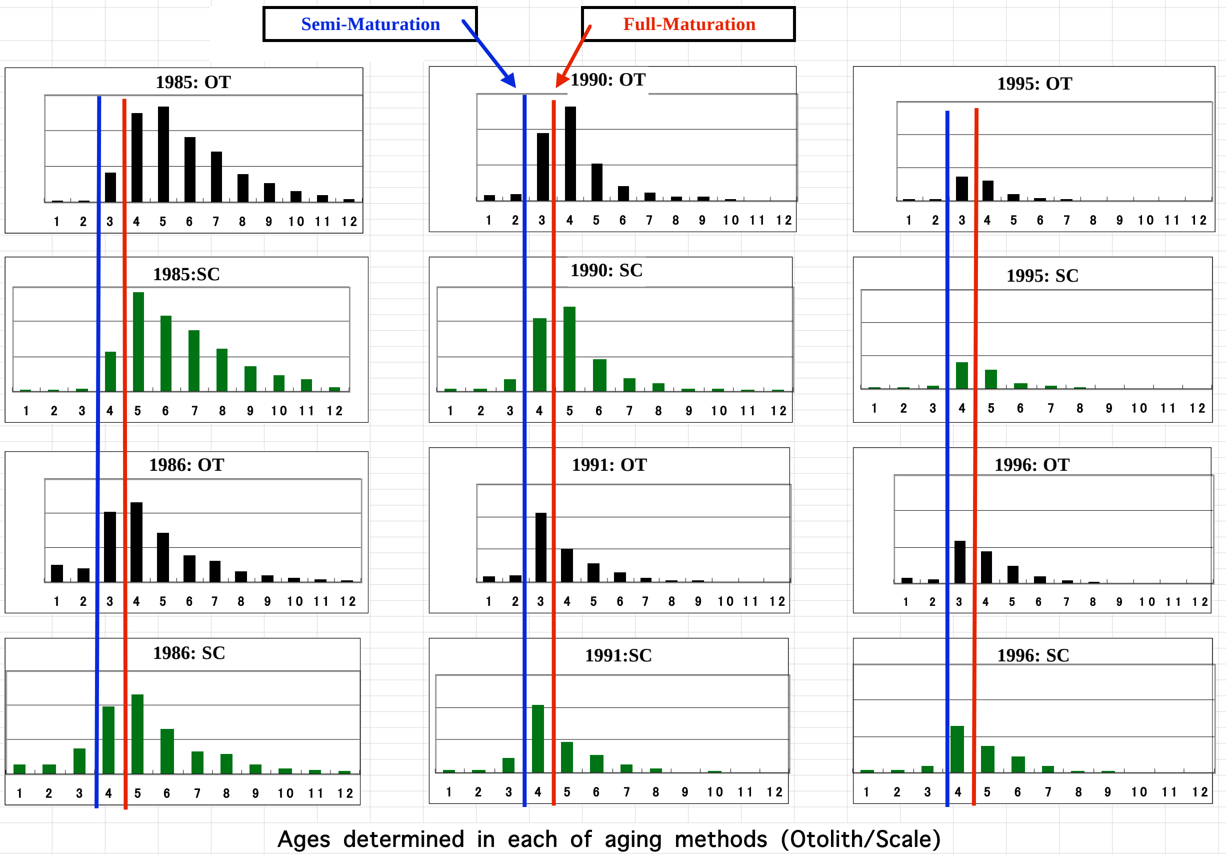
Comparison of Age Composition Data prepared by Otolith- and Scale-Reading.

OT: Data preapred by "otolith-sample-reading", SC: Data prepared by "scale-sample-reading".

On assessment procedure, the ages "at-the-first-mature", or "the-body-length-to-be-matured" should be carefully chosen, then no serious mis-understanding would be reached. In this case for a example, age-4 should be chosen for the data provided by otolith reding, while age-5 for the data provided by scale reading.

"Vertical Red-Line" denotes the index-mark of the age of "Full-Maturation" between both aging methods,

while "Vertical Blue-Line" denotes the age of "Semi-Maturation".



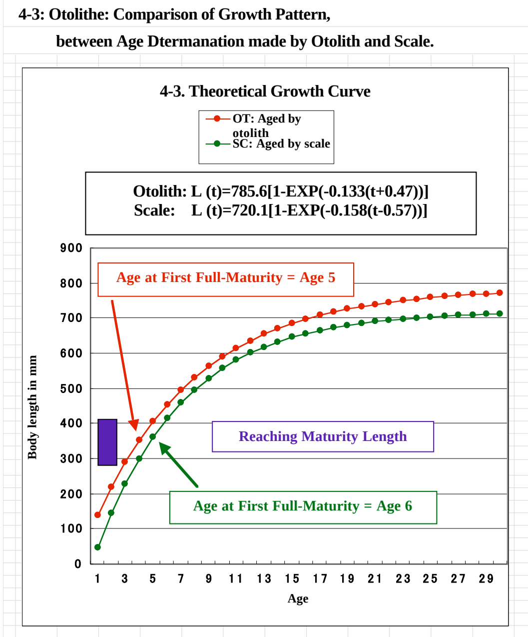
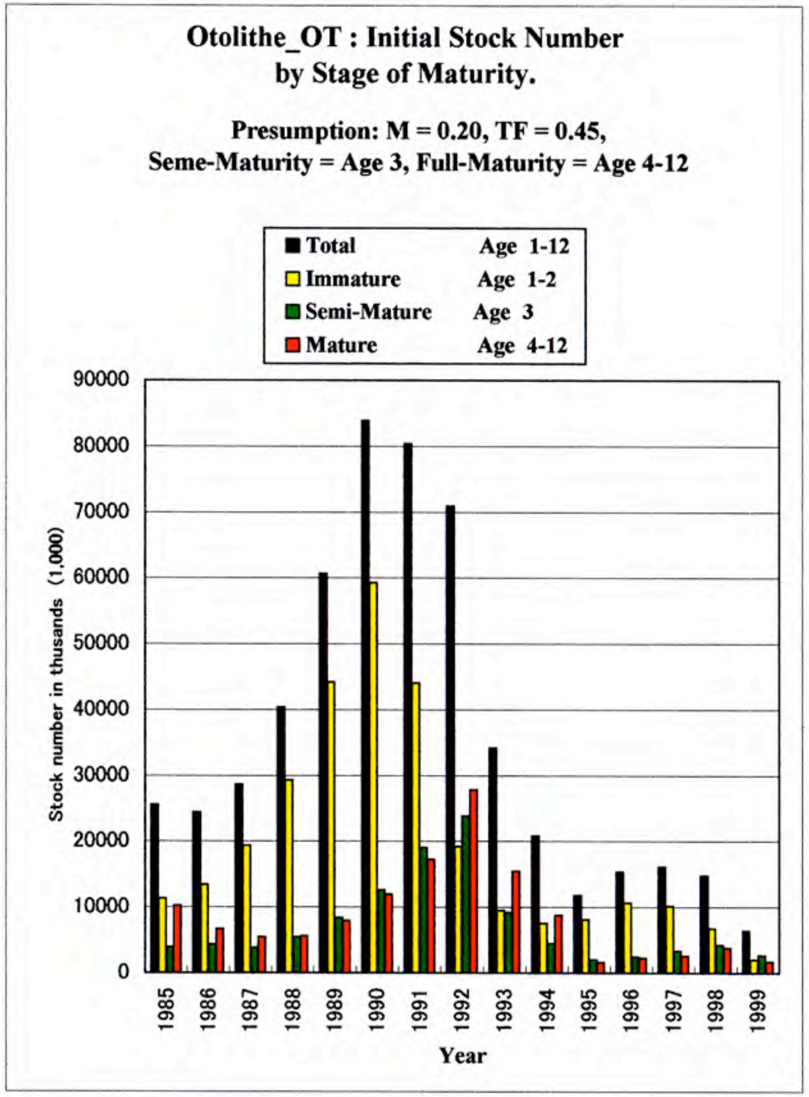


Figure 3-9 Schematic illustration on comparison of age compositions estimated between aging materials by Otolith versus Scale



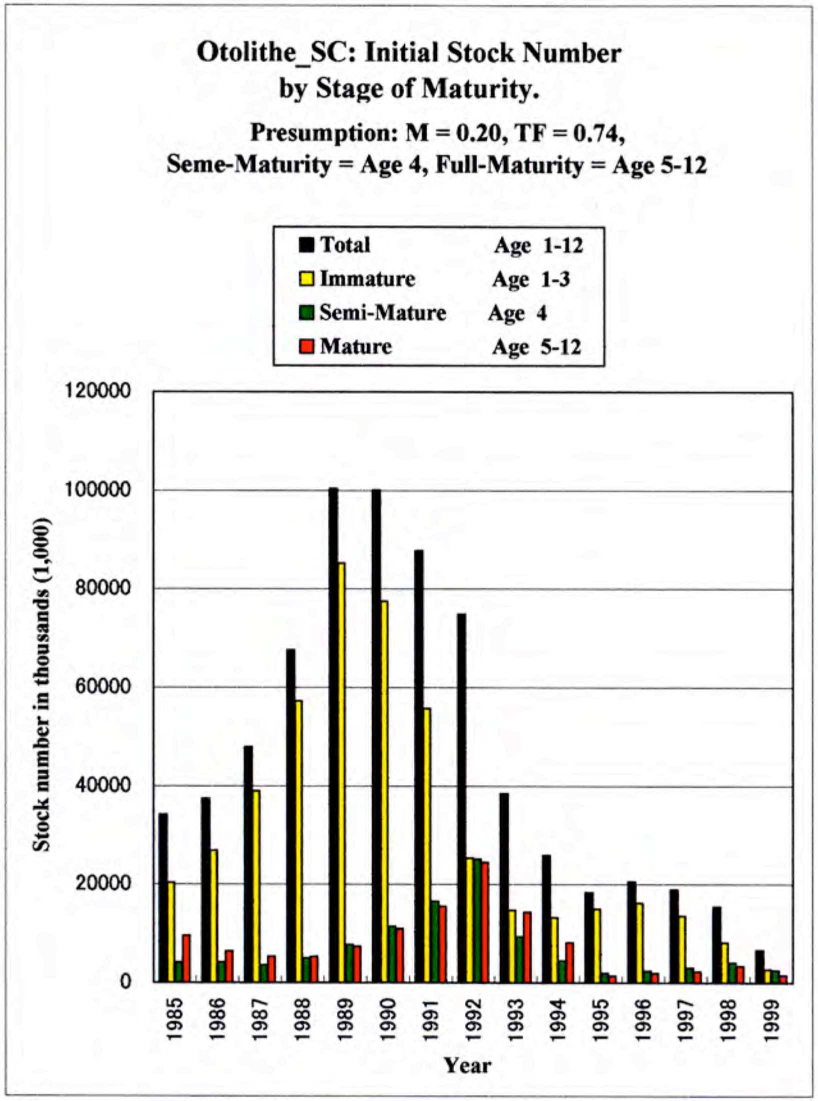


Figure 3-10 Comparison of the results of Cohort Analyses between aging materials, Otolith versus Scale samples

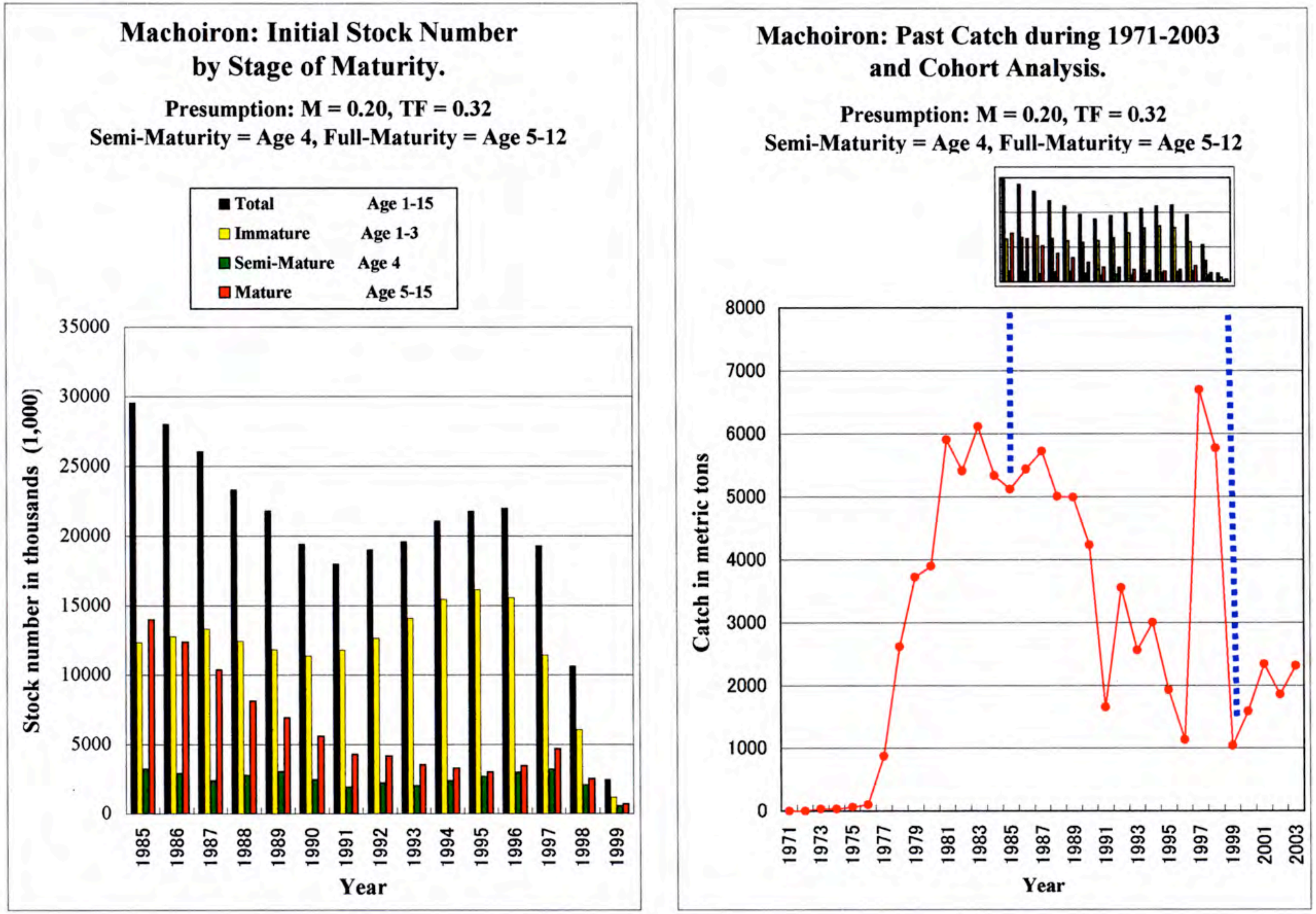
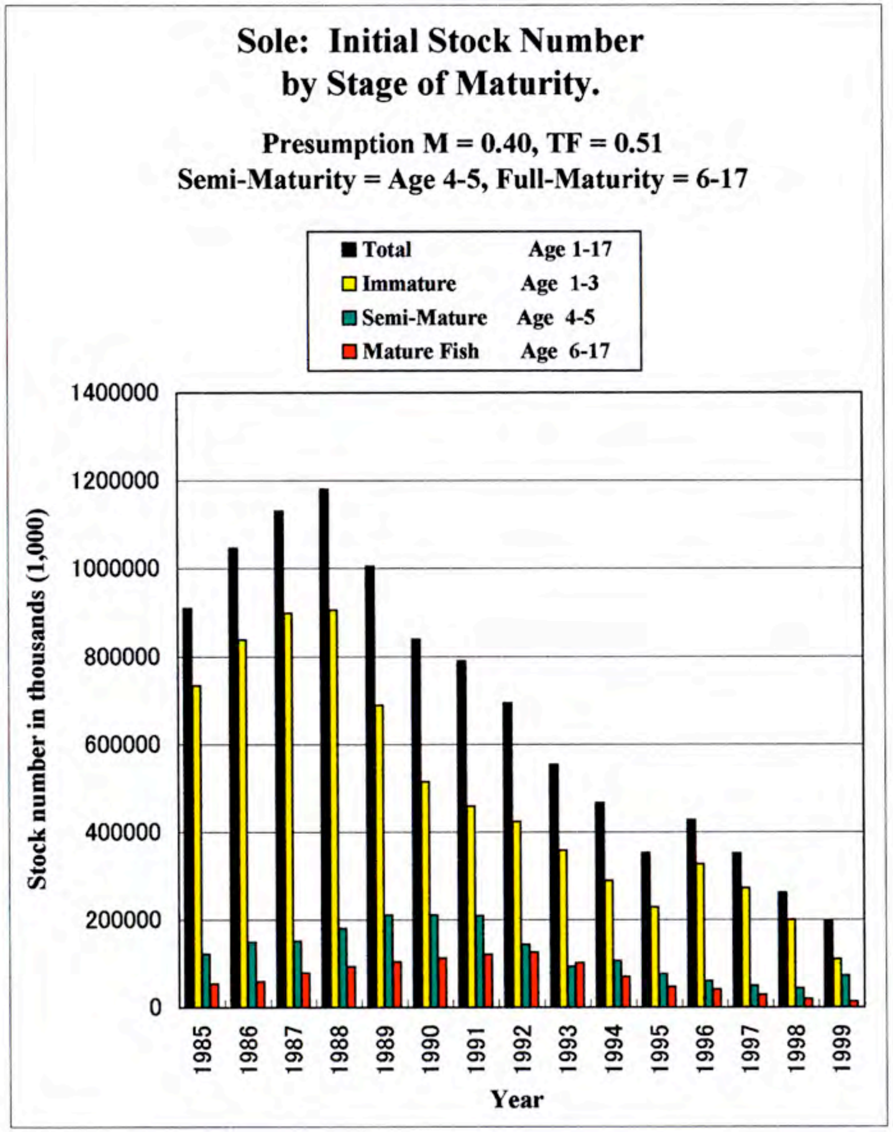


Figure 3-11 Machoiron: The change in initial stock numbers by stage of maturity during 1985-1999, and the past commercial catch during 1971-2003



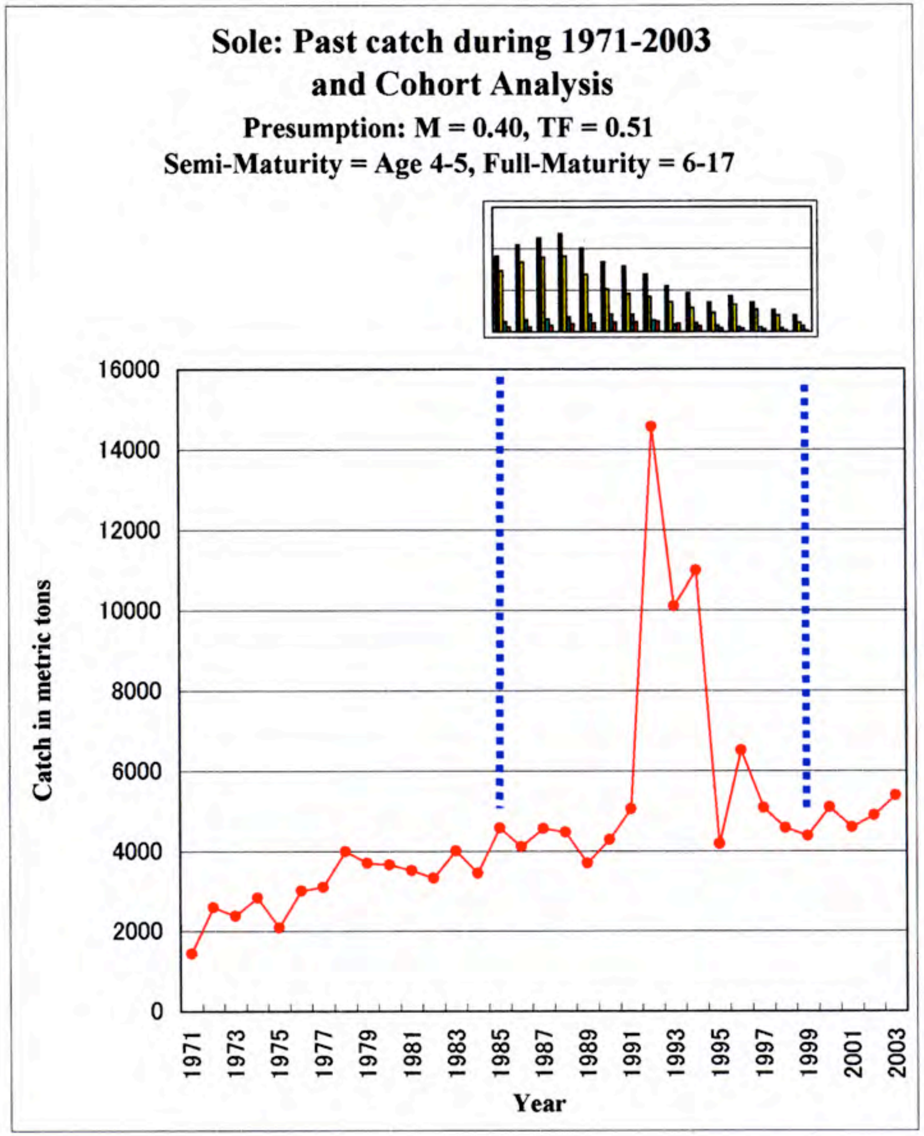
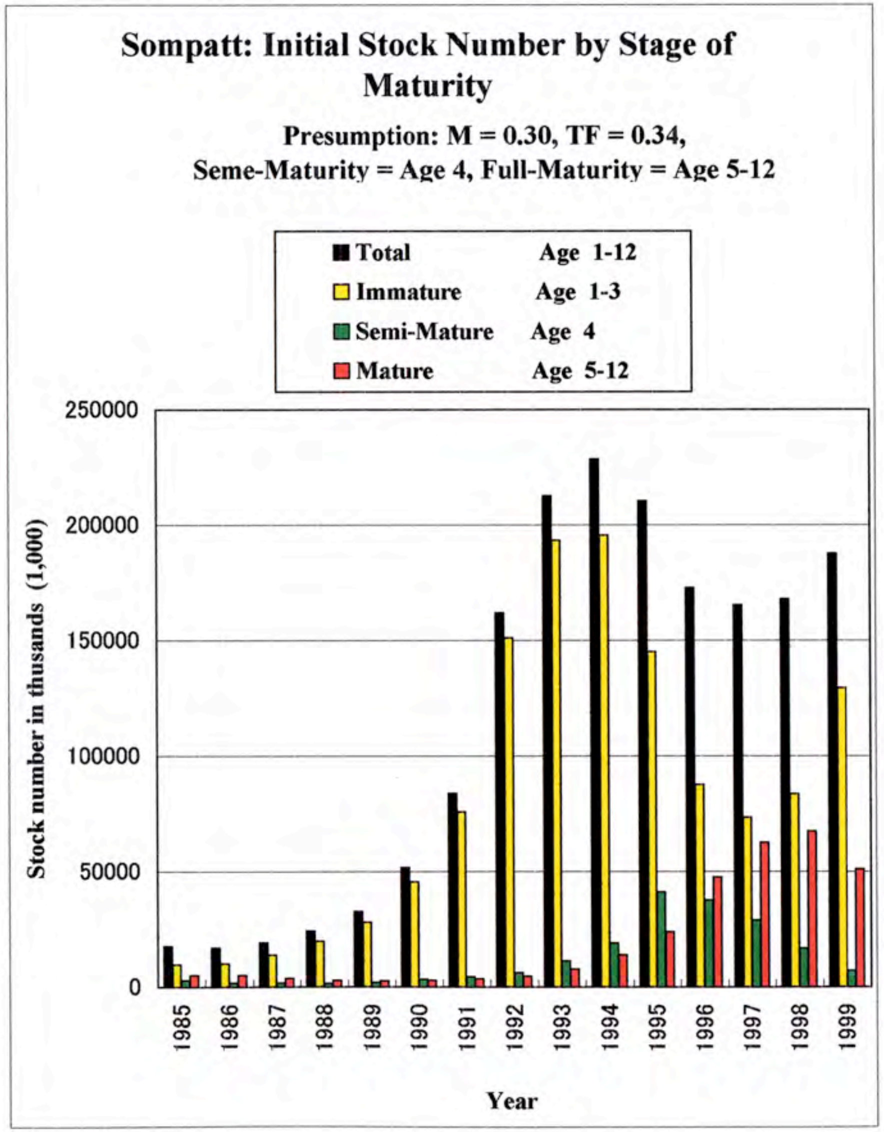


Figure 3-12 Sole: The change in initial stock numbers by stage of maturity during 1985-1999, and the past commercial catch during 1971-2003



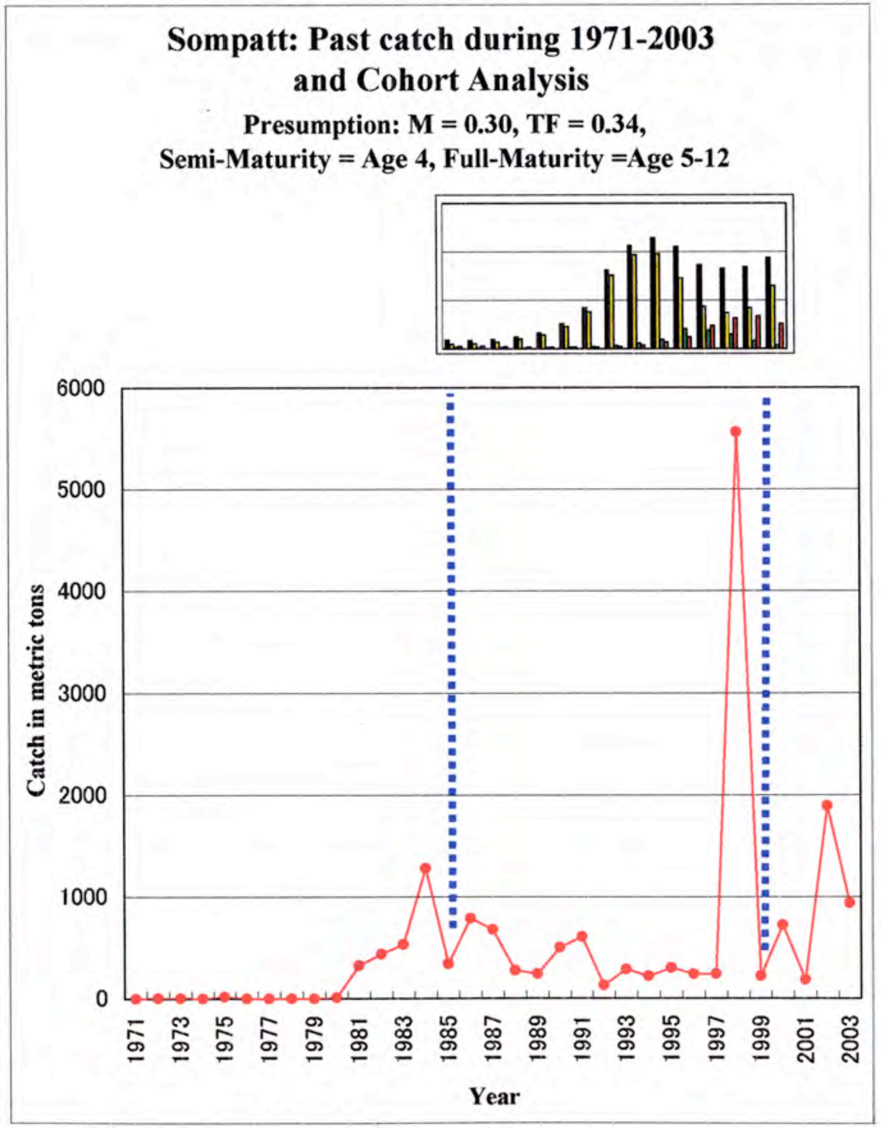


Figure 3-13 Sompatt: The change in initial stock numbers by stage of maturity during 1985-1999, and the past commercial catch during 1971-2003

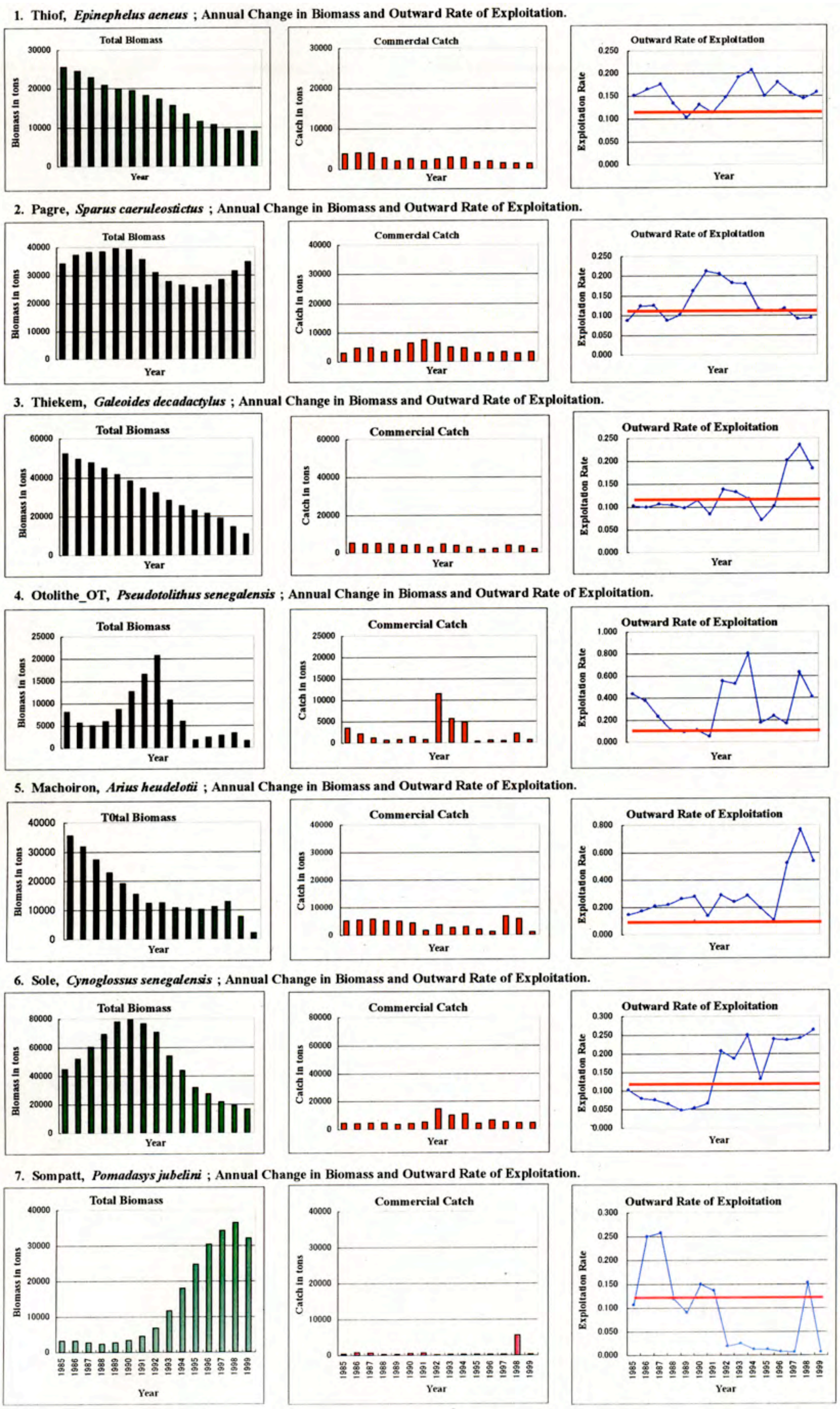


Figure 3-14 Annual change in biomass converted from initial stock numbers, past record of commercial catches, and outward Rate of Exploitation

Table 3-1 Synopses of biological and population parameters estimated for stock assessment purpose on seven target stocks

Target Species		Biological Parameters								Population Parameters				
		Growth			Length-Weight Relationship		Length Composition	Landing Statistics	Age Composition	Mortality Coefficient		Maturity Status by Age		
No.	Local/Scientific Names	$L_{(infinity)}$	k	$t_{(0)}$	a	b	Sample/ Commercial Catch	Annual Catch by Species	Commercial Catch	Natural Mortality (M)	Terminal Mortality (TF)	Immature	Semi-Mature	Full-Mature
1	**Thiof** *Epinephelus aeneus*	992.9	0.145	-0.23	0.00596	3.223	CRODT's Data Prepared	CRODT's Data	Prepared	0.20	0.47	1 - 3	4 - 5	6 - 18
		Sample size: 16 sp. Aging by: Scale			CRODT's Data									
2	**Pagre** *Sparus caeruleostictus*	455.9	0.0982	-0.61	0.0245	2.998	CRODT's Data Prepared	CRODT's Data	Prepared	0.25	0.46	1 - 3	4 - 5	6 - 15
		Sample size: 30 sp. Aging by: Scale			CRODT's Data									
3	**Thiekem** *Galeoides decadactylus*	446.1	0.110	0.52	0.00000617	3.206	CRODT's Data Prepared	CRODT's Data	Prepared	0.35	0.47	1 - 3	4 - 5	6 - 20
		Sample size: 25 sp. Aging by: Scale			Project's Data									
4-1	**Otolithe** *Pseudotolithus senegalensis*	785.6	0.133	-0.47	0.0545	2.469	CRODT's Data Prepared	CRODT's Data	Prepared	0.20	0.45	1 - 2	3	4 - 12
		Sample size: 10 sp. Aging by: Otolith			CRODT's Data									
4-2		720.1	0.158	0.57							0.74	1 - 3	4	5 - 12
		Sample size: 12 sp. Aging by: Scale												
5	**Machoiron** *Arius heudelotii*	722.8	0.162	-0.02	0.114	2.496	CRODT's Data Prepared	CRODT's Data	Prepared	0.20	0.32	1 - 3	4	5 - 15
		Sample size: 18 sp. Aging by: Otolith			CRODT's Data									
6	**Sole** *Cynoglossus senegalensis*	484.8	0.292	0.73	0.00000102	3.255	CRODT's Data Prepared	CRODT's Data	Prepared	0.40	0.51	1 - 3	4 - 5	6 - 17
		Sample size: 12 sp. Aging by: Scale			Project's Data									
7	**Sompatt** *Pomadasys jubelini*	469.2	0.150	-0.18	0.0189	2.991	CRODT's Data Prepared	CRODT's Data	Prepared	0.30	0.34	1 - 3	4	5 - 12
		Sample size: 15 sp. Aging by: Otolith			CRODT's Data									

Table 3-2 CRODT provided catch statistics of target species by fisheries in Senegalese waters for 1971-2003

Regend: TotalPIS = Senegal industrial fisheries
TotalPIEC = Foreign industrial fisheries
TotalPA = Artisernal fisheries

Année		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Thiof	TotalPIS	179	224	406	220	368	228	475	771	826	460	372	449	435	382	482	379	470	241	192	237
Thiof	Total PIEC	0	0	0	0	0	0	0	0	0	0	0	0	215	610	294	376	395	492	404	449
Epinephelus aeneus	Total PA	0	0	0	860	1338	1080	1256	809	856	810	1417	1579	1679	3041	3092	3286	3154	2063	1465	1856
Species Total		**179**	**224**	**406**	**1080**	**1706**	**1308**	**1730**	**1580**	**1682**	**1270**	**1790**	**2028**	**2329**	**4032**	**3867**	**4041**	**4018**	**2796**	**2061**	**2541**
Sparus caeruleostict	Total PA	0	0	0	1379	794	728	569	240	433	682	1443	1053	1107	1526	1815	2671	2120	1774	2371	3032
Dorade rose	TotalPIS	97	156	375	1202	1388	1588	1946	1361	1154	1071	1180	1226	867	874	920	1596	2034	880	1020	2353
Dorade rose	Total PIEC	0	0	0	0	0	0	0	0	0	0	0	0	253	566	267	395	622	693	633	974
Species Total		**97**	**156**	**375**	**2581**	**2182**	**2316**	**2514**	**1601**	**1588**	**1752**	**2623**	**2279**	**2227**	**2966**	**3002**	**4662**	**4776**	**3347**	**4025**	**6358**
Tiekem	TotalPIS	0	157	955	540	429	911	1269	1564	2311	3993	4816	3941	4211	4097	4985	4646	4554	4223	3306	3482
Tiekem	Total PIEC	0	0	0	0	0	0	0	0	0	0	0	0	51	76	17	21	36	36	36	20
Galeoides decadactylus	Total PA	0	0	0	17	7	9	32	23	39	51	371	364	281	207	347	241	465	427	700	892
Species Total		**0**	**157**	**955**	**557**	**436**	**920**	**1302**	**1587**	**2351**	**4044**	**5186**	**4306**	**4543**	**4381**	**5349**	**4908**	**5055**	**4686**	**4042**	**4394**
Capitaine	TotalPIS	241	1093	2550	1951	1675	2881	4359	6501	8000	8889	7375	4947	4294	3579	2773	1601	749	242	305	204
Capitaine	Total PIEC	0	0	0	0	0	0	0	0	0	0	0	0	69	75	19	45	51	55	35	30
Pseud. senegalensis	Total PA	0	0	0	96	34	26	69	73	107	157	65	87	342	525	758	447	342	352	443	1139
Species Total		**241**	**1093**	**2550**	**2047**	**1708**	**2907**	**4428**	**6575**	**8107**	**9046**	**7440**	**5035**	**4704**	**4179**	**3550**	**2092**	**1142**	**649**	**783**	**1373**
Machoiron	Total PIS	0	3	33	37	60	103	876	2616	3724	3896	5899	5411	6090	5290	5051	5076	5486	4692	4571	3935
Machoiron	Total	0	0	0	0	0	0	0	0	0	0	0	0	19	50	26	9	6	57	30	26
Arius heudelotii	Total PA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48	354	227	257	391	276
Species Total		**0**	**3**	**33**	**37**	**60**	**103**	**876**	**2616**	**3724**	**3896**	**5899**	**5411**	**6109**	**5340**	**5125**	**5439**	**5720**	**5007**	**4992**	**4238**
Sole langue	TotalPIS	1448	2595	2389	2836	2091	3000	3016	3950	3656	3584	3251	2864	3044	2307	3051	2834	2427	2242	2211	2082
Sole langue	Total PIEC	0	0	0	0	0	0	0	0	0	0	0	0	201	179	71	76	295	550	185	139
Cynoglossus spp	Total PA	0	0	0	4	8	14	95	37	45	82	266	469	763	966	1455	1208	1838	1681	1300	2066
Species Total		**1448**	**2595**	**2389**	**2840**	**2099**	**3014**	**3110**	**3987**	**3702**	**3666**	**3516**	**3333**	**4008**	**3452**	**4578**	**4118**	**4560**	**4473**	**3696**	**4287**
Carpe blanche	TotalPIS	0	4	4	0	19	0	0	0	1	9	1	49	39	33	50	159	312	9	9	72
Carpe blanche	Total PIEC	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	1	3	2	0	0
Pomadasyidae divers	Total PA	0	0	0	0	0	0	0	1	1	0	325	386	493	1243	293	629	364	264	230	431
Species Total		**0**	**4**	**4**	**0**	**19**	**0**	**0**	**1**	**2**	**9**	**326**	**435**	**532**	**1281**	**343**	**788**	**679**	**275**	**239**	**503**

Année		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Thiof	TotalPIS	142	178	188	136	109	99	189	111	100	37	34	68	55
Thiof	Total PIEC	375	139	255	242	123	155	79	215	43	10	127	75	93
Epinephelus aeneus	Total PA	1546	2203	2519	2400	1483	1662	1226	974	1264	1485	875	968	1110
Species Total		**2063**	**2520**	**2962**	**2778**	**1715**	**1916**	**1494**	**1300**	**1407**	**1532**	**1036**	**1112**	**1259**
Sparus caeruleostict	Total PA	4793	4318	3670	3394	2247	1954	2298	1979	2307	3120	2096	1039	2085
Dorade rose	TotalPIS	1745	1578	990	1113	540	512	940	604	769	607	774	819	839
Dorade rose	Total PIEC	1009	437	385	231	201	450	83	253	160	61	193	138	130
Species Total		**7547**	**6333**	**5044**	**4738**	**2987**	**2916**	**3321**	**2836**	**3237**	**3788**	**3063**	**1996**	**3054**
Tiekem	TotalPIS	2199	2739	2004	1538	1195	1741	3588	2932	1606	1452	2622	2447	2783
Tiekem	Total PIEC	22	68	40	29	19	30	15	51	10	14	12	12	13
Galeoides decadactylus	Total PA	648	1664	1706	1429	412	425	199	427	355	805	407	601	605
Species Total		**2869**	**4471**	**3750**	**2997**	**1626**	**2196**	**3801**	**3410**	**1972**	**2271**	**3042**	**3060**	**3401**
Capitaine	TotalPIS	111	170	122	78	54	90	315	611	83	179	178	180	220
Capitaine	Total PIEC	20	14	19	10	4	7	0	69	1	6	73	73	74
Pseud. senegalensis	Total PA	667	11312	5514	4685	246	451	135	1396	560	4104	290	380	1592
Species Total		**798**	**11496**	**5656**	**4772**	**305**	**548**	**450**	**2076**	**644**	**4290**	**541**	**633**	**1886**
Machoiron	Total PIS	1499	3415	2164	2129	1711	992	6598	5653	904	1398	2212	1787	2186
Machoiron	Total	5	8	11	18	12	6	18	19	2	70	45	53	56
Arius heudelotii	Total PA	147	135	387	859	207	139	80	94	136	116	84	17	72
Species Total		**1651**	**3558**	**2562**	**3007**	**1930**	**1138**	**6696**	**5766**	**1041**	**1584**	**2342**	**1857**	**2314**
Sole langue	TotalPIS	3354	3649	3442	3718	2931	4962	4261	3433	3296	2675	3677	3750	3894
Sole langue	Total PIEC	100	95	136	69	174	109	40	201	23	48	35	35	40
Cynoglossus spp	Total PA	1599	10828	6535	7199	1068	1447	785	940	1055	2370	875	1106	1450
Species Total		**5053**	**14572**	**10113**	**10986**	**4173**	**6517**	**5085**	**4574**	**4374**	**5093**	**4587**	**4891**	**5384**
Carpe blanche	TotalPIS	29	40	4	19	1	9	2	5399	1	2	8	9	9
Carpe blanche	Total PIEC	0	0	0	0	0	0	0	0	1	0	0	0	0
Pomadasyidae divers	Total PA	579	91	281	202	300	230	238	165	217	722	177	1884	928
Species Total		**608**	**130**	**286**	**221**	**301**	**239**	**240**	**5564**	**219**	**724**	**184**	**1893**	**937**

Table 3-3 Thiof: Cohort Matrix for 1985-1999, aged by scale samples, ($C_{(i,t)}$, $F_{(i,t)}$, $N_{(i,t)}$)

1) Commercial catch by age and year ($C_{(i,t)}$), applied to the Cohort Analysis.

(Thousand individuals (1,000))

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	3	9	5	2	1	2	2	2	4	4	8	4	8	9	22
2	30	50	47	23	9	13	9	14	7	25	66	68	40	71	134
3	123	116	92	52	22	26	25	50	22	27	48	53	43	74	72
4	143	199	96	94	46	38	27	76	58	33	40	63	59	85	82
5	94	178	86	67	47	50	31	53	72	42	30	44	38	66	31
6	88	133	92	49	37	40	42	41	71	55	25	47	42	49	26
7	87	97	93	51	37	41	45	38	59	47	32	32	37	37	28
8	109	105	130	72	47	61	57	53	59	68	33	36	29	26	40
9	99	82	125	76	48	52	49	56	59	77	37	19	26	20	29
10	85	65	94	65	53	76	51	63	65	59	41	31	25	21	24
11	56	42	53	42	40	57	33	44	45	41	23	45	20	16	14
12	24	26	20	20	19	19	14	25	27	23	15	35	14	5	6
13	12	16	12	13	10	10	10	15	18	14	10	7	9	2	5
14	6	8	6	6	4	5	6	7	14	11	7	5	5	4	2
15	3	5	4	4	2	3	4	4	6	8	7	4	3	4	6
16	3	4	3	2	2	3	4	4	5	5	3	2	1	1	2
17	2	2	1	1	1	1	1	2	2	3	1	1	1	1	2
18	2	1	1	1	1	1	0	1	1	2	1	0	1	0	2
Total	968	1139	960	639	426	498	411	548	596	542	428	496	401	491	528

2) Estimated fishing mortality coefficient ($F_{(i,t)}$) by age and year.

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	0.001	0.004	0.003	0.001	0.001	0.002	0.001	0.001	0.004	0.004	0.009	0.004	0.006	0.004	0.004
2	0.015	0.023	0.028	0.016	0.009	0.012	0.010	0.014	0.006	0.026	0.086	0.102	0.044	0.070	0.072
3	0.067	0.071	0.055	0.039	0.020	0.032	0.030	0.069	0.026	0.030	0.064	0.092	0.086	0.107	0.095
4	0.095	0.147	0.078	0.072	0.044	0.043	0.042	0.122	0.106	0.052	0.057	0.112	0.141	0.244	0.166
5	0.076	0.165	0.086	0.071	0.047	0.061	0.045	0.108	0.161	0.105	0.061	0.081	0.093	0.230	0.135
6	0.084	0.145	0.120	0.065	0.051	0.051	0.067	0.076	0.205	0.177	0.084	0.125	0.103	0.164	0.131
7	0.115	0.127	0.144	0.090	0.064	0.074	0.075	0.080	0.152	0.203	0.150	0.143	0.138	0.123	0.135
8	0.202	0.197	0.249	0.159	0.112	0.143	0.138	0.119	0.174	0.258	0.217	0.253	0.189	0.138	0.193
9	0.283	0.231	0.383	0.225	0.149	0.175	0.165	0.196	0.190	0.358	0.221	0.189	0.285	0.191	0.222
10	0.425	0.306	0.446	0.351	0.240	0.375	0.261	0.326	0.366	0.290	0.331	0.290	0.405	0.403	0.366
11	0.491	0.391	0.435	0.373	0.381	0.438	0.279	0.375	0.412	0.418	0.173	0.743	0.315	0.474	0.510
12	0.418	0.452	0.325	0.295	0.289	0.307	0.184	0.348	0.410	0.384	0.258	0.442	0.528	0.107	0.359
13	0.368	0.562	0.399	0.346	0.230	0.240	0.264	0.309	0.468	0.383	0.274	0.181	0.187	0.167	0.178
14	0.323	0.445	0.469	0.354	0.179	0.183	0.214	0.316	0.502	0.538	0.349	0.232	0.218	0.113	0.187
15	0.299	0.450	0.371	0.559	0.214	0.193	0.230	0.228	0.449	0.578	0.780	0.301	0.201	0.273	0.259
16	0.425	0.664	0.528	0.355	0.507	0.567	0.460	0.314	0.490	1.001	0.477	0.434	0.077	0.141	0.217
17	0.344	0.722	0.473	0.360	0.260	0.610	0.360	0.337	0.299	0.486	0.880	0.282	0.425	0.155	0.287
18	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470
TF	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470

3) Initial stock number by age and year ($N_{(i,t)}$).

Presumption : M = 0.20, TF = 0.47, Semi-Maturity = Age 4-5, Full-Maturity = Age 6-18

(Thousand individuals (1,000))

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	2917	2294	1890	1380	1394	1261	1377	1526	1302	1083	951	1259	1415	2603	5343
2	2305	2385	1870	1543	1128	1141	1030	1126	1248	1062	883	772	1027	1152	2123
3	2101	1860	1908	1489	1243	916	923	835	909	1015	847	663	571	805	879
4	1732	1609	1418	1479	1172	997	726	733	638	725	806	651	496	429	592
5	1423	1289	1138	1074	1126	918	782	570	531	470	563	624	476	352	275
6	1197	1080	895	854	819	880	707	612	419	370	347	434	471	355	229
7	879	901	765	650	656	637	684	541	464	279	254	261	313	348	247
8	655	641	650	542	486	503	485	520	409	326	187	179	185	223	252
9	440	438	431	415	379	356	357	346	378	281	207	123	114	126	159
10	269	272	285	241	271	267	245	248	233	256	161	136	83	70	85
11	158	144	164	149	139	175	150	154	147	132	157	95	83	46	38
12	75	79	80	87	84	78	92	93	87	79	71	108	37	50	23
13	44	41	41	47	53	52	47	63	54	47	44	45	57	18	37
14	24	25	19	23	27	34	33	29	38	28	26	28	31	39	12
15	14	14	13	10	13	19	23	22	18	19	13	15	18	20	28
16	9	8	7	7	5	9	13	15	14	9	9	5	9	12	13
17	7	5	4	4	4	2	4	7	9	7	3	4	3	7	9
18	5	4	2	2	2	3	1	2	4	6	4	1	3	1	5
Total	14254	13090	11580	9996	9002	8246	7679	7442	6901	6196	5533	5402	5391	6655	10349

Table 3-5 Pagre: Cohort Matrix for 1985-1999, aged by scale samples, ($C_{(i, t)}$, $F_{(i, t)}$, $N_{(i, t)}$)

1) Commercial catch by age and year ($C_{(i, t)}$), applied to the Cohort Analysis.

(Thousand individuals (1,000))

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	0	21	14	4	5	9	20	14	2	16	1	9	4	14	9
2	0	9	6	2	2	4	8	6	1	7	0	4	2	6	4
3	47	486	360	102	249	572	195	184	66	103	22	19	16	11	65
4	347	2846	2005	844	1611	3548	1992	1666	696	635	308	138	320	169	248
5	1394	4846	3643	2383	3139	6611	3722	2907	1345	1230	800	376	754	1251	508
6	1592	3762	3305	2606	2849	5382	3439	2958	1296	1489	969	566	1249	1322	818
7	1274	1889	2269	1625	2148	2989	3229	2249	1435	1461	1253	852	1022	1187	1452
8	967	932	1202	783	1037	1240	2198	1427	1395	1185	1162	901	689	894	1528
9	527	588	719	519	538	682	1274	1056	937	955	674	904	646	635	897
10	265	384	528	359	360	444	1392	1364	1148	735	478	777	528	407	634
11	135	199	348	193	231	242	509	535	428	377	224	319	293	209	222
12	113	130	215	125	155	126	328	399	310	279	132	257	214	132	219
13	95	93	129	102	86	100	219	194	190	247	143	128	184	113	110
14	73	74	95	84	76	115	231	242	236	195	78	108	101	82	62
15	62	52	54	57	59	78	115	121	125	170	82	40	77	38	50
Total	6890	16309	14892	9789	12544	22142	18871	15322	9611	9083	6326	5398	6099	6469	6826

2) Estimated fishing mortality coefficient ($F_{(i, t)}$) by age and year.

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.001	0.010	0.007	0.002	0.006	0.017	0.007	0.007	0.002	0.003	0.000	0.001	0.001	0.000	0.001
4	0.009	0.073	0.054	0.022	0.045	0.121	0.078	0.086	0.037	0.031	0.010	0.004	0.014	0.010	0.009
5	0.057	0.185	0.132	0.089	0.112	0.279	0.191	0.165	0.098	0.089	0.052	0.016	0.032	0.073	0.040
6	0.095	0.227	0.196	0.139	0.154	0.300	0.243	0.241	0.109	0.158	0.099	0.050	0.073	0.075	0.066
7	0.131	0.164	0.220	0.147	0.171	0.254	0.315	0.262	0.186	0.181	0.205	0.125	0.127	0.096	0.116
8	0.156	0.141	0.157	0.116	0.139	0.149	0.318	0.236	0.273	0.245	0.226	0.236	0.149	0.164	0.183
9	0.146	0.142	0.163	0.099	0.115	0.135	0.238	0.263	0.254	0.322	0.226	0.293	0.281	0.210	0.261
10	0.140	0.159	0.193	0.121	0.098	0.138	0.471	0.459	0.539	0.343	0.280	0.468	0.294	0.304	0.355
11	0.129	0.157	0.224	0.106	0.112	0.093	0.244	0.353	0.269	0.361	0.175	0.324	0.342	0.191	0.286
12	0.172	0.186	0.268	0.123	0.122	0.087	0.185	0.326	0.379	0.298	0.217	0.331	0.398	0.269	0.332
13	0.248	0.221	0.300	0.206	0.123	0.113	0.226	0.168	0.269	0.631	0.260	0.360	0.443	0.401	0.401
14	0.340	0.331	0.394	0.344	0.247	0.255	0.438	0.441	0.336	0.519	0.441	0.337	0.569	0.386	0.431
15	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460
TF	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460

3) Initial stock number by age and year ($N_{(i, t)}$).

Presumption : M = 0.25, TF = 0.46, Semi-Maturity = Age 4-5, Full-Maturity = Age 6-15

(Thousand individuals (1,000))

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	93613	86898	74501	64304	48393	46228	49716	72213	74839	55206	39848	62751	227115	53484	44345
2	71210	72906	67663	58010	50080	37684	35995	38704	56228	58285	42982	31033	48866	176877	41642
3	58888	55458	56773	52691	45178	39003	29346	28028	30139	43791	45388	33474	24166	38057	137752
4	41858	45821	42766	43899	40950	34967	29872	22684	21667	23416	34016	35330	26054	18808	29630
5	28316	32294	33186	31543	33448	30476	24119	21515	16204	16263	17678	26223	27394	20011	14499
6	19835	20828	20903	22648	22474	23294	17949	15522	14205	11438	11586	13065	20092	20671	14485
7	11654	14049	12926	13382	15351	15003	13434	10968	9498	9925	7602	8172	9678	14550	14937
8	7522	7959	9285	8079	8996	10072	9068	7639	6573	6138	6449	4823	5616	6640	10289
9	4370	5009	5381	6177	5605	6096	6756	5141	4700	3898	3743	4004	2968	3770	4387
10	2285	2941	3385	3560	4355	3892	4150	4146	3079	2840	2201	2325	2328	1746	2379
11	1262	1547	1954	2173	2457	3075	2641	2018	2040	1398	1570	1296	1134	1351	1003
12	802	864	1030	1217	1523	1711	2182	1612	1104	1214	759	1026	730	627	869
13	483	526	559	614	838	1050	1222	1412	906	589	702	476	574	382	373
14	282	294	328	322	389	577	730	759	930	539	244	422	259	287	199
15	187	156	164	172	178	237	348	367	380	518	250	122	234	114	152
Total	342567	347551	330805	308793	280215	253367	227530	232726	242493	235459	215016	224542	397208	357374	316942

Table 3-7 Thiekem: Cohort Matrix for 1985-1999, aged by scale samples,($C_{(i, t)}$, $F_{(i, t)}$, $N_{(i, t)}$)

1) Commercial catch by age and year ($C_{(i, t)}$), applied to the Cohort Analysis.

(Thousand individuals (1,000))

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	0	0	26	2	4	0	4	0	11	2	1	0	9	0	3
2	0	0	24	2	4	0	4	0	10	2	1	0	8	0	3
3	5	45	343	92	69	64	20	21	3	4	0	10	2	13	22
4	39	841	814	785	707	577	171	211	39	69	71	82	64	287	167
5	947	2387	1867	2705	2024	1381	556	961	508	327	539	461	557	756	296
6	1756	2475	2254	2514	2676	2137	975	1044	667	661	571	736	1290	1588	369
7	2361	1854	2056	2846	2075	1828	926	769	690	1386	631	858	1584	2131	754
8	2924	1739	2605	2627	2428	2384	1536	1692	1241	974	754	805	1590	2082	1165
9	3006	1756	2186	2065	2020	1759	1257	1371	1149	1502	632	855	1374	1448	855
10	2037	1430	1276	1344	974	1364	1296	2060	1901	1059	412	787	1235	1003	939
11	1079	1141	973	796	663	846	653	1528	1152	767	339	521	1010	652	398
12	665	663	600	378	452	620	357	842	770	505	290	374	758	372	222
13	438	439	430	230	246	300	180	253	222	249	162	245	363	242	141
14	173	267	239	158	90	219	120	304	368	153	100	119	174	112	87
15	176	158	148	59	58	90	48	51	34	44	65	32	61	70	36
16	105	84	82	41	14	49	18	30	25	14	17	16	18	12	7
17	117	37	34	19	5	26	7	24	9	8	6	10	22	9	1
18	77	22	20	18	2	14	3	18	6	8	2	4	10	4	2
19	39	17	15	20	0	7	2	13	5	9	0	0	0	0	2
20	8	5	9	3	3	2	1	7	2	1	1	5	6	1	1
Total	15952	15360	16001	16704	14514	13667	8133	11199	8812	7744	4594	5920	10135	10782	5470

2) Estimated fishing mortality coefficient ($F_{(i, t)}$) by age and year.

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.004	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.001
4	0.000	0.010	0.011	0.014	0.013	0.013	0.004	0.006	0.001	0.002	0.002	0.004	0.007	0.042	0.018
5	0.016	0.039	0.034	0.054	0.052	0.039	0.019	0.035	0.021	0.011	0.022	0.020	0.041	0.132	0.064
6	0.046	0.062	0.054	0.068	0.081	0.084	0.040	0.051	0.035	0.040	0.029	0.044	0.083	0.183	0.103
7	0.097	0.073	0.078	0.105	0.086	0.086	0.056	0.047	0.051	0.112	0.057	0.065	0.147	0.225	0.146
8	0.187	0.112	0.164	0.160	0.144	0.158	0.113	0.160	0.117	0.110	0.096	0.113	0.193	0.348	0.218
9	0.287	0.193	0.237	0.223	0.209	0.173	0.137	0.164	0.183	0.238	0.113	0.176	0.340	0.320	0.279
10	0.331	0.255	0.248	0.266	0.184	0.252	0.220	0.412	0.428	0.303	0.111	0.236	0.498	0.539	0.424
11	0.293	0.374	0.328	0.286	0.240	0.285	0.217	0.524	0.517	0.365	0.176	0.235	0.654	0.656	0.515
12	0.327	0.352	0.412	0.241	0.309	0.443	0.220	0.577	0.674	0.546	0.271	0.356	0.774	0.659	0.596
13	0.328	0.448	0.489	0.326	0.289	0.416	0.263	0.284	0.349	0.584	0.404	0.464	0.868	0.753	0.695
14	0.295	0.408	0.571	0.400	0.242	0.546	0.347	1.205	1.085	0.521	0.599	0.722	0.888	0.924	0.845
15	0.501	0.583	0.502	0.317	0.297	0.487	0.258	0.289	0.476	0.413	0.533	0.470	1.402	1.608	1.160
16	0.456	0.579	0.860	0.297	0.134	0.528	0.199	0.304	0.266	0.438	0.330	0.286	0.653	1.754	0.898
17	0.876	0.342	0.599	0.599	0.062	0.467	0.154	0.533	0.164	0.150	0.402	0.396	1.024	1.038	0.819
18	0.718	0.473	0.378	0.965	0.130	0.293	0.103	0.902	0.286	0.253	0.060	0.599	1.106	0.599	0.768
19	1.090	0.406	0.858	1.030	0.000	1.062	0.073	1.015	0.858	1.230	0.000	0.000	0.000	0.000	1.034
20	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470
TF	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470

3) Initial stock number by age and year ($N_{(i, t)}$).

Presumption : M = 0.35, TF = 0.47, Semi-Maturity = Age 4-5, Full-Maturity = Age 6

(Thousand individuals (1,000))

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	193178	177687	146848	135996	116874	137763	119355	112914	67345	29436	23782	32223	82947	21632	21779
2	175126	136130	125214	103461	95835	82360	97080	84108	79569	47448	20743	16759	22707	58446	15244
3	135324	123409	95929	88219	72908	67534	58038	68411	59270	56066	33436	14617	11810	15995	41186
4	105734	95361	86930	67317	62092	51321	47538	40882	48194	41767	39506	23562	10292	8321	11261
5	70102	74480	66498	60582	46783	43169	35684	33359	28634	33931	29377	27781	16536	7199	5624
6	46081	48611	50498	45303	40436	31281	29269	24683	22706	19755	23638	20253	19193	11188	4444
7	30231	31010	32193	33708	29829	26267	20263	19813	16524	15444	13370	16181	13659	12450	6565
8	20169	19338	20308	20973	21384	19292	16988	13507	13321	11069	9730	8896	10688	8308	7005
9	14156	11784	12180	12146	12596	13051	11613	10693	8112	8354	6990	6229	5599	6211	4133
10	8476	7486	6846	6770	6846	7200	7735	7138	6396	4762	4641	4400	3679	2809	3179
11	4987	4288	4090	3766	3657	4015	3943	4375	3330	2939	2479	2928	2448	1576	1155
12	2799	2621	2079	2077	1995	2027	2129	2237	1826	1399	1437	1465	1631	897	576
13	1840	1422	1299	970	1150	1032	917	1204	885	656	571	772	723	530	327
14	795	934	640	561	493	607	480	497	639	440	258	269	342	214	176
15	522	417	438	255	265	273	248	239	105	152	184	100	92	99	60
16	336	223	164	187	131	139	118	135	126	46	71	76	44	16	14
17	232	150	88	49	98	81	58	68	70	68	21	36	40	16	2
18	175	68	75	34	19	65	36	35	28	42	41	10	17	10	4
19	68	60	30	36	9	12	34	23	10	15	23	27	4	4	4
20	25	16	28	9	9	6	3	22	6	3	3	16	19	3	3
Total	810356	735495	652375	582419	513409	487495	451529	424343	357096	273792	210301	176600	202470	155924	122741

Table 3-10 Otolithe_OT: Cohort Matrix for 1985-1999, aged by otolith samples, ($C_{(i,t)}$, $F_{(i,t)}$, $N_{(i,t)}$)

1) Commercial catch by age and year ($C_{(i,t)}$), applied to the Cohort Analysis.

(Thousand individuals (1,000))

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	26	252	40	21	88	79	88	337	99	698	29	78	55	784	54
2	18	196	30	21	67	84	102	685	156	495	23	51	44	639	101
3	400	1018	370	276	470	940	1061	14545	3795	3114	361	579	516	2807	1065
4	1237	1150	788	337	531	1317	516	7640	3192	3365	307	446	386	1646	492
5	1327	704	410	271	294	523	291	4122	3427	2308	101	234	134	629	220
6	909	386	280	162	136	206	140	1919	1529	1067	48	101	72	370	93
7	710	304	189	94	83	116	69	1075	590	486	19	32	39	59	33
8	380	151	84	36	40	47	12	550	191	133	6	18	11	56	8
9	268	102	53	24	38	48	25	249	35	53	2	8	11	1	3
10	145	51	24	21	22	18	8	94	29	44	1	1	3	6	2
11	101	45	13	7	12	7	2	17	15	16	0	1	1	3	1
12	28	20	4	4	4	4	1	3	6	3	0	0	0	2	1
Total	5548	4379	2285	1274	1785	3389	2315	31236	13063	11781	896	1549	1273	7003	2073

2) Estimated fishing mortality coefficient ($F_{(i,t)}$) by age and year.

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	0.005	0.033	0.003	0.001	0.003	0.002	0.007	0.053	0.029	0.189	0.006	0.013	0.012	0.367	0.131
2	0.004	0.045	0.005	0.002	0.005	0.004	0.004	0.065	0.031	0.195	0.008	0.013	0.009	0.196	0.073
3	0.118	0.300	0.112	0.057	0.063	0.085	0.063	1.078	0.600	1.391	0.213	0.299	0.185	1.241	0.575
4	0.511	0.575	0.400	0.141	0.148	0.253	0.061	0.836	0.740	2.045	0.460	0.442	0.334	1.489	0.755
5	0.845	0.622	0.415	0.233	0.175	0.213	0.081	0.944	1.242	2.811	0.291	0.781	0.228	1.495	0.835
6	0.909	0.642	0.544	0.286	0.175	0.179	0.081	1.111	1.234	2.523	0.526	0.529	0.594	1.872	0.998
7	1.095	0.930	0.772	0.353	0.232	0.223	0.084	1.478	1.432	2.615	0.299	0.818	0.396	1.585	0.933
8	1.062	0.734	0.726	0.315	0.251	0.198	0.032	1.775	1.328	2.051	0.205	0.528	0.753	1.845	1.042
9	1.289	0.970	0.620	0.472	0.641	0.528	0.152	1.629	0.496	2.586	0.102	0.519	0.717	0.211	0.482
10	1.116	0.940	0.649	0.542	1.072	0.747	0.158	1.403	0.914	2.891	0.274	0.055	0.422	1.072	0.516
11	0.926	1.519	0.656	0.404	0.661	1.276	0.209	0.582	0.879	2.989	0.245	0.690	0.123	1.003	0.605
12	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450
TF	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450

3) Initial stock number by age and year ($N_{(i,t)}$).

Presumption : M = 0.20, TF = 0.45, Semi-Maturity = Age 3, Full-Maturity = Age 4-12

(Thousand individuals (1,000))

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	6048	8516	12620	18999	28698	35872	14730	7252	3859	4464	5120	6514	4889	2796	488
2	5289	4928	6746	10296	15536	23419	29299	11981	5633	3071	3027	4166	5263	3953	1585
3	3948	4314	3858	5496	8411	12659	19099	23897	9192	4472	2068	2457	3365	4270	2661
4	3383	2873	2618	2825	4251	6463	9517	14679	6655	4131	911	1368	1491	2290	1011
5	2531	1662	1323	1436	2009	3002	4107	7327	5211	2600	437	471	720	874	423
6	1655	890	731	715	932	1380	1987	3100	2333	1233	128	268	176	469	160
7	1156	546	383	347	440	640	944	1500	835	556	81	62	129	80	59
8	630	317	176	145	200	286	419	711	280	163	33	49	22	71	13
9	400	178	124	70	87	127	192	333	99	61	17	22	24	9	9
10	233	90	55	55	36	37	61	135	53	49	4	13	11	9	6
11	182	62	29	24	26	10	15	43	27	18	2	2	10	6	3
12	84	59	11	12	13	11	2	10	20	9	1	1	1	7	2
Total	25539	24436	28674	40420	60638	83906	80373	70968	34198	20827	11829	15393	16101	14833	6421

Table 3-12 Otolithe_SC: Cohort Matrix for 1985-1999, aged by scale samples, ($C_{(i, t)}$, $F_{(i, t)}$, $N_{(i, t)}$)

1) Commercial catch by age and year ($C_{(i, t)}$), applied to the Cohort Analysis.

(Thousand individuals (1,000))

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	14	134	21	11	47	42	47	180	53	373	15	41	29	418	29
2	13	127	20	11	44	40	44	171	50	353	15	39	28	396	28
3	33	360	53	50	117	162	229	1406	329	861	48	92	89	1053	210
4	576	989	491	317	481	1053	1027	15739	4123	3209	395	646	556	2731	1073
5	1422	1153	710	302	542	1212	463	6418	3329	3261	270	374	312	1358	397
6	1085	645	381	263	241	464	272	3702	3091	2165	85	218	132	596	212
7	870	322	263	145	122	187	123	1804	1312	896	43	83	67	334	86
8	612	281	169	83	75	106	62	902	501	415	17	27	32	47	25
9	355	139	75	32	37	41	10	531	189	118	5	16	9	54	8
10	231	84	46	21	32	45	25	205	29	57	2	9	11	4	3
11	170	56	26	17	21	18	5	128	24	28	1	2	4	1	2
12	63	39	17	14	12	10	5	30	14	27	0	0	2	5	2
Total	5446	4329	2272	1267	1771	3380	2312	31216	13042	11763	896	1547	1272	6997	2073

2) Estimated fishing mortality coefficient ($F_{(i, t)}$) by age and year.

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	0.002	0.010	0.001	0.000	0.001	0.002	0.006	0.039	0.012	0.070	0.002	0.007	0.009	0.538	0.185
2	0.002	0.018	0.002	0.001	0.002	0.001	0.003	0.026	0.014	0.103	0.003	0.007	0.006	0.165	0.059
3	0.007	0.085	0.009	0.006	0.009	0.009	0.008	0.127	0.064	0.339	0.018	0.027	0.020	0.324	0.124
4	0.164	0.305	0.161	0.072	0.071	0.107	0.071	1.136	0.659	1.496	0.257	0.359	0.228	1.337	0.641
5	0.585	0.568	0.375	0.140	0.170	0.255	0.062	0.808	0.796	2.140	0.449	0.413	0.295	1.388	0.699
6	0.817	0.580	0.371	0.231	0.159	0.215	0.083	0.966	1.293	2.810	0.283	0.810	0.250	1.529	0.863
7	0.900	0.615	0.497	0.235	0.160	0.178	0.081	1.178	1.208	2.537	0.494	0.493	0.638	1.934	1.021
8	1.065	0.856	0.782	0.288	0.182	0.202	0.083	1.353	1.423	2.250	0.318	0.662	0.362	1.402	0.809
9	1.047	0.752	0.584	0.320	0.198	0.144	0.025	2.056	1.327	2.293	0.149	0.598	0.498	1.966	1.021
10	1.094	0.776	0.615	0.325	0.626	0.401	0.120	1.059	0.617	4.030	0.154	0.372	1.084	0.386	0.614
11	1.045	0.887	0.579	0.478	0.627	0.876	0.071	1.599	0.323	3.649	2.890	0.377	0.298	0.193	0.289
12	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740
TF	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450

3) Initial stock number by age and year ($N_{(i, t)}$).

Presumption : M = 0.20, TF = 0.74, Semi-Maturity = Age 4, Full-Maturity = Age 5-12

(Thousand individuals (1,000))

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	9396	14364	21125	30461	46243	19394	8940	5162	4890	6040	7504	6314	3524	1099	190
2	5926	7680	11640	17276	24930	37819	15840	7277	4063	3956	4609	6131	5132	2859	526
3	5078	4840	6173	9512	14135	20372	30929	12929	5804	3282	2921	3760	4984	4177	1984
4	4184	4128	3638	5007	7743	11467	16533	25116	9318	4456	1914	2348	2996	4000	2474
5	3509	2906	2491	2536	3814	5906	8439	12610	6605	3945	817	1212	1343	1953	861
6	2115	1600	1348	1402	1805	2634	3746	6492	4603	2439	380	427	656	819	399
7	1595	765	734	762	911	1261	1739	2821	2023	1034	120	234	156	419	145
8	1012	531	339	365	493	636	864	1313	711	495	67	60	117	67	50
9	593	286	185	127	224	336	425	651	278	140	43	40	25	67	14
10	377	170	110	84	75	151	238	340	68	60	12	30	18	13	8
11	285	103	64	49	50	33	83	173	96	30	1	8	17	5	7
12	132	82	35	29	25	22	11	63	29	57	1	0	5	10	3
Total	34202	37456	47881	67611	100447	100029	87788	74946	38489	25934	18389	20564	18973	15487	6658

Table 3-13 Machoiron: Cohort Matrix for 1985-1999, aged by otolith samples, ($C_{(i, t)}$, $F_{(i, t)}$, $N_{(i, t)}$)

1) Commercial catch by age and year ($C_{(i, t)}$), applied to the Cohort Analysis.

(Thousand individuals (1,000))

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	0	0	0	4	88	140	17	17	14	58	84	68	648	747	67
2	0	0	0	2	48	76	9	9	8	31	45	37	351	404	36
3	106	34	49	49	471	468	296	532	418	386	455	443	1652	2693	376
4	159	155	149	174	865	717	282	531	358	483	411	242	1694	1533	287
5	143	251	478	245	677	664	305	394	299	467	368	159	1280	803	181
6	89	246	559	313	374	398	167	237	214	327	268	106	733	552	120
7	239	289	207	257	206	260	117	167	129	195	133	74	412	370	46
8	385	253	160	161	91	88	23	123	118	137	58	36	145	133	28
9	288	438	244	152	77	59	14	90	48	54	25	24	99	12	9
10	249	400	214	206	110	51	20	71	33	45	9	9	17	12	3
11	200	144	184	207	143	89	28	107	65	26	3	7	12	11	2
12	50	90	122	121	109	67	16	49	34	26	3	1	0	18	2
13	60	32	102	121	86	58	12	19	22	16	3	1	15	3	2
14	46	8	62	60	47	27	17	22	26	14	3	1	11	2	3
15	0	17	23	48	29	26	7	23	12	9	1	1	5	2	1
Total	2014	2357	2553	2120	3421	3188	1330	2391	1798	2274	1869	1209	7074	7295	1163

2) Estimated fishing mortality coefficient ($F_{(i, t)}$) by age and year.

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	0.000	0.000	0.000	0.001	0.021	0.033	0.004	0.003	0.002	0.010	0.014	0.013	0.355	1.249	0.539
2	0.000	0.000	0.000	0.000	0.015	0.022	0.003	0.002	0.002	0.007	0.009	0.008	0.085	0.391	0.161
3	0.032	0.013	0.016	0.014	0.159	0.197	0.113	0.214	0.148	0.123	0.129	0.117	0.540	1.677	0.778
4	0.056	0.061	0.072	0.072	0.372	0.384	0.175	0.304	0.218	0.254	0.186	0.094	0.857	1.604	0.852
5	0.080	0.117	0.269	0.161	0.436	0.547	0.279	0.394	0.281	0.489	0.313	0.102	0.988	1.505	0.865
6	0.048	0.192	0.410	0.283	0.394	0.497	0.255	0.364	0.387	0.563	0.581	0.139	0.904	2.067	1.037
7	0.119	0.217	0.246	0.335	0.305	0.525	0.264	0.436	0.345	0.739	0.471	0.311	1.188	2.206	1.235
8	0.174	0.178	0.179	0.307	0.189	0.206	0.078	0.488	0.635	0.757	0.510	0.222	1.914	2.169	1.435
9	0.196	0.306	0.261	0.258	0.235	0.180	0.045	0.489	0.358	0.685	0.293	0.414	1.719	0.926	1.020
10	0.235	0.456	0.241	0.366	0.301	0.241	0.085	0.339	0.333	0.671	0.226	0.162	0.588	1.140	0.630
11	0.285	0.207	0.393	0.387	0.469	0.424	0.203	0.859	0.598	0.478	0.081	0.274	0.336	0.967	0.526
12	0.105	0.200	0.272	0.489	0.363	0.420	0.124	0.648	0.753	0.510	0.092	0.035	0.000	1.296	0.474
13	0.368	0.091	0.366	0.474	0.788	0.335	0.122	0.213	0.684	1.021	0.099	0.040	1.066	0.239	0.448
14	0.474	0.075	0.255	0.381	0.341	0.622	0.154	0.345	0.499	1.409	0.514	0.044	0.800	0.371	0.405
15	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320
TF	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320

3) Initial stock number by age and year ($N_{(i, t)}$).

Presumption : M = 0.20, TF = 0.32, Semi-Maturity = Age 4, Full-Maturity = Age 5

(Thousand individuals (1,000))

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	5103	5644	5270	4354	4735	4697	5029	5517	6217	6684	6598	5857	2380	1133	176
2	3587	4178	4621	4315	3561	3797	3719	4102	4502	5078	5420	5326	4734	1367	266
3	3649	2937	3421	3783	3531	2872	3040	3037	3350	3679	4130	4397	4327	3559	757
4	3231	2892	2374	2757	3053	2467	1930	2222	2008	2366	2664	2971	3201	2064	545
5	2047	2502	2228	1809	2100	1723	1376	1326	1342	1322	1503	1811	2214	1112	340
6	2088	1547	1822	1394	1260	1112	816	852	732	830	664	900	1339	675	202
7	2344	1629	1045	990	860	696	554	518	485	407	387	304	641	444	70
8	2650	1704	1074	669	580	519	337	348	274	281	159	198	182	160	40
9	1777	1823	1167	735	403	393	346	255	175	119	108	78	130	22	15
10	1307	1196	1099	736	465	261	269	271	128	100	49	66	42	19	7
11	885	846	621	707	418	282	168	202	158	75	42	32	46	19	5
12	550	545	563	343	393	214	151	112	70	71	38	32	20	27	6
13	214	405	365	351	172	224	115	109	48	27	35	28	25	16	6
14	133	121	303	207	179	64	131	83	72	20	8	26	22	7	10
15	0	68	92	192	116	104	28	92	48	36	4	4	20	8	4
Total	29565	28037	26065	23342	21826	19425	18009	19046	19609	21095	21809	22030	19323	10632	2449

Table 3-15 Sole: Cohort Matrix for 1985-1999, aged by scale samples, ($C_{(i,t)}$, $F_{(i,t)}$, $N_{(i,t)}$)

1) Commercial catch by age and year ($C_{(i,t)}$), applied to the Cohort Analysis.

(Thousand individuals (1,000))

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	0	0	0	0	259	56	66	178	11	861	198	1018	160	617	276
2	0	0	0	0	273	59	70	188	11	908	209	1073	169	650	290
3	0	0	0	0	725	366	197	512	120	3919	2028	2432	701	1080	1001
4	0	0	0	0	7267	4472	6128	5697	2626	28553	12893	11628	7083	9359	18601
5	0	0	0	0	8917	5654	7237	10844	5139	14646	7152	9296	5205	8155	4034
6	0	0	0	0	1973	2738	2517	13445	9856	6557	1908	2952	3162	1731	1534
7	0	0	0	0	551	1511	1348	9915	6466	3666	417	1704	1908	1189	934
8	0	0	0	0	206	611	349	5219	3687	1478	299	1177	1110	1019	449
9	0	0	0	0	118	373	475	2591	1508	1133	169	1256	1092	301	174
10	0	0	0	0	81	334	259	1223	661	416	70	654	609	73	54
11	0	0	0	0	67	213	192	639	873	234	47	231	187	0	54
12	0	0	0	0	50	133	220	368	872	175	47	50	0	0	79
13	0	0	0	0	47	114	146	220	391	83	22	66	190	140	101
14	0	0	0	0	38	89	105	150	227	49	13	56	190	140	87
15	0	0	0	0	28	67	79	113	170	37	10	42	142	105	65
16	0	0	0	0	21	50	59	84	127	27	7	31	106	78	49
17	0	0	0	0	12	9	18	36	39	2	11	2	10	32	21
Total	No Data	No Data	No Data	No Data	20633	16849	19465	51422	32784	62744	25500	33668	22024	24669	27803

2) Estimated fishing mortality ($F_{(i,t)}$) by age and year.

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	0	0	0	0	0.001	0.000	0.000	0.001	0.000	0.009	0.003	0.006	0.002	0.017	0.008
2	0	0	0	0	0.001	0.000	0.001	0.001	0.000	0.013	0.003	0.022	0.001	0.013	0.012
3	0	0	0	0	0.004	0.002	0.002	0.008	0.001	0.061	0.043	0.056	0.022	0.014	0.031
4	0	0	0	0	0.069	0.043	0.060	0.114	0.060	0.631	0.362	0.471	0.287	0.559	0.439
5	0	0	0	0	0.145	0.087	0.112	0.178	0.177	0.702	0.402	0.625	0.512	0.823	0.653
6	0	0	0	0	0.060	0.074	0.062	0.393	0.305	0.454	0.224	0.364	0.582	0.405	0.450
7	0	0	0	0	0.025	0.073	0.058	0.466	0.424	0.221	0.057	0.404	0.545	0.585	0.512
8	0	0	0	0	0.014	0.043	0.026	0.420	0.400	0.200	0.031	0.280	0.654	0.850	0.595
9	0	0	0	0	0.021	0.039	0.052	0.347	0.256	0.257	0.039	0.217	0.584	0.472	0.424
10	0	0	0	0	0.026	0.093	0.042	0.227	0.173	0.128	0.027	0.256	0.193	0.084	0.178
11	0	0	0	0	0.028	0.111	0.087	0.173	0.316	0.105	0.023	0.147	0.134	0.000	0.101
12	0	0	0	0	0.035	0.089	0.198	0.299	0.481	0.118	0.034	0.038	0.000	0.000	0.064
13	0	0	0	0	0.044	0.130	0.165	0.393	0.787	0.093	0.024	0.075	0.249	0.240	0.188
14	0	0	0	0	0.070	0.134	0.211	0.319	1.272	0.258	0.023	0.096	0.401	0.370	0.289
15	0	0	0	0	0.150	0.210	0.210	0.470	0.976	0.998	0.094	0.119	0.475	0.520	0.371
16	0	0	0	0	0.484	0.554	0.364	0.458	2.825	0.503	0.657	0.601	0.631	0.685	0.639
TF	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510

3) Initial stock number by age and year ($N_{(i,t)}$).

Presumption : M = 0.4, TF = 0.51, Semi-Maturity = Age 4-5, Full-Maturity = Age 6

(Thousand individuals (1,000))

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	395445	436380	429180	423419	213313	182717	241554	179843	129961	121310	90541	212401	91061	44615	40665
2	204177	265075	292514	287688	283826	142788	122442	161870	120408	87107	80620	60534	141553	60912	29405
3	134372	136864	177685	196078	192843	190045	95666	82019	108353	80704	57653	53874	39706	94753	40303
4	87597	90072	91743	119106	131435	128686	127098	63967	54563	72537	50917	37001	34139	26047	62638
5	34360	58718	60377	61497	79839	82213	82630	80227	38263	34445	25878	23770	15491	17178	9987
6	18649	23032	39360	40472	41223	46303	50527	49525	45010	21494	11448	11607	8527	6222	5058
7	14371	12501	15439	26384	27129	26031	28818	31827	22405	22236	9154	6134	5408	3193	2782
8	8633	9633	8380	10349	17686	17738	16224	18223	13394	9833	11946	5798	2744	2101	1192
9	6607	5787	6457	5617	6937	11688	11394	10592	8029	6019	5397	7765	2938	956	602
10	3383	4429	3879	4328	3765	4554	7532	7252	5017	4166	3121	3481	4191	1098	400
11	1207	2268	2969	2600	2901	2458	2782	4839	3874	2829	2456	2035	1806	2317	677
12	322	809	1520	1990	1743	1890	1475	1709	2727	1894	1707	1608	1177	1059	1553
13	181	216	542	1019	1334	1128	1159	811	849	1130	1128	1106	1037	789	710
14	403	121	145	363	683	856	664	659	367	259	690	738	688	542	416
15	601	270	81	97	243	427	502	360	321	69	134	452	449	309	251
16	601	403	181	54	65	140	232	273	151	81	17	82	269	187	123
17	0	0	0	0	36	27	54	108	116	6	33	6	30	96	63
Total	910909	1046578	1130452	1181061	1005001	839689	790753	694104	553808	466119	352840	428392	351214	262374	196825

Table 3-17 Sompatt: Cohort Matrix for 1985-1999, aged by otolith samples, ($C_{(i, t)}$, $F_{(i, t)}$, $N_{(i, t)}$)

1) Commercial catch by age and year ($C_{(i, t)}$), applied to the Cohort Analysis.

(Thousand individuals (1,000))

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	0	1	1	2	1	1	4	0	0	6	1	1	1	1	8
2	0	1	1	2	2	2	4	1	0	2	1	0	0	0	6
3	31	54	50	78	68	130	60	13	6	15	40	13	2	185	135
4	222	239	248	196	186	468	259	65	46	96	201	89	41	2338	352
5	368	509	343	180	164	345	541	101	61	126	226	175	127	4285	786
6	154	406	266	111	130	157	286	63	69	92	180	150	133	3097	734
7	48	205	206	50	61	76	117	29	47	54	79	68	113	1554	537
8	25	118	129	32	29	41	69	18	37	35	39	34	52	727	637
9	23	68	78	26	17	31	41	10	20	21	13	23	22	694	430
10	13	37	53	21	10	43	32	6	26	12	11	10	7	375	211
11	10	28	24	11	5	20	19	3	13	6	6	5	6	175	88
12	4	11	16	8	3	16	15	4	14	2	3	3	2	29	41
Total	898	1678	1415	719	676	1330	1448	312	339	466	799	571	507	13460	3964

2) Estimated fishing mortality coefficient ($F_{(i, t)}$) by age and year.

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.014	0.026	0.027	0.035	0.018	0.024	0.008	0.001	0.000	0.000	0.001	0.000	0.000	0.022	0.008
4	0.093	0.164	0.179	0.156	0.120	0.183	0.069	0.012	0.005	0.006	0.006	0.003	0.002	0.175	0.060
5	0.225	0.356	0.419	0.212	0.212	0.380	0.374	0.038	0.016	0.017	0.019	0.007	0.005	0.261	0.091
6	0.141	0.469	0.359	0.260	0.262	0.359	0.719	0.074	0.037	0.033	0.035	0.017	0.007	0.191	0.072
7	0.074	0.314	0.528	0.117	0.247	0.270	0.571	0.155	0.081	0.040	0.039	0.018	0.018	0.116	0.051
8	0.096	0.296	0.378	0.159	0.100	0.297	0.476	0.174	0.349	0.089	0.041	0.024	0.019	0.168	0.071
9	0.132	0.451	0.363	0.133	0.131	0.170	0.619	0.133	0.334	0.391	0.046	0.034	0.021	0.421	0.159
10	0.089	0.369	0.896	0.179	0.078	0.639	0.292	0.196	0.643	0.382	0.383	0.051	0.014	0.665	0.243
11	0.182	0.321	0.499	0.549	0.064	0.246	0.760	0.048	0.914	0.319	0.397	0.384	0.042	0.644	0.357
12	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340
TF	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340

3) Initial stock number by age and year ($N_{(i, t)}$).

Presumption : M = 030, TF = 0.34, Semi-Maturity = Age 4, Full-Maturity = Age 5

(Thousand individuals (1,000))

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	3959	4847	8073	11343	15257	28036	46815	101033	92814	71473	41358	17689	37672	46072	74585
2	3272	2933	3590	5981	8402	11303	20769	34679	74847	68758	52944	30639	13104	27908	34131
3	2502	2424	2172	2659	4429	6223	8372	15383	25691	55448	50937	39222	22698	9708	20675
4	2888	1827	1750	1566	1903	3223	4499	6151	11386	19028	41065	37701	29048	16813	7033
5	2098	1950	1149	1084	992	1251	1988	3111	4501	8396	14015	30249	27855	21485	10460
6	1354	1241	1012	560	650	595	634	1013	2219	3283	6112	10189	22259	20526	12266
7	771	872	575	524	320	370	308	229	697	1585	2353	4374	7420	16377	12564
8	318	530	472	251	345	185	209	129	145	476	1128	1676	3182	5400	10803
9	214	214	292	239	159	231	102	96	80	76	323	802	1212	2313	3380
10	173	139	101	151	155	103	145	41	63	43	38	228	574	880	1124
11	72	117	71	31	93	106	40	80	25	24	22	19	161	419	335
12	17	45	63	32	13	65	62	14	56	7	13	11	10	114	163
Total	17639	17138	19320	24421	32719	51691	83943	161959	212524	228597	210307	172799	165194	168014	187519

Table 3-19 Summary of assessment by stock identified through findings obtained by Cohort Analysis (1/2)

Target Species		Natural Mortality (M)	Sate of Stock in Brief	Further details on the Findings from the Stock Assessment
No.	**Local/Scientific Names**	**Potential Harvest**	**State, phase, Action needed**	
1	**Thiof** ***Epinephelus aeneus***	**0.20** **15,000,000**	**Heavily exploited, in cautious phase, reduction in catch is desirable.**	The lump-sum amount of "Initial-Stock-Number" of "Thiof" has shown a continuous declining tendency, though it suddenly increased since 1997 by abrupt increase in the "immature-fish" by some reasons. This was a superficial phenomenon irrelevant to the population dynamics, but the result of some distortion caused by an inadequate sampling scheme. Because, it might have been impossible to rise a new strong-year-class from greatly depleted spawning-stock. The abundance of spawning-stock, including semi-mature-stock, has declined throughout the period. The level of spawning-stock in recent years has fallen down to about one-third from its original level in 1985. The stock is now categorized to be in a "heavily exploited status", as well as in a "cautions phase". The abundance of the "Thiof-stock" would decline further in the near future as there has been no sign on the recovery of spawning-stock detected. In view of the relatively small potential in stock-size (about 15 millions), the reduction in fishing intensity in immediate future is highly desirable.
2	**Pagre** ***Sparus caeruleostictus***	**0.25** **400,000,000**	**Moderately exploited, in careful phase, future monitoring is needed.**	The total number of the stock has shown a declining tendency but the magnitude of decline was not so large, though it suddenly increased since 1997 which was caused mainly by the increase in "immature-fish" by some other reasons. This was superficial phenomenon as was discussed in the "Thiof's" case. The decline in spawning stock, which was shown once in the early 1990's due probably to the large catch made during the same period, had been leveled off thereafter, and even recovered in recent years. And is nearly at the same level of original status. Further decline in the entire stock abundance is not foreseen, but is warned of even though the potential stock-size is rather large (400 millions) The stock seems to have remained at a "moderately-exploited" status with in a "careful-phase", being supported by the strong tolerable nature including rather large potential stock-size of the stock, for which the careful monitoring is required in the future.
3	**Thiekem** ***Galeoides decadactylus***	**0.35** **900,000,000**	**Heavily exploited, in cautious phase, reduction in catch is desirable.**	The total number and all the maturing-components of the stock has shown a sharp decline during the throughout the period. The results indicates an over-all decline in stock abundance. The recent level of spawning-stock abundance has fallen down to only about one-fifth of its original level, which suggests further decline in spawning-stock level and may be resulted in an over-all decline of stock abundance. The stock is considered therefore to have been "heavily-exploited", and is now at in a "cautious-phase", even though the potential stock-size is rather large (about 900 millions) Further decline in stock abundance would occur if the fishing continues as it is. The reduction in fishing intensity is therefore highly recommended.
4-1, 4-2	**Otolithe** ***Pseudotolithus senegalensis***	**0.20** **90,000,000**	**Most-Heavily exploited, in highly dangerous phase, immediate reduction in catch is required, total ban of fishing is most desirable.**	No substantial difference has been recognized on the two results of Cohort Analyses between the otolith-aging and scale-aging data. The Assessment-Work employed here has been therefore thoroughly made by the "Otolith-Aging" result. The stock seemed to have been depleted already by the large catches made during 1977-1984, prior to the time when this assessment was started in 1985. Then the stock abundance had recovered to some extent during 1987-1992, being supported by rather small catches made during 1986-1991. The large reduction by catch had then been suddenly resumed since 1992 and lasted for three years. Owing to this process, the once recovered stock abundance became to have been declined drastically thereafter. The catch in the following years had continued at substantial level, resulting in further decline in stock abundance, especially in spawning-stocks. Thus the stock in recent years has been at the "Most-Heavily-Exploited-Stage" and in the "highly-dangerous-phase" with least abundance of spawning-stock. It has been only about 4 % (one-twenties) of the level when recovered. The immediate action for the conservation of the stock is therefore required, the stock would be completely devastated unless the appropriate measures are taken, in view of the "potential stock-size" is very small (only about 90,000 millions), the measures to be taken may include the total ban of catching "Otolithe" for a while.

Table 3-19 Summary of assessment by stock identified through findings obtained by Cohort Analysis (2/2)

Target Species		Natural Mortality (M)	Sate of Stock in Brief	Further details on the Findings from the Stock Assessment
No.	**Local/Scientific Names**	**Potential Harvest**	**State, phase, Action needed**	
5	**Machoiron** ***Arius heudelotii***	**0.20** **30,000,000**	**Heavily exploited, in cautious phase, reduction in catch is desirable.**	The total stock abundance had shown a sharp declined during the first half period of this assessment made. This is mainly due to the large catches taken during 1979-1989. The size of spawning-stock in this period had also declined drastically and reached about one-third of the originally level (31 %). Judging from the large catches taken prior to 1985 (starting year of assessment), the stock-size in before (particularly spawning-stock-size) would have been considerably higher than the level at 1985. The change in "spawning-stock size" compared with before would have therefore been much more drastic. The total-stock-size had been once recovered to some extent thereafter in conjunction with the shrink of fishing during 1991-1996, and the decline in spawning-stock had been also leveled off for a while until 1997. However, the stock-size, as well as spawning-stock-size, has been drastically declined since 1998 when extraordinary large fishing were resumed for two years. The stock-size in recent years shows rather miserable status, in which spawning stock-size is less than minimal, with about one-tenth of before or less than 10 %. The stock has been in a "heavily exploited status", and no sign on recovery has been shown. In view of the potential stock-size is rather small (30 millions), further decline in stock abundance is foreseen, the reduction in fishing intensity is therefore desirable.
6	**Sole** ***Cynoglossus senegalensis***	**0.40** **1,150,000,000**	**Heavily exploited, in cautious phase, reduction in catch is required is most desirable.**	The annual catch of sole had gradually increased but remained less than 4,000 tons until 1984 (just prior to this assessment). Under these circumstances, the stock abundance had increased during the early stage of assessment being supported by rather light exploitation during the above mentioned period. This increase in stock-abundance had been gradually slow-downed according to further intensification of fishing thereafter, achieving its annual catch more than 4,000 tons. The steady increase in the spawning-stock had also continued until 1991. The state of stocks until 1991was observed to be quite sound and the exploitation remained within a moderate mode. However, the stock abundance has started decline since 1992 when an extraordinary large catch had suddenly taken place since 1992, which had lasted for three more years. Then rather high fishing intensity has been continued thereafter until recently, and the abundance of spawning-stock has shown a further decline responding to the increase in the fishing intensity. The level of spawning-stock in recent years remains only at 10-15 percent (%) of the highest level in 1992. Taking this drastic change in reproductive-potential into account, it is concluded that the stock has been heavily-exploited with in cautious-phase, for which reduction in catch in the future is highly desirable. The above conclusion has been derived even if the huge potential in stock-size (about 1,150 millions) were taken into account together with the large and numerous distribution of habitat.
7	**Sompatt** ***Pomadasys jubelini***	**0.30** **230,000,000**	**Moderately exploited, in careful phase, future monitoring is needed, no need immediate actions.**	The history of exploitation of this stock is very new, for which substantial catch was achieved only since 1981. The stock abundance had shown a gradual-increasing-tendency throughout the history, and there is no sign of over-exploitation. The stock appeared to have been only slightly-moderately exploited in careful phase. No immediate action for conservation measure is therefore required. Monitoring stock abundance is however needed in the future because the potential stock-size appeared to be rather small (230 millions), for such a stock decline in the abundance would easily be occurred if it encounters excess in fishing intensity .

Table 3-22 Change in Biomass converted from initial stock size and outward Rate of Exploitation

TBM: Total Biomass, CCT: Commercial Catch, ORE: Outward Rate of Exploitation.

Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1) Thiof, *Epinephelus aeneus*															
Potential Harvest in Stock Number: 15,000,000 individuals and in Biomass: 28,000 tons.															
TBM	25588	24501	22831	20839	19912	19429	18161	17175	15538	13398	11460	10624	9550	9017	8935
CCT	3867	4041	4018	2796	2061	2541	2063	2520	2962	2778	1715	1916	1494	1300	1407
ORE	0.151	0.165	0.176	0.134	0.103	0.131	0.114	0.147	0.191	0.207	0.150	0.180	0.156	0.144	0.158
2) Pagre, *Sparus caeuleostictus*															
Potential Harvest in Stock Number: 400,000,000 individuarls and in Biomass: 40,000 tons.															
TBM	34126	37313	38170	38396	39565	39228	35662	30961	27679	26415	25579	26265	28259	31319	34673
CCT	3002	4662	4776	3347	4025	6358	7547	6333	5044	4738	2987	2916	3321	2836	3237
ORE	0.088	0.125	0.125	0.087	0.102	0.162	0.212	0.205	0.182	0.179	0.117	0.111	0.118	0.091	0.093
3) Thiekem, *Galeoides decadactylus*															
Potential Harvest in Stock Number: 900,000,000 individuals and in Biomass: 60,000 tons.															
TBM	52224	49489	47513	44720	41522	38342	34485	32197	28330	25400	23019	21534	18876	14478	10754
CCT	5349	4908	5055	4686	4042	4394	2869	4471	3750	2997	1626	2196	3801	3410	1972
ORE	0.102	0.099	0.106	0.105	0.097	0.115	0.083	0.139	0.132	0.118	0.071	0.102	0.201	0.236	0.183
4) Otolithe_OT, *Pseudotolithus senegalensis*															
Potential Harvest in Stock Number: 90,000,000 individuals and in Biomas: 25,000 tons.															
TBM	8072	5594	4972	5967	8654	12643	16533	20697	10704	5963	1762	2324	2741	3274	1570
CCT	3550	2092	1142	649	783	1373	798	11496	5656	4772	305	548	450	2076	644
ORE	0.440	0.374	0.230	0.109	0.090	0.109	0.048	0.555	0.528	0.800	0.173	0.236	0.164	0.634	0.410
5) Machoiron, *Arius heudelotii*															
Potential Harvest in Stock Number: 30,000,000 individuals and in Biomass: 40,000 tons.															
TBM	35471	31802	27293	22855	19088	15309	12319	12399	10761	10529	10151	11075	12789	7525	1942
CCT	5125	5439	5720	5007	4992	4238	1651	3558	2562	3007	1930	1138	6696	5766	1041
ORE	0.144	0.171	0.210	0.219	0.262	0.277	0.134	0.287	0.238	0.286	0.190	0.103	0.524	0.766	0.536
6) Sole, *Cynoglossus senegalensis*															
Potential Harvest in Stock Numer: 1,200,000,000 individuals and in Biomass: 75,000 tons.															
TBM	44825	51919	60271	69278	77784	79270	76474	70351	54122	43926	31797	27251	21506	18960	16602
CCT	4578	4118	4560	4473	3696	4287	5053	14572	10113	10986	4173	6517	5085	4574	4374
ORE	0.102	0.079	0.076	0.065	0.048	0.054	0.066	0.207	0.187	0.250	0.131	0.239	0.236	0.241	0.263
7) Sompatt, *Pomadasys jubelini*															
Potential Harvest in Stock Number: 230,000,000 individuals an in Biomass: 40,000 tons.															
TBM	3221	3153	2632	2316	2641	3359	4451	6792	11634	17992	24761	30352	34186	36412	31992
CCT	343	788	679	275	239	503	608	130	286	221	301	239	240	5564	219
ORE	0.106	0.250	0.258	0.119	0.091	0.150	0.136	0.019	0.025	0.012	0.012	0.008	0.007	0.153	0.007

Table 3-24 Catch statistics of clams, Cymbium spp. and Murex spp. provided by CRODT and DPM

(metric tons)

Species	Cymbium spp		Murex spp	
Year	CRODT	DPM	CRODT	DPM
1981	687	8,075	−	−
1982	5,216	4,075	−	−
1983	9,127	2,437	1,363	−
1984	3,509	3,786	237	308
1985	6,650	5,818	N.A.	−
1986	6,254	5,684	N.A.	−
1987	6,871	114	N.A.	3
1988	4,621	4,625	N.A.	−
1989	6,156	3,018	381	−
1990	13,249	4,476	486	−
1991	16,499	4,920	862	−
1992	14,751	5,413	864	−
1993	12,536	4,835	1,197	−
1994	11,952	5,906	903	450
1995	5,759	7,453	469	749
1996	8,952	6,577	4,274	1,212
1997	6,961	5,161	2,989	1,223
1998	6,477	4,679	1,999	2,543
1999	7,379	5,700	2,877	1,254
2000	10,033	4,915	3,517	1,529
2001	8,173	7	4,553	5,411
2002	10,400	77	4,531	4,275
2003	9,535	−	4,200	−

Remarks:
N.A. : Not available

Table 3-25 Provincial catches of Cymbium spp. and Murex spp. reported in DPM statistics, during the two years when high productions were achieved, and their average value and component ratio in the total

(metric tons)

Species	Cymbium spp.				Murex spp.			
Region / Year	1995	1996	Average	Ratio (%)	2001	2002	Average	Ratio (%)
Fleuve/St-Luise	45	28	36.5	0.52	19	14	16.5	0.34
Louga	1	29	15.0	0.21	45	91	68.0	1.40
Thies	7,032	6,160	6,596.0	94.03	4,908	3,483	4,195.5	86.63
Cap Vert/Dakar	115	167	141.0	2.01	104	9	56.5	1.17
S. Saloum/F Kaolack	−	−	−	−	−	−	−	−
Fatick	134	120	127.0	1.81	153	456	304.5	6.29
Cazamance/Ziguinchor	126	73	99.5	1.42	182	222	202.0	4.17
TOTAL	7,453	6,577	7,015.0	100.00	5,411	4,275	4,843.0	100.00

CHAPTER 4

FISHERIES MANAGEMENT

CHAPTER 4
FISHERIES MANAGEMENT

4.1 Approach of the Senegalese Government

Senegal is the most prolific fisheries country in Western Africa, producing 400,000 tons in 2001. During the 1980s, the volume of catches was only around 200,000 tons, however, as a result of modernization in the sector, namely the introduction of purse seine net technology and the adoption of engine-powered and larger fishing boats in the artisanal fisheries sector, production rapidly increased. There were other favorable factors such as the exemption of taxes on fishing boat fuel and fishing gear, boosting of export pressure due to the currency devaluation of 1994, and fisheries has since developed into one of the country's important industries. However, in recent years, catches have reached the maximum permissible limit and fisheries stocks are said to be in decline. In particular, concerning demersal fish stocks, warnings have been issued about the indiscriminate catching of a number of species (see Figure 4-1).

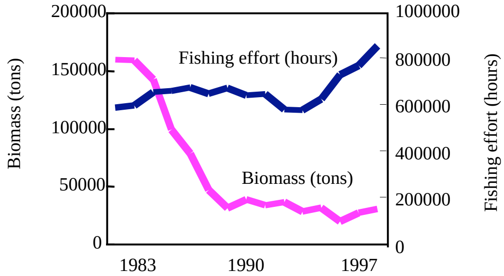


Figure 4-1 Movements in the Biomass and Industrial Fishing Effort of Major Demersal Fish Stock

The problems facing fisheries in Senegal include the following:

i) Because open access is guaranteed to artisanal fishery fishing grounds, there is competition to get to fisheries resources first.

ii) In addition to the increasing catch capacity of artisanal fishing boats, encroachment of coastal areas by industrial fishing boats is leading to the depletion of demersal fish stocks.

iii) Public agencies are charged with monitoring the sector, however, there are not sufficient personnel or budgets to cover more than 100 landing areas that are dotted around approximately 700 km of coastline.

The Senegalese government established the fisheries law (No. 98-32) in 1998 and sought to change the structure and content of fisheries through promoting resource management to fishermen and seeking participation from donors and NGOs, however, fisheries stocks have continued to deteriorate.

The government considers that excessive fishing effort is the greatest obstacle to resource management in Senegal, and it is advancing preparations for the introduction of a concession system to counter this. Receiving advice from France, and with the Fisheries Ministry acting as coordinator, this entails first controlling the catch effort through limiting the number of fishing licenses at four pilot sites (Kayar, Sindia, Joal and Foundiougne) and providing compensation and unemployment countermeasures for fishermen who suffer losses as a result. When selecting fishermen to receive licenses, it appears that legal standards (not conferring licenses to violators) and economic standards (not conferring licenses to tax delinquents or fishing boats that do not employ Senegalese crewmembers) will be referred to. However, in reality there are numerous problems and revisions that are making the government's job very difficult. One official has pointed out the following considerations: (i) lack of accurate data on stock volumes and fishing boat numbers to back up catch effort reduction, (ii) strong opposition by fishermen to reducing the number of fishing boats, and (iii) accordingly, the need to examine effort reduction based on regulating fishing seasons, fishing grounds and fishing gear.

In addition to concessions, another popular topic recently is the Conseil Locaux de Pêche Artisanale (CLPA) or regional fisheries council. Senegal already has the Conseil National Consultative des Pêches Maritimes (CNCPM), which examines important points regarding the development and management of mainly industrial fisheries on the national level, however, the concept of regional fisheries councils envisages discussion of resource management and tackling of artisanal fishery problems based on democratic discussions between the government and fishermen on the local level. The CLPA will comprise representatives from the DPM, DPSP, CRODT and fishermen's groups, and it is planned to establish councils in 30 sites throughout the country from Saint Louis in the north to Ziguinchor in the south.

4.2 Fisheries Statistics System

4.2.1 Objective of Improving Fisheries Statistics

Rapid and accurate fisheries statistics are essential in order for government agencies to plan fisheries policy, especially regarding resource management. For fishermen, fish buyers and processors, too, knowing current conditions and past trends of catch sizes by fish species is important for determining future fishing, processing and selling targets. Declining fish species are sold at high prices, however, statistics make it possible to decide whether prices are sufficient compensation for the catch effort. They also emphasize to people that catching too many fish leads to the risk of certain species becoming extinct. Such uses of statistics can be expected to pave the way for the stable supply of caught fish based on the protection and management of fisheries stocks.

4.2.2 Survey Implementation

Survey pertaining to fisheries statistics was implemented as follows.

- Review of the current fisheries statistics system
- Gauging of current problems in fisheries statistics and examination of countermeasures
- Discussions with the Senegalese side and proposal of improvements
- Based on the proposed improvements, transfer of technology via seminars, etc.
- Gauging of conditions and problems in the introduction of improvements and presentment of improvement promotion measures
- Arrangement and analysis of existing information in the fisheries resource management sector
- Identification of necessary information for assessing stocks and proposal of methods for obtaining such information
- Creation and dissemination of fishing boat/fishermen registration and landing data collection systems in the pilot project sites

4.2.3 Review of Existing Fisheries Statistics

(1) rtisanal fisheries statistics

Until 1996, the DPM and CRODT collected and estimated artisanal fisheries statistics using their own respective data collection methods and techniques. From 1996 it was decided to unify methods in line with the CRODT approach, however, only recently has data collection based on CRODT survey sheets become established at eight major landing areas excluding Saint-Louis (see Table 4-1), while the DPM and CRODT still maintain their separate methods of estimation.

Table 4-1 Eight Major Landing Areas

Zone (Water Area)	Main Landing Area
Saint Louis	Saint Louis
Thiès Nord (Grand Côte)	Kayar
Dakar (Cap Vert)	Yoff、Quakam、Soumbedioune、Hann
Thiès Sud (Petite Côte)	Mbour、Joal

1) Artisanal fisheries statistics by CRODT

CRODT uses a computer system to conduct work from data input for estimation of landed quantities, however, this system takes a year or more to generate final results. Moreover, CRODT only prepares estimates for the area from Saint-Louis to Thies (excluding Louga), but it does not cover the southern areas of Saloum Delta and Casamance.

The method used by CRODT to estimate landed quantities each month in each water area is as outlined below.

(*1) Survey of the number of landing boats by fishing method (100%)
Survey all landing fishing boats according to the fishing method.

(*2) Estimation of the number of landing fishing boats by fishing method (monthly)
The number of landing fishing boats (L) by fishing method can be estimated by the following expression:

$L = \alpha * \Sigma l_i$

Number of fishing boats (l_i) on the survey day (i)
Number of survey days (n)
Number of days in the month (m)
Extrapolation coefficient ($\alpha = m/n$)

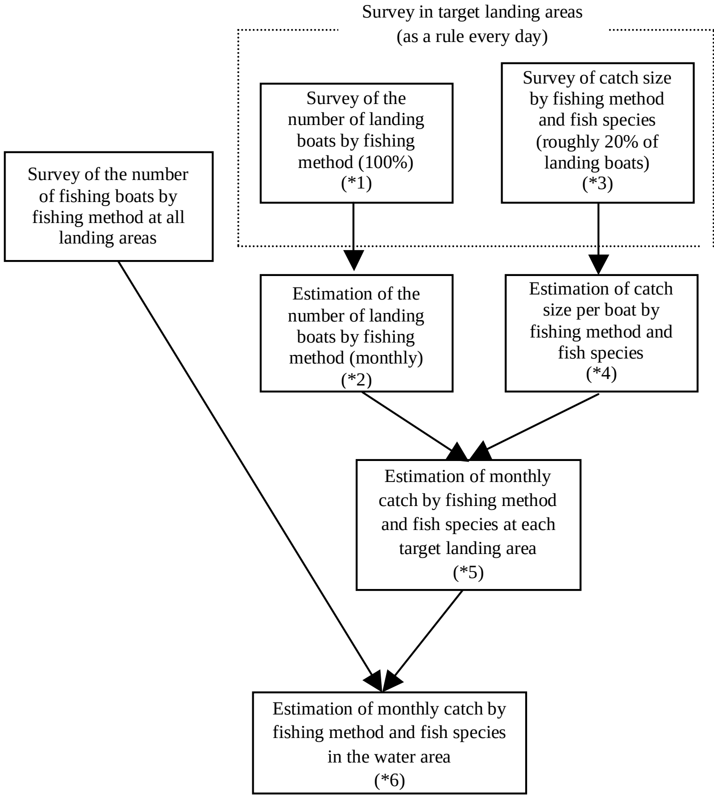


Figure 4-2 Method for Estimating Landed Quantities

(*3) Survey of catch size by fishing method and fish species
Survey landed quantities (by fishing method and fish species) for 0% or more of all fishing boats by using CRODT survey sheets.

(*4) Estimation of catch size per boat by fishing method and fish species
This can be estimated by means of the following expression.
Catch size per boat by fishing method and fish species = total landed quantity by sample fishing boats/number of sample boats making fishing trips

(*5) Estimation of monthly catch by fishing method and fish species at each target landing area
The monthly catch by fishing method and fish species is obtained through multiplying (*4) catch size per boat by fishing method and fish species by (*2) monthly number of landing boats by fishing method.

(*6) Estimation of monthly catch by fishing method and fish species in the water area
There are sometimes multiple survey points in each water area. The combined monthly catch by fishing method and fish species at these points is V.

As a rule, survey of all fishing boats according to fishing method is carried out at all coastal landing areas (not just the survey points) two times every year in Senegal. If the total number of fishing boats in each water area (by fishing method) is N and the number of fishing boats (by fishing method) at sites selected as survey points in the said area is M, then the monthly catch by fishing method and fish species for the whole water area can be obtained by the following expression:

$$Y = V * (N / M)$$

2) Artisanal fisheries statistics by the DPM

In addition to estimating catch sizes, the DPM surveys catch value (beach prices), quantities purchased and transported by middlemen, quantities sold by local retailers (local consumption) and weight of processed products, and it compiles its findings in the manner shown in Table 4-2.

Table 4-2 DPM Format for Artisanal Fisheries Statistics

TABLEAU SYNOPTIQUE DE LA PECHE ARTISANALE EN 2001

Régions	NDP	Nombres de Pirogues (1)		Mises à terre	V.C.E (x 1000 f cfa)	Mareyage (tonnes)	Consommation locale (tonnes)	Produits Transformés (tonnes)
		Fleuve	*Mer*	(tonnes)				
Dakar	16	0	2 187	33 929	16 571 830	5 180	14 280	1 942
Thiès	16	0	2 627	235 606	25 261 922	122 698	23 447	29 757
St – Louis	15	149	1 670	32 751	6 202 300	18 835	6 362	2 389
Fatick	65	988	646	11 267	4 007 207	6 266	1 585	1 146
Ziguinchor	72	1 943	420	15 519	6 508 010	1 542	2 729	3 371
Louga	8	0	66	2 532	602 030	659	328	479
Kaolack	3	11	0	757	302 561	249	491	2
Total 2001	186	3 091	7 616	332 360	59 455 860	155 429	49 222	39 086
Rappel 2000	186	3 091	7 616	338 209	54 345 370	182 353	44 016	36 857
Evolution en %	0,0%	0,0%	0,0%	- 1,7	9,4	-14,8	11,8	6,05

NPD: Nombre de points de débarquements

(1) recensement 1997

The quantities purchased and transported by middlemen are based on self-declarations, while quantities sold by local retailers (local consumption) are estimated through interviewing retailers at the main landing sites and also taking into account the results of hearings at major markets outside the area. The weight of processed products is estimated through weighing products at processing plants.

The DPM has data collection personnel assigned to the eight major landing areas and branch offices (Post de Contrôle), and instead of survey sheets like those adopted by CRODT, it relies on the ledger entry method to collect data. The style of ledgers is entrusted to the responsible staff on the ground, and there is no unified standard.

Fisheries statistics for each month are collected at the branch offices, and are then reported to the prefectures, regions and headquarters, where quantities are totaled by manual calculation.

There are no unified standards concerning totaling either, however, landing ledgers are used as reference data in numerous cases and landed quantities are arrived at through adding the quantities purchased and transported by middlemen, quantities purchased by processing plants, quantities consumed around landing sites, and quantities of products processed (converted to raw fish) by small-scale operators.

(2) Industrial fisheries statistics

Concerning industrial fisheries, since the DPM and CRODT use the same survey sheets and target all fishing boats, there is no disparity between their respective catch statistics. However, because catch data is obtained based on self-declarations by fishing boats, doubts remain over underestimations and the low accuracy of estimations.

Surveys of industrial fisheries are conducted using three types of survey sheet targeting the following three fish types:

- Statistiques Piroguiers Pelagiques（mainly pelagic fish）
- Fiche Statistique Poissonniers（mainly demersal fish）
- Fiche Statistique Crevettiers（mainly prawns）

Concerning pelagic fish, it is only necessary to enter the area of fishing operations, whereas concerning demersal fish and prawns, fishing boats are required to enter fishing locations (latitude and longitude) and quantities of fish caught and dumped by fish species. However, the accuracy of dumped quantities remains unclear and it may be necessary to reexamine the contents regarding dumped quantities in order to contribute to the conservation and effective utilization of fisheries stocks.

4.2.4 Problems and Countermeasures Regarding Artisanal Fisheries Statistics

(1) Improvement and dissemination of the CRODT survey sheets

The CRODT survey sheet includes no section for entering fish prices. Revision is being advanced with a view to adding this. Apart from this, the survey sheet is not a problem and needs no more revision.

The DPM has data collection personnel assigned to the eight major landing areas and branch offices (Post de Contrôle), however, apart from the eight major landing areas (excluding Saint-Louis), it hardly used the CRODT sheets at all.

It is guessed that the DPM personnel are not trained in handling the CRODT survey sheets. Therefore, it is necessary to implement leader training in Dakar as well as seminars in each region in a joint effort with the CRODT personnel.

(2) Joint collection of catch data and data sharing

At the eight major landing areas too, leaving aside Thies, conditions are as follows.

The DPM and CRODT have conducted join data collection in Saint-Louis Region in the past, however, now both sides collect data and estimates monthly catch based their own respective systems. As a result, the catch for 2000 estimated by the DPM was approximately 1.7 times larger than the catch estimated by CRODT.

In Dakar Region, the DPM used CRODT survey sheets, however, it collects data independently and estimates monthly catch based only on its own collected data. As a result, the catch for 2000 estimated by CRODT was approximately 2.4 times larger than the catch estimated by the DPM.

In order to avoid large disparities such as these, it is necessary for the DPM and CRODT to work together on data collection and to share data.

(3) Establishment of a method for estimating monthly catch sizes based on manual calculation

In order to enable daily average catch by fishing method and fish species to be calculated manually, it is necessary to compile daily record sheets, prepare a manual of catch size calculation (by fishing method and fish type), and establish a procedure for estimating monthly catch. The estimation method should be based on the computerized system of CRODT. In line with this, it will be necessary to implement training in this matter.

(4) Fact finding on fishermen statistics

It is thought that the number of fishermen is estimated from the number of crew per fishing boat. It is necessary to examine conventional statistics on this subject based on the fisheries consensus including socioeconomic survey of fishing villages that was implemented in the first half of 2004.

4.3 Approaches by Other Donors

Major donors such as the World Bank, EU, FAO and European Union, and also NGOs conduct various activities in their respective fields of interest (see Table 4-3). In geographical terms, assistance is concentrated around Saloum Delta in the south, however, hardly any aid is being directed to northern coastal areas.

Table 4-3 Case Studies of Activities by Donors and NGOs for Fisheries Management

World Bank	Name of project: GIRMaC (Integrated management of Marine and Coastal Resources). This aims to support ecosystem preservation (from the latter part of 2004) in order to aid sustainable development of artisanal fisheries and maintenance of biodiversity by the Senegalese government. Japan's Policy and Human Resources Development Fund (PHRD) is used for technical assistance.
EU	The Programme d'Appui à la Pêche Artisanale (PAPA-SUD)（support program for artisanal fisheries in the south） is being implemented in a joint effort with France. This aims to improve fisheries statistics collection methods south of Mbour. Steps are also being taken to improve the quality of catches, bolster the capacity of fisheries organizations, construct fisheries infrastructure and educate fishermen in safety.
FAO	The Sustainable Fisheries Livelihoods Programme (PMEDP) is being implemented in a joint effort with the United Kingdom. This entails developing and disseminating post harvest technology for poor fishermen in Mbour and Foundiougne. Activities include surveys, planning and job training geared to alleviating poverty. The project headquarters is located in Cotonou and the implementation period is until November 2006.
France	As an advisor to the Minister of Fisheries, this supports the CNCPM and is also involved in the introduction of fisheries concessions. The advisor to the DPM Director supports the regional fisheries councils (CLPA), reform of legal systems, reconstruction of statistics systems and human resources development among fisheries related personnel.
Switzerland	Switzerland developed a fishing boat registration system and implemented it on a trial basis in Hann, Rufisque and Kayar. Also, it developed reading devices to aid the computerization of fisheries information. The counterparts in Senegal are Ports Systems and Fenagie-Peche.
OCEANIUM	An NGO in Senegal, this organization sets and manages marine protected areas in Bamboung in the Saloum Delta based on funding from France. It also implements eco tourism as an alternative means of livelihood.
ENDA	An NGO in Senegal, this organization has announced numerous essays concerning preferential measures for the promotion of artisanal fisheries. It also advises the Senegalese government and is actively involved in the policymaking process. Recently it has worked on the issue of open access. It supports the staging of international conferences in the fisheries sector
WWF	An environmental NGO, the WWF implements the West Africa Marine Ecoregion (WAMER) project. Countries participating in this are Mauritania, Senegal, Gambia, Cape-Verde, Guinea Bissau and Guinea. It conducts surveys of marine protected areas, compiles plans and stages seminars.
IUCN	An environmental NGO, this organization implemented trial closed period for bivalve and snail in Saloum Delta in a joint effort with CRODT. It also promoted the establishment of beach committees in an effort to promote autonomous fisheries management. It is currently planning to set closed zone of fishing over a wide area in Saloum Delta.

4.4 Collaboration with Other Donors (especially the World Bank)

Immediately after the start of the project, only NGOs displayed understanding and cooperation towards bottom-up resource management, and it wasn't possible to build cooperative relations with international agencies and European and American donors, who were in favor of the top-down approach. Furthermore, fisheries officials in Senegal were also dubious over bottom-up resource management.

However, when the other donors saw residents autonomously commence resource management and this spread to surrounding fishing villages in the project, they changed their point of view. The World Bank, FAO, France and Switzerland, etc., which were implementing or planning similar projects, contracted the Study Team to provide information and exchange opinions, and there were also requests to visit and observe the project sites and cover the contents. Regarding this as a good chance to disseminate bottom-up resource management to other areas, the Study Team decided to positively cooperate with other donors' projects. It has so far exchanged cooperation agreements with the World Bank's GIRMaC (Integrated management of marine and coastal resources), OCEANIUM (NGO), which collaborates with the French development agency (AFD) and ENDA-GRAF, which supports women's activities in fishing villages; moreover, it regularly holds a meeting for fisheries donors under cooperation from JICA.

GIRMaC (2005~2010) conducts the closest cooperation with the project. GIRMaC shares the same objective with the project in that it emphasizes resident participation and local autonomy in artisanal fisheries resource management, and it also willing to learn from the experiences of Asia, which is an advanced region in this field. On receiving a strong request from GIRMaC, the Study Team agreed to provide know-how on bottom-up resource management. The specific contents of cooperation were as follows.

(1) Resource management classes and on the job training

The Study Team conducted classes on resource management and survey methods over two days for four facilitators of GIRMaC. Moreover, the facilitators were accepted onto the JICA pilot project sites (Nianing and Yenne) for two weeks and took part in on-site training simulating GIRMaC.

(2) Planning and implementation of a training tour

A six-week training tour for learning about advanced case studies in Japan, the Philippines and Thailand was planned and implemented for three superior employees and four facilitators of GIRMaC. Realizing that there is great significance in learning about the resource management experiences of Asia, where fisheries conditions are extremely similar to Senegal, the trainees took part in this training with a high degree of motivation. In addition to learning numerous ideas from the lessons of similar projects in Asia and the approaches of governments and NGOs, the trainees also realized the difficulties involved in resource management.

(3) Dispatch of long-term experts

There was a request for the dispatch of long-term experts in order to guide and nurture Senegalese staff members of GIRMaC and ensure that the GIRMaC pilot projects realized definite outcomes. Three reasons may be considered as to why GIRMaC requested help from Japanese experts: 1) Japanese experts possess the best experience in the world regarding artisanal fisheries resource management, 2) Japanese experts can be expected to implement projects that incorporate knowledge and experience from Southeast Asia, where Japan conducts cooperation, and 3) JICA's pilot projects have generated sound results in Senegal. Positively responding to this request, the Study Team decided to dispatch an expert to GIRMaC for two years starting April 2006.

Furthermore, regarding collaboration between the project and GIRMaC, neither one unilaterally aims to provide cooperation to the other; rather, the goal is to build a relationship that is advantageous for both sides and thereby maximize the effectiveness of both. When the Japanese side provides expert technology-based support for GIRMaC, not only dos this benefit GIRMaC, but also it enables the outcomes and know-how obtained in the JICA pilot project to be disseminated to other areas, governments and agencies, thereby enabling the effectiveness of the Japanese model to be validated in different parts of the country. For the Japanese side, which is unable to demonstrate the dissemination effects of the pilot projects due to geographical and time constraints, this is a major advantage. GIRMaC may be regarded as "Phase 2 of the development study" and also serves to conduct follow-up on the study.

4.5 Sociological Survey of Fishing Villages

One of the major components of the project is implementation of the pilot project as described later, however, it is first necessary to survey and gauge current conditions regarding the state of fisheries and socioeconomic conditions in fishing villages as well as the awareness of fishermen towards resource management. Information concerning such items was collected through hearing surveys by the Study Team members as well as questionnaire surveys that were consigned to subcontractors.

4.5.1 Background of Subcontracted Survey Implementation

The coastline of Senegal stretches for 718 km and it is dotted with numerous fishing villages. Since it was not possible to survey every village during the limited time available, it was decide to implement surveys at a number of important locations. In the preliminary study (JICA 2003) that was implemented before this Study, a bilateral agreement was reached to implement socioeconomic surveys in villages selected from 34 villages including the eight major landing areas in the country (see Table 4-4). The Study Team classified the villages on this list according to coastal division and administrative division and determined the target villages in such a way that each division had almost the same number. Next, the villages were screened in order from the villages with the most fishing boats per division, and also the opinions of the DPM and CRODT were taken into consideration before deciding on the final survey targets. Data concerning the number of fishing boats was based on the results of the fisheries census implemented by the DPM and CRODT in 1997. Eventually, the survey was implemented in 22 villages with 25 samples as a rule being taken from each village, although some minor adjustments were made to this number allowing for the characteristics of each village. In all, 562 samples were obtained (see Table 4-5). The survey targets (informants) were limited to boat owners since they are directly involved in decision-making regarding resource management.

As for the questionnaire survey, this was consigned to the local consulting company SENAGROSOL, which is based on Dakar. This company conventionally specializes in rural development, however, it was deemed able to undertake this work because it also has experience in the fisheries field and JICA work. The survey was implemented over a short period from November 18 to 23, 2003, and surveyors were divided into four groups covering the northern coast, Dakar and its environs, the southern coast, and Casamance.

4.5.2 Survey Findings

(1) Socio-economic aspects of informants

The average age of fishing boat owners is early 40s across all areas. The average age on the north coast and around Dakar is early 40s, which is slightly younger than on the south coast and Casamance where it is mid-40s. This is indication of the fact that ocean conditions are harsher and fishermen need to have more physical strength to work in the first two areas.

In terms of tribal composition, more than 80% of fishermen on the north coast and around Dakar are Wolof, whereas this ratio falls to 53% on the south coast and Casamance, where the ratio of Serer conversely increases to 33%. These results would seem to indicate the historical and social background in which fishing villages were formed when Wolof fishermen migrated to predominantly Serer areas. In Casamance, there is no one single tribe accounting for the majority of fishermen; rather there is an equal distribution between Wolof (28%), Serer (29%) and Jola (21%) of Casamance origin.

A survey of boat ownership showed that 53% of boat owner own one pirogue, 31% own two, 11% own three and 5% own four or more. Across the whole country, most boat owners have just one fishing boat, and there is little evidence of an elite group of fishermen that monopolize boats.

Upon surveying gross annual income, there were found to be extreme disparities between each area. The income of boat owners increases significantly in Senegal as one moves from the north to the south. It may be said that the economic facts support the migration of fishermen from the north to the south. The ratio of fisheries income out of gross annual income is 84% on the north coast, 91% around Dakar, 79% on the south coast and 100% in Casamance, indicating that fisheries account for a high ratio of incomes in all areas. The ratio decreases relatively on the south coast, however, income from the retailing and processing of marine products increases by that amount.

Regarding the mobility of fishermen, 50% are permanently settled, 25% have settled following migration, and 23% are migratory fishermen. In other words, permanently settled fishermen account for half of the overall total. By area, the ratio of migratory fishermen is high on the south coast (43%) and low in Casamance (3%). One of the reasons for this may be that octopus fishing and other fisheries that offer large seasonal fluctuations can be found on the south coast and many fishermen migrate to the area with the aim of benefiting from these.

(2) Fishing disputes

Concerning the question, "Have you encountered fishing disputes in the past 10 years?" 60% of informants across the country responded that they had. By area, the encounter rate is very high on the south coast (86% of informants) and, conversely, low around Dakar and in Casamance (the figure is the same as the national average on the north coast). Analysis of the results so far shows that clashes occur frequently on the south coast, where there is a higher ratio of migratory fishermen, but are rare in Casamance, where the number of migratory fishermen is small.

Next, concerning the targets and causes of disputes, there is a high ratio of disputes with foreign fishing boats and domestic commercial fishers across the country. Almost half of all the informants responded that they had encountered such cases. Next, the targets of disputes descended in order from coastal fishermen in a different fishery, migratory fishermen, and coastal fishermen in the same fishery, and the ratio of disputes tended to increase the more disparities arose in the character of informants' fishing activities. Characteristic features by area are the fact that disputes with migratory fishermen are relatively few on the north coast, whereas disputes with coastal fishermen in different fisheries are relatively common in Casamance. Since the north coast is located close to the area of origin of Guet-ndarian migratory fishermen, sentiment and family relations may play a part in the low incidence of disputes.

Next, the main causes of fisheries disputes are as follows:

- Encroachment of protected waters
- Over fishing of stocks
- Infringement of closed seasons and closed zones
- Breakage and theft of fishing gear

Leaving aside breakage and theft of fishing gear, it may be inferred that concerns over the over fishing and depletion of fisheries stocks lie behind a large number of disputes.

Regarding the question, "Have you been able to resolve past fishing disputes?" more informants responded that they hadn't rather than they had across the country. Responses that disputes had not been resolved were more common on the north coast and around Dakar than in the other two areas. Looking into the reasons for this, the following kinds of responses concerning the means resorted to in order to resolve disputes were commonly heard:

- Through mediation by a third party
- Through traditional practices
- Through administrative procedures

In area terms, on the south coast, settlement through traditional practices and mediation by third party agencies is common. In Casamance, settlements through methods other than those three mentioned above are overwhelmingly common. Meanwhile, on the north coast and around Dakar, many disputes are resolved through resorting to administrative procedures. It may be inferred that many disputes in these two areas fail to be resolved because traditional practices and third party mediation are not functioning well and fishermen have little choice but to rely on administrative procedures.

4.5.3 Current Status and Awareness of Resource management

Since fisheries stocks are the bread of life for fishermen, attention should be directed towards trends in them. Regarding the question, “How have catches changed over the past 10 years?” 95% of informants throughout the country responded that catches have gone down. The reasons given for this in order were as follows: 1) over fishing by industrial fishing boats, 2) excessive increase in the number of artisanal fishermen, and 3) ongoing use of inappropriate fishing gear and fishing methods (monofilament nets and beach seine nets, etc.). Even though close inspection of catch sizes shows that the catching ratio of industrial fisheries to artisanal fisheries is 15 to 85, indicating that artisanal fisheries accounts for the overwhelming share, the artisanal fishermen seek the main cause for declining catches outside of themselves in industrial fisheries.

The species of fish for which fishermen feel that resources have declined are as follows (see Table 4-6).

Table 4-6 Representative Fish Species that have Become Depleted

Coastal Area	North Coast	Around Dakar	South Coast	Casamance
1st	Grouper（Thiof）	Grouper	Grouper	Otolithe (Capitaine）
2nd	Sea bream (Diarigne)	Sea bream	Prawn（Crevette）	Shark (Requin)
3rd	Sea bream（Dorade）	Grouper (Doye)	Otolithe（Beur）	Otolithe（Tonone）

Since forms of fishing and target fish differ according to area, the species indicated above also differ, however, grouper (thiof) is given as the top answer in three of the areas apart from Casamance. Since this is such an important species in commercial terms, the catching pressure is high and it is thought this has led to the depletion of stocks.

Against this background of stock depletion, fishermen are currently implementing various resource management measures, namely setting of closed seasons, closed zones, body length regulations, catch size restrictions and so on. 36% of all informants responded that they practiced closed seasons, 34% enforced fishing gear regulations, and 29% set closed zones (multiple responses allowed). Conversely, 27% of informants responded that they did not implement any kind of resource management activities. Regarding the question, “Are these resource management measures functioning effectively?” only 44% responded in the positive. 88% of the informants who responded that measures are not functioning well have not been able to clarify the reasons for this. Informants who responded that resource management measures were working well gave three reasons for this, namely 1) administrative monitoring is working well, 2) resident monitoring is working well, and 3) penal regulations are functioning well.

Leaving aside the question of whether or not resource management measures are functioning at the present time, 98% of all informants responded that resource management was necessary, and almost 100% responded that they would be willing to participate in the compilation of resource management rules. However, even though resource management cannot be implemented by individuals and needs to be conducted based on collaboration of fishermen who share the same interests, fishermen’s organizations for implementing resource management hardly exist at all. Fishery is a difficult sector in that the economic activity of fishing is an individual business and it is difficult to foster collaboration. However, the fact is that some sort of action needs to be taken in order to put a brake on the depletion of stocks, and when asked about their opinions on some of the basic measures of resource management, the informants responded as shown in Table 4-7.

Table 4-7 How Fishermen Think about Resource management Measures

Measure	For	Against
Closed seasons	68%	31%
Fishing gear and fishing method regulations	77%	21%
Closed zones	70%	28%
Body length restrictions on caught fish	78%	20%
Catch size restrictions	27%	72%

Maybe because it is easy to surmise that restricting catch sizes will directly lead to reduced incomes, 72% of all respondents were against this measure, whereas around 70% were in favor of each of the other measures.

Regarding the question of what kind of organization should play the central role in implementing resource management in the future, 48% of informants said the DPM, indicating a strong sense of dependence on officialdom. Furthermore, in response to the question of what resources are required for deploying activities, the top answer given was the existence of trustworthy leaders, second was funding and third was equipment.

Finally, when asked about a registration system for pirogues (fishing boats), 88% of informants were in favor and 4% were in favor with conditions attached. However, regarding the imposition of restrictions on the number of fishing boats based on registration data, 69% were opposed while 22% were in favor. It may be surmised that the fishermen realize the number of pirogue fishing boats is too many.

4.6 Preferential Measures for Artisanal Fisheries

The artisanal fisheries sector in Senegal expanded production through adopting tax benefits for fisheries fuel and producer goods and promoting modernization. However, against the current critical background surrounding coastal stocks, it will be difficult to promote coastal resource management measures so long as preferential measures for artisanal fisheries are upheld. Here, we consider the current situation regarding preferential measures in the artisanal fisheries sector.

4.6.1 Tax Exemption for Fuel Oil

(1) Outline of tax benefits

Before Senegal gained independence in 1960, there were only a handful of engine-powered pirogues. The government passed a resolution to exempt pirogue engines from import tariffs in 1966, and signed an agreement to import 3,500 outboard engines from Canada in 1972. As a result, pirogue became motorized and, at the same time, the government commenced the sale of pirogue engine fuel at a special price. If general duties were applied to pirogue engine fuel, the resulting price increases would be as follows:

(a) Tariff (droit de douane): 10%

(b) Value added tax (TVA): 18%

(c) Specific tax (taxe specifique;Impot): 38.56Fcfa/ℓ

(d) Statistical levy (SR: redevance statistique): 1%

(e) Payment to the freight transportation council (COSEC:conseil senegalais des chargeurs): 0.2%

The tariff on pirogue engine fuel (10%) is exempted according to Article 188 of the Customs Clearance Law, while value added tax (18%) is also exempted. Of the above duties, (c), (d) and (e) are applicable to pirogue engine fuel[1]. For example, the price of pirogue engine fuel in August 2004 was 359 Fcfa/l. Since the above (c), (d) and (e) were included in this price, the CIF Dakar price worked out as 317 Fcfa (per liter), whereas the tariff and value added tax per liter were 32 Fcfa and 57 Fcfa respectively. The price differential between pirogue engine fuel and fuel for general use (359 + 32 + 57 = 448 Fcfa) was 89 Fcfa/l, which meant that the price of pirogue engine fuel was held to 80% of the regular price.

(2) Fuel consumption in the artisanal fishery sector

Consumption of fuel in the artisanal fisheries sector in 2003 was worth 15.1 billion Fcfa, which was equivalent to 18% of the value of annual landed catches (82.5 billion Fcfa). The price of pirogue engine fuel this year varied between 281~315 Fcfa/l, and a total of 51,260,000 liters was consumed. Assuming that the price differential with fuel for general use was 20%, this means that 3.8 billion Fcfa ($7,000,000) was used in maintaining a preferential price for pirogue engine fuel. Compared with 10 years earlier in 1993, the amount of fuel consumption was 24,930,000 liters worth a combined value of 6.5 billion Fcfa. In this year, the amount of money used to maintain the preferential price for pirogue engine fuel was 1.6 billion Fcfa. Over these 10 years, the value of fuel consumption in the artisanal fishery sector increased by 2.3 times and the amount of consumption increased by 2.1 times, whereas the cost of preferential price maintenance jumped 2.4 times from 1.6 billion Fcfa to 3.8 billion Fcfa. Figure 4-3 shows the annual changes in the value of fuel consumption over this 10-year period. Leaving aside the sudden jump in 1998, the trend of increase was almost constant throughout the period. Accordingly, it must be presumed that this trend will continue from now on, providing there are no major changes in the environment.

[1] According to the hearing interview with Mr. Omar Cisse (Inspecteur des Douanes, Dakar-Petroles) on August 19, 2004.

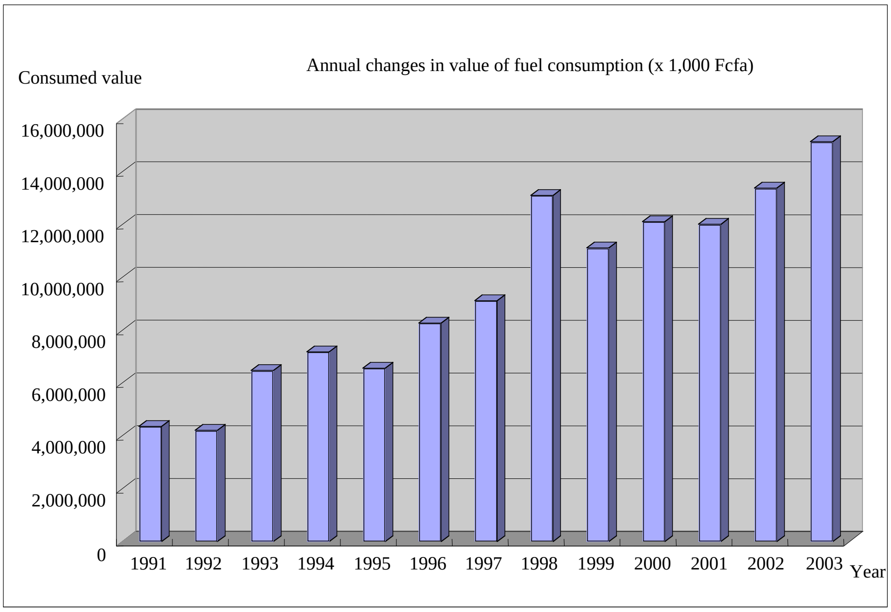


Figure 4-3 Annual Changes in the Value of Fuel Oil Consumption

(3) Fuel tax benefits in terms of fishing household economy

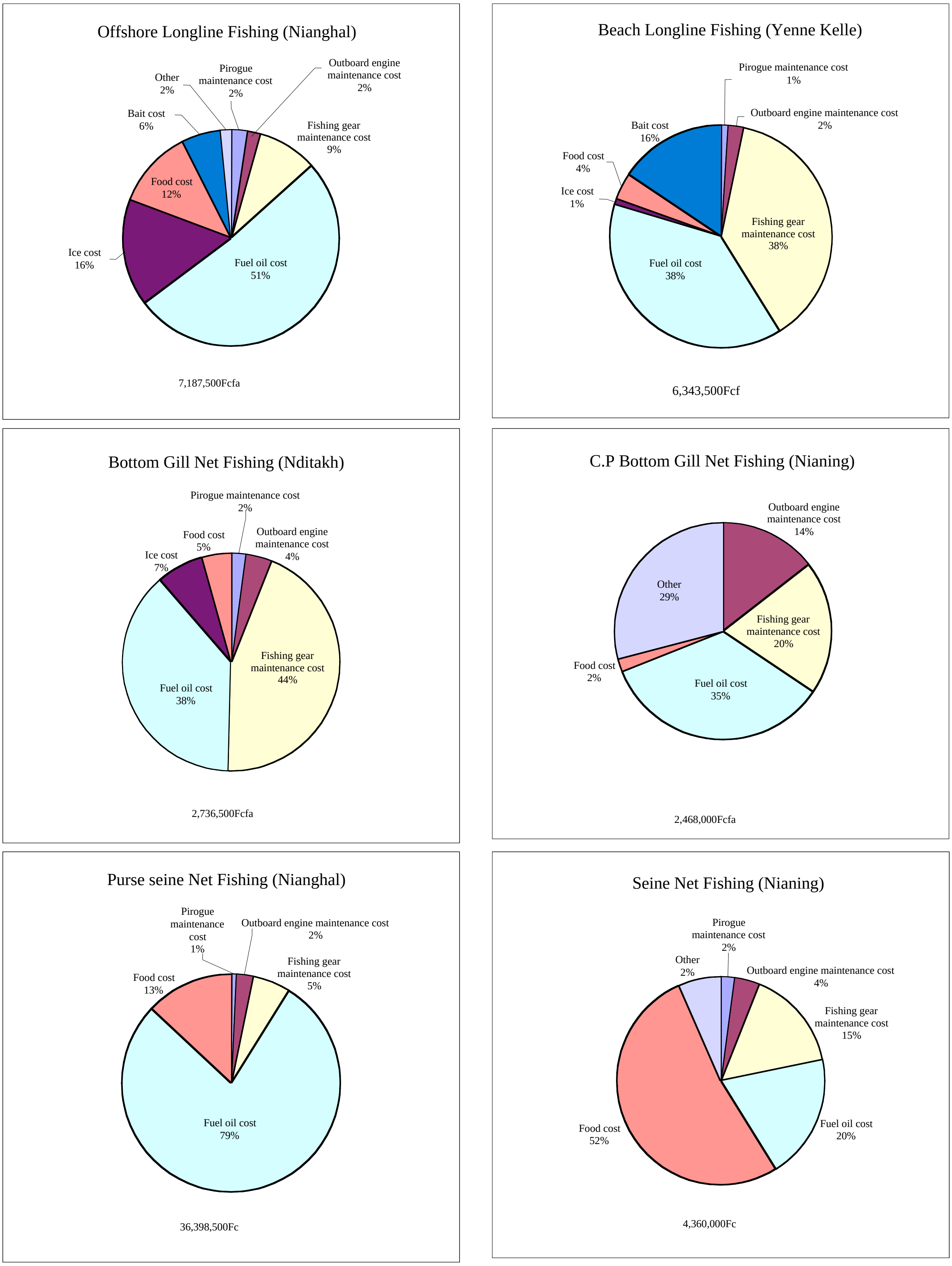
The number of motorized pirogues in Senegal in 2003 was 7,085. Average fuel consumption per pirogue was 7,235 l or 2,140,000 Fcfa in money terms. This meant that, as a result of the fuel tax benefits, each pirogue benefited by 534,000 Fcfa on average per year. What is the situation in terms of the effect on household economy in different types of fishery? From the surveys of fishing household economy in the villages targeted for the pilot projects described later, Figure 4-4 shows the results of calculating the ratios of major items among annual operating costs in representative fishing households selected from each sector. The figures indicated below the pie graph show the total annual costs of each fishing household.

In the case of a longline fishing household in Yenne, in the offshore longline fishery, annual operating coasts are 7,190,000 Fcfa, of which fuel accounts for the largest share of 51% (3,700,000 Fcfa), ice for 16% and food for 12%. The benefit received by this household from the fuel preferential price is 925,000 Fcfa per year, and this corresponds to 15% of that household's annual operating profit (the amount remaining after deducting operating costs from landed value) of 6,050,000 Fcfa. Meanwhile, in the coastal longline fishery, annual operating coasts are 6,340,000 Fcfa, of which fuel costs and fishing gear maintenance costs account for 38% each, and bait costs for 16%. In the offshore longline fishery, where fishing boats make fishing trips for between 6~10 days to waters off the coast of Gambia, Casamance and Guinea, fuel and ice account for a higher share of costs than in the coastal longline fishery.

In the case of a fishing household that practices two types of gillnet fishing in Yenne Nditakh, annual operating costs are 2,740,000 Fcfa, of which fishing gear maintenance accounts for the highest share of 44%, followed by fuel, which accounts for 38% (1,040,000 Fcfa). The benefit received by this household from the fuel preferential price is 260,000 Fcfa per year, corresponding to 9.3% of the annual operating profit of 2,770,000 Fcfa. Meanwhile, in the case of a cymbium gillnet fishing household in Nianing, out of the annual operating cost of 2,470,000 Fcfa, fuel (860,000 Fcfa) accounts for 35%, while fishing gear maintenance only accounts for 20%. The benefit received by this household from the fuel preferential price is 210,000 Fcfa per year, and this corresponds to 10.5% of the annual operating profit of 2,040,000. In the case of a bottom gillnet fishing household that fishes in front of the village, the benefit received from the fuel preferential price accounts for around 10% of annual operating profit.

Comparing a purse seine net fishing household and a beach seine net fishing household in Niangahl, whereas the cost of fuel (28,400,000 Fcfa) accounts for 79% of the annual operating cost of 36,4000,000 Fcfa in the former, it only accounts for 20% (860,000 Fcfa) of the annual operating cost of 4,360,000 Fcfa in the latter. In the latter case, food costs account for the largest share of costs at 52%. In the purse seine net fishery, where fishermen use large nets and migrate between different fishing grounds, fuel costs account for an overwhelming share of expenses. Conversely, in the beach seine net fishery where fishing grounds are located close to fishing villages, since this is a labor intensive fishery, food costs account for a large share of the expenses. In the purse seine net fishing household, the benefit received from the fuel preferential price (7,100,000 Fcfa) is 16.2% of the annual operating profit of 43,730,000 Fcfa. On the other hand, in the gillnet fishing household, where fuel consumption is low, the benefit received from the fuel preferential price is just 210,000 Fcfa or 3.2% of the annual operating profit of 6,670,000 Fcfa.

To sum up, the ratio of the benefit received from the fuel preferential price compared to annual operating profit varies according to the type of fishery. In households that practice high fuel consuming fisheries such as longline fishing, which targets distant fishing grounds, and purse seine net fishing, which targets migratory species, the ratio is around 15%. Meanwhile, in households that practice gillnet fishing in nearby beach grounds, the ratio is 10%, whereas in labor-intensive beach seine net fishing, the ratio is 3%.



(Note) C.P refers to the large univalve Cymbium pepo.

Figure 4-4 Breakdown of Annual Operating Costs by Fishing Method

4.6.2 Tax Exemption for Fisheries Supplies

(1) Outline of tax exemptions

The government in 1966 made the decision to exempt taxes from pirogue outboard engine sold to artisanal fishermen. Similar preferential measures have been adopted with respect to other artisanal fishery equipment. Here, we clarify the situation regarding preferential measures for pirogue outboard engine and equipment.

The taxes applied to artisanal fisheries are as follows:

(a) UEMOA (Union Economique Monnataire Ouest Africain): 1%
(b) CEDEAO (Communaute Economique des Etats de l'Afrique de l'ouest): 0.5%
(c) COSEC (payment to the freight transportation association): 0.2%
(d) Redevance Statistique (statistical levy): 1%

Therefore, the total tax payment is 2.7%.

Meanwhile exempted tax items are the following:

(e) Custom tariff
(f) Value added tax (TVA)

Regarding customs tariffs, a specific tariff rate is applied to the CIF price of each commodity, whereas concerning value added tax, a uniform rate of 18% is levied on the CIF price + tariff. Here, in order to make calculations easier, in addition to the value added tax and tariff, the tax rate pertaining to CIF price (%) is displayed (see Table 4-8).

Table 4-8 Tax Exemptions and Tax Rates for Artisanal Fisheries

Item	Value added tax (%)	Custom tariff (%)	Total (%)
Fishing nets	19.8	10	29.8
Line	19.8	10	29.8
Rope	21.6	20	41.6
Floats	18.9	5	23.9
Fish hooks	21.6	20	41.6
Life jackets	21.6	20	41.6
Rainwear	19.8	10	29.8
Outboard motors	18.9	4.8	23.7
Spare parts	19.8	9.8	29.6

Source: According to interview surveys conducted in July 2005

(2) Equipment and supplies consumption in the artisanal fishery sector

Table 4-9 shows sales figures for fishing equipment and supplies to artisanal fishermen in Senegal in 2004[2]. Since the sale prices in the table include taxation of 2.7%, this is converted into the CIF price and the tax benefit based on the tax rates in Table 1 is sought. As a result, the cost of preferential measures regarding sales of fisheries equipment and supplies in the artisanal fishery sector in 2004 works out as 640 million Fcfa.

Table 4-9 Value of Supplies Sold to Fishermen in Senegal (2004)

Equipment	Quantity (Unit)	Sales (Fcfa)	CIF value (Fcfa)	Tax rate (%)	Tax benefit (Fcfa)
Outboard motors	971	1,436,431,000	1,398,666,991	23.7	331,484,077
Spare parts		437,159,491	425,666,496	29.6	125,997,283
Fishing nets		302,208,132	294,263,030	29.8	87,690,383
Line		141,740,000	138,013,632	29.8	41,128,062
Rope	27,300	23,540,000	22,921,130	41.6	9,535,190
Floats		11,397,000	11,097,371	23.9	2,652,272
Fish hooks		50,922,770	49,584,002	41.6	20,626,945
Rainwear	1,380	72,080,000	70,185,005	29.8	20,915,131
Total		2,475,478,393	2,410,397,656		640,029,343

4.6.3 Overall Preferential Measures for Artisanal Fisheries

When the previously mentioned fuel tax benefits are combined with the preferential measures for fisheries equipment and supplies, the cost of benefits for the artisanal fisheries sector works out as 4.44 billion Fcfa (800 million yen) in 2003. Similar to the trend of increase in fuel consumption over the past 10 years, it is likely that the cost for the government of sustaining preferential measures will continue to rise in future.

Turning to the role of fisheries benefits in fishing household economy, annual costs related to preferential measures and resulting tax benefits were calculated and the ratio of benefits to annual operating profit was sought for representative households in each type of fishery (see Table 4-10). The ratio of benefit arising from outboard engine and fishing gear costs (row (j) in the table) is 9% for the bottom longline fishing household, 6% for the offshore longline fishing household, 4% for the purse seine net fishing household and 3% for the beach seine net fishing household. In terms of the absolute amount of benefit, this is by far the highest in the purse seine net fishery, which is the largest scale operation, however, because annual profits are also large, the ratio of benefit is smaller. The total benefit

[2] According to Mr. Ibrahima Faye (Technicien des Peches) of the DOPM, July 18, 2005.

combined with that from preferential fuel measures (row (k) in the table) is roughly 20% of annual operating profit except in the seine net fishery.

Table 4-10 Ratio of Tax Exemption to Annual Operating Profit for Typical Fishing Households

	Type of fishery	Offshore longline fishing household	Bottom gillnet fishing household	Purse seine net fishing household	Beach seine net fishing household
	Village	Nianghal	Nianing	Nianghal	Nianing
(a)	Annual fuel cost	3,700,000	855,000	28,400,000	855,000
(b)	Outboard engine depreciation cost	522,500	182,500	2,080,000	150,000
(c)	Annual fishing gear cost	633,200	494,000	4,000,000	670,000
(d)	Fuel oil benefit	925,000	213,750	7,100,000	213,750
(e)	Outboard engine benefit	120,577	42,115	480,000	34,615
(f)	Fishing gear benefit	256,486	143,342	1,160,662	194,411
(g)	(d)+(e)+(f)	1,302,063	399,207	8,740,662	442,776
(h)	Annual operating profit	6,046,500	2,036,250	43,725,000	6,670,500
(I)	(d)/(h)x100	15	10	16	3
(j)	[(e)+(f)]/(h)x100	6	9	4	3
(k)	(g)/(h)x100	22	20	20	7

Table 4-4 List of Fishing Villages Targeted in the Study

Region /région	Prefecture /département	Fishing Village/Landing Area	Number of Fishing Boats
St. Louis	St. Louis	St. Louis	1,611
		Piote	19
		Tassinière	11
		Mouit	35
		Degouniaye	
		Mbao	28
		Taré	6
Louga	Kébémer	Lompoul	44
Thiès	Tivaouane	Fass Boye	137
		Mboro	28
	Thiès	Kayar	551
Dakar	Dakar	Yoff	348
		Hann	167
		Soumbédioune	269
		Ouakam	99
	Pikine	Thiaroye	185
		Mbao	51
	Rufisque	Rufisque	295
		Bargny	134
		Yenne	318
Thiès	Mbour	Popenguine	12
		Ngaparou	103
		Mbour	718
		Nianing	117
		Joal	579
		Ngazobil	
		Mbodiene	3
		Warang	7
Fatick	Fatick	Fimela	11
		Djifère	257
	Foundioune	Foundioune	32
		Sokon	14
		Toubacouta	
		Niodior	64
		Missirah	52
Ziguinchor	Ziguinchor	Ziguinchor	497
		Cap skiring	41
		Diogué	148
	Oussouye	Elinkine	51
	Bignona	Kafountine	56

Table 4-5 Process of Fishing Village Screening

Target number of villages per coast	Target number of villages per region	Target number of villages per prefecture	Selected fishing village	Reason for selection	Number of samples
5	2	2	St. Louis	Largest fishing village	33
				Most fishing boats in the area	
			Mouit		17
	1	1	Lompoul	Only fishing village in the region	26
	2	1	Fass Boye	Number of fishing boats	25
		1	Kayar	Only fishing village in the region	25
6	6	2	Yoff	Priority was given to the number of fishing boats but DPM comments were also considered.	25
			Hann		24
		1	Thiaroye	Number of fishing boats	25
		3	Rufisque	All fishing villages in this area	25
			Bargny		25
			Yenne		44
7	4	4		Number of fishing boats	
			Ngaparou		25
			Mbour		25
			Nianing		27
			Joal		25
	3	1		Number of fishing boats	
			Djifère		27
		2		Number of fishing boats	
			Niodior		13
			Missirah		25
4	4	2	Ziguinchor	Number of fishing boats	25
			Diogué		25
		1	Elinkine	Only fishing village in the region	25
		1	Kafountine	Only fishing village in the region	26

Total 22 villages Number of samples: 52

(Note) Data regarding the number of fishing boats taken from the 1997 Fisheries Census (DPM & CRODT)