

SPATIAL PATTERN OF MIGRATION AND RECRUITMENT OF NORTH EAST ATLANTIC MACKEREL

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Abstract:

An International tagging program on both adult and young mackerel was implemented in 1997 (and partly in 1998) from Portugal to the Shetland isles within the frame of European Study Project 96-035 with the objectives of clarifying the migration pattern of adult mackerel from the southern and western areas and determining the recruitment spatial pattern of juveniles from two nursery areas, different from the current Mackerel box i.e. from the Northwest of Ireland and West of the Iberian Peninsula. Both external and internal tags were used in all the surveys in different proportions. A total of 161,115 mackerel were tagged along the European Atlantic coasts, 119,913 of them in 1997 and 41,202 extras in 1998.

We report here for the recaptures obtained up to march 2001: Adult recoveries show that almost all adult mackerel (regardless of the discrete areas of tagging, southern or western areas) follow the same northward migration in late spring and summer time from the spawning grounds along the west of the British Islands to the north of Faeroes, Norwegian sea and northern part of the North Sea. The northward migration often extends in summer time into the north-eastern areas of the Faeroes EEZ and further north to the International waters. From September to December mackerel from all areas are mainly found in Norwegian Sea and northern part of North Sea (mainly division IVa). At the end of the year and during wintertime those mackerel migrate southward towards the spawning grounds through the west of the British islands. These observations on migration behaviour of adults are consistent with the results obtained from previous tagging experiments. A strong presence of southern adult mackerel during spring in the western spawning grounds has been observed what cast doubts on the reliability of the assumption of separate spawning components in these areas. Recaptures of tagged juveniles (both from the west of the Iberian Peninsula and from the north-west of Ireland) suggest that in general, juveniles remain closer to the areas where they were tagged. Once they become adults, recoveries show the recruitment to the general migration pattern of adults.

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1- INTRODUCTION.

Mackerel is a highly migratory species, for which, in the East Atlantic, tagging experiments led to conclude that mackerel from the North sea & western and southern spawning areas mix and are caught together during the second half of the year in the North sea (Subarea IV) and in the Norwegian sea (Subareas II and V) (IVERSEN & SKAGEN 1989, URIARTE & LUCIO 1996). Therefore the catches taken in the different fisheries are not separable and combined assessments on all mackerel are being carried out by ICES since 1995 (ICES 1996). In that year ACFM, for practical reasons, combined the stocks into a large single Northeast Atlantic Mackerel population (NEAM), with several spawning components (North Sea, Western and Southern). Although some research on parasite infestation, otolith morphology and tagging do support the existence of spawning populations (see review in LOCKWOOD 1988), the existence or nature of these components is still a matter open to discussion, particularly for the western and southern components due to the lack of any clear spawning boundaries (ICES 1992, 1996) and to their parallel migration patterns arising from a tagging experiment in the southeast corner of the Bay of Biscay (URIARTE & LUCIO 2001). Recently, NESBO et al. (2000) by studying two regions in mitochondrial DNA detected some genetic differentiation among eastern Atlantic spawning populations, sampled in parallel to the tagging experiments presented in this paper. In contrast, and indicative of homing behaviour, no genetic structuring was observed among shoals of individuals outside the spawning season (taken in the fishery during the half of the year in Subareas IV). In past, based on tagging data, the intermixture (or relative presence) of Western and North sea components in the North and Norwegian seas was measured (BAKKEN & WESTGARD 1986, IVERSEN & SKAGEN 1989), but this has not been made for the southern component yet.

A management measure introduced during the eighties was the definition of a mackerel box (The Cornwall Box) off the Southeast coast of England. This was designed to protect juvenile mackerel on which a large fishery had developed. However, in addition to the area off Cornwall, other areas also contain important concentrations of 1 and 2 year old juvenile mackerel. For instance, in recent years young mackerel (of the 1994 and 1995 year classes) had been observed at a more northerly distribution than usual, off Northwest Coasts of Ireland and off West Coasts of Scotland during the 4th and 1st quarters (ICES 1997). The International bottom trawl surveys carried out by several countries have provided the basis to review the spatial distribution of juvenile mackerel since the beginning of the eighties up to 1996 within the SEFOS project (Reid D. editor, 2001). From this review it has become evident that the distribution of 1st winter juveniles have sifted northward since the beginning of the nineties, passing to occupy preferably ICES divisions VIa and IVa while diminishing its abundance in area VII where traditionally occurred. Another important juvenile area of mackerel is placed off west coast of the Iberian Peninsula (ICES, 1998, Villamor 1997), although no study has been made about the recruiting areas of those juveniles (Do they recruit to the adult NEAM population?).

In 1997 an international tagging project on mackerel (EU project 96-035) developed with the general aim of further understanding the migration behaviour of adult mackerel from all areas and their mixing in time, and to study the recruitment processes of juvenile mackerel. The concrete objectives proposed were:

1- To clarify the migration pattern of adult mackerel from the southern areas, i.e., from Subdivisions VIIIc east and VIIIc west and to clarify the extent of mixing and joining with the major migration routes of NEA mackerel.

2- To determine the recruitment spatial pattern of juveniles from two nursery areas, different from the current Mackerel box *i.e.* from the north-west of Ireland (Divisions VIa & VIIb) and north-west of the Iberian peninsula (IXa North).

3-To monitor the extent of the northward feeding migration of western and southern NEA mackerel components into the North and Norwegian seas.

To accomplish with these objectives, the project implemented in 1997 and 1998 an International tagging program on both adult and young mackerel, by Portugal (IPIMAR), Spain (IEO and AZTI), Ireland (MI) and Norway (IMR). This program is innovative compared to previous tagging programs particularly by the simultaneous coverage of very distant (southern and western) spawning areas and the effort paid to study recruitment processes of young mackerel from the south and western areas, other than the current Mackerel box. For the southern area (Divisions VIIIc and IXa) the study greatly expands the tagging areas covered previously by Uriarte and Lucio (2001), assuring now evenly tagging over the whole adult spawning area of this region, and studying by the first time nursery area off the western coast of the Iberian Peninsula. This report presents the results obtained from that International tagging program up to march 2001 and discusses the general pattern of migration and mixing of adult mackerel and recruitment processes arising from the study.

2- MATERIAL and METHODS:

2.1 The surveys

The Surveys: The 1997 tagging surveys and additional surveys made in 1998 (not initially planned) are presented in **Figure 1a & b**. Eight tagging areas were covered in 1997: Coded areas 1 and 6 correspond to juvenile areas, whereas 2,3 and 4 correspond to southern spawning areas and 5, 7 and 8 to western spawning areas. In 1998, both juvenile areas were target again as well as the western spawning areas, but not the southern adult areas. All tagging surveys on adults took place during the first half of the year at spawning times. Tagging on juvenile area 1 took place several times from February to September and in area 6 in summer time.

All tagging surveys were planned to make use of both external and internal tags. Internal tags are reported basically by Norway and Ireland, because they have in their factories metal detector devices, whilst the rest of the countries usually do have such devices and hence do not report the internal tags and only report for the external tags.

The number of mackerel tagged per survey was variable ranging between 10,000-40,000

depending upon actual number of days planned for each survey and the availability of fish during the surveys. Most of the participating Institutes considered the most convenient way to carry out the surveys hiring fishing vessels. In the case of Marine Institute (MI) the Killybegs Fishermen's Organisation (K.F.O.) from the northwest of Ireland were very interested in the purpose of the International tagging project and decided to support it by giving the facility of a fishing boat to MI for both years.

The fishing gear consisted of handlines, except in the case of Portugal that used trawling in 1997. Length distributions and otolith collections were obtained from tagged and discarded fishes respectively during the surveys. Complete data about the tagging surveys and individual releases are available from the authors on request.

External tagging: The tags were of type TBA-2, T-bar anchor tag of plastic, with a yellow (but also red or blue) external marker part of 20-30 mm (depending upon the actual size of the fish) and an exposed filament length of 19 mm. These external tags carried the name of the institution with the code number of the fish. These tags were inserted into the flesh, at the back of the fish, about 1 cm. posterior to the base of the first dorsal fin, if possible as deep as to let it bridging through the interneural spines.

Internal tagging: The internal tags were standard small pieces of steel, rounded at the end, 20 mm long, 4 mm wide and 1 mm thick (HOFF et al. 1988). They all carried on one side the identity of the institute (the name or an abbreviation) and an identification code number for the fish. The injection of tags was made following the "Gundersen tagging pumps" model (MYKLEVOLL, 1994). Tags were inserted into the belly or into the flesh of the belly wall.

All partners took care of producing adequate posters and publicising the International tagging and recapture programme on their own and neighbour countries assuring sufficient broadcasting of it in the concerned fishing sector.

2.2 Quantitative analysis of migratory fluxes.

In order to address the objective of monitoring the extent and annual variability of the northward feeding migration of the western and southern mackerel components into the North and Norwegian seas some quantitative analysis of the data has been made based on the internal tags recovered during the third and fourth quarters of 1998, 1999 and 2000 from the spawners released in 1997 at the different adult tagging areas by AZTI, IEO and IMR. Two methods of analysis were used:

2.2.1 Iversen and Skagen (1989) Method.

If C is the number of fish of a certain component represented by the recovered tags in the catch, R is the amount of recovered tags, N is the stock size in numbers and T the number of released tags, then:

$$C = R \cdot \frac{N}{T} \quad \text{eq. 1}$$

and the percentages of the western (W) and the southern (S) components in the catches are calculated according to:

$$W\% = \frac{C_w}{C_w + C_s} \cdot 100 \quad \text{and} \quad S\% = \frac{C_s}{C_w + C_s} \cdot 100 \quad \text{eq.2}$$

From this the presence of a component (for instance the Western mackerel, W%,) can be estimated by:

$$W\% = \frac{C_w}{C_w + C_s} = \frac{R_w \cdot \frac{N_w}{T_w}}{R_w \cdot \frac{N_w}{T_w} + R_s \cdot \frac{N_s}{T_s}} = \frac{R_w / T_w}{R_w / T_w + R_s / T_s \cdot \left(\frac{N_s}{N_w} \right)} \quad \text{eq.3}$$

and a symmetric expression can be written for the presence of Southern mackerel in these Subareas (S%). The symbols used so far mean:

$W\%$ and $S\%$ are the relative presence of the western and southern populations in the area of analysis (Subareas II,III and IV).

R_w and R_s are the Recaptures of tagged mackerel obtained in the area of analysis corresponding to the western and southern areas.

T_w and T_s refer to the total amount of mackerel tagged in the western and southern areas respectively. In this study the T_s has been corrected by a Δ factor (see section 2.3.2 below) in order to account for the additional mortality experienced by the southern fishes until the time when the tagging survey at the western area took place.

N_w and N_s are the Population size (in numbers) of the western and southern components.

The relative size of the southern component is about 15% of the western component (N_s/N_w) (ICES, 1999). If both components migrate in the same proportion and mix completely in the North Eastern area then the expected percentage in those catches should be 13% and 87% for the southern and western components respectively.

This analysis relies obviously on the existence of these two different spawning components, one in the South and the other in the western areas, for which the population sizes are believed to be known. In addition it must be assumed that the initial adult tagging mortality is the same for all the teams involved in the experiment (IMR, AZTI and IEO).

2.2.2 Contingency table analysis of recoveries in the North-eastern area.

Under the hypothesis of equal migratory fluxes, the expected frequencies of recoveries in Subareas II,III and IV originating from the different adult tagging areas should be proportional to the number of mackerel released by area. For instance, calling R to the total amount of recaptures in the North-eastern area ($R = R_w + R_s$), the expected number of recaptures of southern and western mackerel in that area should be respectively equal to:

$$\hat{R}_s = R \cdot \frac{T_s \cdot \Delta}{T_w + T_s \cdot \Delta} \quad \text{and} \quad \hat{R}_w = R \cdot \frac{T_w}{T_w + T_s \cdot \Delta} \quad \text{eqs. 4}$$

with R_w , R_s , T_w and T_s having the same meaning as in section 2.2.1 and for Δ see below.

The difference between the observed and these two expected number of recaptures can be checked by a G test (likelihood ratio test) of goodness of fit (Sokal & Rohlf, 1997). Thus the hypothesis that adult mackerel from all areas migrate with the same intensity to the North-eastern area is tested.

Δ is a corrector factor for the initial population of mackerel tagged in the southern areas (T_s) in order to account for the additional mortality experienced by these fishes until the time when the tagging survey at the western area took place. Since the elapsed time between the tagging surveys for adults in the southern and western areas in 1997 was about two months during the second quarter, Δ can be approximated as follows, using

data from the ICES 1999/ACFM:6):

$$F_{\Delta} = 2/3 \text{ (of Quarter2)} * 7.34\% \text{ (of annual catches)} * 0.25 \text{ (Annual F)} = 0.0122$$

$$M_{\Delta} = 2/12 \text{ (of the year)} * 0.15 \text{ (Annual M)} = 0.025$$

$$\text{And therefore } \Delta = \exp(-F_{\Delta} - M_{\Delta}) = \exp(-0.0122-0.025) = 0.9635.$$

If the G test for goodness of fit leads to the rejection of the hypothesis that adult mackerel from all areas migrate with the same intensity to the North-eastern area, the relative migratory fluxes of mackerel from the southern and western areas to the North-eastern areas can be estimated by the ratio of recovery rates (the odds ratio) in the latter area:

$$\frac{J_s}{J_w} = \frac{R_s/T_s}{R_w/T_w} \cdot \frac{1}{\Delta} = \frac{R_s/(T_s \cdot \Delta)}{R_w/T_w} \quad \text{eq 5.}$$

Where J_w and J_s are the migratory fluxes of the western and southern components in the North-eastern area (Subareas II,III and IV).

It should be noticed that both analyses rely on the same assumption of equal initial tagging mortality rates of the adults and this may not be true given that IMR has more experience in tagging mackerel with internal tags than either AZTI or IEO. This means that in case of significant differences arising between the expected and the observed results from either or both methods then the reasons for such differences must be discussed. *i.e.* the differences may be due to different migratory fluxes of southern and western mackerel or simply to different initial tagging mortality rates caused by the actual tagging procedures of the different teams.

For this reason we start the analysis checking the hypothesis of equal tagging mortality of the IEO and AZTI teams in the southern area according to their recoveries in the North-eastern area, with a similar G test of goodness of fit.

3. RESULTS:

3.1 Tagging surveys and recaptures programme.

All tagging surveys took place as foreseen, in general successfully completing the target number of releases (**Table 1**). The major difficulties were encountered by IPIMAR while tagging juveniles in area 1 (IXa north, off Portugal) which was completely unsuccessful in 1998 due to bad weather.

A total of 161,115 mackerel were tagged along the European Atlantic coasts, 119,913 of them in 1997 and 41,202 extras in 1998 (**Figure 1a & b**). The tags were distributed as follow (**Table 1**): a) In 1997, 83,514 mackerels were released from adult areas (56596 bearing internal tags and 26,918 with external tags) and 36,399 were released in juvenile areas (9,412 with internal tags and 26,987 with external tags).

b) In 1998, 28,994 mackerels were released from western spawning areas (21,999 bearing internal tags and 6,995 with external tags) and 12,208 were released in juvenile area 6 (all were external tags).

Age compositions inferred for each area of tagging and year appear in **Table 2**. In 1997

the juveniles tagged in all areas were mostly (0 group young) of the year and 1 year old mackerels. In 1998 the juveniles tagged north-west of Ireland were almost entirely 1 year old. Mackerel tagged in adults areas were mostly 4 or more year old.

Fishermen and Research Institutes of almost all Atlantic European coastal countries from Norway to Portugal were contacted and informed about the tagging program, through a mailing performed by the participants. This mailing included posters (in the native languages of each country of destination) describing the program with instructions as to what to do in case a tagged mackerel is caught.

4. RECAPTURES of tagged mackerel

Up to March 2001 a total of 1592 recaptures have been reported. 1149 mackerel were recovered from the 1997 tagging releases and 443 tags from the 1998 surveys. This is for both surveys a global recovery rate of about 1 % of the tagged mackerels. The origin of these tags is summarised in **Table 1** according to years and institutes. Cumulative recovery rates since the surveys (table 1) are clearly lower for juveniles than for adults, this becomes particularly evident in the years subsequent to the surveys when the amount of recoveries has for all the juvenile tagging experiments sharply diminished. This has led to very reduced number of recoveries from the recruitment process. Recovery rates of adults show rather different values among institutes and tag types: For IEO and IMR, internal tags worked better in terms of recoveries than external tags; whilst both tag types performed equally well in the case of AZTI tagging. Among institutes, IMR had the longest experience with internal tagging and showed the highest recovery rates of this type of tags.

Recoveries from every adult tagging areas show the same spatio-temporal distribution (**Table 3**). Maximum amount of recaptures occur at the first and fourth quarters of the year when the mackerel entry the northern fisheries in subareas VI, II and IV. Minimum recoveries occur at spring time when mackerel is at spawning grounds, subareas VI, VII and VIII, when the fishery is reduced compared to other time of the year and there is little chance of getting internal returns from those fisheries. Summary of recaptures by ICES divisions and quarters through the different years and tag types from the 1997 tagging surveys in the southern and western spawning grounds are presented in **Tables 4** and **5** respectively. For the former region areas 2, 3 and 4 are pooled and for the latter adult areas 5, 7 & 8 are put together. **Table 6** show the same synopsis of recoveries concerning the mackerel tagged on western spawning grounds in 1998.

Figures 2 a-d present maps of adult recaptures from the 1997 surveys by years 1997-2000 respectively, for those recaptures which had sufficient information to enable plotting them on a map (about 50% only). The pattern of spatial distribution is rather similar among years with some exceptions concerning in 1997 the edge of the northern distribution and in 1998 some winter recaptures compared to subsequent years. **Figure 3 a** and **b** show the maps of location of recaptures obtained from the tagging surveys in adult areas carried out in 1997 and 1998 respectively (pooling the returns from all years together). On the maps, the recaptures obtained per quarter of year are identified by mean of different symbols, and inside of them, the original tagging areas where they were released is shown. The spatial distribution of returns from the 1998 survey agrees sufficiently with the general distribution obtained from the 1997 surveys, except for the fact that only 1 spring return (out of 5) has got sufficient information as to plot it on to

the map and hence that quarter is not sufficiently visualised on the map.

Concerning Juveniles, **Table 7** and **8** show the synopsis of recoveries by years arising from the 1997 juvenile tagging surveys in the southern and western areas respectively (areas 1 and 6). **Table 9** summarise for the latter (western) area the results concerning the tagging survey in 1998. **Figures 4a** and **b** show the maps of recaptures of mackerel from the juvenile areas in 1997 and 1998 respectively. The vast majority of recaptures have been recorded close to the areas of tagging during the year of the survey and the next year. In that period, however, a few interesting recaptures from other areas were as well recorded: Some juvenile mackerel moved from Donegal area to Celtic Sea or Irish Sea and Bristol channel in summer time and some others to the north of the North Sea. Nevertheless, the results imply that young mackerel do not follow the general migration pattern of adults. In general, recaptures show that the juveniles remained in the nursery areas during the first year and a half after the tagging survey (this is while they were 1, 2 or three years old, according to the age distribution of mackerel in these tagging areas (Table 2). The exceptions mentioned above occurring just 1 year after the tagging correspond in general to relatively big individuals in the juvenile areas, probably of 2 or 3 years old when tagged, which were probably recruiting to the adult population when they were recaptured as 3 or 4 years old (see **Table 10**). The only three recaptures of juvenile releases obtained two or more years after the tagging surveys (Table 10) are also indicative of the recruitment process taking place by joining the migration routes of adults: From the tagging in 1997 in the southern area two recoveries have been reported by Denmark one in the first quarter of 1999 (before 8 of April 1999) and the other the 24/08/00, both somewhere in the western areas, presumably once they had already achieved the age of three. This demonstrates that juveniles from this southern area do also recruit to the general migration pattern of adult NEAM. From the 1998 tagging survey in area 6 there is one recovery the 3/03/00 in Division VIIe, once it was about 3-4 years old, i.e. far south of the tagging area and just close the major spawning grounds of the western area. All these observations confirm recruitment to the migration of NEAM adults from all juvenile areas once mackerel are three years old.

Quantitative analysis of migratory fluxes.

In **Table 11** is shown the analysis of internal recaptures obtained in Subareas II,III, IV (and VI¹) in the second half of the years 1998, 1999 and 2000. The analysis include all the many recoveries of internal tags in these selected periods, including those for which recapture locations are unknown or dubious, although presumably mostly from these Subareas. The proportions of recaptures among institutes do not significantly differ across years (G test for independency of $G=6.87$ with 4 d.f. and $P(G)=0.15$, analysis not included in the table), so results are consistent in time.

Using the Iversen and Skagen method (eq.3), the percentages of presence of southern and western mackerel in the north-eastern areas were calculated at 6.5% and 93.5% respectively over all these years (Table 11b). This is about half the expected result of assuming equal migratory fluxes of all mackerel into this area (about 13% and 87 % respectively). This disagreement explain that the relative migratory flux estimated for

¹ The few recoveries well located in area VI (2) were also included because probably among those of unknown or dubious location there will be some of that area as well.

the southern adults into the north-eastern areas (from eq.4) is on average about 46.3 % that of the western mackerel (instead of 1:1 or 100%).

Next, the G (likelihood ratio) test is used to check whether the amount of recoveries of different origins which were produced in the North-eastern area can be predicted by the proportion of releases in the tagging areas. If this was true, it would imply that the migratory fluxes from all areas into the North-eastern area is similar for all mackerel (and that the initial tagging mortality is as well similar). A general test of the three tagging teams (IEO, AZTI and IMR) leads to reject this null hypothesis (Table 11d). We have therefore continued with several G tests by pairs of Institutes. This lead to accept as compatible the recovery results for IEO and AZTI, but they both together have different recovery rates than expected when compared with those obtained by IMR for the tagging in the western area.

| | | | | | | |
|--------------------------|------------|------|-----|-----------------|--|---------|
| Visually the results is: | Institutes | | | Areas: Southern | | Western |
| Institutes | IEO | AZTI | IMR | IEO+AZTI | | IMR |
| Recaptures | ----- *** | | | *** | | |

Notice that the detection of lower recovery rates (and presence) than expected of southern mackerel in the Northeastern region during the second half of the years can be due to lower migratory fluxes than the western mackerel (as estimated above) but also symmetrically to lower initial tagging mortality induced in the western area compared to that induced in the southern tagging surveys (see discussion).

5- DISCUSSION

5.1 Migration pattern of adults.

General pattern of migration: The adult recaptures (**Table 3** and **Figures 2 & 3**) show that almost all adult mackerel (regardless of the discrete areas of tagging) follow a northward migration in late spring and summer time from the spawning grounds along the west of the British Islands to the north of Faeroes, Norwegian sea and northern part of the North Sea. In addition the recaptures recorded in the English Channel and the North Sea suggest that some migration may also go through North Sea. The northward migration during late spring and summer often extends into the north-eastern areas of the Faeroes EEZ and further north to the International waters. This has been well observed in summer 1997 after the surveys and in some recaptures of the 1998 surveys in the summer of the same year.

From September to December mackerel from all areas are mainly found in Norwegian Sea and northern part of North Sea (mainly division IVa). At the end of the year and during wintertime those mackerel migrate towards the spawning grounds through the west of the British islands in a southward progression. All of these observations on migration behaviour are consistent with the results obtained from previous tagging experiments and the analysis of location of fishery catches, including the suggestion of some summer migration through the North Sea to the Norwegian Coasts (Lockwood, 1988, Reid 2001,- SEFOS project). A summary of the migration pattern, deduced from this tagging experiment, is presented in **Figure 5**.

There are several recoveries which do not match the above migration pattern of adults and which require some discussion:

- The recoveries made in autumn and winter 1997 in the southern area of fishes

tagged in the southern adult areas may be understood in the context that not all fishes tagged in those adult areas were necessarily mature. At least two of the three recoveries made in the southern area in the third and fourth quarter of 1997 corresponded to juveniles of 22 and 27 cm. Therefore, according to the behaviour of juveniles, it is not surprising that these fish have remained close to the areas in which they were tagged.

- There were recaptures of adults in Sub-areas VI and especially in VII in the fourth quarter 1997 and January 1998 which may contradict partly the simple scheme resumed above. However there have always been some autumn migration through the Minch Channel towards an overwintering area in the Celtic Sea and around the Cornwall peninsula, which may correspond with those recaptures. That migration and the overwintering area off Cornwall used to be more important in the 1970's than it has been in the eighties and in the nineties (Lockwood 1988, Anon. 1990).

The migratory behaviour of southern mackerel can now be better understood in the light of these tagging experiments:

- Adult mackerels from all the southern spawning areas (Division VIIIc east and west) join the general migration pattern of adult mackerel to the north of Europe during the second half of the year with the rest of the Northeast Atlantic population. This finding complete and corroborates the conclusions of a previous tagging experiment performed in 1994 in the Southern area, but restricted to the eastern part of Subdivision VIIIc east (Uriarte and Lucio, 2001), assuring now its applicability to the whole adult mackerel spawning in the southern region.
- The migration of these adults in spring along the North of the Iberian Peninsula agrees with the description made by URIARTE and LUCIO (2001). Adult mackerel migrate from the western area and enter Division VIIIc east in March through the eastern part and then they move westerwards during April along the Cantabrian Sea till Galicia region (VIIIc west). These authors (Op. Cit.) also pointed out the possibility that the pathway north from the north-western coast of Spain (VIIIc west) during May could be either directly done by crossing the ocean towards to north of the Bay of Biscay or by following the way back along the continental shelf edge of the Cantabrian Sea. In the spring of 1997 several recaptures of fish which had been tagged at the northwest and central part of the Cantabrian Sea were recorded to the east of those areas. These observations demonstrate that the northward migration is at least partly being made (if not entirely) following the way back along the continental shelf edge of the Cantabrian Sea before entering the western areas again.
- There has been a strong presence of southern adult mackerel during spring in the western spawning grounds in months when they are supposed to be at southern spawning grounds (Figure 2).: For instance, taking only into account the recoveries of external tags, in Spring 1998 15 recoveries out of 20 of southern adult mackerel were made in the western spawning areas; In Spring 1999 this was the case of 5 out of 6, and in 2000 of 1 out of 2 (table 4). These recoveries mostly happened in April but some recoveries were also made in June and May. April is probably the peak period of presence of mackerel in the southern area according to the catches taken in the Spanish fishery (Villamor et al. 1997). Therefore in April almost all of the recoveries should have taken place in the southern area not so much in the western spawning grounds. All this suggests a strong presence of southern mackerel during spring in the western spawning

grounds. This result is consistent with the observations of Uriarte and Lucio (2001) and indicates the possibility of mixing of spawners from both areas. This would not be the case if all those recoveries in the western areas belonged to maturing mackerel which were moving south or to spent mackerel which were moving north from the southern spawning grounds. To elucidate this issue, in **Table 12** all the recaptures from the southern areas made in the western areas from March to June during these years and for which information on maturity was available have been included. These information was mostly available for the 1998 and a few 97 and 99 recoveries. Most of those recoveries were referred as Stage 3 (pre-spawning, Late ripening/partly spent fishes) and these are mature fishes already entering the cycle Stages 3-4-5 (pre, spawning and partly spent) (according to M. Walsh's maturity key for mackerel- 1989). Two fish are labelled as Stage 5 (partly spent). One (the first one) is labelled as Stage 6 (spent). Therefore this information suggest that spawning mixing is likely to happen.

A quantitative look at the results concerning the presence of southern mackerel at the western spring spawning grounds can be made as follows: Under the assumption of a single well mixed (panmitic) population in the western and southern regions, the proportion of recaptures per area would be equal to the proportion of catches by areas assuming equal efficiencies in reporting recaptures in all areas. Catches of mackerel in the southern area in the second quarter of 1998 and 1999 have supposed 23% and 33% respectively of total catches (ICES 2000, 2001). Then the expected proportion of recoveries of the southern adults in the western and southern fisheries in the second quarter can be expected to be respectively 77% and 23 % in 1998 and 67% and 33 % in 1999. A G test of goodness of fit of recaptures per areas to this "a priori" expectations for a panmitic population applied to the 1998 and 1999 recoveries of southern mackerel during the second quarter turn out to be $G=0.655$ with 2 d.f and $P(G)=0.66$. Therefore these observations based exclusively in mackerel tagged at the southern area do not contradict the idea of a well mixed single stock (without components). Under the hypothesis of a single Northeast Atlantic stock with no components, the estimate of biomass made by the triannual egg surveys of the so called southern mackerel would approximately correspond to the percentage of adult mackerel occupying on average the southern area during spawning time.

A recovery of a mackerel, which had been tagged in the western areas by IMR in spring 1996 (a year before the commencement of the current project) was recorded in the spring of 1998 in the southern area off the coast of the Basque Country. This observation could be interpreted as an indication of some mixing of southern and western mackerel as well. It could also indicate that a southern mackerel may have been tagged in the western area. In any case, this gives additional support to the previously deduced idea of strong mixing of western and southern adults in the second quarter. As the mixing of adults has already been shown to occur during quarters 1, 3 and 4 when fish are distributed in the northerly areas, it seems likely that mixing takes place throughout the entire year.

In relation to the present understanding of mackerel components it can be stated that the mixing of mackerel from the southern and western areas throughout most of the year and their cohabitation in the western spawning grounds in spring (with the likely possibility of mixing) do not agree with the assumption of two separate spawning

components in these areas. If two spawning components exist in these two areas then the observations made by the tagging experiments would require that southern mackerel caught in spring in the western area were just migrating northward or southward without spawning. Alternatively these tagged fishes could have been western mackerel moving across the southern area without spawning at the time of the tagging surveys in the southern area. Although those explanations are possible they do not seem likely according to the observations on the maturity of the tagged and recaptured fishes. Therefore, by parsimony the observations from these experiments alone seem to better support the hypothesis of the existence of a single population without separate components in the southern and western areas than the hypothesis of the existence of two separate spawning components.

The results, although casting doubts on the reliability of the latter assumption, can not be taken as conclusive. In fact, they do not match the conclusions of Nesbo et al. (2000) who indicated the existence of a separate spawning component in the southern area, according to mtDNA genetic structuring; their work suggest a homing migration every year to the geographic spawning areas, contrasting with the visual realisation obtained from this tagging study. This does not fit either the conclusions about homing behaviour from previous research on otolith measurements in space (Dawson, 1983, 1986). These issues seem therefore to require further research in order to reconcile these different views. All the above discussion has tried to analyse the results from a wide a critical perspective about the current definitions of components, but it must be admitted that this work alone can not be conclusive on this issue by itself. These remarks do not concern to the perception of the North Sea Stock as a separate spawning component.

5.2 Migration of adults into subareas II, III and IVa,b (Quantitative analysis).

The comparison of the recoveries rates in the North-eastern areas from the western (IMR) and southern (IEO+AZTI) tagging surveys showed differences highly significant between these two groups of releases. Much of this differences already appeared among institutes concerning the recoveries from all areas and seasons.

If this different recoveries in the north-eastern areas are due to different migration fluxes or to different initial tagging mortalities is uncertain. In the former case the results would imply that southern mackerel would have a migratory flux rate to the North-eastern areas of about 46 % that of western mackerel. In the second case, AZTI+IEO Institutes would have produced an initial tagging mortality at least 60 % higher than the one produced by IMR (that is the amount required to make the differences not statistically significant at $\alpha=0.05$).

Certainly the general implications of the quantitative analysis are uncertain when the underlying assumptions of the analysis are closely examined. These are:

1. The tagging mortality caused by IMR, AZTI and IEO in their tagging experiments on mackerel are all similar.
2. The fish tagged in the western area are 100% western and fish tagged in the southern area are 100% southern.
3. In addition the Iversen and Skagen method (1989) assumes that the two components do exist and their relative sizes are the ones given in ICES (1999).

The first assumption of equal initial mortality after tagging for the different Institutes

may not be true. Despite that handling of fishes was conceived to be made as homogenous as possible, the conditions were not exactly the same and the tagging teams had different lengths of experience with handling fish for tagging. Due to this the tagging mortalities might as well be different. In fact, although AZTI and IEO did not show significant different rates of recaptures in the North-eastern areas, the probability of them being due to chance were not too high ($P=0.25$), letting space for arguing about the assumption of equal tagging mortalities between teams.

In addition the second assumption is false because southern fish pass through the western area during the tagging period and therefore southern fish might have been tagged in the western area as well. Therefore the results of this analysis are not very robust and the question whether the mackerel spawning in the southern and western areas migrate with the same intensity to the North-eastern areas can not be ascertained with enough precision. Nevertheless, it is clear from this quantitative analysis that southern mackerel has in any case an important migration into ICES sub-areas II, III and IV, of at least a minimum intensity of 46 % of that shown by the mackerel spawning in the western area. The possibility of equal intensity of migration fluxes can not be discarded and seem to better fit the qualitative and visual pattern of migration obtained from the rest of the information. In summary the recaptures corroborates that significant parts of mackerel spawning in the southern and western areas migrate to the North Sea and Norwegian Sea (ICES sub-areas II to IV) for the second half of the year.

5.3 Migration pattern of juveniles.

The distribution of recaptures of tagged juveniles for the first year and a half after the surveys imply that young mackerel (mainly of ages 0,1 and 2) do not follow the general migration pattern of adults. Instead it seems that juveniles stay rather close to the nursery areas, with a very few exceptions. Nevertheless it must be admitted that this perception may be partly biased because of the dependence of the recoveries on the fisheries and on their areas of distribution. Therefore this result may not completely reflect the actual movements of juvenile mackerel, as tagged fishes may also migrate to areas in which there are no direct fisheries for mackerel but which may also contain important nursery areas (e.g to North Sea or the Cornwall Box). In support of this there are observations of some juvenile mackerels moving from the tagging area. For instance, in summer 1997 two mackerels tagged off northwest Ireland were recaptured in the Celtic Sea and in the Irish Sea, both in areas close to the coast.

However, in any case the general rather non-migratory behaviour of juvenile should prevail. This feature has for instance also been observed in the adult southern areas: Several juvenile mackerel, which had been tagged together with adults, have been recaptured several months later in the same southern area and long after the bulk of the adults had left the area.

The recaptures which most apparently were in disagreement with the above general pattern of juveniles have been shown to correspond with recruiting individuals of about 3 years old when they were recaptured (Table 10). This was the case, among others, of the recapture in autumn 1998 close inshore off the west coast of Norway which had been released in the northwest of Ireland. The two last recoveries of mackerel released in juvenile southern tagging areas, which were reported by Denmark from the western fishery grounds, corresponded with recruiting 3 year old mackerel.

These observations confirm that recruitment to the adult migration pattern is achieved in general at the age of three. This is the age when most of juveniles definitively mature (ICES 2001). In addition, the recaptures concerning the southern juvenile releases definitively demonstrate that juveniles from this southern area do also recruit to the general migration pattern of adult NEAM, which had not been shown previously.

The strong reduction of the number of recoveries from juvenile tagging obtained in recent years, in comparison with the first year and a half after the survey, suggest that there might be higher tagging mortality rates for juveniles than for adults (see table 1). Despite it, it is evident that for the current year 2001 the recruitment of all these tagged juveniles will have to occur and hence relevant recoveries confirming the above findings are expected. It is therefore very important that the recapture programmes should be continued.

(see conclusions in the next page)

6. CONCLUSIONS.

The conclusions that may be derived from the recaptures of adult and juvenile mackerel obtained in this study are:

- a) Almost all adult mackerel (regardless of the discrete areas of tagging) follow a northward migration in late spring and summer time from the spawning grounds along the west of the British Islands to the north of Faeroes, Norwegian sea and northern part of the North Sea.
 - a.1) Adult mackerel spawning in the western area migrated at the end of summer and early autumn into the Norwegian Sea and northern part of the North Sea. This finding is consistent with the observations made for years by the IMR of an entry of western mackerel into these areas in late summer (Iversen and Skagen, 1989).
 - a.2) Adult mackerel from all the southern spawning areas (Division VIIIc) join the general migration of mackerel to the north of Europe during the second half of the year with the rest of the Northeast Atlantic population. This finding complete and corroborates the conclusions of a previous tagging experiment performed in 1994 in the Southern area, at the east of Subdivision VIIIc east (Uriarte and Lucio, 2001).
- b) Most adult mackerel to the south and west of Europe seem to follow the same route towards the north along the shelf edge. Mackerel may also enter to the North Sea through the Channel. However, based on the present results it is impossible to conclude whether this is an important route or not.
- c) The seemingly similar migration pattern of the southern and western mackerels towards the north as shown by maps, can not be refuted or supported from the quantitative analysis made in this report. This is due to uncertainties in the assumptions implied in the analysis about equal initial tagging mortality rates generated by the different tagging teams. Nevertheless the quantitative analysis show that southern mackerel has in any case a significant migration into ICES sub-areas II, III and IV.
- d) The migration towards the spawning grounds seems to take place mainly during wintertime along the west of Scotland and Ireland in a southward progression.
- e) Recaptures of tagged adults in Sub-areas VII in the fourth quarter and in January probably indicate that some fish remain in this area in autumn and overwinter in the Celtic Sea and around the Cornwall peninsula. This has already been described in literature (Anon. 1990).
- f) A strong presence of southern adult mackerel during spring in the western spawning grounds has been evidenced. This observation is consistent with that of Uriarte and Lucio (2001). As mixing of southern and western mackerel is already demonstrated for the other quarters of the year, it seems likely that mixing takes place throughout the entire year.
- g) In relation to the present understanding of mackerel components it can be stated that the mixing of mackerels from the southern and western areas throughout most of the year and their cohabitation in the western spawning grounds (with the likely possibility of mixing) cast doubts on the reliability of the assumption of separate spawning components in these two areas. However, these observations do not match the conclusions of a parallel genetic research (Nesbo et al. 2000), nor of previous studies on otolith measurements (Dawson, 1983, 1986), that supported the existence of homing behaviour and separate spawning components. This conclusion do not

- affect the perception of the North Sea Stock as a separate spawning component.
- h) The recaptures of tagged juveniles (both from the west of the Iberian Peninsula and from the northwest of Ireland) show that juveniles in general remain close to the coastal areas where they were tagged while they are 0, 1 and 2 years old (with minor exceptions).
 - i) Recruitment of tagged juveniles to the migratory adult population of NEAM has been shown to happen mostly at the age of 3, once they become mature, based on the few but significant recoveries achieved so far. This recruitment is shown to occur for the two studied juvenile areas, what supposes the first demonstration of recruitment to NEAM of juveniles from Division IXa (from the southern area). New recoveries expected for these years should endorse this conclusion.

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Figure 5: General pattern of spatial distribution and migration of adult mackerels in the north east Atlantic, resulting from tagging surveys carried out in 1997 and 1998.

Table 1: Released of tagged mackerel and annual recoveries by Institutes and type of tags for the 1997 (a) and 1998 (b) surveys.

1997

| Adult/Juveniles | Juveniles | | Juveniles | | Juveniles | | Adults | | Adults | | Adults | | TOTALS | | |
|-----------------|-----------|----------|-------------|----------|--------------|----------|---------------|----------|---------------|----------|----------------------|----------|----------|----------|--|
| Region(area) | South (1) | | South (1) | | Northwest(6) | | South (2 & 3) | | South (3 & 4) | | Northwest (5, 7 & 8) | | TOTALS | | |
| Institute | IPIMAR | | IEO (Spain) | | MI (Ireland) | | IEO (Spain) | | AZTI (Spain) | | IMR (Norway) | | TOTALS | | |
| Released | 0 | 607 | 7,513 | 10,069 | 1,899 | 16,311 | 9,600 | 9,166 | 11,998 | 14,752 | 34,998 | 3,000 | 66,008 | 119,913 | |
| Recoveries | Internal | External | Internal | External | Internal | External | Internal | External | Internal | External | Internal | External | Internal | External | |
| 1997 | 0 | 0 | 0 | 81 | 0 | 21 | 3 | 13 | 12 | 48 | 39 | 2 | 54 | 165 | |
| 1998 | 0 | 0 | 0 | 9 | 9 | 6 | 21 | 16 | 45 | 49 | 234 | 6 | 309 | 86 | |
| 1999 | 0 | 0 | 1 | 0 | 0 | 0 | 28 | 3 | 36 | 31 | 192 | 4 | 257 | 38 | |
| 2000 | 0 | 0 | 1 | 0 | 0 | 0 | 15 | 1 | 13 | 9 | 153 | 2 | 182 | 12 | |
| 2001 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 1 | 9 | 1 | 29 | 2 | 42 | 4 | |
| Total | 0 | 0 | 2 | 90 | 9 | 27 | 71 | 34 | 115 | 138 | 647 | 16 | 844 | 305 | |

Average recovery rates

1997 to 1st half 2001 0.0% 0.0% 0.9% 0.5% 0.2% 0.7% 0.4% 1.0% 0.9% 1.8% 0.5% 1.3% 0.6%

1998

| Adult/Juveniles | Juveniles | | Juveniles | | Juveniles | | Adults | | Adults | | Adults | | TOTALS | | |
|-----------------|-----------|----------|-------------|----------|--------------|----------|---------------|----------|---------------|----------|----------------------|----------|----------|----------|--|
| Region(area) | South (1) | | South (1) | | Northwest(6) | | South (2 & 3) | | South (3 & 4) | | Northwest (5, 7 & 8) | | TOTALS | | |
| Institute | IPIMAR | | IEO (Spain) | | MI (Ireland) | | IEO (Spain) | | AZTI (Spain) | | IMR (Norway) | | TOTALS | | |
| Released | 0 | 0 | 0 | 0 | 0 | 12,208 | 0 | 0 | 0 | 0 | 21,999 | 6,995 | 21,999 | 19,203 | |
| Recoveries | Internal | External | Internal | External | Internal | External | Internal | External | Internal | External | Internal | External | Internal | External | |
| 1998 | 0 | 0 | 0 | 0 | 0 | 79 | 0 | 0 | 0 | 0 | 20 | 3 | 20 | 82 | |
| 1999 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 173 | 9 | 173 | 16 | |
| 2000 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 114 | 8 | 114 | 9 | |
| 2001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 28 | 1 | 28 | 1 | |
| Total | 0 | 0 | 0 | 0 | 0 | 87 | 0 | 0 | 0 | 0 | 335 | 21 | 335 | 108 | |

Average recovery rates

1997 to 1st half 2001 0.7% 1.5% 0.3% 1.5% 0.6%

| | 1997 Adults | | 1997 Juveniles | |
|------------|-------------|----------|----------------|----------|
| | Internal | External | Internas | External |
| TOTALS | 83,514 | | 36,399 | |
| Releases | 26,918 | | 26,987 | |
| Recoveries | 56,596 | 26,918 | 9,412 | 26,987 |
| 1997 | 54 | 63 | 0 | 102 |
| 1998 | 300 | 71 | 9 | 15 |
| 1999 | 256 | 38 | 1 | 0 |
| 2000 | 181 | 12 | 1 | 0 |
| 2001 | 42 | 4 | 0 | 0 |
| Total | 833 | 188 | 11 | 117 |

Recovery rates 1.5% 0.7% 0.1% 0.4%

| | 1998 Adults | | 1998 Juveniles | |
|------------|-------------|----------|----------------|----------|
| | Internal | External | Internas | External |
| TOTALS | 28,994 | | 12,208 | |
| Releases | 6,995 | | 12,208 | |
| Recoveries | 21,999 | 6,995 | 0 | 12,208 |
| 1997 | 20 | 3 | 0 | 79 |
| 1998 | 173 | 9 | 0 | 7 |
| 1999 | 114 | 8 | 0 | 1 |
| 2000 | 28 | 1 | 0 | 0 |
| 2001 | 335 | 21 | 0 | 87 |

Recovery rates 1.5% 0.3% 0.7%

Table 2: Age composition of tagged mackerel by areas of tagging for the surveys in 1997 (a) and 1998 (b).

A) 1997

| Area Code Institute Sub-division Date | Area 1 | | | Area 2 | Area 3 | | | Area 4 | Area 5 | Area 6 | Area 7 | Area 8 |
|--|--|----------------------------|-------------------------------|-------------------------------|---------------------------------|--------------------------------|------------------------------------|----------------------------|-------------------------------|-----------------------|-----------------------|--------|
| | IPIMAR IXa central nor 21-23 Feb | IEO IX north 9-12May | IEO IXa north 9-29Sept. | IEO VIIIc west 13-18May | IEO VIIIc east 29Abr-2May | AZTI VIIIc east 22-26Apr | AZTI VIIIc east 24 Mar-18Apr | IMR VIIIb 16May-1Jun | MI VIa South 7Jul-15Aug | IMR VIa 2-7 Jun | IMR IVa 8-9 Jun | |
| Age | | | | | | | | | | | | |
| 0 | | 0.0 | 52.5 | 0.0 | 0.0 | 0.0 | 0.00 | 0.0 | 20.6 | 0.0 | 0.0 | |
| 1 | 45.2 | 49.2 | 28.3 | 4.1 | 0.6 | 0.0 | 0.02 | 7.3 | 52.9 | 3.6 | 8.0 | |
| 2 | 47.3 | 35.5 | 15.7 | 9.6 | 2.4 | 1.4 | 0.37 | 13.8 | 16.9 | 12.3 | 33.5 | |
| 3 | 7.5 | 6.4 | 2.0 | 4.7 | 3.3 | 2.1 | 4.49 | 26.0 | 7.4 | 25.3 | 27.6 | |
| 4 | | 5.7 | 1.5 | 24.9 | 27.1 | 25.8 | 20.07 | 20.3 | 0.7 | 19.9 | 8.0 | |
| 5 | | 1.6 | 0.0 | 16.9 | 19.1 | 22.7 | 15.59 | 11.1 | 1.5 | 11.5 | 10.3 | |
| 6 | | 0.4 | 0.0 | 6.4 | 7.3 | 6.0 | 9.53 | 4.4 | | 5.0 | 3.4 | |
| 7 | | 0.3 | 0.0 | 7.1 | 8.3 | 8.4 | 10.90 | 5.7 | | 6.9 | 3.4 | |
| 8 | | 0.3 | 0.0 | 10.4 | 12.2 | 13.5 | 11.25 | 3.8 | | 5.9 | 3.4 | |
| 9 | | 0.2 | 0.0 | 7.7 | 9.3 | 9.8 | 10.42 | 2.6 | | 2.7 | 0.0 | |
| 10 | | 0.2 | 0.0 | 4.8 | 6.0 | 5.0 | 5.72 | 0.7 | | 1.0 | 0.0 | |
| 11 | | 0.0 | 0.0 | 1.9 | 2.3 | 2.7 | 4.27 | 2.0 | | 2.6 | 2.3 | |
| 12 | | 0.0 | 0.0 | 0.6 | 0.6 | 0.4 | 3.73 | 0.9 | | 1.0 | 0.0 | |
| 13 | | 0.0 | 0.0 | 0.2 | 0.3 | 0.4 | 1.41 | 0.1 | | 0.2 | 0.0 | |
| 14 | | 0.0 | 0.0 | 0.1 | 0.3 | 0.2 | 0.58 | 1.5 | | 2.0 | 0.0 | |
| 15+ | | 0.0 | 0.0 | 0.6 | 1.0 | 1.8 | 1.65 | | | | | |
| Mean age | 1.6 | 1.8 | 0.7 | 5.4 | 6.0 | 6.1 | 6.7 | 4.3 | 1.2 | 4.7 | 3.4 | |

B) 1998

| Area Code Institute Sub-division Date | Area 5 | Area 5 | Area 6 | Area 7 |
|--|-------------------------|---------------------------|---------------------------------|-------------------------|
| | IMR VIIj 8-15 May | IMR VIIIb 18-20 May | MI VIa South 27Jul-23 Sep | IMR VIa 22-24 May |
| Age | Percentage (%) | | | |
| 0 | 0.0 | 0.0 | 0.45 | 0.0 |
| 1 | 0.0 | 0.0 | 98.19 | 0.0 |
| 2 | 0.5 | 3.4 | 0.90 | 0.5 |
| 3 | 4.1 | 11.4 | 0.45 | 5.7 |
| 4 | 16.8 | 21.6 | 0.00 | 24.2 |
| 5 | 25.8 | 15.9 | 0.00 | 22.2 |
| 6 | 19.0 | 17.0 | 0.00 | 16.0 |
| 7 | 16.3 | 10.2 | 0.00 | 9.8 |
| 8 | 6.5 | 3.4 | 0.00 | 5.2 |
| 9 | 4.1 | 3.4 | 0.00 | 4.1 |
| 10 | 1.9 | 6.8 | 0.00 | 5.2 |
| 11 | 1.6 | 1.1 | 0.00 | 1.5 |
| 12 | 2.7 | 4.5 | 0.00 | 3.6 |
| 13 | 0.5 | 0.0 | 0.00 | 0.0 |
| 14 | 0.0 | 1.1 | 0.00 | 0.5 |
| 15 | 0.0 | 0.0 | 0.00 | 1.5 |
| Mean age | 6.0 | 5.9 | 1.0 | 6.1 |

Table 3: Summary of recaptures of adult mackerel tagged in the 1997 surveys (up to march 2001) by Tagging areas (pooling all years and tag types). Details are given on the number of tag returned by Divisions and Seasons (Quarters).

Adults Area 2 (SubDivision VIIIc-west) Totals 1997-March 2001

| Quarter/Division | IIIa,b,IVa,b | Ila,Vb | VI | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
|-----------------------|--------------|----------|-----------|-----------|-----------|----------|----------|-----------|-----------|
| <i>first quarter</i> | 9 | 0 | 13 | 4 | 0 | 2 | 0 | 3 | 31 |
| <i>second quarter</i> | 0 | 0 | 0 | 6 | 2 | 2 | 1 | 4 | 15 |
| <i>third quarter</i> | 6 | 0 | 0 | 1 | 0 | 0 | 1 | 3 | 11 |
| <i>fourth quarter</i> | 15 | 1 | 1 | 1 | 0 | 0 | 1 | 2 | 21 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Total | 30 | 1 | 14 | 12 | 2 | 4 | 3 | 13 | 79 |

Adults Area 3 (western part of SubDivision VIIIc-east) Totals 1997-March 2001

| Quarter/Division | IIIa,b,IVa,b | Ila,Vb | VI | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
|-----------------------|--------------|----------|-----------|-----------|-----------|----------|----------|-----------|-----------|
| <i>first quarter</i> | 10 | 1 | 10 | 7 | 0 | 1 | 0 | 12 | 41 |
| <i>second quarter</i> | 0 | 0 | 0 | 4 | 2 | 6 | 0 | 4 | 16 |
| <i>third quarter</i> | 5 | 0 | 0 | 5 | 1 | 0 | 1 | 1 | 13 |
| <i>fourth quarter</i> | 10 | 0 | 6 | 0 | 0 | 0 | 0 | 7 | 23 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 4 |
| Total | 25 | 1 | 16 | 16 | 3 | 7 | 1 | 28 | 97 |

Adults Area 4 (eastern part of SubDivision VIIIc-east) Totals 1997-March 2001

| Quarter/Division | IIIa,b,IVa,b | Ila,Vb | VI | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
|-----------------------|--------------|----------|-----------|-----------|-----------|-----------|----------|-----------|------------|
| <i>first quarter</i> | 25 | 0 | 30 | 14 | 0 | 0 | 0 | 10 | 79 |
| <i>second quarter</i> | 1 | 0 | 6 | 8 | 0 | 18 | 0 | 0 | 33 |
| <i>third quarter</i> | 5 | 6 | 1 | 1 | 0 | 0 | 0 | 5 | 18 |
| <i>fourth quarter</i> | 34 | 0 | 5 | 1 | 0 | 0 | 0 | 3 | 43 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 9 |
| Total | 65 | 6 | 42 | 24 | 0 | 18 | 0 | 27 | 182 |

Adults Area 5 (West of Ireland, Division VIIj, VIIIh). Totals 1997-March 2001

| Quarter/Division | IIIa,b,IVa,b | Ila,Vb | VI | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
|-----------------------|--------------|----------|-----------|----------|-----------|----------|----------|------------|------------|
| <i>first quarter</i> | 27 | 1 | 82 | 1 | 0 | 0 | 0 | 91 | 202 |
| <i>second quarter</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 43 | 43 |
| <i>third quarter</i> | 29 | 3 | 1 | 0 | 0 | 0 | 0 | 46 | 79 |
| <i>fourth quarter</i> | 61 | 3 | 2 | 0 | 0 | 0 | 0 | 48 | 114 |
| Unknown | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 21 |
| Total | 118 | 7 | 85 | 1 | 0 | 0 | 0 | 248 | 459 |

Adults Area 7 (West of Hebrides Islands, Division VIa). Totals 1997-March 2001

| Quarter/Division | IIIa,b,IVa,b | Ila,Vb | VI | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
|-----------------------|--------------|----------|-----------|-----------|-----------|----------|----------|-----------|------------|
| <i>first quarter</i> | 16 | 0 | 20 | 16 | 0 | 0 | 0 | 35 | 87 |
| <i>second quarter</i> | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 11 | 12 |
| <i>third quarter</i> | 8 | 2 | 0 | 0 | 0 | 0 | 0 | 13 | 23 |
| <i>fourth quarter</i> | 18 | 0 | 1 | 0 | 0 | 0 | 0 | 22 | 41 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 10 |
| Total | 42 | 2 | 22 | 16 | 0 | 0 | 0 | 91 | 173 |

Adults Area 8 (West of Shetlands Islands, Division IVa). Totals 1997-March 2001

| Quarter/Division | IIIa,b,IVa,b | Ila,Vb | VI | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
|-----------------------|--------------|----------|----------|----------|-----------|----------|----------|-----------|-----------|
| <i>first quarter</i> | 2 | 0 | 6 | 0 | 0 | 0 | 0 | 8 | 16 |
| <i>second quarter</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| <i>third quarter</i> | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 5 |
| <i>fourth quarter</i> | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 6 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| Total | 7 | 0 | 6 | 0 | 0 | 0 | 0 | 18 | 31 |

ALL ADULT AREAS (Areas 2,3,4,5,7 & 8) Totals 1997-March 2001

| Quarter/Division | IIIa,b,IVa,b | Ila,Vb | VI | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
|-----------------------|--------------|-----------|------------|-----------|-----------|-----------|----------|------------|-------------|
| <i>first quarter</i> | 89 | 2 | 161 | 42 | 0 | 3 | 0 | 159 | 456 |
| <i>second quarter</i> | 1 | 0 | 7 | 18 | 4 | 26 | 1 | 64 | 121 |
| <i>third quarter</i> | 55 | 11 | 2 | 7 | 1 | 0 | 2 | 71 | 149 |
| <i>fourth quarter</i> | 141 | 4 | 15 | 2 | 0 | 0 | 1 | 85 | 248 |
| Unknown | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 46 | 47 |
| Total | 287 | 17 | 185 | 69 | 5 | 29 | 4 | 425 | 1021 |

Table 4: Summary of recaptures by year and tag type of mackerel tagged in the southern spawning grounds in 1997 (adult areas 2, 3 & 4 together). Details are given year by year (up to the 2000) on the number of tags returned by Divisions and Seasons (Quarters).

Number of internal and external tags of adult mackerels reported by year from 1997 to March 2001. Southern adult are

| Number of Tags | Year of recapture | | | | | | |
|----------------|-------------------|------|------|------|------|---------|-------|
| | 1997 | 1998 | 1999 | 2000 | 2001 | unknown | Total |
| Internal Tags | 15 | 66 | 64 | 28 | 13 | 0 | 186 |
| External Tags | 61 | 65 | 34 | 10 | 2 | 0 | 172 |
| TOTAL | 76 | 131 | 98 | 38 | 15 | 0 | 358 |

Number of recaptures per season and ICES Sub_area or Division Obtained from 1997 to 2000

| External tags 1997 | | | | | | | | | | |
|--------------------|--------------|--------|-----|---------|-----------|-------|-----|---------|-------|--|
| Quarter/Division | IIIa,b,IVa,b | Ila,Vb | VIa | VII,IVc | VIIIa,b,d | VIIIc | IXa | Unknown | Total | |
| first quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| second quarter | 0 | 0 | 0 | 2 | 4 | 20 | 0 | 0 | 26 | |
| third quarter | 2 | 6 | 1 | 3 | 0 | 0 | 2 | 2 | 16 | |
| fourth quarter | 5 | 0 | 5 | 2 | 0 | 0 | 1 | 2 | 15 | |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 4 | |
| Total | 7 | 6 | 6 | 7 | 4 | 20 | 3 | 8 | 61 | |

| Internal tags 1997 | | | | | | | | | | |
|--------------------|--------------|--------|-----|---------|-----------|-------|-----|---------|-------|--|
| Quarter/Division | IIIa,b,IVa,b | Ila,Vb | VIa | VII,IVc | VIIIa,b,d | VIIIc | IXa | Unknown | Total | |
| first quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| second quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| third quarter | 5 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 6 | |
| fourth quarter | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 8 | |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | |
| Total | 10 | 1 | 0 | 0 | 1 | 0 | 0 | 3 | 15 | |

| External tags 1998 | | | | | | | | | | |
|--------------------|--------------|--------|-----|---------|-----------|-------|-----|---------|-------|--|
| Quarter/Division | IIIa,b,IVa,b | Ila,Vb | VIa | VII,IVc | VIIIa,b,d | VIIIc | IXa | Unknown | Total | |
| first quarter | 7 | 0 | 13 | 10 | 0 | 0 | 0 | 1 | 31 | |
| second quarter | 0 | 0 | 5 | 10 | 0 | 4 | 1 | 0 | 20 | |
| third quarter | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 3 | |
| fourth quarter | 7 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 11 | |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Total | 14 | 0 | 22 | 23 | 0 | 4 | 1 | 1 | 65 | |

| Internal tags 1998 | | | | | | | | | | |
|--------------------|--------------|--------|-----|-----|-----------|-------|-----|---------|-------|--|
| Quarter/Division | IIIa,b,IVa,b | Ila,Vb | VIa | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total | |
| first quarter | 9 | 0 | 14 | 0 | 0 | 0 | 0 | 14 | 37 | |
| second quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | |
| third quarter | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 5 | |
| fourth quarter | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 19 | |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 4 | |
| Total | 26 | 0 | 14 | 0 | 0 | 0 | 0 | 26 | 66 | |

Table 4 (Cont.): Recaptures from Southern Areas

| External tags 1999 | | | | | | | | | |
|--------------------|--------------|--------|-----|-----|-----------|-------|-----|---------|-------|
| Quarter/Division | IIIa,b,IVa,b | IIa,Vb | VIa | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 4 | 0 | 5 | 8 | 0 | 2 | 0 | 2 | 21 |
| second quarter | 0 | 0 | 1 | 3 | 0 | 1 | 0 | 1 | 6 |
| third quarter | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 2 |
| fourth quarter | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 5 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 6 | 0 | 7 | 12 | 0 | 3 | 0 | 6 | 34 |

| Internal tags 1999 | | | | | | | | | |
|--------------------|--------------|--------|-----|-----|-----------|-------|-----|---------|-------|
| Quarter/Division | IIIa,b,IVa,b | IIa,Vb | VIa | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 8 | 1 | 12 | 5 | 0 | 1 | 0 | 3 | 30 |
| second quarter | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 5 | 7 |
| third quarter | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| fourth quarter | 13 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 17 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 5 |
| Total | 26 | 1 | 14 | 7 | 0 | 1 | 0 | 15 | 64 |

| External tags 2000 | | | | | | | | | |
|--------------------|--------------|--------|-----|-----|-----------|-------|-----|---------|-------|
| Quarter/Division | IIIa,b,IVa,b | IIa,Vb | VIa | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 2 | 8 |
| second quarter | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 2 |
| third quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| fourth quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 0 | 0 | 6 | 1 | 0 | 1 | 0 | 2 | 10 |

| Internal tags 2000 | | | | | | | | | |
|--------------------|--------------|--------|-----|-----|-----------|-------|-----|---------|-------|
| Quarter/Division | IIIa,b,IVa,b | IIa,Vb | VIa | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 7 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 10 |
| second quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| third quarter | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 5 |
| fourth quarter | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 21 | 0 | 2 | 0 | 0 | 0 | 0 | 5 | 28 |

Table 5: Summary of recaptures by year and tag type of mackerel tagged in the western spawning grounds in 1997 (adult areas 5, 7 & 8 together). Details are given year by year (up to the 2000) on the number of tags returned by Divisions and Seasons (Quarters).

Number of internal and external tags of adult mackerels reported by year from 1997 to March 2001. Northern adult are

| Number of Tags | Year of recapture | | | | | | Total |
|----------------|-------------------|------------|------------|------------|-----------|----------|------------|
| | 1997 | 1998 | 1999 | 2000 | 2001 | unknown | |
| Internal Tags | 39 | 234 | 192 | 153 | 29 | 0 | 647 |
| External Tags | 2 | 6 | 4 | 2 | 2 | 0 | 16 |
| TOTAL | 41 | 240 | 196 | 155 | 31 | 0 | 663 |

Number of recaptures per season and ICES Sub_area or Division Obtained from 1997 to First half of 2001

| External tags 1997 | | | | | | | | | |
|--------------------|--------------|----------|----------|----------|-----------|----------|----------|----------|----------|
| Quarter/Division | IIIa,b,IVa,b | IIa,Vb | VIa | VII,IVc | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| second quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| third quarter | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| fourth quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 2 |

| Internal tags 1997 | | | | | | | | | |
|--------------------|--------------|----------|----------|----------|-----------|----------|----------|----------|-----------|
| Quarter/Division | IIIa,b,IVa,b | IIa,Vb | VIa | VII,IVc | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| second quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| third quarter | 9 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 12 |
| fourth quarter | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 21 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 6 |
| Total | 30 | 3 | 0 | 0 | 0 | 0 | 0 | 6 | 39 |

| External tags 1998 | | | | | | | | | |
|--------------------|--------------|----------|----------|----------|-----------|----------|----------|----------|----------|
| Quarter/Division | IIIa,b,IVa,b | IIa,Vb | VIa | VII,IVc | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 4 |
| second quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| third quarter | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| fourth quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 4 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 6 |

| Internal tags 1998 | | | | | | | | | |
|--------------------|--------------|----------|-----------|----------|-----------|----------|----------|------------|------------|
| Quarter/Division | IIIa,b,IVa,b | IIa,Vb | VIa | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 18 | 0 | 64 | 0 | 0 | 0 | 0 | 6 | 88 |
| second quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 50 |
| third quarter | 7 | 1 | 0 | 0 | 0 | 0 | 0 | 42 | 50 |
| fourth quarter | 24 | 3 | 0 | 0 | 0 | 0 | 0 | 19 | 46 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 49 | 4 | 64 | 0 | 0 | 0 | 0 | 117 | 234 |

Table 5 (Cont.) Recaptures from the 1997 western adult tagging surveys.

| External tags 1999 | | | | | | | | | |
|--------------------|--------------|----------|----------|----------|-----------|----------|----------|----------|----------|
| Quarter/Division | IIIa,b,IVa,b | IIa,Vb | VIa | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| second quarter | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| third quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| fourth quarter | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 4 |

| Internal tags 1999 | | | | | | | | | |
|--------------------|--------------|----------|----------|-----------|-----------|----------|----------|------------|------------|
| Quarter/Division | IIIa,b,IVa,b | IIa,Vb | VIa | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 22 | 0 | 7 | 16 | 0 | 0 | 0 | 66 | 111 |
| second quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| third quarter | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 12 |
| fourth quarter | 17 | 0 | 1 | 0 | 0 | 0 | 0 | 24 | 42 |
| Unknown | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 26 | 27 |
| Total | 50 | 0 | 8 | 16 | 0 | 0 | 0 | 118 | 192 |

| External tags 2000 | | | | | | | | | |
|--------------------|--------------|----------|----------|----------|-----------|----------|----------|----------|----------|
| Quarter/Division | IIIa,b,IVa,b | IIa,Vb | VIa | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| second quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| third quarter | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| fourth quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 |

| Internal tags 2000 | | | | | | | | | |
|--------------------|--------------|----------|-----------|----------|-----------|----------|----------|-----------|------------|
| Quarter/Division | IIIa,b,IVa,b | IIa,Vb | VIa | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 1 | 1 | 22 | 0 | 0 | 0 | 0 | 44 | 68 |
| second quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 6 |
| third quarter | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 28 |
| fourth quarter | 19 | 0 | 2 | 0 | 0 | 0 | 0 | 30 | 51 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 30 | 1 | 24 | 0 | 0 | 0 | 0 | 98 | 153 |

Table 6: Summary of recaptures by year and tag type of mackerel tagged in the western spawning grounds in 1998 (adult areas 5, 7 & 8 together) up to 2000: number of tags returned by Divisions and Seasons (Quarters). (Summary by years can be seen in Table 1 -IMR data).

| External tags 1998 | | | | | | | | | |
|--------------------|--------------|----------|----------|----------|-----------|----------|----------|----------|----------|
| Quarter/Division | IIIa,b,IVa,b | Ia,Vb | VIa | VII,IVc | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| second quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| third quarter | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 2 |
| fourth quarter | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 3 |

| Internal tags 1998 | | | | | | | | | |
|--------------------|--------------|----------|----------|----------|-----------|----------|----------|----------|-----------|
| Quarter/Division | IIIa,b,IVa,b | Ia,Vb | VIa | VII,IVc | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| second quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| third quarter | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| fourth quarter | 7 | 3 | 0 | 0 | 0 | 0 | 0 | 7 | 17 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 10 | 3 | 0 | 0 | 0 | 0 | 0 | 7 | 20 |

| External tags 1999 | | | | | | | | | |
|--------------------|--------------|----------|----------|----------|-----------|----------|----------|----------|----------|
| Quarter/Division | IIIa,b,IVa,b | Ia,Vb | VIa | VII,IVc | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 4 |
| second quarter | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 3 |
| third quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| fourth quarter | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 4 | 9 |

| Internal tags 1999 | | | | | | | | | |
|--------------------|--------------|----------|-----------|----------|-----------|----------|----------|-----------|------------|
| Quarter/Division | IIIa,b,IVa,b | Ia,Vb | VIa | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 19 | 0 | 16 | 0 | 0 | 0 | 0 | 45 | 80 |
| second quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| third quarter | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 18 |
| fourth quarter | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 37 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 38 | 38 |
| Total | 60 | 0 | 16 | 0 | 0 | 0 | 0 | 97 | 173 |

| External tags 2000 | | | | | | | | | |
|--------------------|--------------|----------|----------|----------|-----------|----------|----------|----------|----------|
| Quarter/Division | IIIa,b,IVa,b | Ia,Vb | VIa | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 5 | 8 |
| second quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| third quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| fourth quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 5 | 8 |

| Internal tags 2000 | | | | | | | | | |
|--------------------|--------------|----------|-----------|----------|-----------|----------|----------|-----------|------------|
| Quarter/Division | IIIa,b,IVa,b | Ia,Vb | VIa | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 0 | 0 | 16 | 0 | 0 | 0 | 0 | 28 | 44 |
| second quarter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| third quarter | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 29 |
| fourth quarter | 17 | 0 | 1 | 0 | 0 | 0 | 0 | 23 | 41 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 22 | 0 | 17 | 0 | 0 | 0 | 0 | 75 | 114 |

Table 8: Summary of recaptures by year and tag type of mackerel tagged in the western juvenile area in 1997 (Divisions VIa & VIIIb). Details are given year by year (up to the 2000) on the number of tags returned by Divisions and Seasons (Quarters).

Number of internal and external tags reported by year from 1997 to 2000 from the 1997 survey. Area 6(Juvenile) MI.

| Number of tags | Year of recapture | | | | |
|----------------|-------------------|------|------|------|-------|
| | 1997 | 1998 | 1999 | 2000 | Total |
| Internal tags | 0 | 9 | 0 | 0 | 9 |
| External tags | 21 | 6 | 0 | 0 | 27 |
| Total | 21 | 15 | 0 | 0 | 36 |

Number of recaptures per season and ICES Sub_area or Division Obtained from 1997 to January 1999. Area 6 MI

| External tags1997 | | | | | | | | | |
|-------------------|--------------|-------|----|-----|-----------|-------|-----|---------|-------|
| Quarter/Division | IIIa,b IVa,b | IIa,b | VI | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| second quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| third quarter | 0 | 0 | 7 | 1 | 0 | 0 | | 0 | 8 |
| fourth quarter | 1 | 0 | 8 | 4 | 0 | 0 | | 0 | 13 |
| Unknown | 0 | 0 | 0 | | 0 | 0 | | 0 | 0 |
| Total | 1 | 0 | 15 | 5 | 0 | 0 | | 0 | 21 |

| Internal tags1997 | | | | | | | | | |
|-------------------|--------------|-------|----|-----|-----------|-------|-----|---------|-------|
| Quarter/Division | IIIa,b IVa,b | IIa,b | VI | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| second quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| third quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| fourth quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| Total | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |

| External tags1998 | | | | | | | | | |
|-------------------|--------------|-------|----|-----|-----------|-------|-----|---------|-------|
| Quarter/Division | IIIa,b IVa,b | IIa,b | VI | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| second quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| third quarter | 0 | 1 | 0 | 1 | 0 | 0 | | 0 | 2 |
| fourth quarter | 0 | 0 | 1 | 3 | 0 | 0 | | 0 | 4 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| Total | 0 | 1 | 1 | 4 | 0 | 0 | | 0 | 6 |

| Internal tags1998 | | | | | | | | | |
|-------------------|--------------|-------|----|-----|-----------|-------|-----|---------|-------|
| Quarter/Division | IIIa,b IVa,b | IIa,b | VI | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 0 | 0 | 0 | 2 | 0 | 0 | | 0 | 2 |
| second quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| third quarter | 0 | 0 | 4 | 3 | 0 | 0 | | 0 | 7 |
| fourth quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| Total | 0 | 0 | 4 | 5 | 0 | 0 | | 0 | 9 |

| External tags1999 | | | | | | | | | |
|-------------------|--------------|-------|----|-----|-----------|-------|-----|---------|-------|
| Quarter/Division | IIIa,b IVa,b | IIa,b | VI | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| second quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| third quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| fourth quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| Total | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |

Table 9: Summary of recaptures by year and tag type of mackerel tagged in the western juvenile area in 1998 (Divisions VIa & VIIb). Details are given year by year (up to the 2000) on the number of tags returned by Divisions and Seasons (Quarters).

Number of internal and external tags reported by year from 1998 to March 2001 from 1998 survey. Area 6(Juvenile) MI.

| Number of tags | Year of recapture | | | | | Total |
|----------------|-------------------|------|------|------|---------|-------|
| | 1998 | 1999 | 2000 | 2001 | unknown | |
| Type of tags | | | | | | |
| Internal tags | 0 | 0 | 0 | 0 | 0 | 0 |
| External tags | 79 | 7 | 1 | 0 | 0 | 87 |
| Total | 79 | 7 | 1 | 0 | 0 | 87 |

Number of recaptures per season and ICES Sub_area or Division Obtained from 1997 to January 1999. Area 6 MI

| External tags1998 | | | | | | | | | |
|-------------------|--------------|-------|----|-----|-----------|-------|-----|---------|-------|
| Quarter/Division | IIIa,b IVa,b | IIa,b | VI | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 0 | 0 | 1 | 0 | 0 | 0 | | 0 | 1 |
| second quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| third quarter | 0 | 0 | 28 | 6 | 0 | 0 | | 0 | 34 |
| fourth quarter | 0 | 0 | 35 | 9 | 0 | 0 | | 0 | 44 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| Total | 0 | 0 | 64 | 15 | 0 | 0 | | 0 | 79 |

| Internal tags1998 | | | | | | | | | |
|-------------------|--------------|-------|----|-----|-----------|-------|-----|---------|-------|
| Quarter/Division | IIIa,b IVa,b | IIa,b | VI | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| second quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| third quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| fourth quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| Total | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |

| External tags1999 | | | | | | | | | |
|-------------------|--------------|-------|----|-----|-----------|-------|-----|---------|-------|
| Quarter/Division | IIIa,b IVa,b | IIa,b | VI | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 0 | 0 | 1 | 3 | 1 | 0 | | 0 | 5 |
| second quarter | 0 | 0 | 0 | 1 | 0 | 0 | | 0 | 1 |
| third quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| fourth quarter | 0 | 0 | 1 | 0 | 0 | 0 | | 0 | 1 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| Total | 0 | 0 | 2 | 4 | 1 | 0 | | 0 | 7 |

| Internal tags1999 | | | | | | | | | |
|-------------------|--------------|-------|----|-----|-----------|-------|-----|---------|-------|
| Quarter/Division | IIIa,b IVa,b | IIa,b | VI | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| second quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| third quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| fourth quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| Total | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |

| External tags 2000 | | | | | | | | | |
|--------------------|--------------|-------|----|-----|-----------|-------|-----|---------|-------|
| Quarter/Division | IIIa,b IVa,b | IIa,b | VI | VII | VIIIa,b,d | VIIIc | IXa | Unknown | Total |
| first quarter | 0 | 0 | 0 | 1 | 0 | 0 | | 0 | 1 |
| second quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| third quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| fourth quarter | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| Total | 0 | 0 | 0 | 1 | 0 | 0 | | 0 | 1 |

Table 10: Details of the Most relevant recaptures of juvenile releases according to the distance to the tagging areas and concerning the recruitment process. Likely ages at released time are deduced from the length and the ALK built up during the surveys.

| RELEASE | | | | | | RECAPTURE | | | | | | |
|---------|------------|----------|------|------|---------|-----------------|--------------|-------------|----------|--------------|---------|-----------------|
| N° | Tag N° | Date | Type | Area | L (cm.) | Likely age | Date | Latitud (N) | Longitud | Sub-division | L (cm.) | Likely age |
| 11 | IRL05413 | 16/07/97 | E | 6 | 28 | 2 (3?) year old | 18/10/97 | 59°15' N | 2°30' W | IVa | ? | 2 (3?) year old |
| 1 | 487 | 08/07/97 | E | 6 | 30 | 2-3 year olds | 13/09/98 | 54° 15' N | 4° 15' W | VIIa | | 3-4 year old |
| 4 | 7039 | 21/07/97 | E | 6 | 27 | 2 year olds | 25/09/98 | 62° 15' N | 6° 45' E | Ila | 30 | 3 year old |
| 1 | RL FRC1776 | 30/09/98 | E | 6 | 30 | 3 year olds | 31/06/99 | 54° 15' N | 4° 15' W | VIIa | | 4 year old |
| 6 | 14578 | 27/08/98 | E | 6 | 27 | 1-2 year olds | 3/03/00 | | | VIIe | | 3-4 year old |
| 84 | IEO30903 | 13/09/97 | E | 1 | 29 | 1-2 year olds | 03/03/98 | 43° 53' N | 7° 36' W | VIIIc East | 29.5 | 2-3 year olds |
| 90 | IEO30928 | 13/09/97 | E | 1 | 30 | 1-2 year olds | 30/05/98 | 43° 12' N | 9° 2' W | VIIIc west | 29? | 2-3 year olds |
| 92 | IEO17155 | 26/09/97 | I | 1 | 29 | 1-2 year olds | before 8-04- | ? | ? | IVb? | - | 3-4 year old |
| 93 | IEO10271 | 11/09/97 | I | 1 | 23 | 0- group | 24/08/00 | ? | ? | IVb? | ? | 3 year olds |

Table 11: Quantitative analysis of the recaptures obtained in 1998 in Subareas II,III, IV and VI, including those of uncertain origin, which came from the adults released in 1997 in the southern and western areas.

$$(\Delta = \exp(-0.0122-0.025) = 0.9635)$$

$$\Delta = \exp(-0.0372) = 0.9635$$

A) TAGGING RELEASES AND RECAPTURES

| Institutes and tagging area | IEO 2+3 | AZTI 2+3+4 | IMR 5,7,8 | TOTAL | IEO+AZTI 2+3+4 |
|---|---------|------------|-----------|-------|----------------|
| RELEASED INTERNAL TAGS | 9600 | 11998 | 34998 | 56596 | 21598 |
| Delta Corrected number of tags | 9249 | 11560 | 34998 | 55807 | 20809 |
| Expected proportions of recaptures by Institutes | 0.17 | 0.21 | 0.63 | 1.00 | 0.37 |
| Relative proportions IEO/AZTI | 0.44 | 0.56 | | 1.00 | |

| RECAPTURES | IEO 2+3 | AZTI 2+3+4 | IMR 5,7,8 | TOTAL | IEO+AZTI 2+3+4 |
|--------------------|---------|------------|-----------|-------|----------------|
| Recaptures in 1998 | 8 | 16 | 96 | 120 | 24 |
| Recaptures in 1999 | 7 | 15 | 54 | 76 | 22 |
| Recaptures in 2000 | 10 | 7 | 79 | 96 | 17 |
| Total 1998-2000 | 25 | 38 | 229 | 292 | 63 |

B) ANNUAL AND GLOBAL PRESENCE ESTIMATES OF SOUTHERN AND WESTERN COMPONENTS IN THE NORTHERN AREAS.
Based on IMR recaptures in comparison to IEO+AZTI recaptures & Relative Migratory Fluxes

| | W% | S% | S/W |
|---------------|--------------|-------------|--------------|
| 1998 | 94.1% | 5.9% | 42.0% |
| 1999 | 90.7% | 9.3% | 68.5% |
| 2000 | 94.9% | 5.1% | 36.2% |
| Global | 93.5% | 6.5% | 46.3% |

C) EXPECTED RECAPTURES ACCORDING TO RELEASED NUMBERS AND TOTALS

| Institutes and tagging area | IEO 2+3 | AZTI 2+3+4 | IMR 5,7,8 | TOTAL | IEO+AZTI 2+3+4 |
|------------------------------------|---------|------------|-----------|-------|----------------|
| Expected Recaptures in 1998 | 19.9 | 24.9 | 75.3 | 120 | 44.7 |
| Expected Recaptures in 1999 | 12.6 | 15.7 | 47.7 | 76 | 28.3 |
| Expected Recaptures in 2000 | 15.9 | 19.9 | 60.2 | 96 | 35.8 |
| Expected Recaptures from 1998-2000 | 48.4 | 60.5 | 183.1 | 292 | 108.9 |

EXPECTED RECAPTURES

| Institutes and tagging area | IEO 2+3 | AZTI 2+3+4 | TOTAL |
|------------------------------------|---------|------------|-------|
| Expected Recaptures in 1998 | 10.7 | 13.3 | 24 |
| Expected Recaptures in 1999 | 9.8 | 12.2 | 22 |
| Expected Recaptures in 2000 | 7.6 | 9.4 | 17 |
| Expected Recaptures from 1998-2000 | 28.0 | 35.0 | 63 |

D) G test of Goodness of fit of recaptures by Institutes/areas with the proportions of releases

G test Goodness of fit of recaptures by the three Institutes with the proportions of releases

| Partial Gs | d.f. | Razón G | William's CF | G adj | Prob(G) |
|------------|------|---------|--------------|--------|---------|
| 1998 | 2 | 18.078 | 1.006 | 17.978 | 0.0001 |
| 1999 | 2 | 3.811 | 1.009 | 3.778 | 0.1512 |
| 2000 | 2 | 19.025 | 1.007 | 18.894 | 0.0001 |
| Global | 6 | 40.914 | | | 0.0000 |

Conclusion the rates of recoveries in the Northeastern area differ among Institutes (AZTI, IEO e IMR)

G test Goodness of fit of recaptures between IEO and AZTI with the proportions of releases

| Partial Gs | d.f. | Razón G | William's CI | G adj | Prob(G) |
|------------|------|---------|--------------|-------|---------|
| 1998 | 1 | 1.232 | 1.021 | 1.207 | 0.2719 |
| 1999 | 1 | 1.466 | 1.023 | 1.433 | 0.2312 |
| 2000 | 1 | 1.412 | 1.029 | 1.372 | 0.2415 |
| Global | 3 | 4.110 | | | 0.2498 |

Conclusion the rates of recoveries in the Northeastern area do not significantly differ for IEO and AZTI

G test Goodness of fit of recaptures from Southern (IEO+AZTI) and western (IMR) areas according to the proportions of releases

| Partial Gs | d.f. | Razón G | William's CF | G adj | Prob(G) |
|------------|------|---------|--------------|--------|---------|
| 1998 | 1 | 16.846 | 1.004 | 16.776 | 0.0000 |
| 1999 | 1 | 2.345 | 1.007 | 2.330 | 0.1269 |
| 2000 | 1 | 17.613 | 1.005 | 17.522 | 0.0000 |
| Global | 3 | 36.804 | | | 0.0000 |

Conclusion the rates of recoveries in the Northeastern area differ between the southern (IEO+AZTI) and western (IMR) origin of releases.

Table 12: Summary of biological information concerning maturity of adults recaptured during mars and the spring of 1997 and 1998 which were released at the southern tagging areas.

| RELEASE | | | | | | | RECAPTURE | | | | | | | |
|---------|----------|----------|------|------|--------------|---------|-----------|-------------|----------|--------------|---------|-----|------|----------|
| N° | Tag N° | Date | Type | Area | Sub-division | L (cm.) | Date | Latitud (N) | Longitud | Sub-division | L (cm.) | Sex | Mat. | Origin |
| 1 | AZT30426 | 18/4/97 | E | 4 | VIIIc East | 43 | 20/05/97 | 50°02'N | 5°37'W | VIIIc East | 43 | F | 6 | MAFF |
| 2 | AZT27999 | 16/4/97 | E | 4 | VIIIc East | 38 | 03/03/98 | unknown | unknown | VIa | ? | M | 2 | Irlanda |
| 3 | IEO03436 | 3/5/97 | I | 2 | VIIIc West | - | 03/03/98 | unknown | unknown | VIa | 37 | F | 3 | Noruega |
| 4 | AZT38359 | 7/4/97 | I | 4 | VIIIc East | 32 | 09/03/98 | 61°45'N | 0°30'W | IVa | 33 | M | 4 | Noruega |
| 5 | AZT42753 | 17/4/97 | I | 4 | VIIIc East | 36.5 | 09/03/98 | 61°45'N | 0°30'E | IVa | 36 | F | 3 | Noruega |
| 6 | AZT30943 | 22/04/97 | E | 3 | VIIIc East | 38 | 10/03/98 | 49°16'N | 11°12'W | VIIj | 37.9 | F | 3 | RIVO |
| 7 | AZT30244 | 18/4/97 | E | 4 | VIIIc East | 44.5 | 10/03/98 | 49°16'N | 11°12'W | VIIj | 44 | M | 5 | RIVO |
| 8 | AZT38874 | 8/4/97 | I | 4 | VIIIc East | 40 | 10/03/98 | 60°15'N | 4°30'W | IVa | 42 | F | 3 | Noruega |
| 9 | AZT38124 | 7/4/97 | I | 4 | VIIIc East | 43 | 13/03/98 | 59°45'N | 4°30'W | VIa | 43 | F | 3 | Noruega |
| 10 | AZT42943 | 18/4/97 | I | 4 | VIIIc East | 46.5 | 13/03/98 | 59°45'N | 4°30'W | VIa | 45 | F | 3 | Noruega |
| 11 | AZT31216 | 22/4/97 | E | 3 | VIIIc East | 38 | 20/03/98 | unknown | unknown | VIa | 38 | M | 3 | Irlanda |
| 12 | AZT25944 | 10/4/97 | E | 4 | VIIIc East | 38 | 03/04/98 | 55°15'N | 9°30'W | VIa | 38 | F | 3 | Noruega |
| 13 | AZT26100 | 10/4/97 | E | 4 | VIIIc East | 34 | 05/04/98 | 51°00'N | 11°00'W | VIIi | 36.1 | M | 6 | RIVO |
| 14 | IEO23302 | 3/5/97 | E | 2 | VIIIc West | 33 | 16/04/98 | unknown | unknown | VIIj | 34 | M | 5 | Irlanda |
| 15 | AZT25850 | 9/4/97 | E | 4 | VIIIc East | 39 | 03/03/99 | 53°30'N | 11°50'W | VIIc | ? | F | 3 | Holanda |
| 16 | AZT26269 | 10/4/97 | E | 4 | VIIIc East | 45 | 19/03/99 | 61° 00'N | 10° 00'W | Vb | ? | F | 3 | Escocia |
| 17 | AZT29123 | 17/4/97 | E | 4 | VIIIc West | - | 19/04/99 | 43°30'N | 3°30'W | VIIIc East | ? | F | 3 | AZTI |
| 79 | IEO28286 | 17/5/97 | E | 2 | VIIIc West | 38 | 30/03/01 | - | - | VIIJ | 39 | F | 3 | Irlanda? |

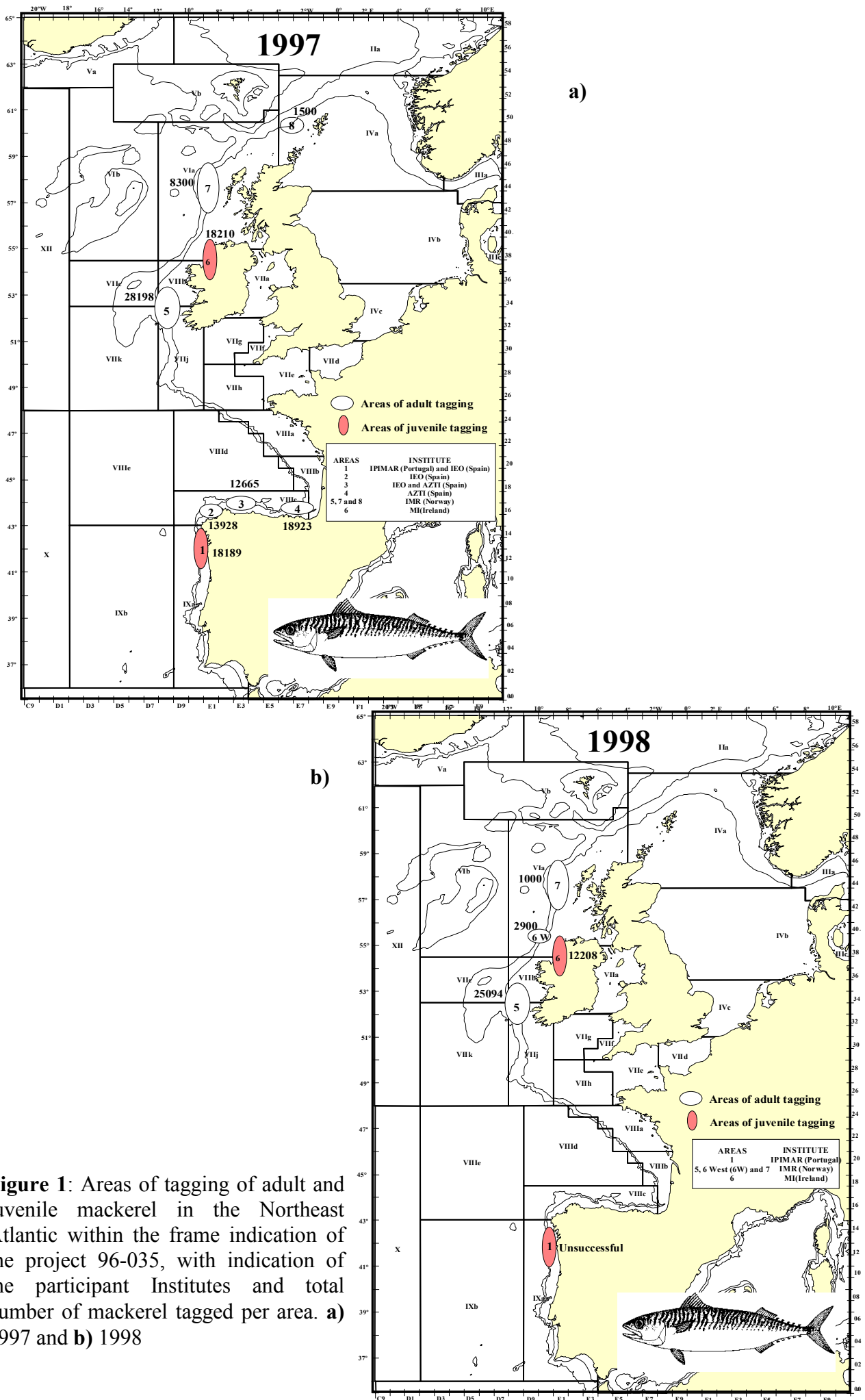


Figure 1: Areas of tagging of adult and juvenile mackerel in the Northeast Atlantic within the frame indication of the project 96-035, with indication of the participant Institutes and total number of mackerel tagged per area. **a)** 1997 and **b)** 1998

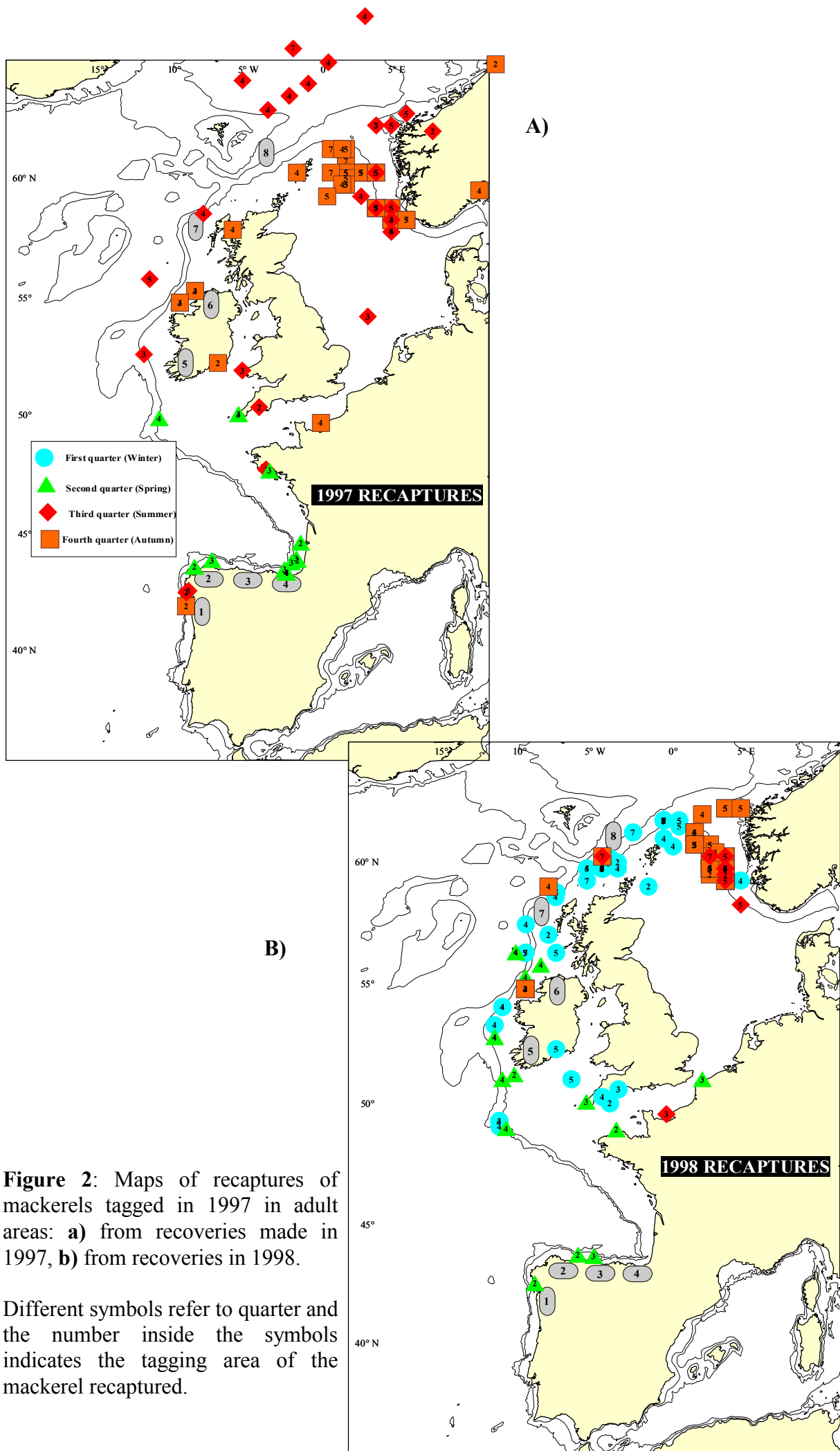
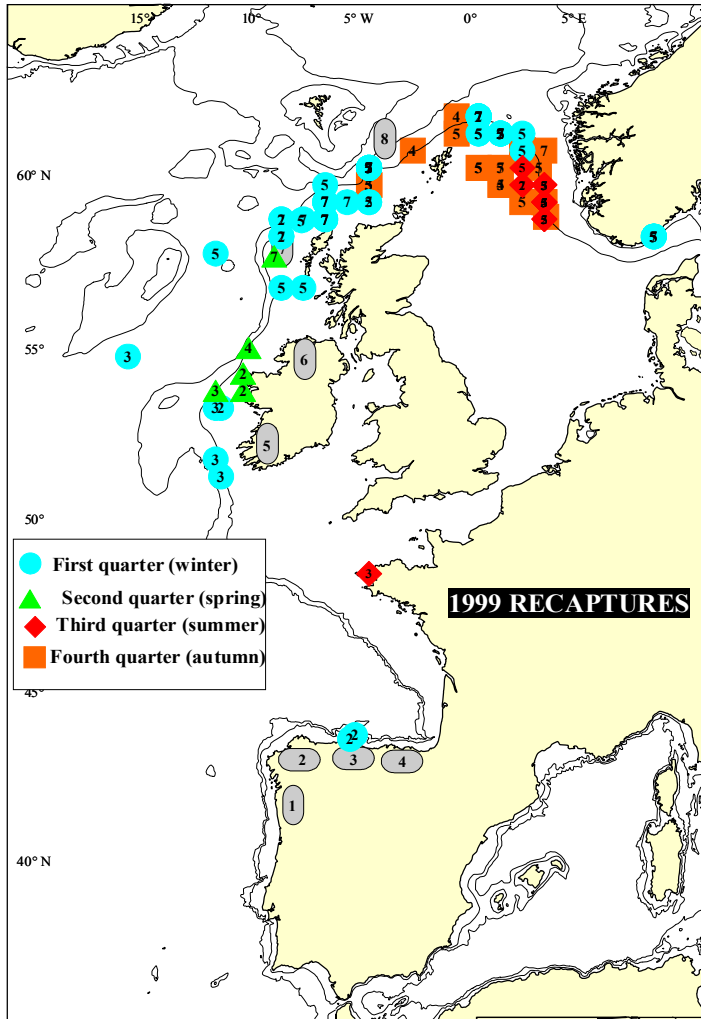
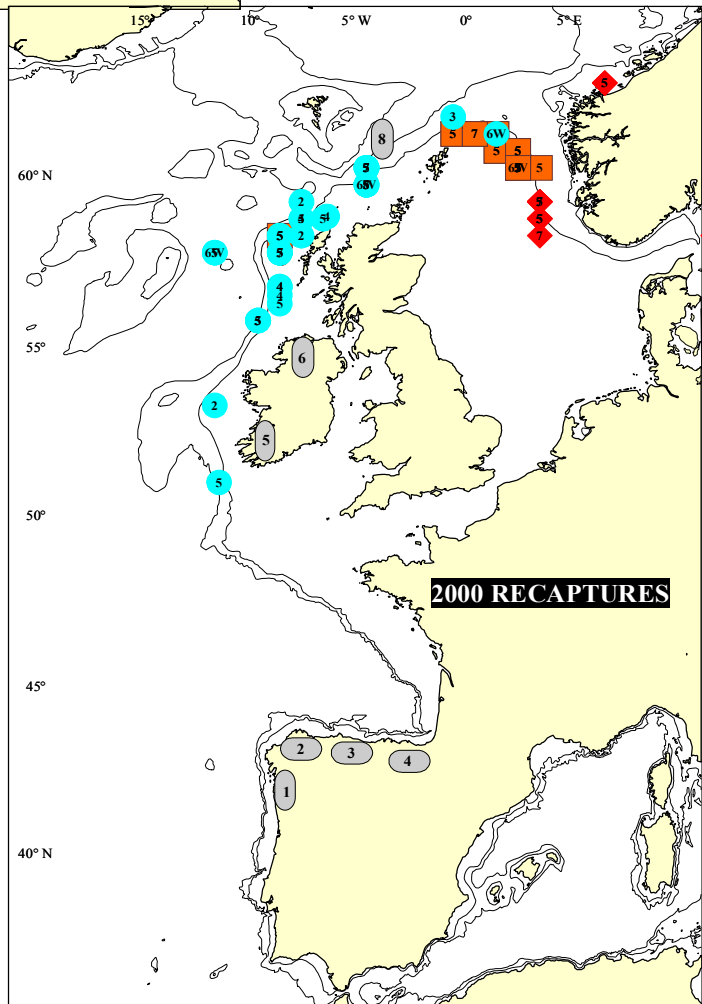


Figure 2: Maps of recaptures of mackerels tagged in 1997 in adult areas: **a)** from recoveries made in 1997, **b)** from recoveries in 1998.

Different symbols refer to quarter and the number inside the symbols indicates the tagging area of the mackerel recaptured.



C)



D)

Figure 2c: Maps of recaptures of mackerels tagged in 1997 in adult areas: **c)** from recoveries in 1999 and **d)** from recoveries in 2000.

Different symbols refer to quarter and the number inside the symbols indicates the tagging area of the mackerel recaptured.

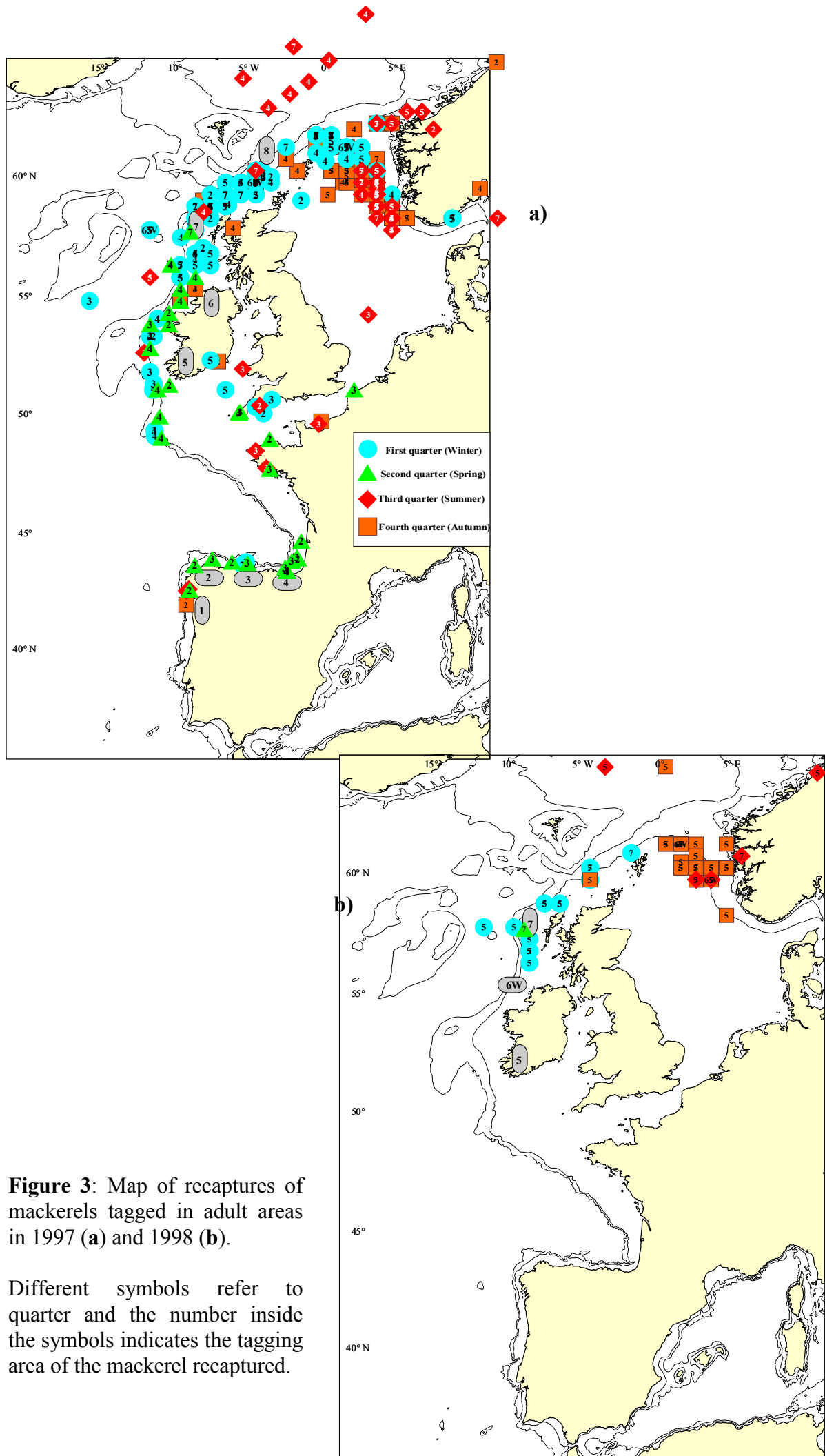
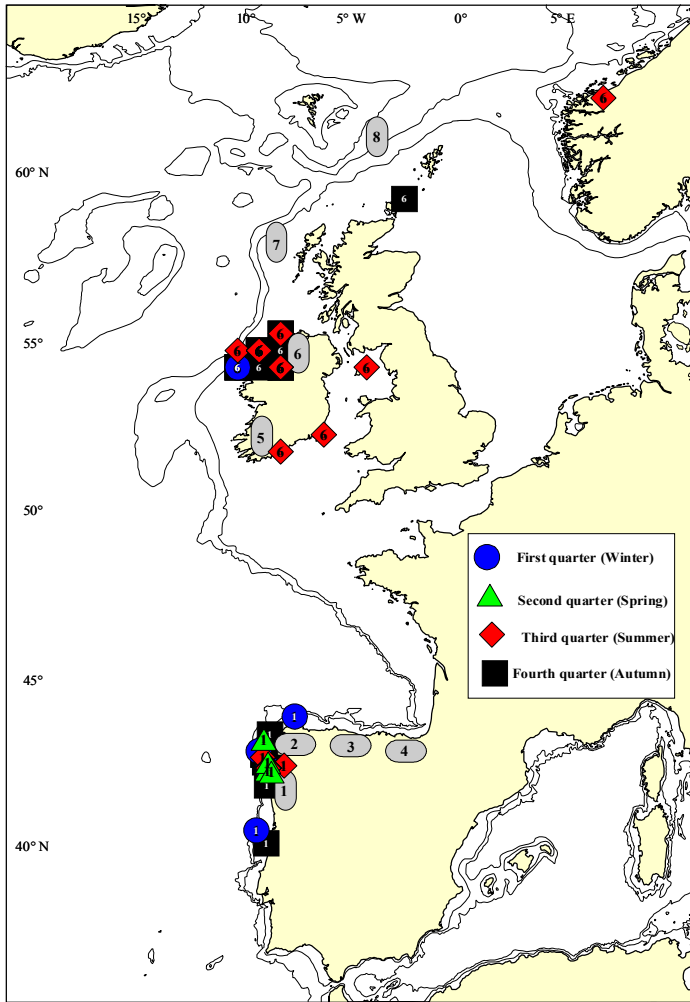
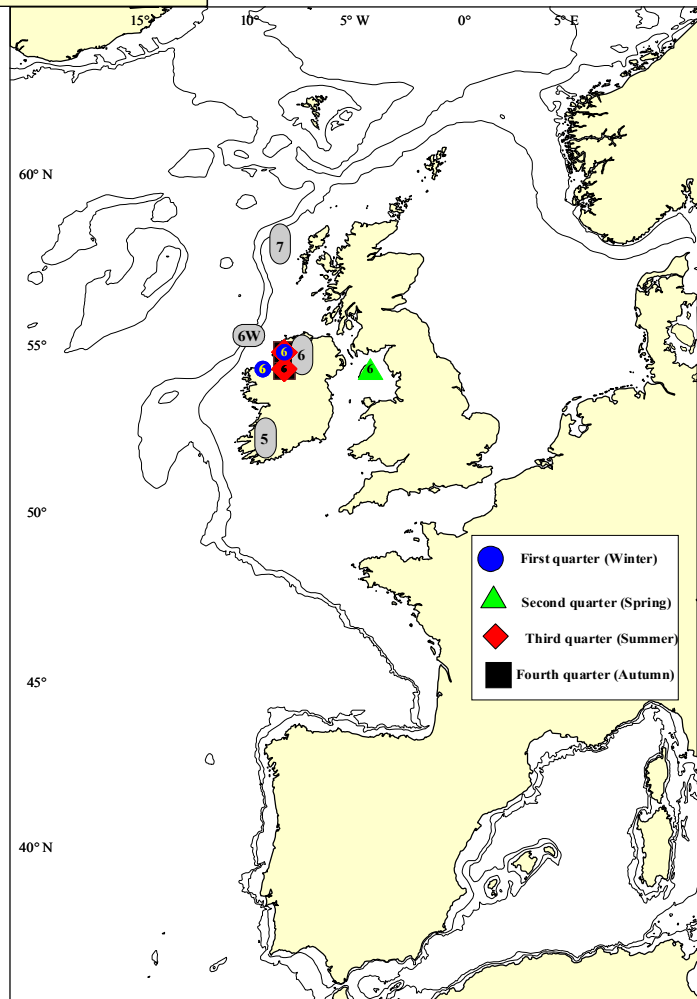


Figure 3: Map of recaptures of mackerels tagged in adult areas in 1997 (a) and 1998 (b).

Different symbols refer to quarter and the number inside the symbols indicates the tagging area of the mackerel recaptured.



A)



B)

Figure 4: Map of recaptures of mackerels tagged in juvenile areas in 1997 (a) and 1998 (b).

Different symbols refer to quarter and the number inside the symbols indicates the tagging area of the mackerel recaptured.

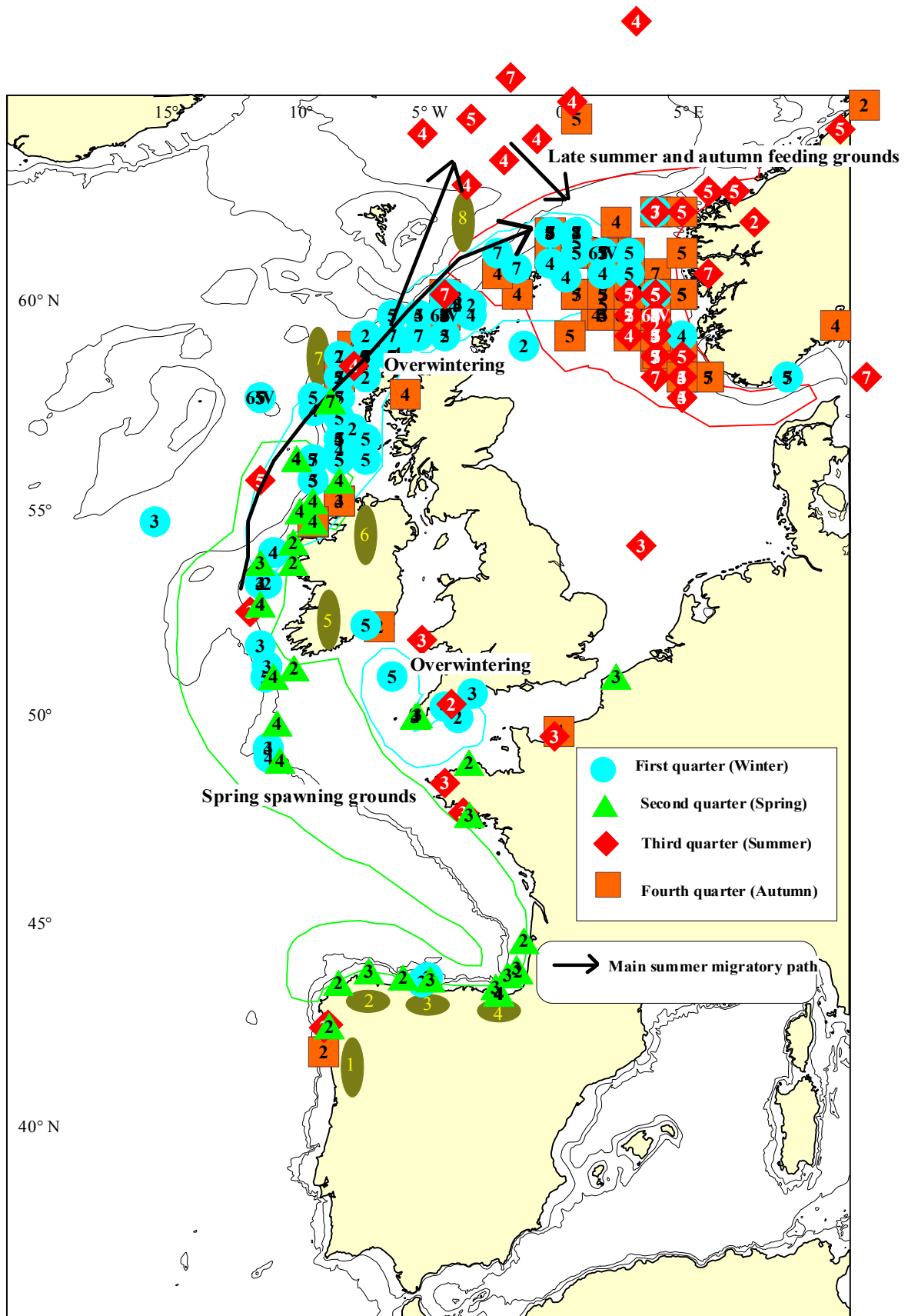


Figure 5: General pattern of spatial distribution of adult mackerels in the north east Atlantic area, resulting from tagging surveys carried out in 1997 and 1998.