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Report of the Study Group on the evaluation of assessment and management strategies of the western herring stocks (SGHERWAY)

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Executive summary

The ICES Study Group on the evaluation of assessment and management strategies of the western herring stocks [SGHERWAY] met in early December 2008 to consider issues surrounding the assessment and management of the herring stocks to the west of the British Isles.

SGHERWAY arose out of the EU funded project WESTHER which evaluated the uncertain stock identity of herring stocks to the west of the British Isles. SGHERWAY recognizes the need to provide sound management advice for the western herring areas, and in particular the importance of ensuring as far as possible that there is no depletion of local components. Currently it is unclear what management regime would provide the most cost-effective method for successful management and what data would be needed to support this management.

SGHERWAY considered that it is necessary to move towards management for this area through a series of iterations involving the following steps: (I) Investigation of a combined assessment of the three currently assessed stocks, VIaN, VIaS/VIIbc and VIIaN (to be called the Malin Shelf stock), including an investigation of the utility of a combined acoustic survey; (II) Examination of alternative management strategies based on their ability to deliver protection to local populations and provide cost-effective information applicable for management of the new proposed stock unit of herring to the west of the British Isles (Malin Shelf); (III) Amendment of existing, or development of new, cost-effective assessment and data collection schemes which will be required to support this management.

In December 2008, SGHERWAY addressed the first of the two steps above. During the meeting the majority of the data required to perform a combined assessment of the three herring stocks were compiled and a combined assessment carried out using FLICA with the VIaN survey as the tuning index. This combined assessment gave a lower catchability than the current VIaN assessment, suggesting that the inclusion of additional catch from the VIaS/VIIb c and VIIaN stocks was an improvement. However, the retrospective pattern was very poor. This may be as a result of the partial area coverage of the single tuning index used. This survey does not extend as far south as VIaS/VIIbc or VIIaN. Another possibility is that the selection pattern assumed for the fishery may not represent the combined fishery. The development of a time-series of a synoptic acoustic survey of the Malin and Hebrides shelf areas will allow survey coverage to be extended to the whole sea area in which mixing of the various western herring stocks is thought to occur, and, through the creation of a time-series, a more apposite tuning index to be developed. The first such synoptic survey was carried out in 2008. The area was surveyed in June/July 2008 by vessels from Scotland, Northern Ireland and the Republic of Ireland. The three survey estimates were combined in the same manner as the surveys in the North Sea. The Malin Shelf estimate of SSB was 826,000 tonnes and 4,007 million fish. This is largely dominated by the VIaN estimate.

A simulation model developed to study the sustainability of fishing on metapopulations was available to SGHERWAY. This model provided a good starting point to evaluate alternative management strategies for these populations west of the British Isles, where there is evidence of component mixing during the feeding season. By simulating step changes in fishing mortality, different for each fishery, and varying the amount of population mixing, potential management indicators could be investigated. However, shifts in fishing effort which would have an effect on all populations

caught were not investigated. To fully evaluate alternative management strategies for herring stocks west of the British Isles, it is recommended to adapt the model setup to reflect current knowledge of the biological status of these populations. Therefore, the model should be adjusted to a year-by-year management strategy evaluation (MSE) platform. Using this approach, the efficacy of different management strategies could, be evaluated.

1 Background

SGHERWAY was convened to address a series of recommendations produced by the EU funded project WESTHER (A multidisciplinary approach to the identification of herring (*Clupea harengus* L.) stock components west of the British Isles using biological tags and genetic markers. – Q5RS-2002-01056).

WESTHER ran from 2003–2006. Its overall goal was to describe the population structure of herring stocks in western European waters, distributed from the southwest of Ireland and the Celtic Sea to the northwest of Scotland via four research objectives: (i) estimation of genetic and phenotypic differentiation between spawning aggregations; (ii) determination of stock origins and life history of juveniles; (iii) determination of composition of feeding aggregations; (iv) improved guidelines for the conservation and management of biodiversity and stock preservation.

WESTHER examined the assessment and management issues that derived from its results and presented the following conclusions to the 2007 HAWG:

1) **assess the herring to the west of the British Isles as two stock units** – Malin Shelf (including the current ICES stocks VIa North, VIaS and VIIb, c, Clyde and Irish Sea (VIIaN)) and Celtic Sea (the current Celtic Sea and VIIj stock). In the area studied in WESTHER we can hypothesize that there are two stock units within which data can be pooled for assessment. However, the boundary at the northern edge is unclear and there is no evidence presented in the report which separates autumn spawners in the north of Scotland west of 4°W from autumn spawning fish east of 4°W (the North Sea stock). The boundary is here for convenience

2) survey effort should be increased or diverted to a combined survey on non-spawner distributions mixing on the Malin Shelf

3) the current monitoring of the spawning components should be maintained, but not to the detriment of a wider scale Malin Shelf survey. Spawning ground surveys might provide data on the dynamics of individual stock components, which are thought to be useful for the development of a fleet-based advice

However,

4) **management plans should be fleet/area based,** aiming at preventing the local depletion of any population unit in the area, and should make adaptive changes if current fishing practices change, specifically the introduction of a new 1st or 2nd quarter fishery in the southern part of VIa North and/or northern part of VIaS and VIIb,c

5) management plans should recognize the importance of the populations in the north of area VIa as a potential source of herring to spawning grounds to the south

6) management plans should recognize that there are potentially two separate stock units on the west coast of the British Isles, these constitute a population in the Celtic Sea and VIIj and a metapopulation centred on area VIa

The HAWG supported the results and conclusions of WESTHER.

HAWG recognized the need to provide sound management advice for these areas, and in particular the importance of ensuring as far as possible that there is no depletion of local components. However, HAWG noted that WESTHER was not funded to evaluate the extent of mixing in the fisheries or to evaluate alternate management strategies for the area. It is unclear what management regime would provide the most cost-effective method for successful management and what data would be needed to support this management.

HAWG considered that it was necessary to move towards an integrated management plan for the whole of the western herring stock area through a series of iterations involving the following steps:-

- examination of alternative management strategies based on their ability to deliver protection to local populations and provide cost-effective information applicable for management of the two stock units of herring to the west of the British Isles
- replacement of existing or development of new cost-effective assessment and data collection schemes which will be required to support this management
- movement to coordinated management for the region

Additionally, HAWG was requested to "examine the WESTHER report and its recommendations to provide information on necessary changes to ICES long-term management advice concerning the herring stock to the West of Scotland (herring in VIa(N))".

The HAWG response stated that that in the absence of any evaluated and coordinated management strategy for the herring to the west of the British Isles, the current separation of management units (VIa(N), VIa(S) and VIIb,c Irish Sea and Celtic Sea) affords the best possible protection for local spawning stocks. However it does not afford protection to the fish of one stock distributed in another management area at feeding time.

Provided both the spawning fisheries (VIa(S), Irish Sea and Celtic Sea) and the fishery in the mixing area (predominantly VIa(N)) are maintained at a fishing mortality that would be sustainable for each component, this should afford protection for these units, in the short term. HAWG considered that further work was required on examining the issues surrounding surveys, assessment and management of each of the current three management units to the north of the area. This could be initiated partly through a new study group or study contract. It would be a number of years before ICES could provide a fully operational integrated strategy for these units. HAWG proposed a number of terms of reference for a study group, SGHERWAY. These are given below in Section 2.

2 Participation and Terms of Reference

The ICES SGHERWAY met in Aberdeen, UK from 8–12 December 2008. The participants were:

Steven Beggs	UK [Northern Ireland]
Maurice Clarke	Ireland
Afra Egan	Ireland
Emma Hatfield [Chair]	UK/Scotland
Niels Hintzen	the Netherlands

Charlotte Main	UK [Scotland]
Richard Nash [part-time]	Norway
Beatriz Roel	UK [England & Wales]
Marine Pomarede	UK
John Simmonds	UK [Scotland]

Contact details for each participant are given in Annex 1.

Taking into account the results of WESTHER in relation to VIaN, VIaS and VIIaN stocks, SGHERWAY met to:

a) evaluate the utility of a synoptic acoustic survey in summer for the Hebrides, Malin and Irish shelf areas, in conjunction with PGHERS surveys of VIaN and the North Sea;

b) explore a combined assessment of the three stocks and investigate its utility for advisory purposes;

c) evaluate, through simulation, alternative management strategies for the metapopulation of VIaN, VIaS and VIIaN;

d) comment on the best way to maintain each spawning component in a healthy state, while managing the fish of that component when they are in a neighbouring area.

3 Progress against ToRs

3.1 Evaluation of the utility of a synoptic acoustic survey in summer for the Hebrides, Malin and Irish shelf areas, in conjunction with PGHERS surveys of VIaN and the North Sea

The Study Group was asked to evaluate the utility of a synoptic acoustic survey in summer for the Hebrides, Malin and Irish shelf areas, in conjunction with PGHERS surveys of VIaN and the North Sea. This evaluation is based on results of a combined survey programme in 2008, and an analysis of time-series of existing surveys in the area.

3.1.1 2008 survey programme

In 2008, for the first time, a joint survey programme was initiated to cover the Malin Shelf stock complex. This programme was a combination of an existing survey (VIaN), a new survey of VIaS/VIIb,c, and a new survey of southeastern VIaN, the North Channel and Firth of Clyde. The VIaS/VIIb,c survey was a replacement to winter spawning area survey. That survey was discontinued in 2007, being of no utility for tracking the development of the stock. The VIaN/North Channel/Firth of Clyde survey was completely new.

The area was surveyed in June/July 2008 by vessels from Scotland (MFV *Chris Andra*), Northern Ireland (RV *Corystes*) and Republic of Ireland (RV *Celtic Explorer*) (Table 3.1.1.1, Figures 3.1.1.1 and 3.1.1.2). Transect interlacing was incorporated into the coordinated survey design in the boundary regions of VIaN and VIaS and in the southern area of VIaN in the approaches to the Northern Channel. In the latter area all three vessels allocated survey effort.

Table 3.1.1.1. Component surveys of the Malin Shelf metapopulation, conducted in 2008.

Vessel	Period	Area	Rectangles
RV Celtic Explorer	28 June – 14 July	52°30'–56°N ,12°–6°W	34D9-E0, 35D9-E0, 36D9-E0, 37D9-E1, 38D9-E1, 39E0-E3, 40E1-E3
MFV Chris Andra	30 June – 19 July	55°30'-60°30'N, 4°-10°W	41E0-E3, 42E0-E3, 43E0-E3, 44E0-E3, 45E0-E4, 46E2-E5, 47E2-E5, 48E4-E5, 49E5
RV Corystes	6–12 July	Clyde, North Channel	40E3-E5, 39E4-E5,38E4

For the first time, a synoptic survey of what is currently considered the Malin Shelf stock complex of herring was carried out. This provides an estimate comprising four stocks to the west of the British Isles: the West of Scotland herring stock in Division VIaN (identified in ICES as her-vian); the Clyde stock (her-clyd); the stock in Division VIaS and VIIbc (her-irlw) and the Irish Sea stock (her-nirs). These were combined in the same manner as the surveys in the North Sea, with weighting applied to individual survey estimates at ICES statistical rectangle according to the amount of survey effort in the rectangle measured in nautical miles. The Malin Shelf estimate of SSB was 826,000 tonnes and 4,007 million fish (Table 3.1.1.2). This is largely dominated by the west of Scotland estimate.

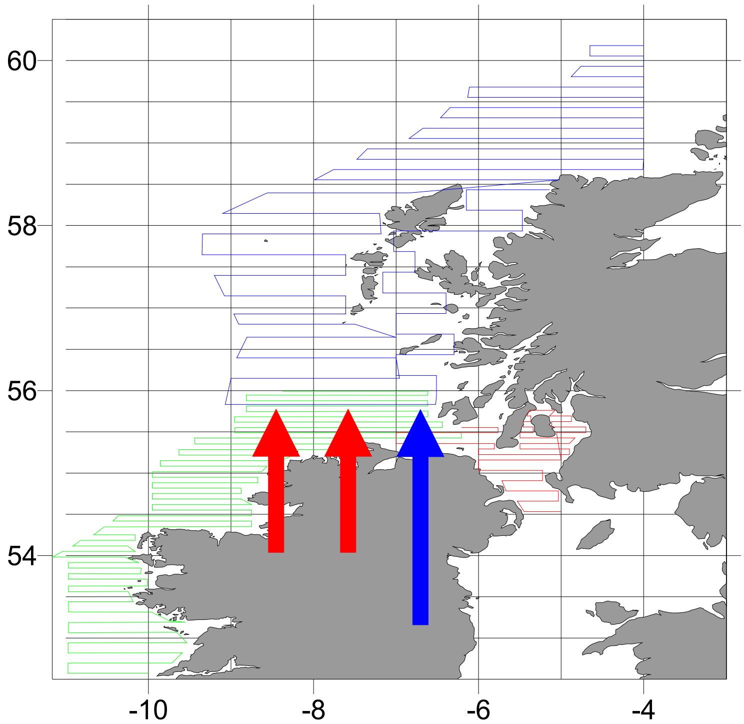

Figure 3.1.1.1. Cruise tracks for the Malin shelf survey July 2008. Cruise tracks (green RV *Celtic Explorer* (Republic of Ireland); red RV *Corystes* (Northern Ireland); blue MFV *Chris Andra* (Scotland)). Red arrow indicates 2 vessels transect interlacing, blue represents 3 vessel interlacing.

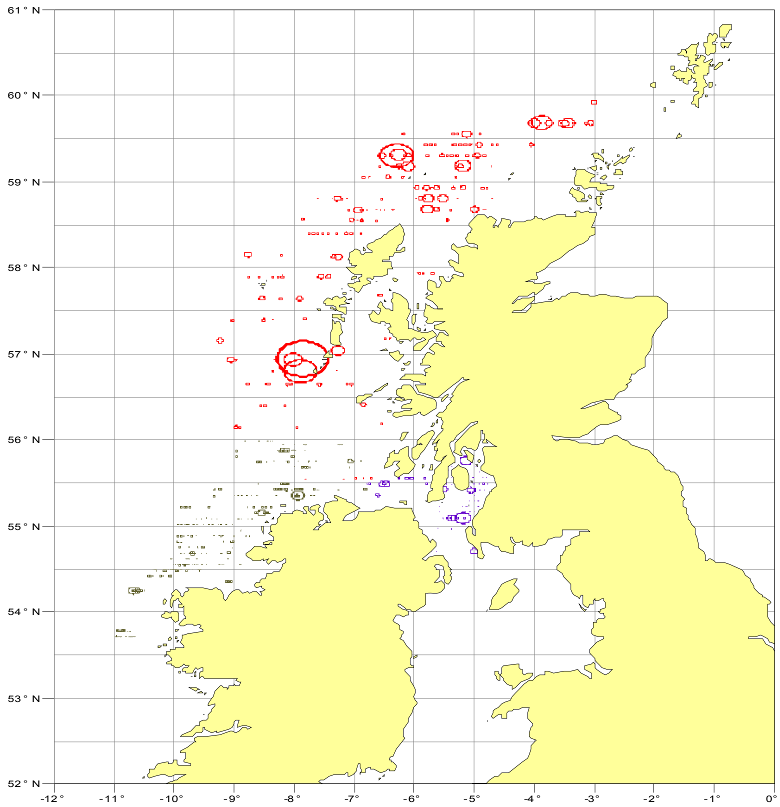

Figure 3.1.1.2. Post plot of the distribution of total herring nautical area scattering coefficient (NASC) values (circle size is proportional to NASC but only within a survey) obtained from the three hydroacoustic surveys carried out in June/July 2008. Relative NASC comparisons are approximate and scaled to a maximum value of 50,000. Red circles MFV *Chris Andra*, purple circles RV *Corystes* and khaki circles RV *Celtic Explorer*.

Table 3.1.1.2. Total numbers (millions of fish) and biomass (thousands of tonnes) of Malin Shelf herring in the area surveyed in the acoustic surveys July 2008, with mean weights, mean lengths and fraction mature by age ring.

Age (winter ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0					
1	425	27	0.01	63.4	19.5
2	377	56	0.76	147.5	25.1
3	1000	189	1.00	188.7	27.1
4	718	149	1.00	207.0	27.9
5	362	77	1.00	213.6	28.2
6	286	61	1.00	214.9	28.1
7	721	159	1.00	220.6	28.5
8	366	82	1.00	224.2	28.6
9+	264	63	1.00	238.5	29.2
Immature	510	36		70.6	20.1
Mature	4007	826		206.2	27.8
Total	4517	862	0.89	190.9	27.0

The new survey programme may provide a time-series for tuning a joint assessment of the Malin Shelf stock complex. However such a time-series will not be available for a number of years. Until a time-series of Malin Shelf surveys is available, the current assessments can continue uninterrupted. If a new combined series became available it would have to be evaluated for its utility in tuning. Such work could not take place before 4 or 5 years of data are available. It should be noted that work in developing a new survey programme does not interfere with the tuning index time-series for any current stock.

The VIaS/VIIbc sub-survey may provide a tuning index for that stock component, in time. A summer survey is considered a better index, because the fish are less contagiously distributed. However, it is unclear what the spatial extent of that stock is during summer.

It remains unclear to what extent fish from one stock are being registered in another stock area. It is likely that a proportion of the fish registered in the VIaN survey belong to the other two stocks. It is also possible that VIIaN and Firth of Clyde fish may be registered in the VIaS.

3.1.2 Time series of existing surveys

In order to explore the relationships between the stock areas, with survey data, historical spatial distributions were investigated. From 1994 to 1996, Ireland conducted acoustic surveys in summer, from 56°N southwards. Figure 3.1.2.1 displays the distribution of total herring nautical area scattering coefficient (NASC) values for these surveys and the VIaN surveys conducted by Scotland. Overall there was a tendency for increased abundance moving from south to north. The Irish and Scottish surveys were conducted at roughly the same time (Table 3.1.2.1) and suggest a continuous distribution of herring across the divide between VIaN and VIaS.

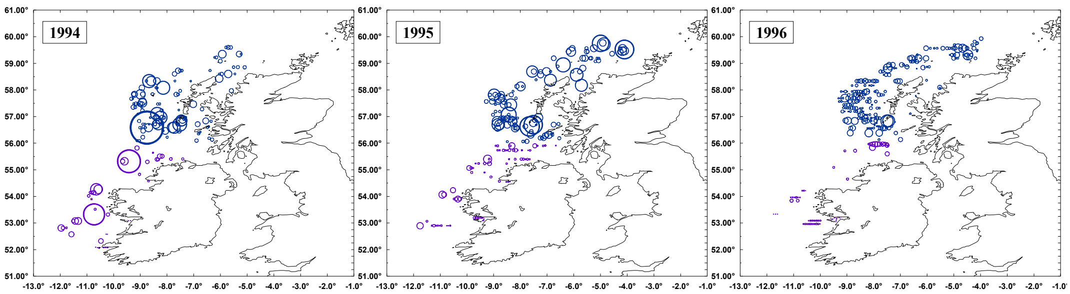

Figure 3.1.2.1. Distribution of total herring NASC values for Scottish and Irish surveys of VIaN (blue), and of VIaS/VIIbc (purple) respectively. Surveys by both countries were only conducted from 1994 to 1996. Relative NASC comparisons are approximate and scaled to a value of 15,157.

Table 3.1.2.1. Surveys carried out in both VIaN and VIaS, VIIb in 1994, 1995 and 1996.

Year	VIaN survey vessel	VIaN survey dates	VIaS, VIIb survey vessel	VIaS, VIIb survey dates
1994	MFV *Kings Cross*	9 to 29 July	RV *Lough Foyle*	11 to 27 July
1995	MFV *Kings Cross*	8 to 28 July	RV *Lough Foyle*	17 July to 4 August
1996	MFV *Christina S*	13 to 30 July	RV *Lough Foyle*	15 July to 2 August

Figure 3.1.2.2 shows the spatial distribution of herring NASC values over time for the Scottish VIaN herring acoustic surveys, since 1992. It can be seen that the contribution from the area west and south of the Hebrides has declined in recent years. However, in many years throughout the series, there were considerable NASC values recorded in the southern part of the survey area.

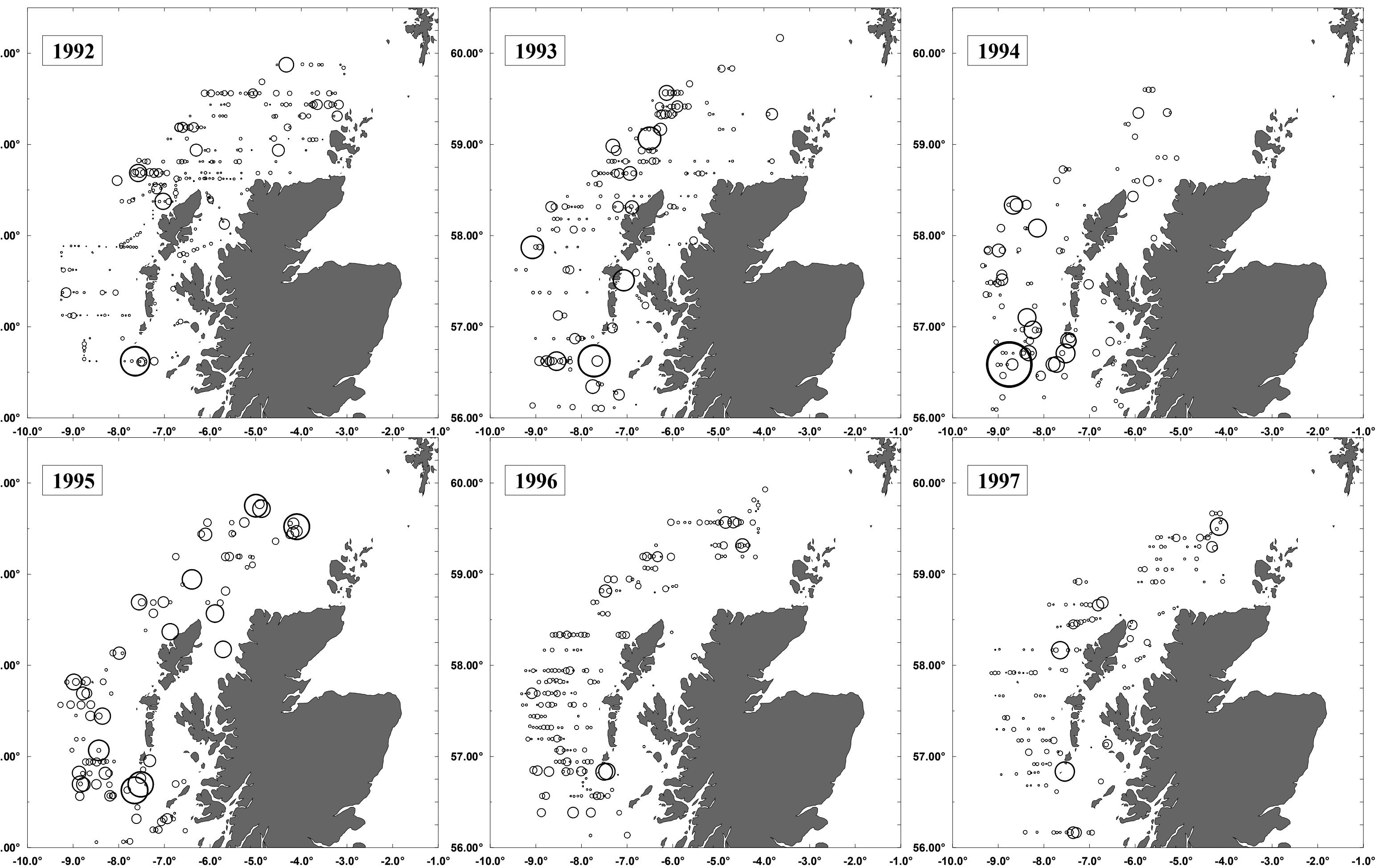

Figure 3.1.2.2. Post plot of the distribution of total herring NASCs (on a proportional scale relative to the third largest value of 15157) obtained from the west of Scotland herring acoustic surveys (1992–2008).

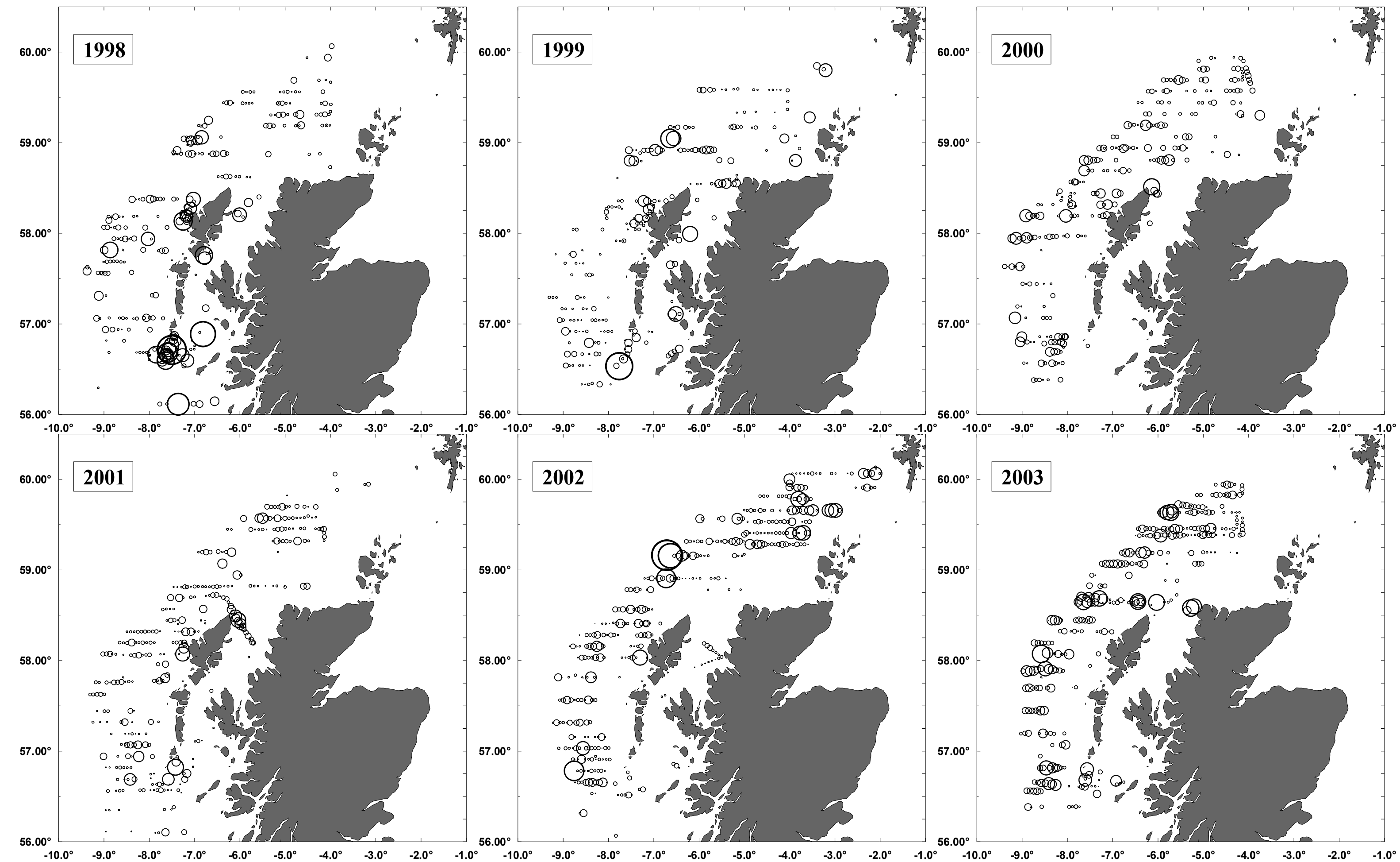

Figure 3.1.2.2. (continued). Post plot of the distribution of total herring NASCs (on a proportional scale relative to the third largest value of 15157) obtained from the west of Scotland herring acoustic surveys (1992–2008).

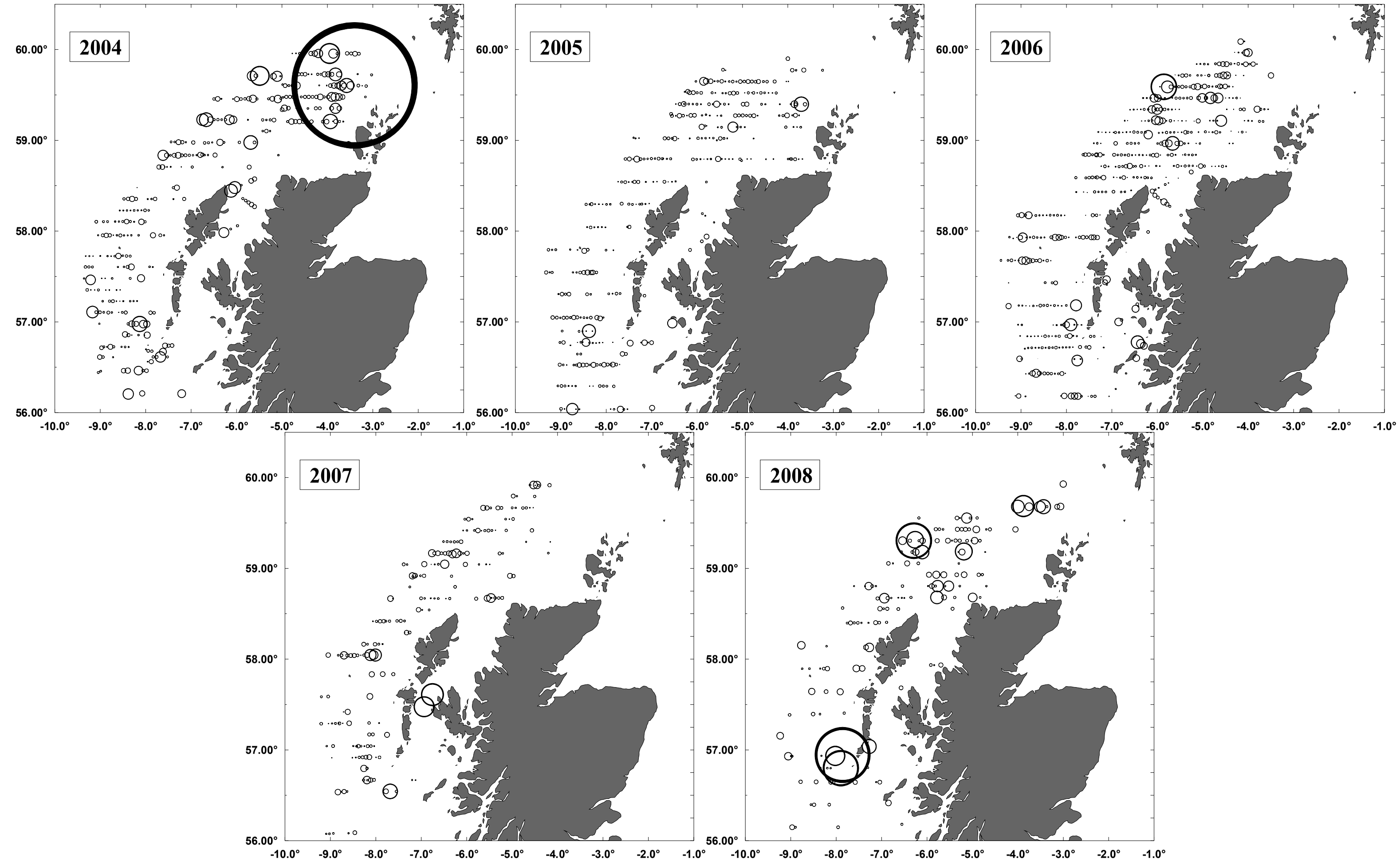

Figure 3.1.2.2. (continued). Post plot of the distribution of total herring NASCs (on a proportional scale relative to the third largest value of 15157) obtained from the west of Scotland herring acoustic surveys (1992–2008).

A comparison of the age compositions in the commercial catches, both for VIaN alone and for VIaN and VIaS/VIIbc combined (see Section 3.2 for combination descriptions), and for the VIaN acoustic survey is presented in Figure 3.1.2.3. Good agreement between the VIaN survey and fishery was observed in about 8 out of 16 years. In recent years agreement has been lower, (only 1 out of the last 4 years). The differences are mainly in younger (1 and 2-winter ring) fish. Good agreement between the VIaN survey and the combined catch-numbers-at-age (CNAA) was only found in 5 out the 16 years. The combined CNAA tends to differ both in young and older ages.

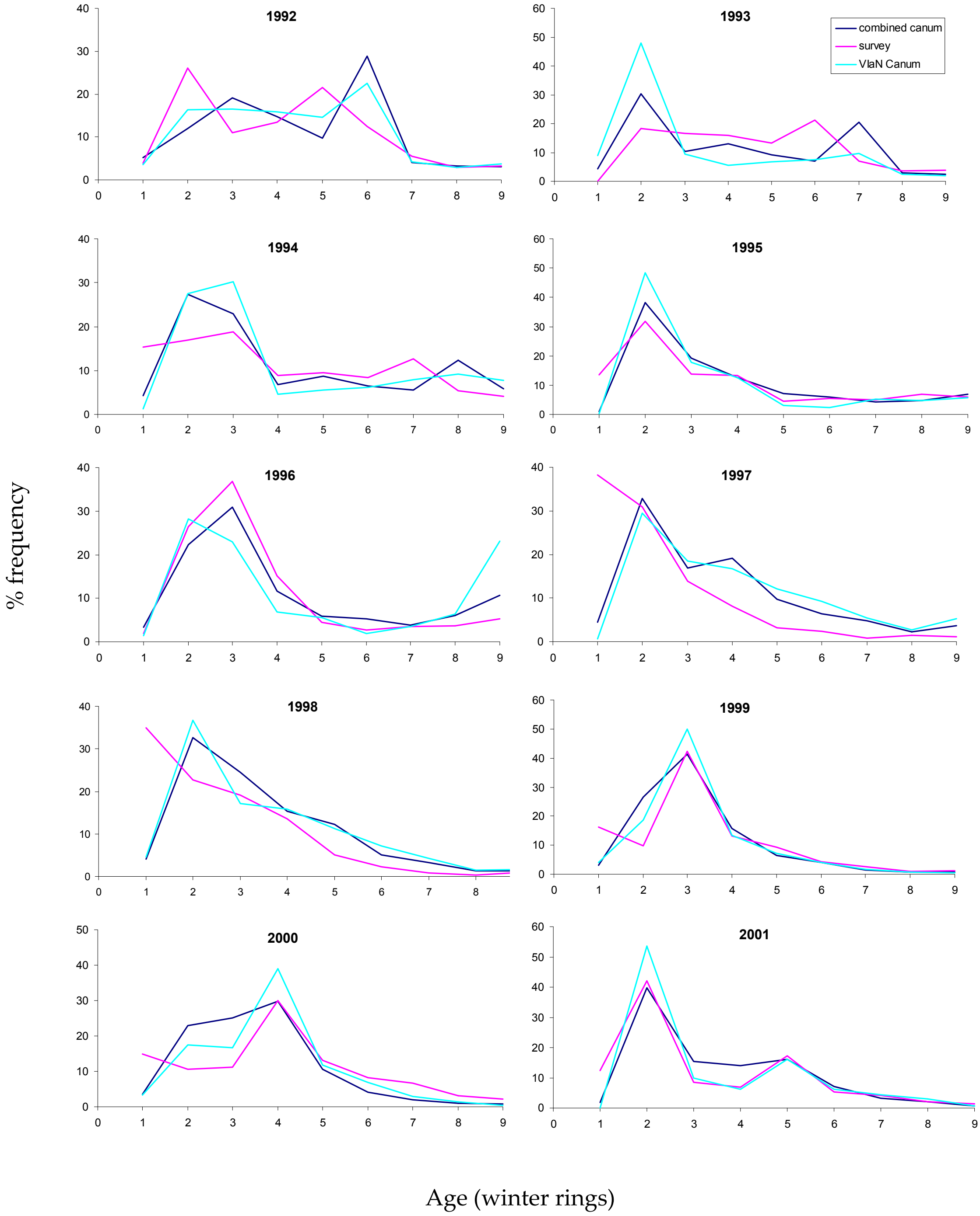

Figure 3.1.2.3. Percentage age composition in VIaN acoustic survey, VIaN catch-numbers-at-age (CNAA) and combined Malin Shelf CNAA. Age in winter rings.

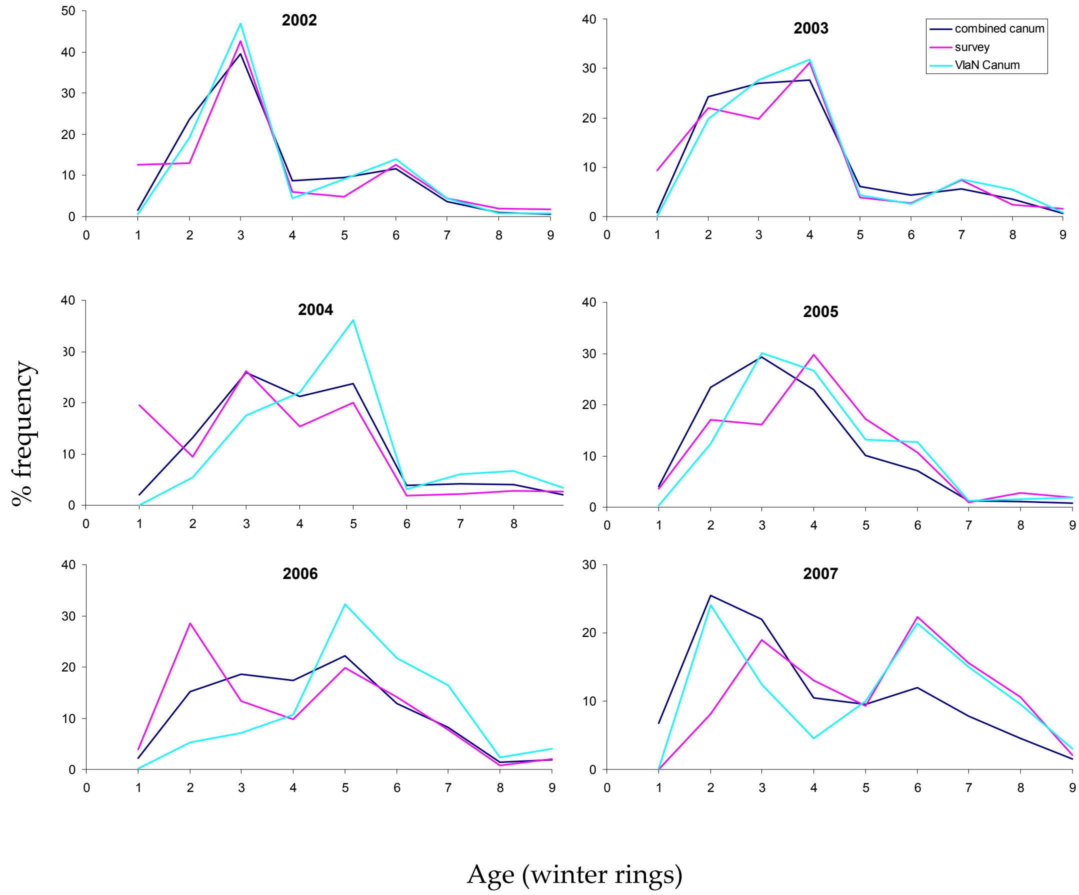

Figure 3.1.2.3. (continued). Percentage age composition in VIaN acoustic survey, VIaN catch-numbers-at-age (CNAA) and combined Malin Shelf CNAA. Age in winter rings.

Substantial herring abundance south of 57°N was found from 1992 to 1999 and from 2002 to 2003, and again in 2008 (Figure 3.1.2.2). In total this pattern was found in 10 years. In 7 of those years the combined CNAA had better agreement with the VIaN survey than the VIaN CNAA. Good agreement between all three dataseries was found only in 2 of those years. This may indicate that the VIaN survey picks up herring from the other stocks in those years. Further evidence of this is demonstrated by the good agreement between the VIaN survey and CNAA in those years when fewer fish were found south of 57°N.

The strong 1985 year class present in VIaS/VIIbc was evident in the combined CNAA, but not in the VIaN survey. Interestingly, both the strong 1981 and 1985 year classes from VIaS/VIIbc were also strongly evident in the catch numbers-at-age for VIaN from 1987 to 1994 (data in ICES files). Either these cohorts were also strong in the VIaN stock, or they were mixing with local fish in the fishery in that area.

These comparisons illustrate that there is not full coherence between the existing VIaN survey and the VIaN catch numbers at-age. However the coherence with the survey and combined Malin Shelf CNAA is lower. There is evidence that fish from the more southern stocks occur in the VIaN area. Further work needs to be done. In particular, the Firth of Clyde CNAA must be included in the Malin Shelf data.

3.1.3 Utility of a combined survey

It can be concluded that the existing surveys on the Malin Shelf are not completely adequate for tuning either their respective stocks or the combined stock complex. The spatial extent of the different complexes and the degree of mixing is difficult to assess. A combined survey would encapsulate more of this variability. Therefore the work of developing a Malin Shelf survey should continue. Such a survey does not prejudice the continuation of the VIaN survey nor the use of that survey for tuning the VIaN stock assessment, which should be continued until it can be replaced by better combinations of catch and survey data.

3.1.4 Towards a Malin Shelf survey

Experience from 2008 allows some decisions to be made about the design of the Malin Shelf survey in future years. There is a need for increased coordination during the planning and data collection phases. This will take place in 2009 and will improve the efficiency of the survey design and data collation. In particular, it is recommended that a survey supervisor be appointed and that pre- and post-survey liaisons take place under the *aegis* of PGIPS (replaced the PGHERS name).

Until a series of a Malin Shelf synoptic survey is available, the integrity of the existing surveys should be maintained. This will mean that they can be/continue to be used for tuning of the three separate stocks. In future, when several years are available a fully tuned assessment of the stock complex can be explored.

Future synoptic surveys should give some consideration to covering the following areas that were not covered in 2008:

Galway Bay Porcupine Shelf west to 12°W	Herring located here from 1994 to 1996
Donegal Bay	Herring located here from 1994 and 1995
Dubh Artach to Firth of Lorne East of Isles of Coll and Tiree Inner Minch inside isles of Rum, Eigg and Canna	Not always surveyed before

The inshore areas above may only contain juveniles and may not be useful for a future tuning index. However, they should be covered at least once, to achieve a synoptic snapshot of the stock complex. The lack of fish in VIIb,c in 2008 suggests that less time be spent there in future, but with broader transect spacing extending to 12°W.

3.2 Exploration of a combined assessment of the three stocks and an investigation of its utility for advisory purposes

3.2.1 Compilation of a common dataset

In order to facilitate a common assessment of the various stock units that constitute the Malin Shelf metapopulation, it was necessary to compile a common dataset. This dataset should include the following units:

1) VIaN (incl. historical Moray Firth juvenile fishery)
2) VIaS
3) VIIaN
4) VIIb and c
5) Firth of Clyde

This was considered an approximation of the Malin Shelf metapopulation. Data for the first 3 stocks were obtained from the current ICES assessment working group files.

Data for VIaN were obtained from unpublished data used to extend the time-series for this stock, in 2004 (ICES, 2004). Before 1982, VIa was not split but was assessed and managed together. In order to extend the time-series backwards, for inclusion in ICES (2004), the catches for the entire Division (excluding the Clyde) were allocated using fleet/country based ratios. These ratios were applied to the data to obtain the most plausible catch dataset, according to what was conducted by ICES. Fleet/country catch-at-age keys were used to raise the relevant catches in VIaN and VIaS/VIIbc. Remaining unsampled catches were raised using the combined catch-at-age key for each area. This analysis was performed for VIaN (ICES, 2004), and performed for VIaS/VIIbc at this meeting.

Data for VIIbc were only available from 1967 (catch in tonnes only) and from 1970 (catch numbers). The catch in numbers data were understood to be included in the ICES files post 1970, anyway. Catch in tonnes for VIIbc were included in the combined dataset for 1967–1970 (ICES, 1978; 1980). Catch in numbers from these Divisions were small in the 1960s and were understood to have been included in the VIa Division, as they were taken near the boundary between these areas. Fisheries in VIIb, not along the VIa boundary, only developed in the 1970s (Molloy, 2006).

Data for the Firth of Clyde were not available in electronic format, though they were available from paper records. These data were digitized from paper records during the meeting, though they have not yet been included in the combined dataset. The Clyde data were obtained from Anon. (1978); Bailey *et al.* (1986); ICES (2005). For the period 1960 to 1978 catch in numbers were available from Anon. (1978). Catch in tonnes were available for the period 1960 to 1984 (Anon, 1978; Bailey *et al.*, 1986). Catch-at-age, catch in numbers and mean weights were available for the period 1970 to 2004 (ICES, 2005). The new time-series was composed of the elements outlined in Table 3.2.1.1.

Table 3.2.1.1. Description and sources of the time-series for the Malin Shelf metapopulation of herring.

UNIT	SOURCE	YEARS
VIaN (incl. Moray Firth)	ICES Files	1970–2007
VIaS, VIIbc	ICES Files	1970–2008
VIIaN	ICES Files	1970–2009
Clyde*	Anon, 1978; Bailey *et al.*, 1986; ICES, 2005	1960–2005
VIaN (incl. Moray Firth)	Data revision 2003, raised	1961–1969
VIaS	Segregated from VIa, using allocation keys from 2003 revision	1961–1970
VIIaN	ICES files	1961–2007
VIIbc	Only catch in tonnes available	1967–1970

*** Not included in combined assessment at meeting.**

It was found that the datasets presented in Table 3.2.1.1 agreed with combined datasets used in a joint assessment of the four main western herring stocks (Nash, Presentation to ICES HAWG in 2004).

The plus group is different for VIIaN and the other areas. In the former area it was 8+, while elsewhere it was 9+. In order to maintain the 9+ group in the combined series, 50% of the VIIaN 8+ group were allocated to 9+ in the combined series.

The combined time-series developed at this meeting did not include the Clyde. These data will be added to the time-series intersessionally.

3.2.2 Combined Assessment

3.2.2.1 Data Available

	VIaN	VIaS, VIIb,c	VIIaN
Time Series	1957-2007	1970-2007	1961-2007
Age Range	1-9	1-9	1-8
Surveys	Acoustic 1989-2007		Acoustic 1994-2007 Larval 1983-2007

3.2.2.2 Data combination

The data were combined as follows:

The new canum (Figure 3.2.2.1) was created by adding the catch numbers-at-age which are recorded in thousands from each area. The new catch weight in tonnes was calculated by summing the landings reported from each area. The combined catch weights-at-age (weca) were calculated by (canum a1, y1) * (weca a1, y1) for each area. These were then summed and the total divided by the new canum. The stock weights were the currently used VIaN weights which are derived from the VIaN acoustic survey. The remaining assessment inputs used were from the 2008 VIaN assessment. The exploratory assessment was tuned using the VIaN survey which is carried out annually in July. The plus group was set at 9+. The combined time-series started in 1961.

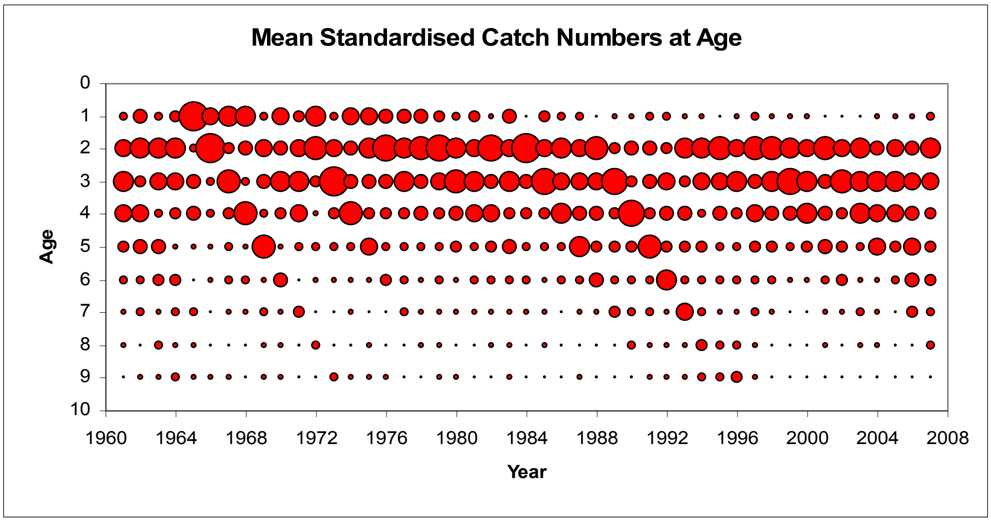

Figure 3.2.2.1. Catch numbers at-age for the combined series 1961–2007, excluding Firth of Clyde, standardized by annual mean. Age in winter rings.

3.2.2.3 Assessment

The assessment was run using FLICA with the same settings as the 2008 VIaN assessment (ICES, 2008). The diagnostics from this run (Run 1) are presented in Figures 3.2.2.2 to 3.2.2.16 below. The separable period was 8 years and selection was fixed at 1.0 relative to age 4. Additional exploratory assessments were performed and the details of these runs are presented in the text table below. These changes did not have a marked affect on the overall diagnostics.

FLICA Runs	Run 1	Run 2	Run 3	Run 4	Run 5
Separable Period	8	6	10	8	8
Reference Age	4	4	4	4	4
Selection at oldest age	1	1	1	1	1
Plus group	9+	9+	9+	9+	8+
Surveys	All	All	All	No 05 survey	All

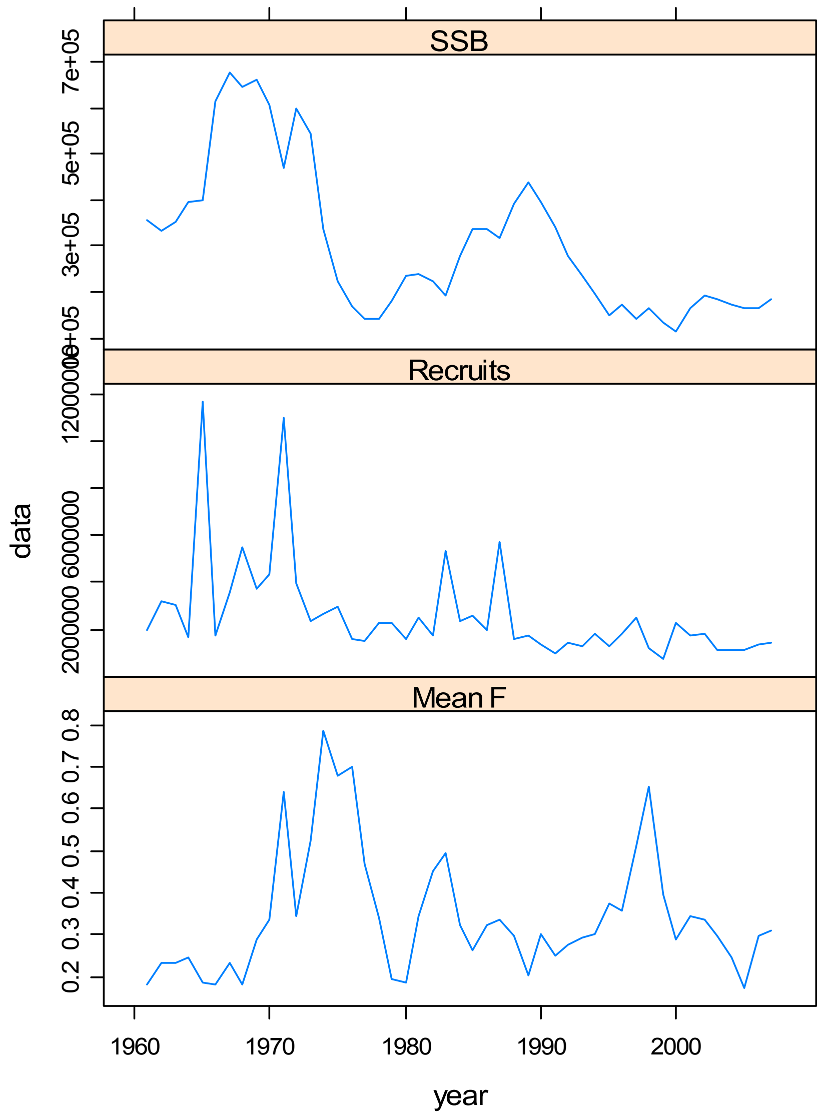

Figure 3.2.2.2. Run 1. Combined assessment SSB, Recruits and Mean F ages 3–6 (winter rings).

The assessment produced using the combined data has certain advantages over the individual assessments. The assessment could be expected to encompass more of the interstock variability as a result of lack of containment within the stock boundaries. Also, the difference between the survey and modelled abundances (the catchability) is less than for the VIaN survey. The catchability of the VIaN acoustic survey in the combined assessment was around 2. In the VIaN assessment, this survey has a catchability of about 4, which is higher than in other herring assessments (Celtic Sea, North Sea and Irish Sea). This indicates that the inclusion of additional catch from the VIaS/VIIb c and VIIaN stocks was an improvement. Each run displays a similar pattern for SSB, Mean F and Recruitment. The magnitude and location of the catch residuals is similar also, with 2005 revealing the largest residuals in each scenario. The residuals produced are smaller overall than from single-stock assessments.

Examination of the diagnostics displays that the observed and fitted time-series are noisy for younger ages. It can also be seen that from age 5 to age 9 there is a mismatch between the fitted index and the observed index. This may be because the acoustic survey did not pick up the strong 1985 year class evident in the combined catch data.

A retrospective analysis of the combined assessment tuned by the VIaN survey is given in Figure 3.2.2.16. This displays repeated downward revision of SSB and upward revision of F over the last 8 years. This is in contrast to the VIaN assessment (ICES, 2008) which has a more balanced retrospective pattern. The poor retrospective pattern produced in each scenario may be as a result of the partial coverage of the single tuning series used. In most years this survey does not extend as far as VIaS/VIIbc or VIIaN. Another possibility is that the selection pattern assumed for the fishery, which is the same as for VIaN, may not represent the combined fishery. Further work in this area is required. In 2008 the first synoptic survey covering the whole area was carried out and its utility will be further investigated as a longer time-series becomes available. Until a sufficient time-series of such a synoptic survey is available the only available survey is that for VIaN. However, this was shown to comprise components of all of the stocks in the metapopulation during the survey in two years (2003 and 2004) (Campbell *et al.*, 2007; Hatfield *et al.*, 2007).

The combined assessment is a first step in a process. Some of the findings of the assessment are encouraging, but further work is required before the assessment could be used as a basis for the formulation of management advice.

The next steps in this work are to:

- Include data for the Firth of Clyde historical fishery
- Investigate further the reasons for the retrospective bias
- Explore a range of settings for separable period
- Investigate which ages are most appropriate for tuning

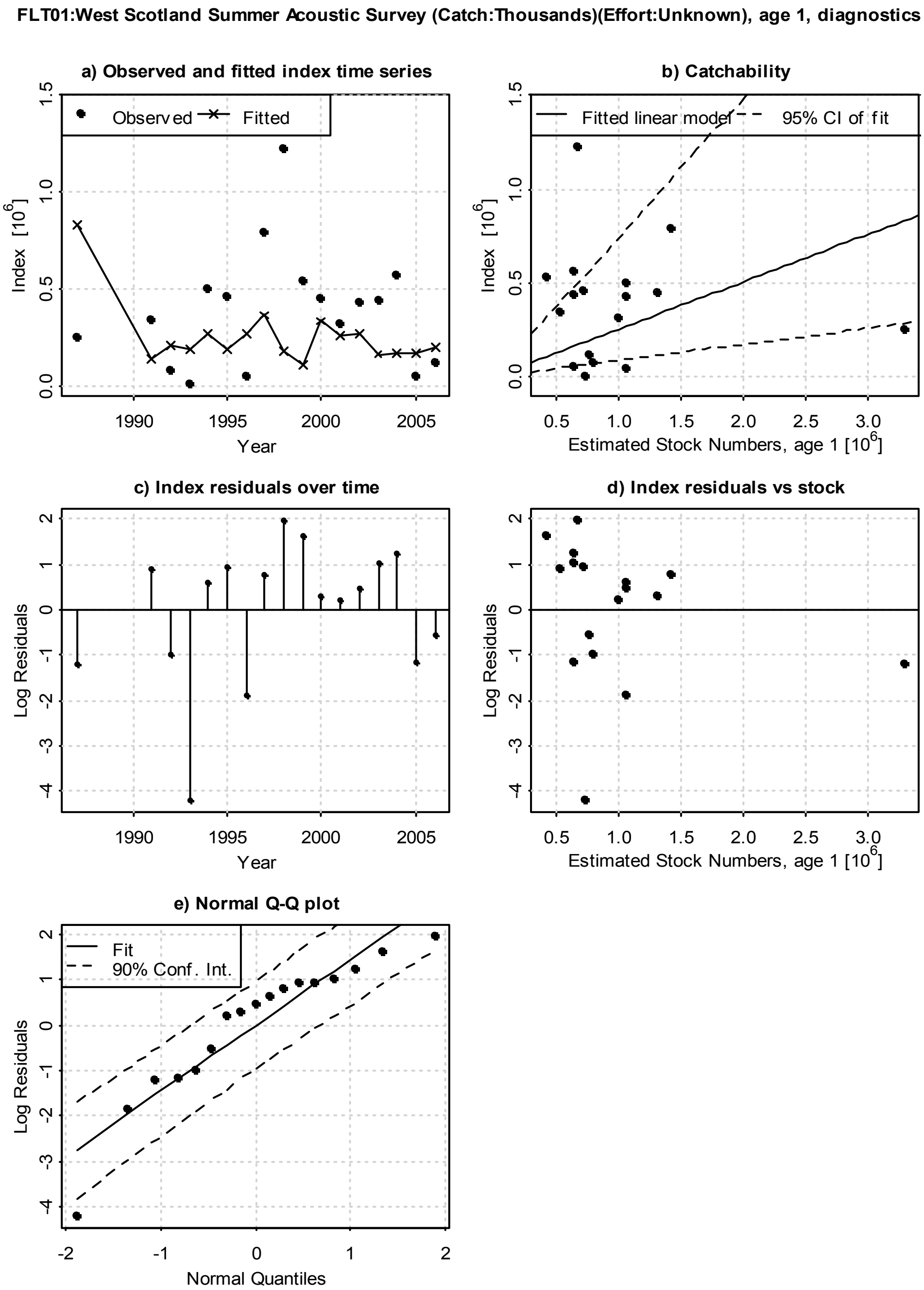

Figure 3.2.2.3. Run 1. Combined Assessment. Diagnostics of the VIaN acoustic survey fit at 1 wr from the FLICA assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations vs. FLICA estimates of stock numbers at-age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at-age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

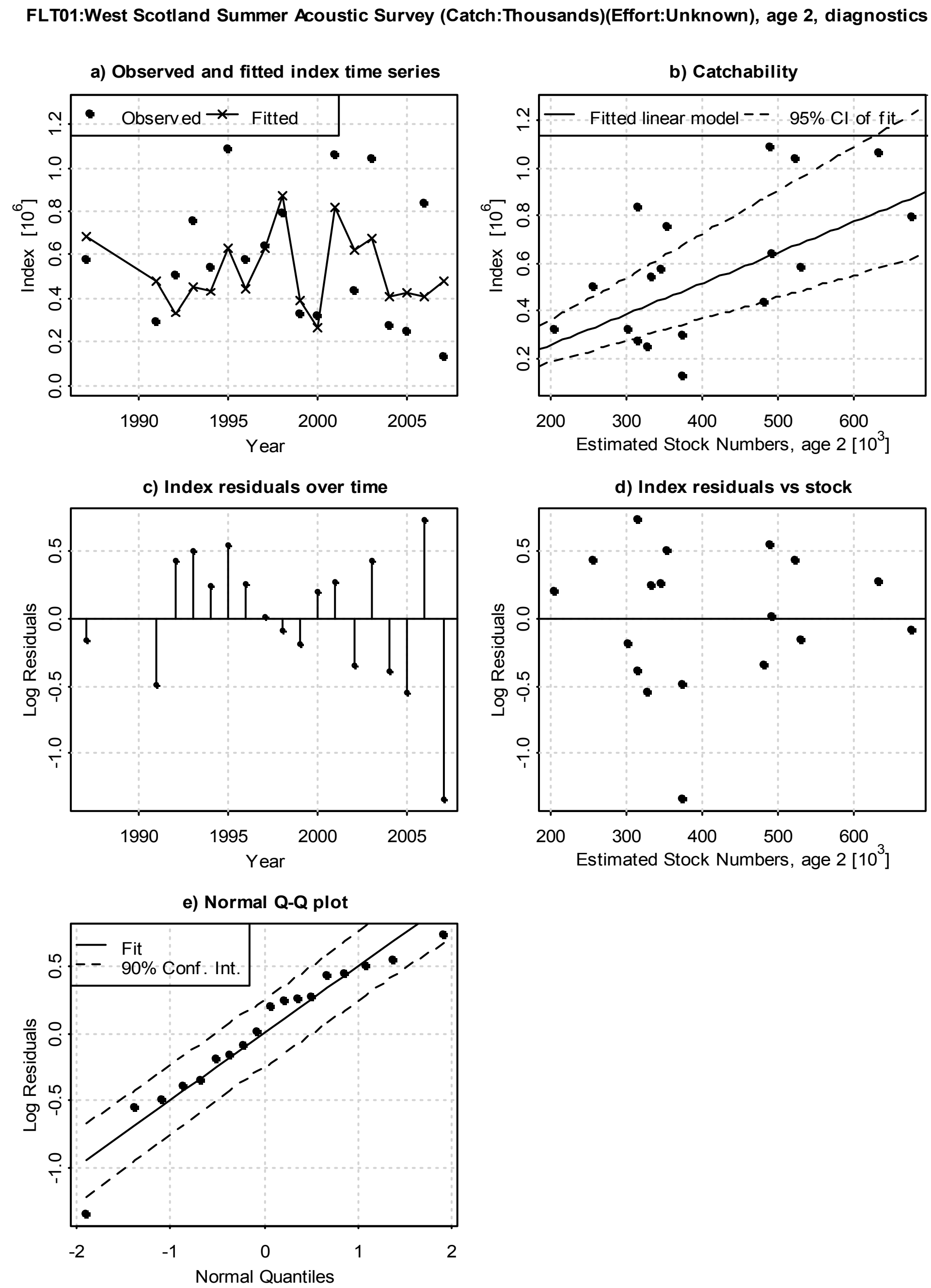

Figure 3.2.2.4. Run 1. Combined Assessment. Diagnostics of the VIaN acoustic survey fit at 2 wr from the FLICA assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations vs. FLICA estimates of stock numbers at-age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at-age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

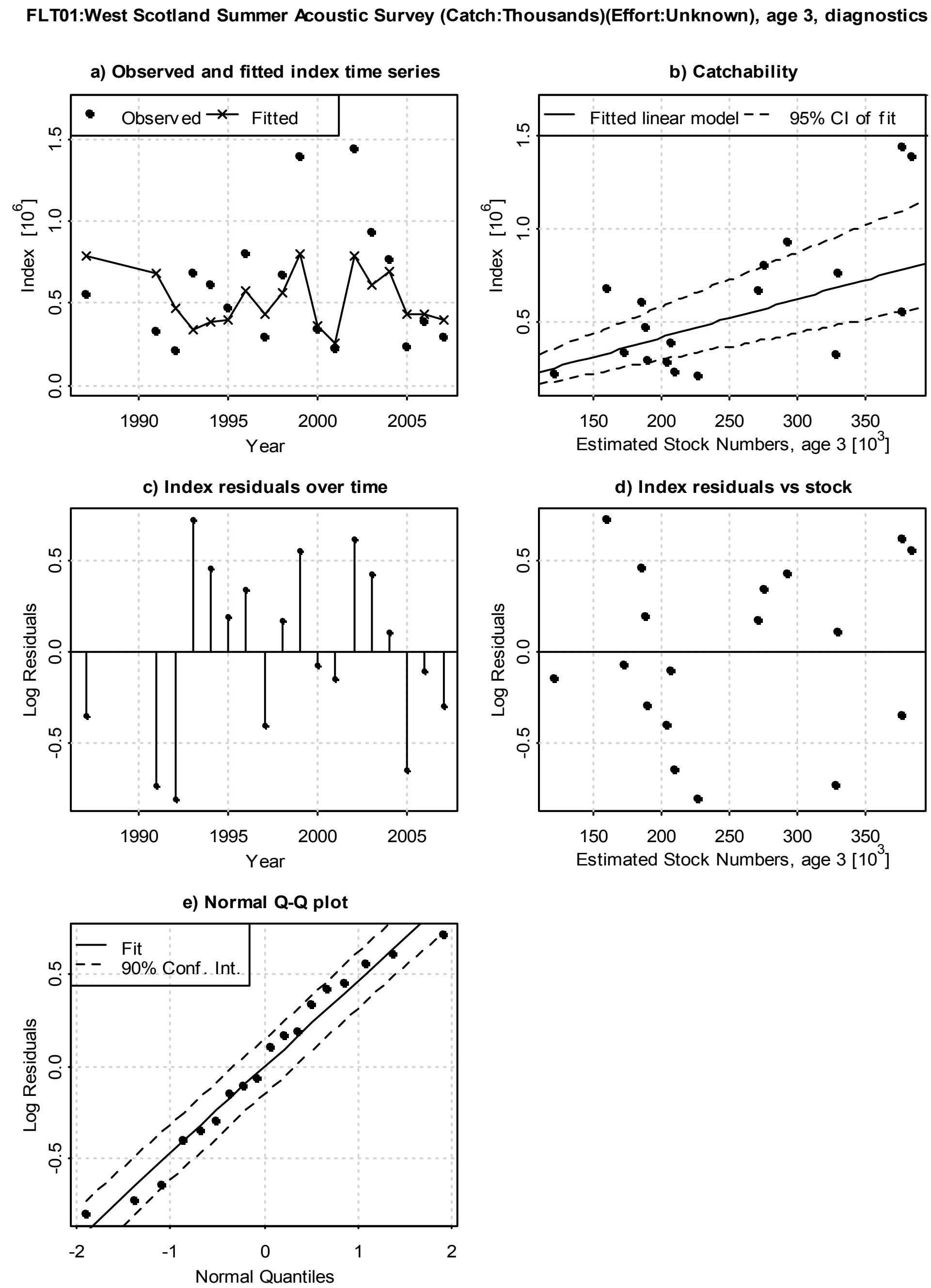

Figure 3.2.2.5. Run 1. Combined Assessment. Diagnostics of the VIaN acoustic survey fit at 3 wr from the FLICA assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations vs. FLICA estimates of stock numbers at-age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at-age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

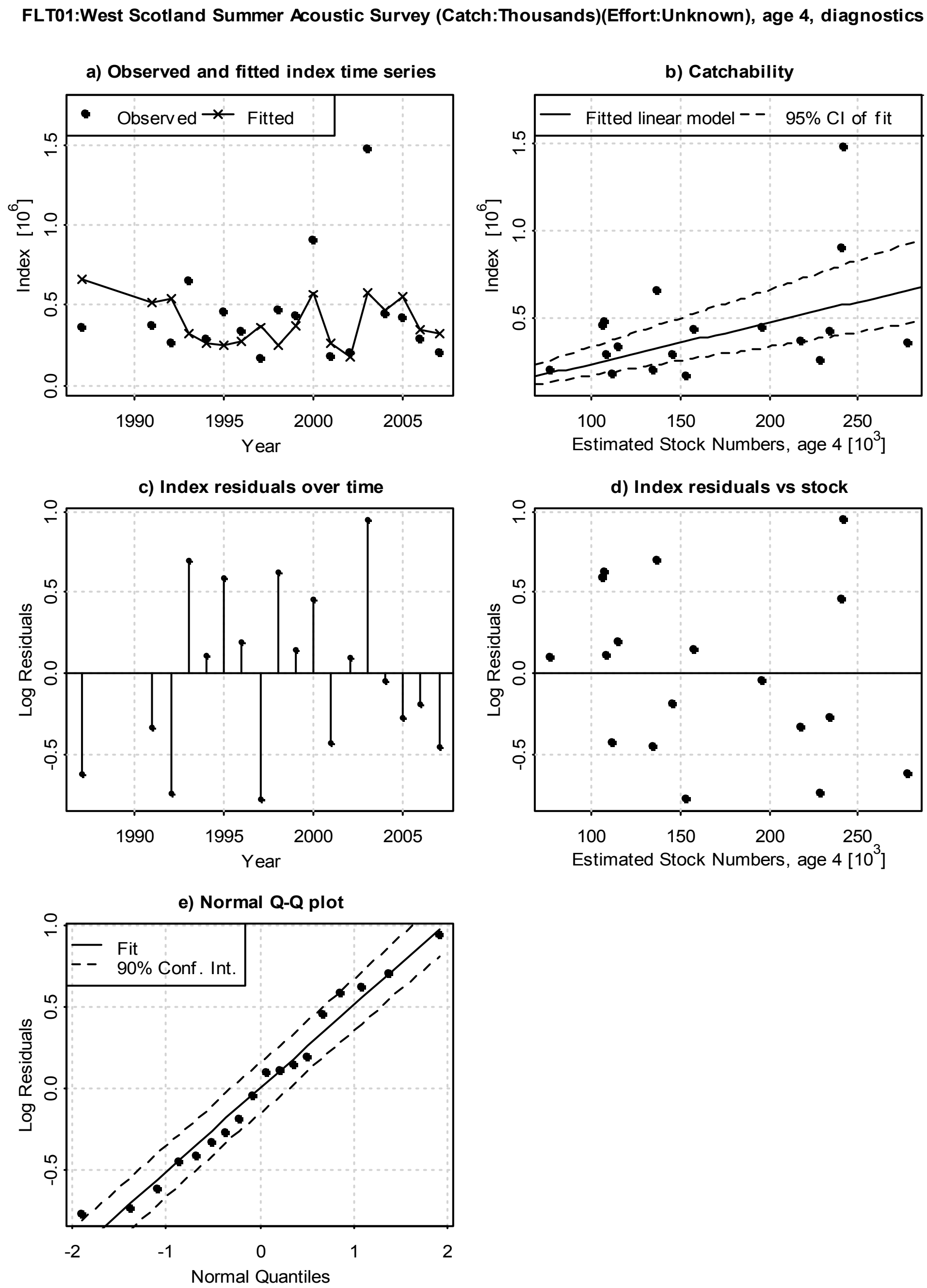

Figure 3.2.2.6. Run 1. Combined Assessment. Diagnostics of the VIaN acoustic survey fit at 4 wr from the FLICA assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations vs. FLICA estimates of stock numbers at-age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at-age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

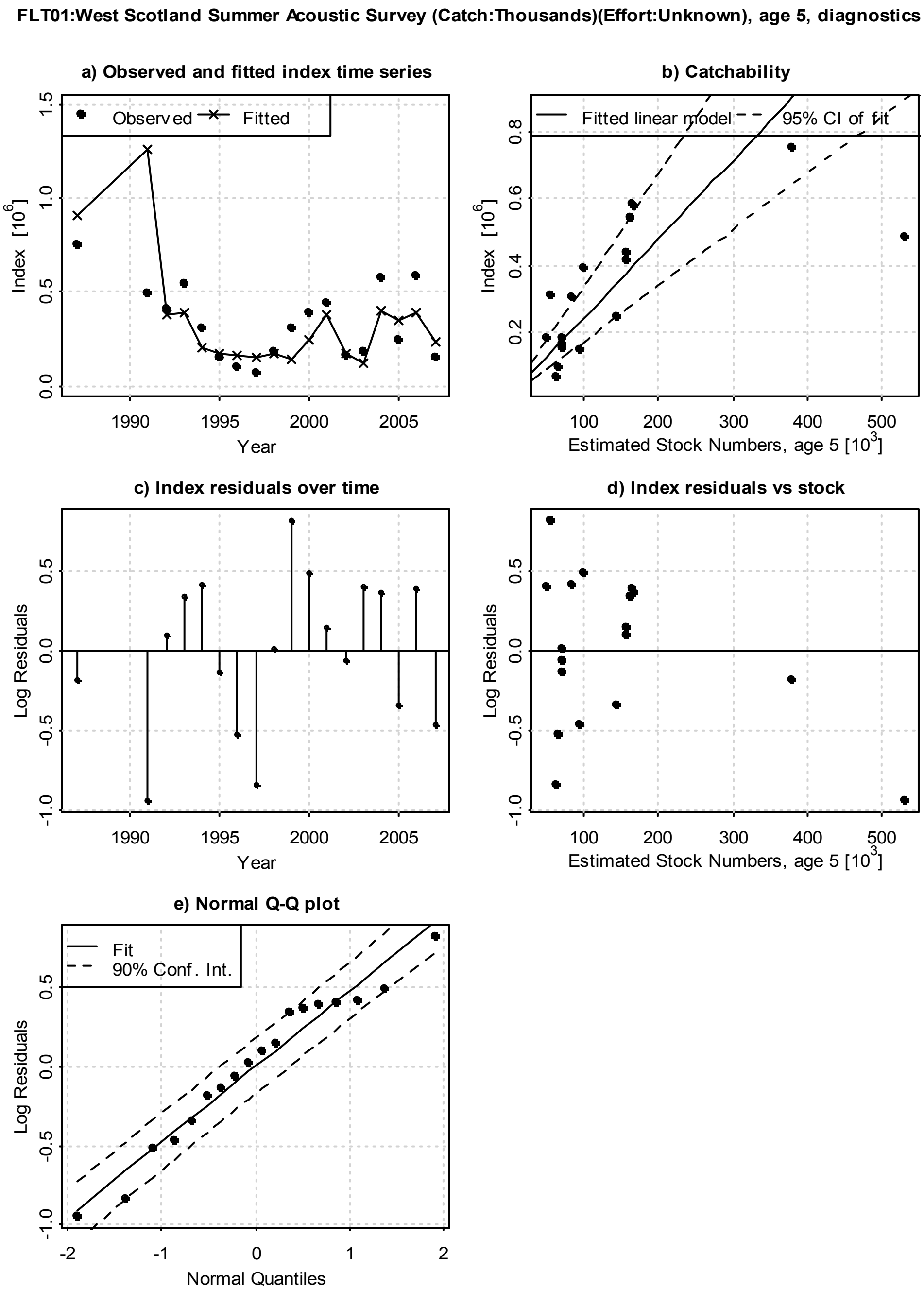

Figure 3.2.2.7. Run 1. Combined Assessment. Diagnostics of the VIaN acoustic survey fit at 5 wr from the FLICA assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations vs. FLICA estimates of stock numbers at-age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at-age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

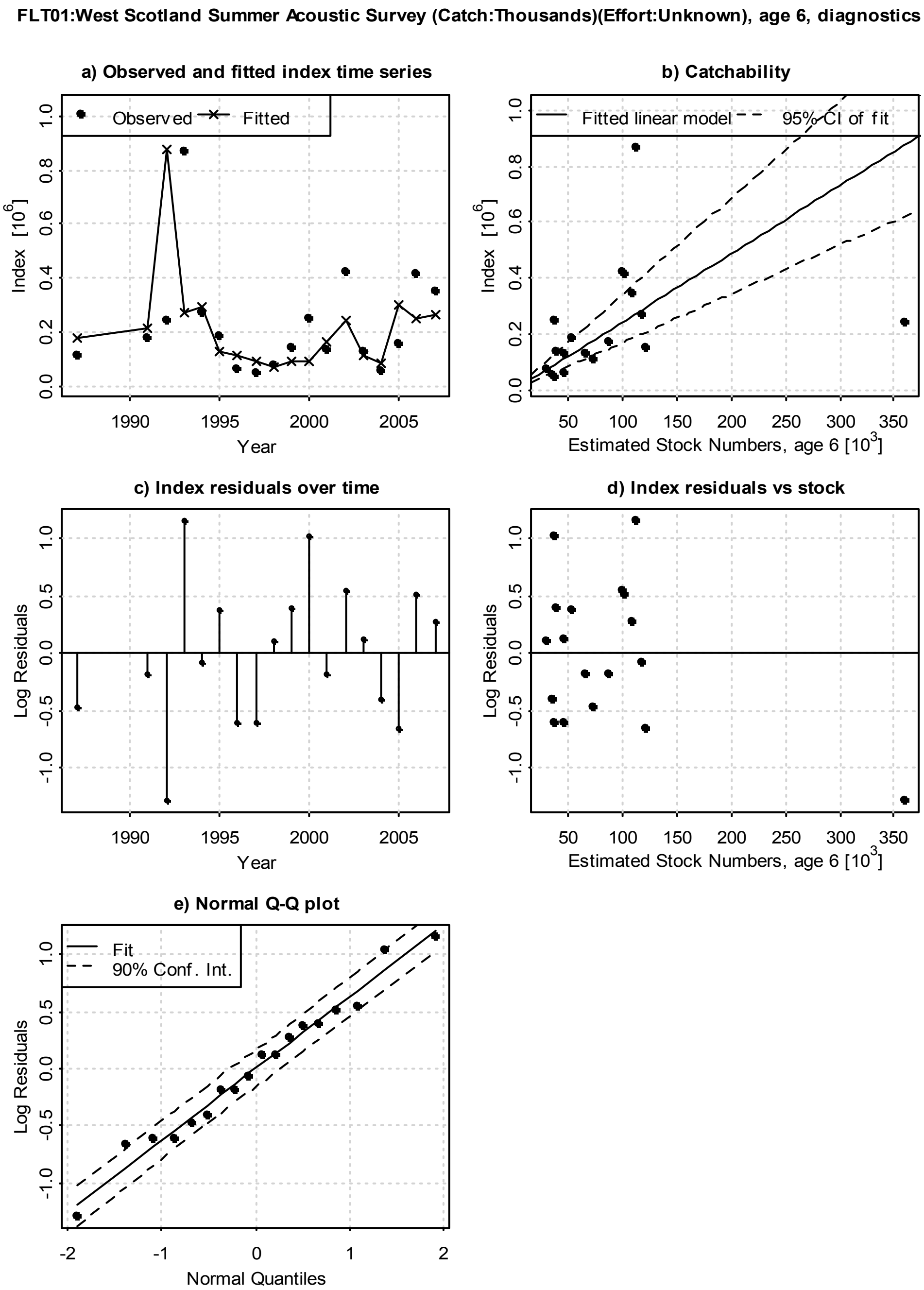

Figure 3.2.2.8. Run 1. Combined Assessment. Diagnostics of the VIaN acoustic survey fit at 6 wr from the FLICA assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations vs. FLICA estimates of stock numbers at-age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at-age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

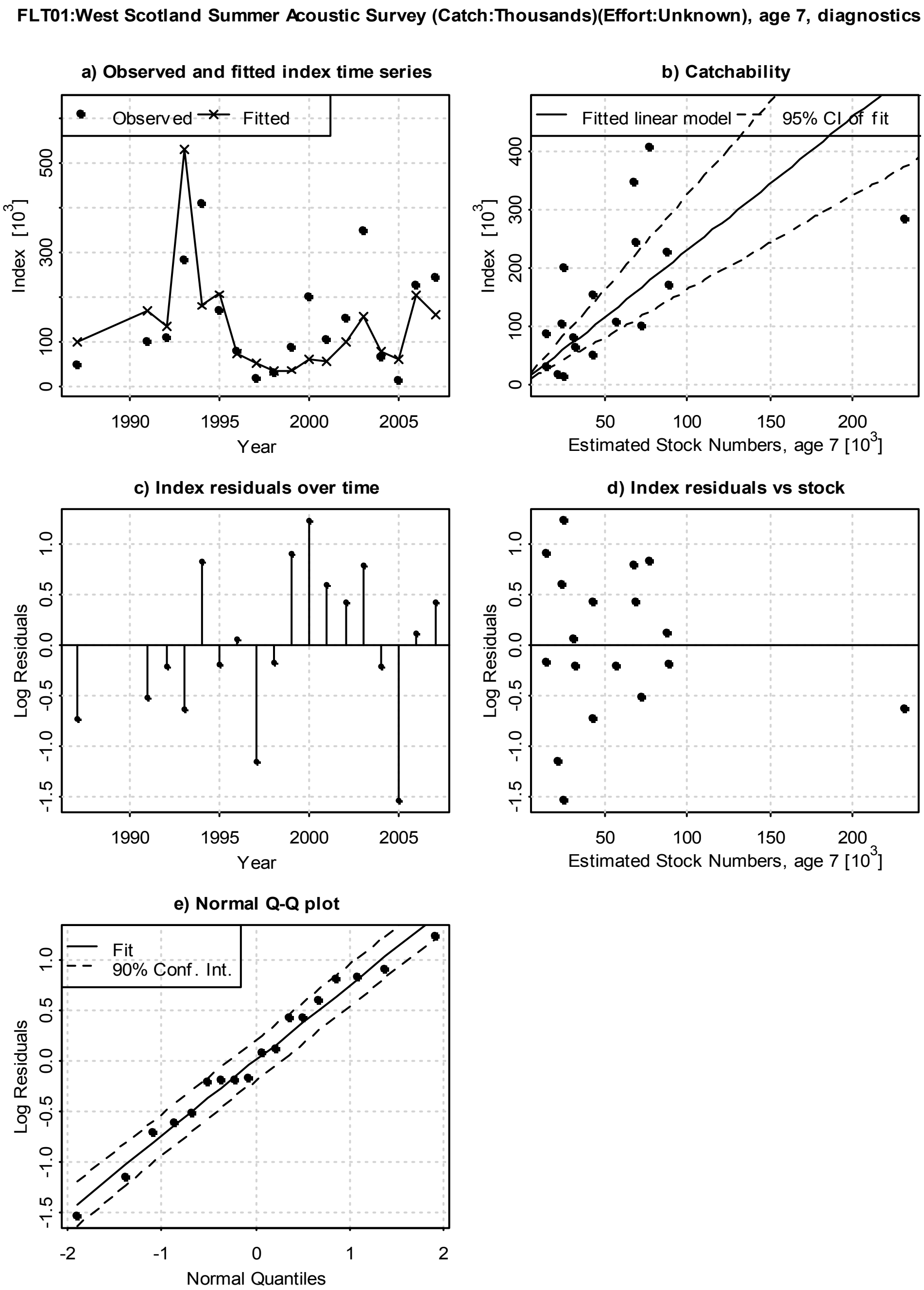

Figure 3.2.2.9. Run 1. Combined Assessment. Diagnostics of the VIaN acoustic survey fit at 7 wr from the FLICA assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations vs. FLICA estimates of stock numbers at-age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at-age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

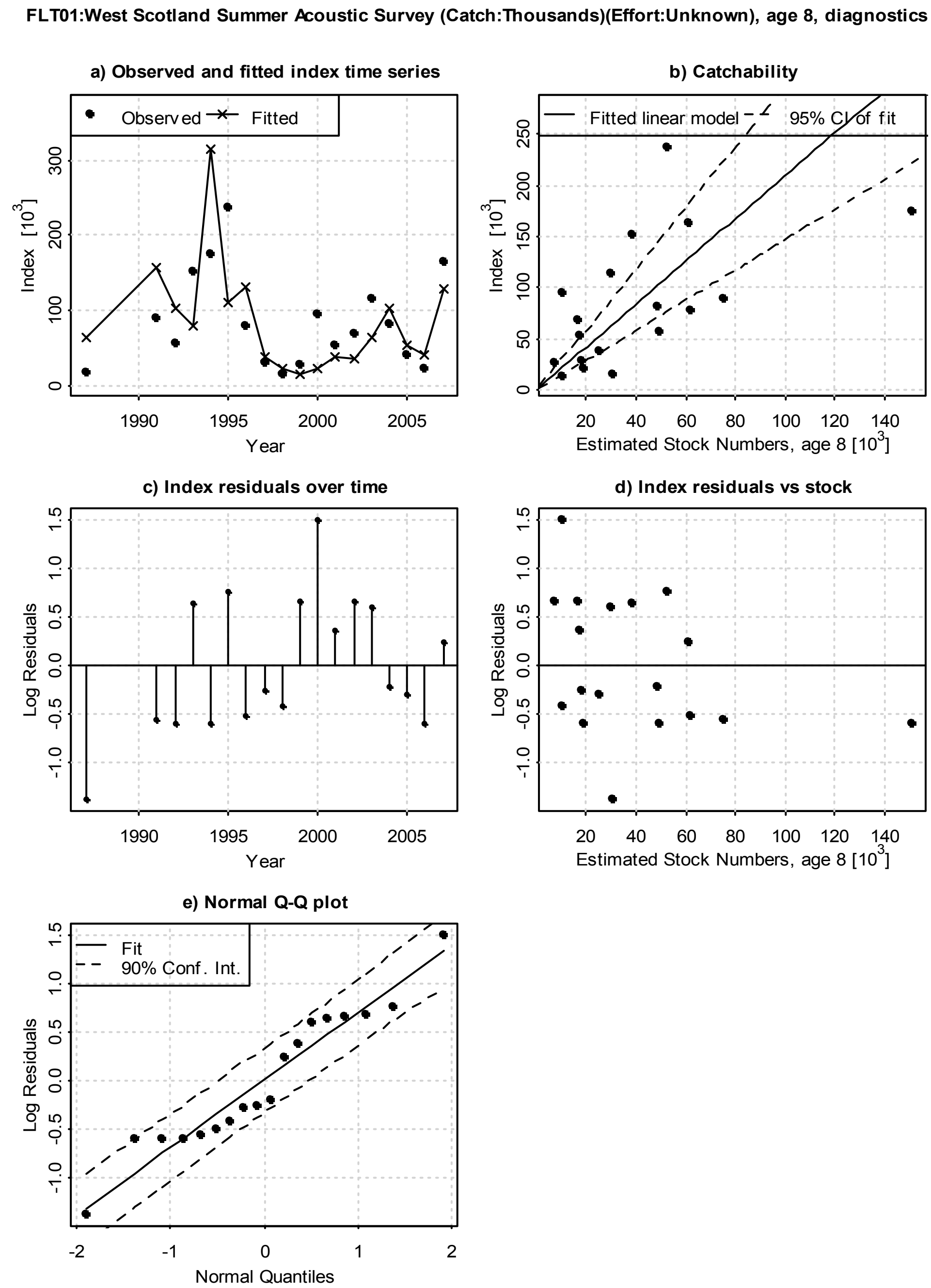

Figure 3.2.2.10. Run 1. Combined Assessment. Diagnostics of the VIaN acoustic survey fit at 8 wr from the FLICA assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations vs. FLICA estimates of stock numbers at-age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at-age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

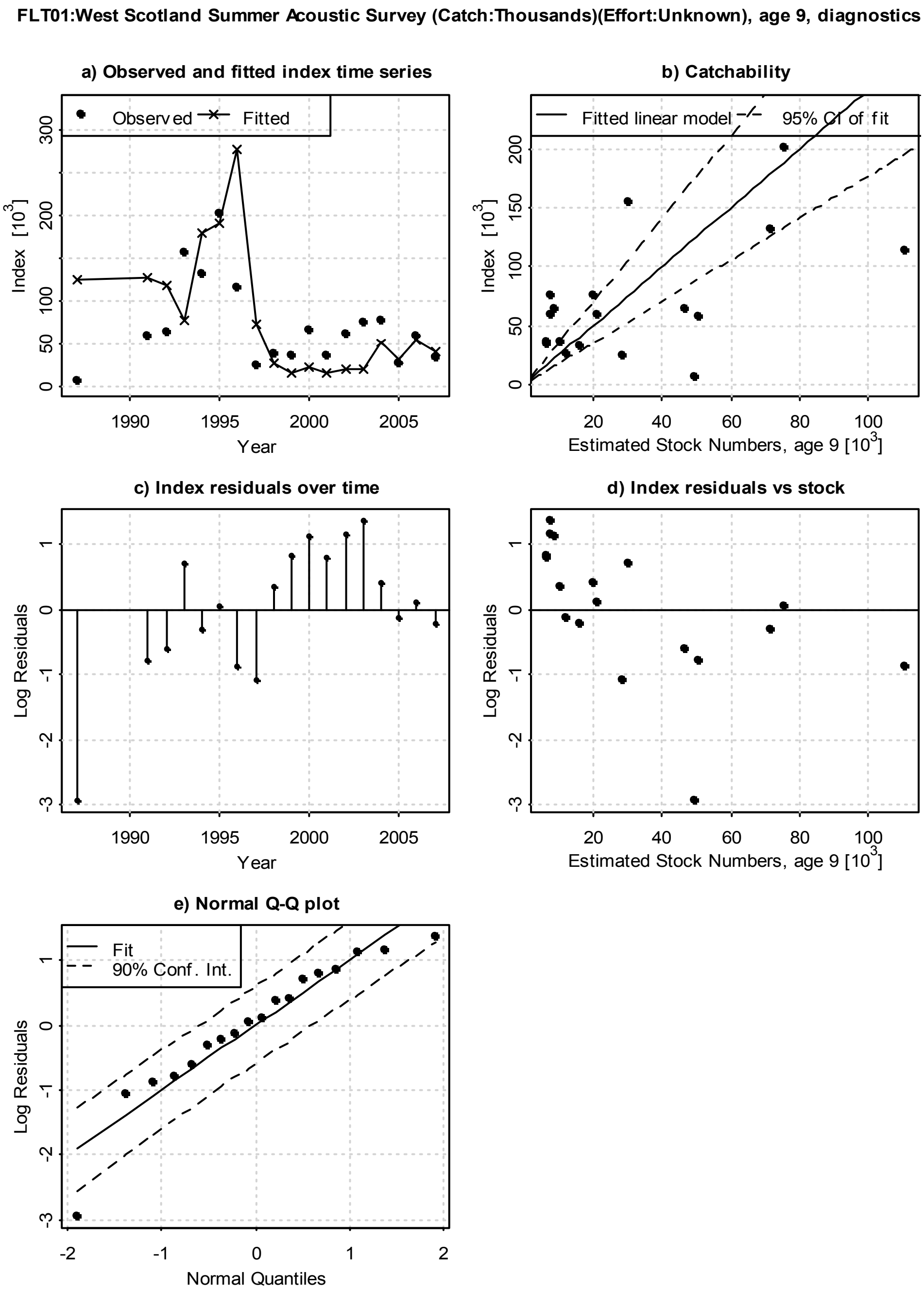

Figure 3.2.2.11. Run 1. Combined Assessment. Diagnostics of the VIaN acoustic survey fit at 9 wr from the FLICA assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations vs. FLICA estimates of stock numbers at-age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at-age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

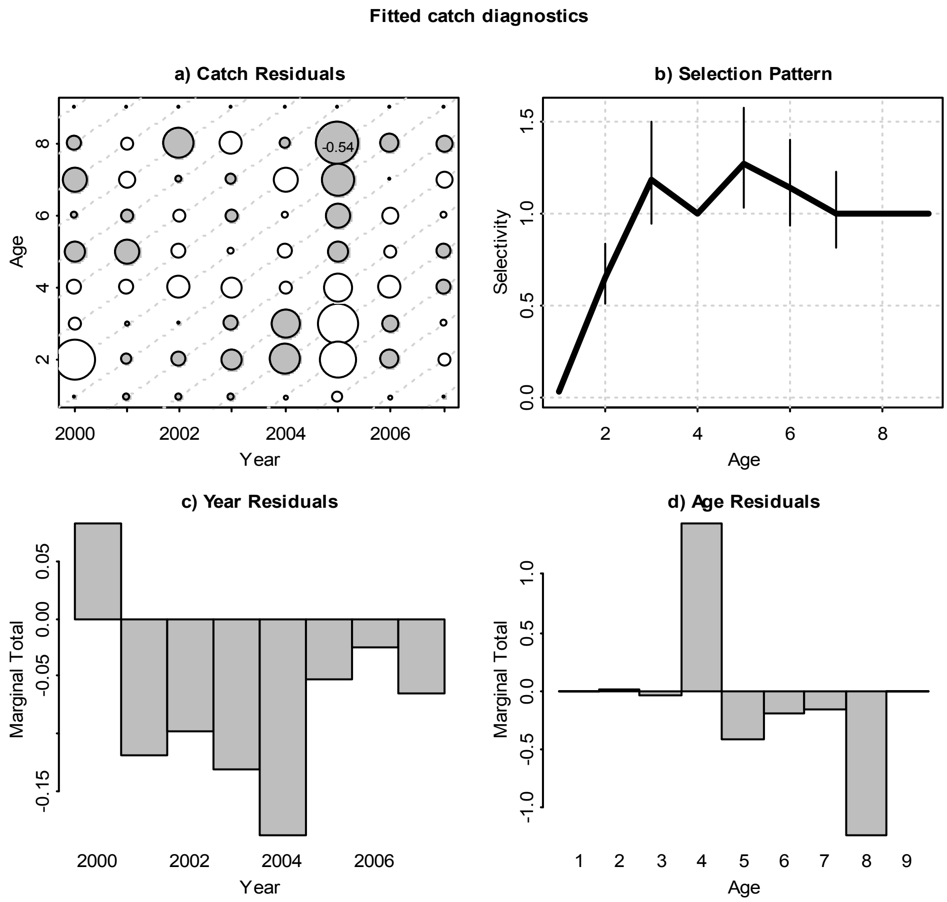

Figure 3.2.2.12. Run 1. Combined Assessment. Catch diagnostics from FLICA. a) Bubble plot of log catch residuals by age (weighting applied) and year. Grey bubbles correspond to negative log residuals. The largest residual is given. b) Estimated selection parameters (relative to 4 wr) with 95% confidence intervals. c): Marginal totals of residuals by year. d). Marginal totals of residuals by age (wr).

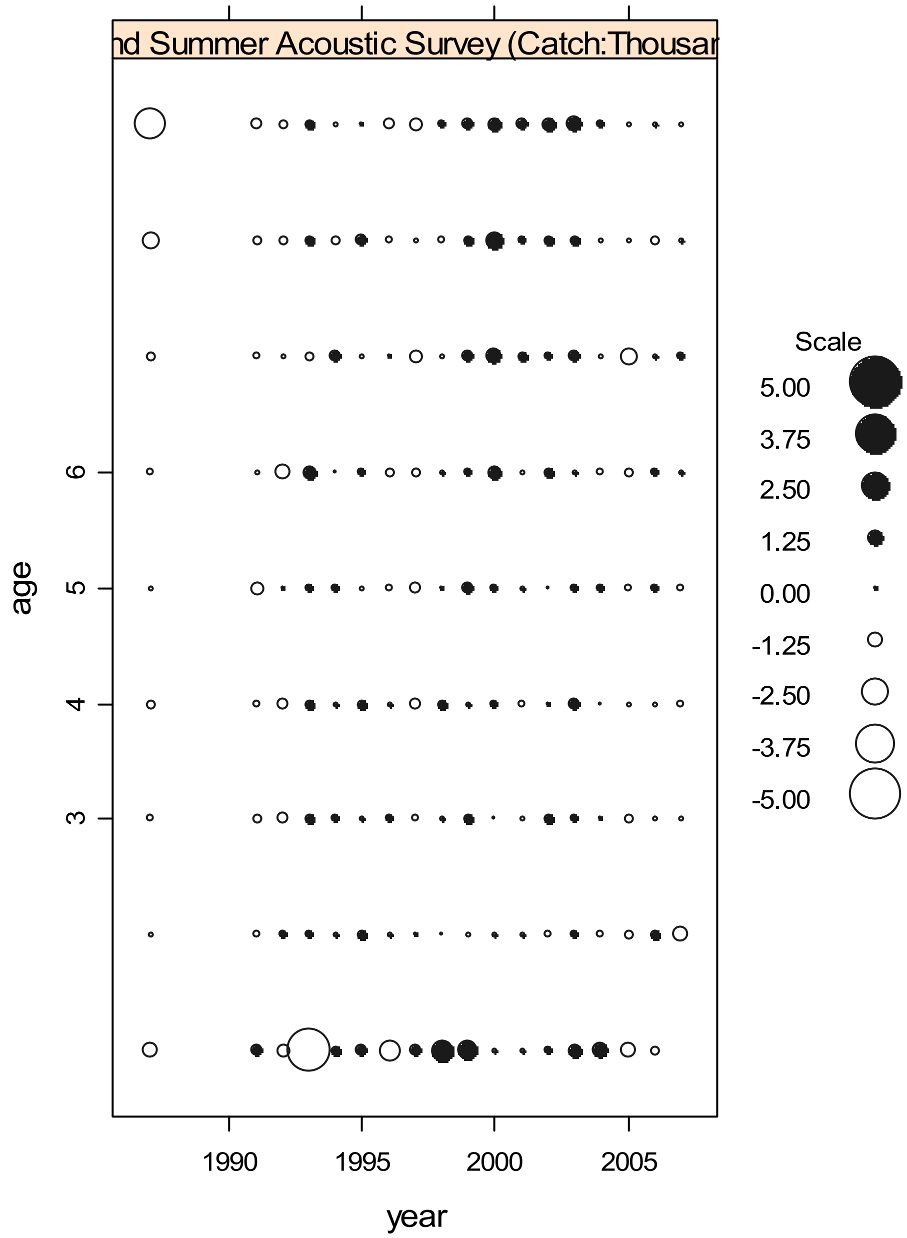

Figure 3.2.2.13. Run 1. Combined Assessment Survey residuals from the VIaN Summer acoustic survey

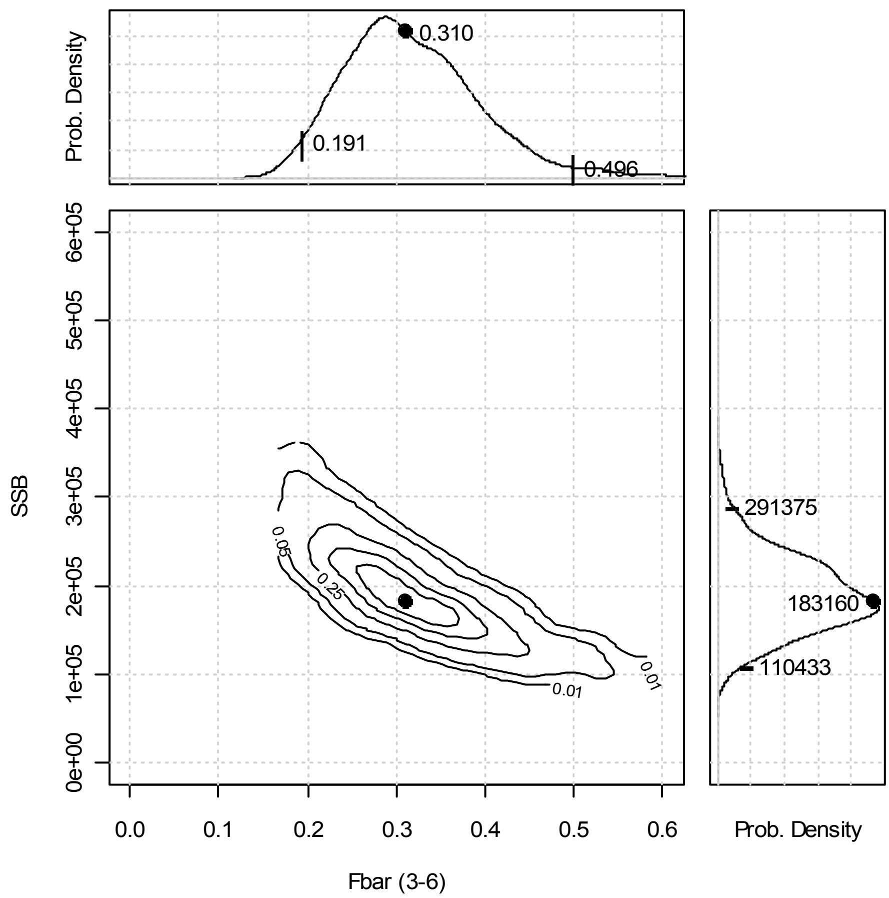

Figure 3.2.2.14. Run 1. Model uncertainty; distribution and quantiles of estimated SSB and F in the terminal year of the assessment. Estimates of precision are based on a parametric bootstrap from the FLICA estimated variance/covariance estimates from the model.

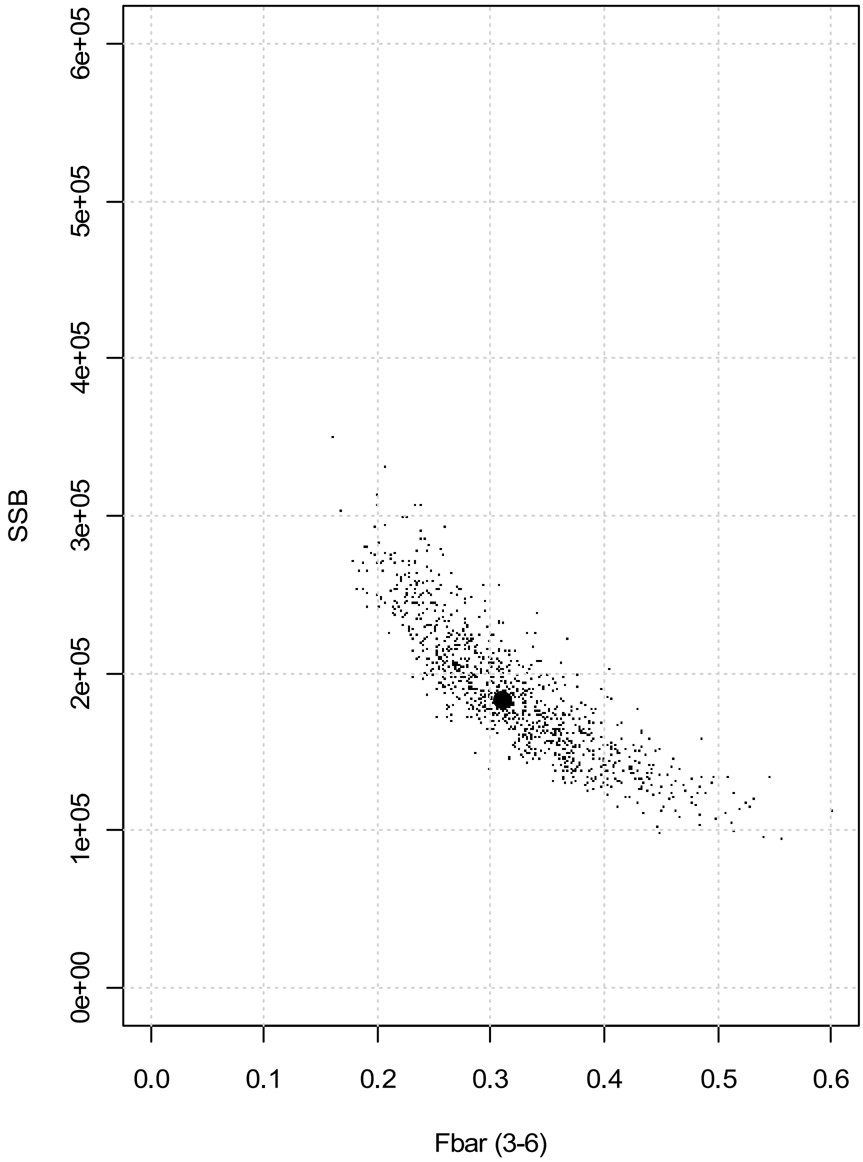

Figure 3.2.2.15. Run 1. Combined Assessment Estimates of Fbar and SSB in the terminal year.

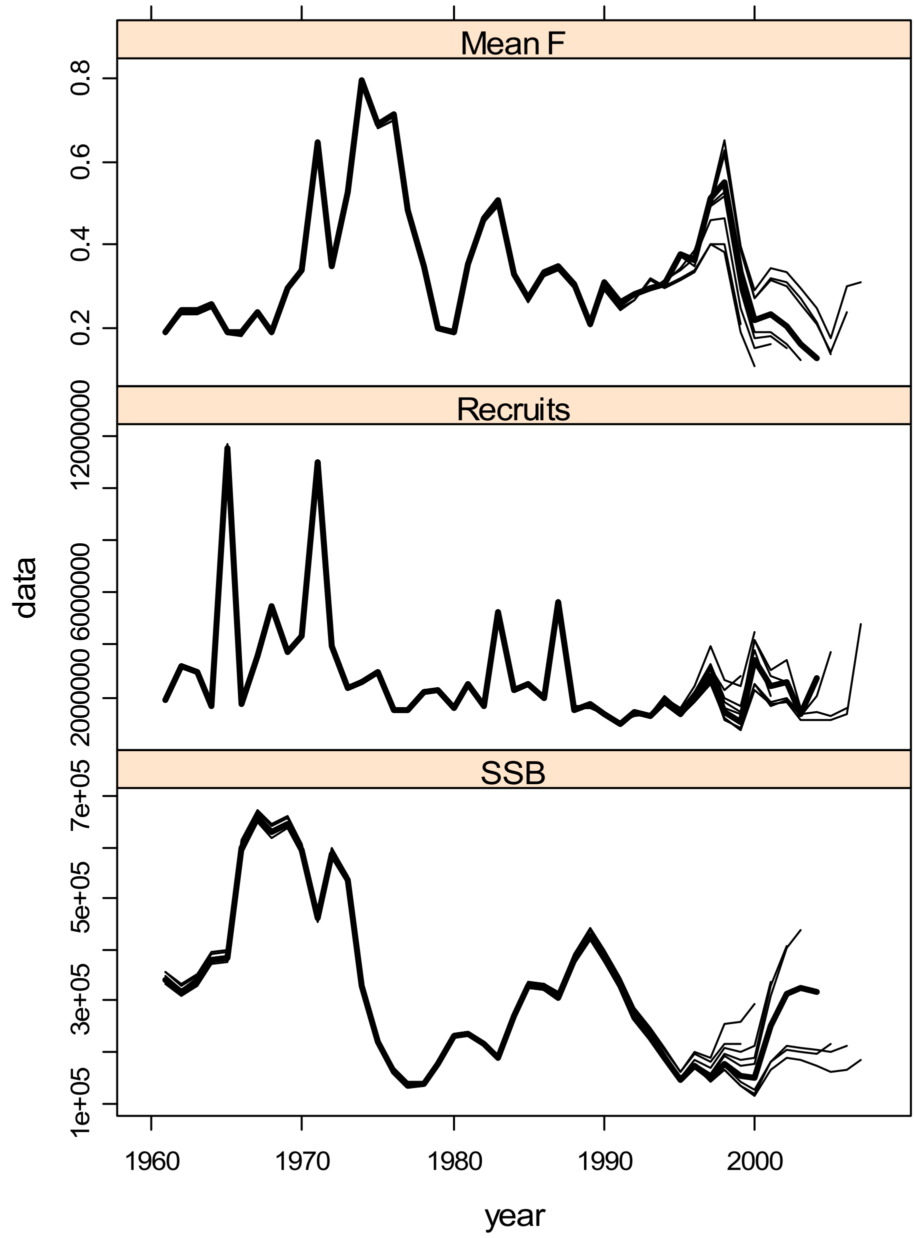

Figure 3.2.2.16. Run 1. Retrospective pattern in the combined assessment.

3.3 Evaluation, through simulation, of alternative management strategies for the metapopulation of VIaN, VIaS and VIIaN

Assessing components of metapopulations individually, that mix at different stages of their life cycle, poses problems because the assumptions made by conventional assessment procedures are violated (e.g. a stock is a closed unit, data used in assessments are representative of the entire stock). Stock mixing and history of exploitation and the effects of lumping or splitting stocks in the assessment can be best investigated by means of simulation. Through these simulations, alternative management options can be evaluated.

The FLR framework (Kell *et al.*, 2007; www.flr-project.org) for management strategy evaluation (MSE) has recently been used to build an operating model (OM) that can represent alternative hypotheses about stock and fishery dynamics, allowing a higher level of complexity and knowledge than used by stock assessment models. An observation error model is then used to sample pseudo-data from the OM, and to perform a stock assessment (Kell *et al.*, submitted; presented to the 2008 Linking Herring symposium in Galway, Ireland). In the specific case of herring populations to the west of the British Isles, four populations were constructed on the basis of their spawning behaviour, i.e. herring in VIaN, VIaS/VIIbc, Irish Sea and Celtic Sea. Additionally, four fisheries were prosecuted during the feeding migrations when the spawning populations overlap to different extents. A generic configuration, slightly different from the herring population configuration to the west of the British Isles was initially used to test broad assessment approaches.

The four fisheries operate in particular areas and seasons, which determine the availability of a population to a fishery (see Section 3.3.1.1). Given the selection pattern (*S*) of a fishery, and the catchability (*q*) of a population for a given effort (*E*), the fishing mortality-at-age *a*, for year *y*, fishery *i*, and population *j* is given by

$$F_{a,y,i,j} = E_{y,i} q_{y,j} S_{a,i,j} A_{a,i,j} \quad (1)$$

where *Aa,i,j* is the availability of population *j* at age *a* to fishery *i*.

The population abundance at age *a*+1, at the start of year *y*+1, in population *j*, is given by

$$N_{a+1,y+1,j} = \sum_{k \neq j} N_{a,y,k} \mathrm{e}^{-Z_{a,y,k}} D_{a,k \to j} + N_{a,y,j} \mathrm{e}^{-Z_{a,y,j}} (1 - \sum_{k \neq j} D_{a,j \to k}) \quad (2)$$

where *Za,y,j* and *Za,y,k* correspond to the total mortality-at-age *a*, by year *y* and populations *j* and *k*, respectively, $D_{a,k \to j}$ corresponds to the diffusion proportion of population *k* into population *j* at age *a*, and $D_{a,j \to k}$ is the equivalent from population *j* into population *k*. We assume that diffusion takes place just after the start of the year, followed by mortality.

A Beverton and Holt (1957) stock/recruitment relationship was assumed:

$$R = \frac{\alpha S}{S + \beta} \quad (3)$$

where *R* is recruitment, *S* the spawning-stock biomass and *α* and *β* are estimated stock-specific parameters.

The stock assessment procedure combined a particular sampling regime and stock assessment technique. The sampling regime, the "Observation Error Model", is simulated by generating total catch-at-age and indices of abundance from the simulated fisheries and populations. Timing of the indices of abundance was either (i) during spawning or (ii) during fishing. The former represents an unbiased estimate of the spawning population; the latter an index of abundance of the stocks caught in each fishing area (i.e. at the time of mixing). In both cases, a single series that covered all the age ranges in the population was constructed assuming a lognormal observation error with a CV of 30%.

A single assessment method (XSA; Shepherd 1999), based upon Virtual Population Analysis (VPA), was used to estimate fishing mortality (F) and numbers-at-age in the population, conditional on the assumed values of natural mortality and reported catch-at-age. The indices of abundance were used to tune the VPA. The assessment was run once at the end of the projection period.

The Celtic Sea stock is also examined here for comparison as this stock is one of the assessed herring populations to the west of the British Isles and mixes, partially, with the Irish Sea stock in its juvenile phase.

3.3.1 Material and methods

It was decided by the Study Group that the model as defined by Kell *et al.* (submitted) would suffice as a good starting point to evaluate alternative management strategies for the metapopulations west of the British Isles. However, several adjustments had to be made to the model setup.

To be able to represent the population dynamics as well as the fisheries, as well as possible, it was necessary to include more biological and ecological plausibility into the model. Therefore, 2008 analytical assessments outputs and VPA outputs were used to parameterize the model. Given possible instability in last few years of the assessments the simulations were started with the numbers-at-age estimated for 2002.

Stock-recruitment relationships were fitted to the data using the Beverton and Holt stock–recruit model. However, as the fitted model for VIaN herring resulted in rather reduced and less resilient stock–recruitment behaviour, the model parameters were adjusted to obtain more realistic values. Stock to recruit (S/R) plots are shown in Figure 3.3.1.1. These S/R plots must be regarded as preliminary as they exhibit some problems for simulations. Only the Celtic Sea herring model represents a good model of the scattered stock–recruit data. The Irish Sea model shows a poor fit to the recruitment at high biomass. The VIaS/VIIbc herring model rises continuously and implies a potential for much higher recruitment at high SSB. The same would be true for the VIaN model. In an attempt to constrain the model for VIaN the slope at the origin has been increased, with the effect of bringing down the mean recruitment at high biomass. This approach solves one aspect of the problem, generally constraining the population within its observed range but at the expense of expecting much higher recruitment at low biomass, thus implying a much more resilient population than the one observed. More work is required to select numerically and biologically feasible models that are supported by the data but do not imply major changes in population size outside the previously observed ranges. One such option for VIaN is given in Figure 3.3.1.2. The hockey-stick model shown there has some advantages: it maintains the slope at the origin supported by the observed SSB and recruit data; it reaches a maximum value well within the range of observations, and therefore represents more plausible population dynamics than either the modified Beverton and Holt in Figure 3.3.1.1 or the fitted Beverton and Holt model in Figure 3.3.1.2. However, it still expresses a perception of a population that will rise to SSB levels seen only in the 1950s and '60s. The VIaS/VIIbc population exhibits similar problems for modelling with Beverton and Holt models. Given these difficulties more work is required to obtain plausible models of recruitment for each of the components.

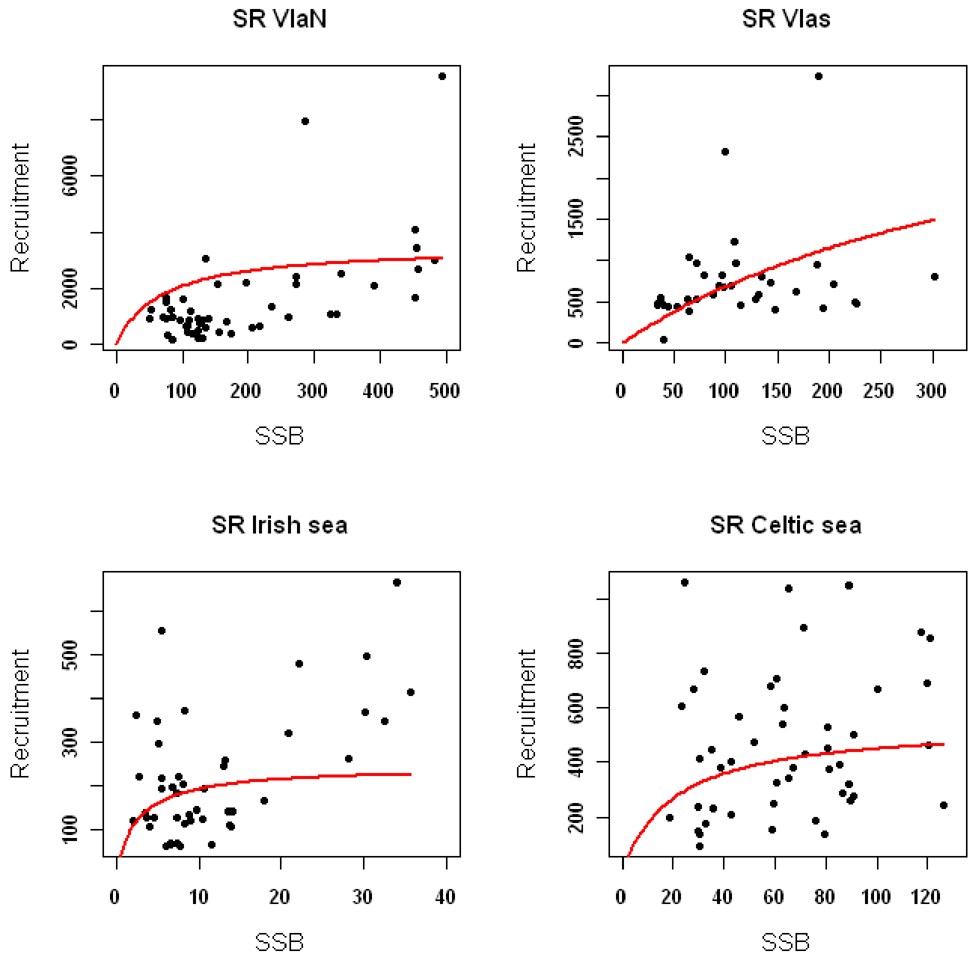

Figure 3.3.1.1. Stock-recruit plots, fitted to the Beverton and Holt equation, for the four populations. N.B. the VIaN fit has been modified.

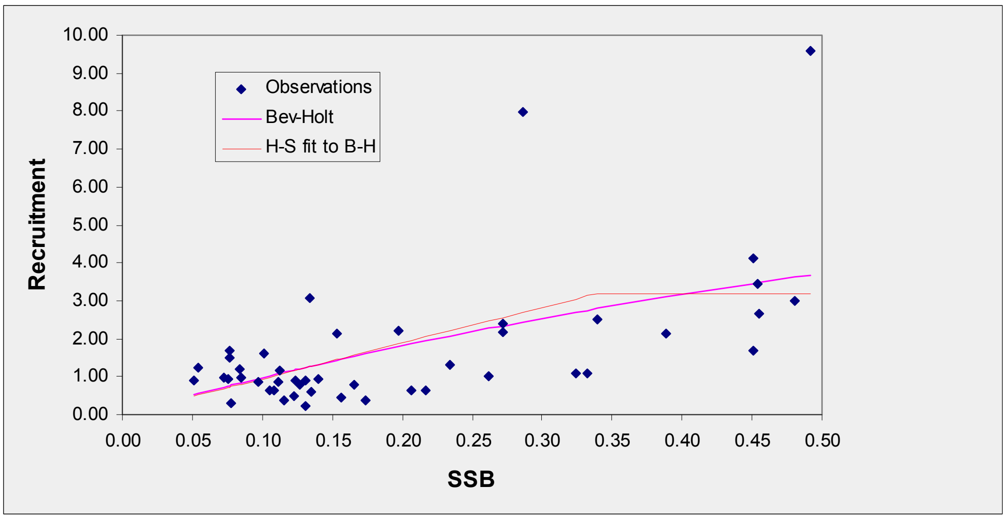

Figure 3.3.1.2. Stock-recruit plots, fitted to the Beverton and Holt equation and a hockey-stick approximation for the VIaN population.

Due to the changes in the stock–recruit relationships assumed, MSY reference points of the populations changed accordingly. Updated values are presented in Table

3.3.1.1. Again these are preliminary; the low value of F_{MSY} for VIaS/VIIbc results from the peak in the S/R relationship outside the observed range. The much higher value for VIaN results from the modified model in Figure 3.3.1.1. Similarly the high values of F_{CRASH} (Table 3.3.1.1) for all components except VIaS/VIIbc imply resilience that may not be realistic. Table 3.3.1.1 therefore gives only the values used in the simulations and does not reflect final values that are expected to reflect the true stock components.

Table 3.3.1.1. The target reference points for the four populations used in the simulation runs.

POPULATION	FMSY	MSY	RMSY	BMSY	FCRASH
1 (VIaN)	0.32	118272	2930095	348236	2.15
2 (VIaS/VIIbc)	0.12	49306	1991397	535377	0.39
3 (VIIaN)	0.29	6811	214171	19961	2.48
4 (CS and VIIj)	0.25	11785	412068	65245	3.11

3.3.1.1 Scenarios

In order to evaluate whether we would able to detect and correctly identify the causes of changes in F, S and R with existing data collection programs, several scenarios were considered for the fisheries and populations. This allowed the perception of the stock (resulting from the stock assessment) and the status of the true population to be contrasted. Four scenarios (A-D) of availability of the populations to the fisheries were investigated (Table 3.3.1.2).

Table 3.3.1.2. Availability of populations to fisheries for scenarios A – D, where the same proportions apply across all ages. Pops 1 to 4 refer to the populations given in Table 3.3.1.1.

	Availability of population 1–4 to the fishery in %			
	FISHERY 1 (VIAN)			
Scenario	Pop 1	Pop 2	Pop 3	Pop 4
A	100	25	25	0
B	100	50	50	0
C	100	75	75	0
D	100	25	75	0
	FISHERY 2 (VIAS)			
	Pop 1	Pop 2	Pop 3	Pop 4
A	0	75	0	0
B	0	50	0	0
C	0	25	0	0
D	0	75	0	0
	FISHERY 3 (IRISH SEA)			
	Pop 1	Pop 2	Pop 3	Pop 4
A	0	0	75	0
B	0	0	50	0
C	0	0	25	0
D	0	0	25	0
	FISHERY 4 (CELTIC SEA)			
	Pop 1	Pop 2	Pop 3	Pop 4
A – D	0	0	0	100

Additionally, the following run settings were explored:

i) constant fishing mortality in all fisheries a) constant F = 0.3 across all populations

ii) A one-off increase in F in a single fishery in year 2025

b) 100% increase in F in population 1, 2, 3 or 4

c) 50% increase in F in population 1, 2, 3 or 4

The current framework provides the options of examining the following assessment options:

- performing separate assessments by fishery (splitting) or combining catches over fisheries (lumping)
- indices of abundance conducted at either the time of spawning or the time of the fishery.

3.3.2 Runs performed during the meeting

The simulations were run under a number of F and mixing settings as described above. Results were presented for deterministic and stochastic settings. Log-catch ratios from the fishery data were presented as diagnostics.

Table 3.3.2.1. Overview of settings for runs performed.

RUN	F1 (in Fbar)	F2 (in Fbar)	F3 (in Fbar)	F4 (in Fbar)	Shift in Pop	F shift (in Fbar)
1	0.25	0.5	0.5	0.25	1	+100%
2	0.3	0.3	0.3	0.3	1	+100%
3	0.3	0.3	0.3	0.3	2	+100%
4	0.3	0.3	0.3	0.3	3	+100%
5	0.3	0.3	0.3	0.3	4	+100%
6	0.3	0.3	0.3	0.3	1	+50%
7	0.3	0.3	0.3	0.3	2	+50%
8	0.3	0.3	0.3	0.3	3	+50%
9	0.3	0.3	0.3	0.3	4	+50%

Figure 3.3.2.1 represents the SSB over time, per population, as assessed by both the fleet and the survey vs. the true / known population size. The sudden shift in SSB in population 1, as is described by Run 2 (Table 3.3.2.1), Availability Scenario A (Table 3.3.1.2), is picked up by both the fleet and survey. However, estimates of both these surveys overestimate the true state to a small extent in the longer term. As both populations 2 and 3 are also fished by fishery 1, we would have expected to see a decline in SSB for both these populations as well. However, there is no indication for this in Figure 3.3.2.1b and c. Hence, we concluded that the model did not simulate what we expected it to simulate, i.e. a shift in fishery 1 would affect all populations caught by that fishery. It rather simulates an increased catchability of fishery 1 on population 1, and therefore only affects population 1. However, the mixed status of the populations does result in an incorrect perception of the stocks, as is presented in Figure 3.3.2.2. Here, a shift occurred in population 2, and, as population 2 is also available for fishery 1, and therefore assessed as such, the decline of population 2 starting from 2025 also results in a rather marginal decline in the SSB perception of population 1. Note the difference between the biological interpretation of a population and a stock (where a stock is here defined as the combination of multiple populations with only 1 fishery).

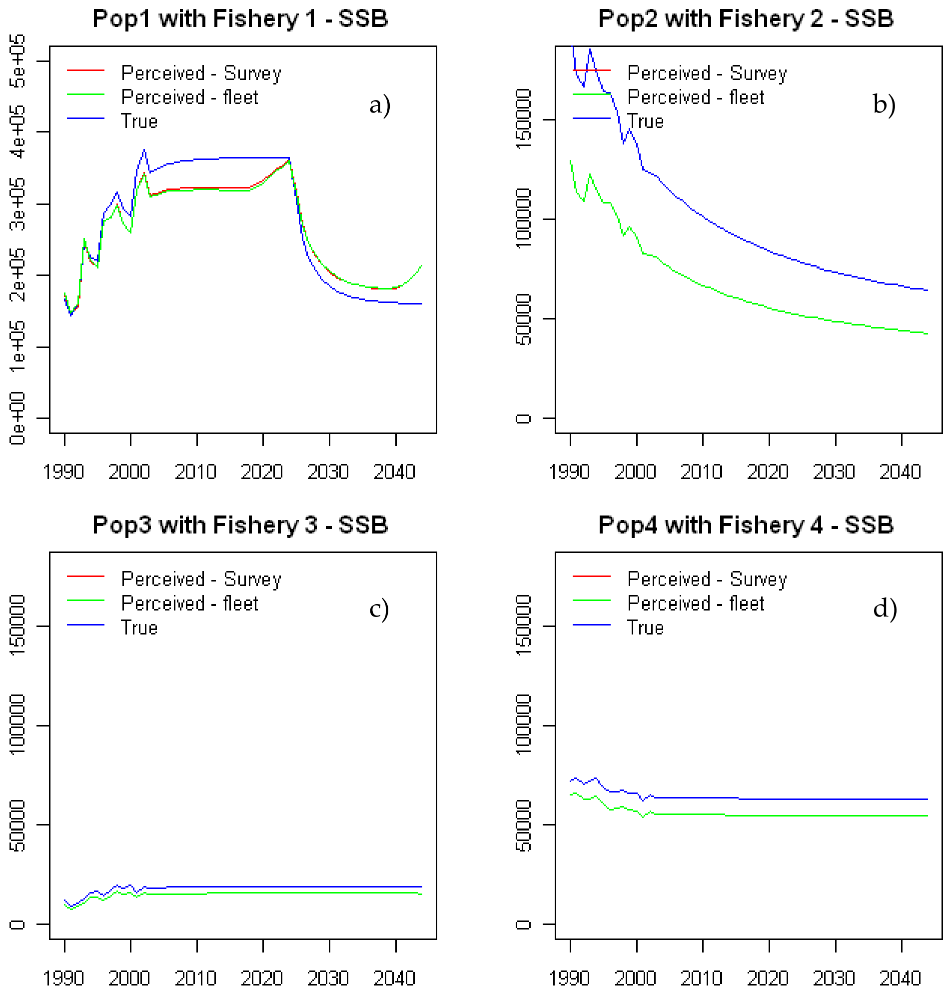

Figure 3.3.2.1. True and perceived SSB status of the stocks under Run 2, Availability Scenario A.

From the log-catch ratios we expected to observe a shift in these ratios around the time of the shift. The shift is clearly visible (in the deterministic run) in Figure 3.3.2.3a. However, Figure 3.3.2.3b represents the stochastic output where the signal of the shift is masked by the noise. This points to the difficulty in identifying biological shifts in the population from fisheries data only. This may prove even more difficult if shifts need to be detected in the short term.

As the shift only occurred in population 1, other populations are not affected and therefore no shift in log-catch ratios can be observed in Figures 3.3.2.3c-g.

From all other runs performed similar results were obtained. SSB patterns stabilized over time, and only diverged when a shift in a population's fishery occurred. However, as the shift reflects on the population, other populations are not affected at all. However, in the runs where high mixing of populations occurred, an incorrect perception of the total stock could be observed as such a stock might comprise several populations. However, this incorrect perception cannot be observed in the log-catch ratios (see Figure 3.3.2.4).

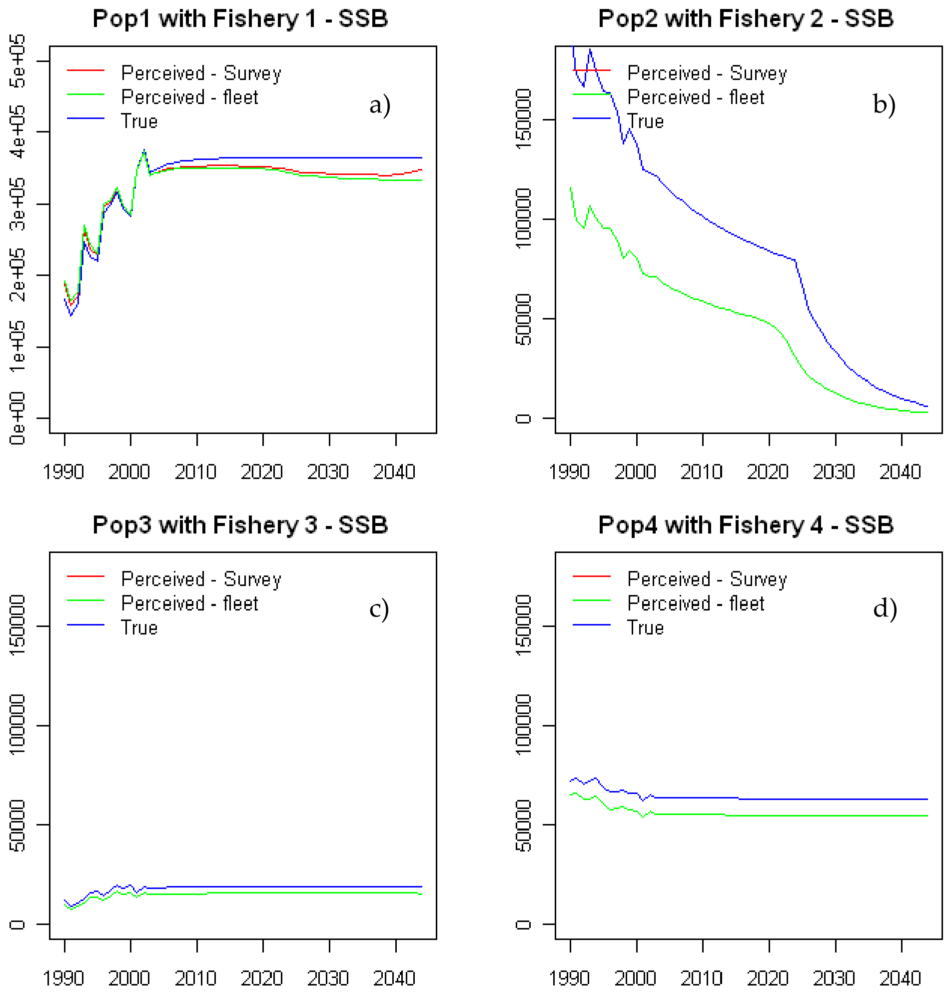

Figure 3.3.2.2. True and perceived status of the stocks under Run 3, Availability Scenario A.

The model supplied by Kell *et al.* (submitted) allowed the study of some aspects of the dynamics of a fishery operating on mixed populations. In particular, the model allowed investigation of the effects of a sudden increase in catchability in one of the populations. However, shifts in fishing effort which should have an affect on all populations caught were not investigated.

3.3.3 Future work

It is important to select a set of plausible but simple S/R relationships that can be used to simulate the populations in the area. These need to give similar levels of recruitment to those observed. They should have suitable attributes such as B_{MSY} that lie within the observed range and an F_{CRASH} that is plausible for herring stocks. It may be necessary to consider recent recruitment as more likely than recruitment observed more than 30 years ago. This is because with the exception of Celtic Sea herring, all stocks showed marked changes in the average productivity between different periods (ICES, 2007).

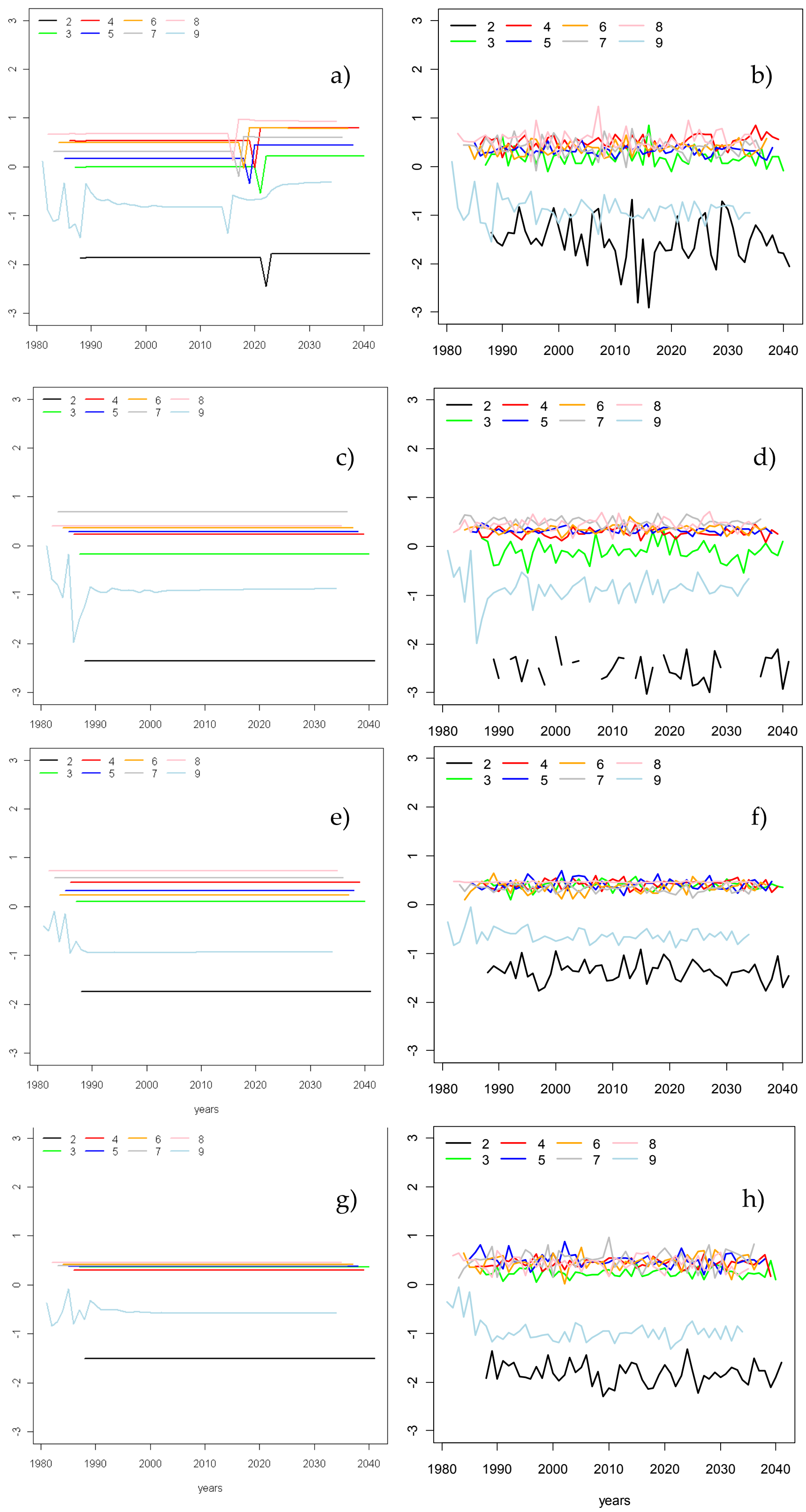

Figure 3.3.2.3. Log-catch ratios obtained from the fishery data. Each succeeding age-pair is presented with a different colour, e.g. the log-catch ratios of ages 1 and 2 are represented in black as (2). Run 2, Availability Scenario A. From top to bottom respectively, populations 1 to 4. Left panel: deterministic outcomes, right panel: stochastic outcomes.

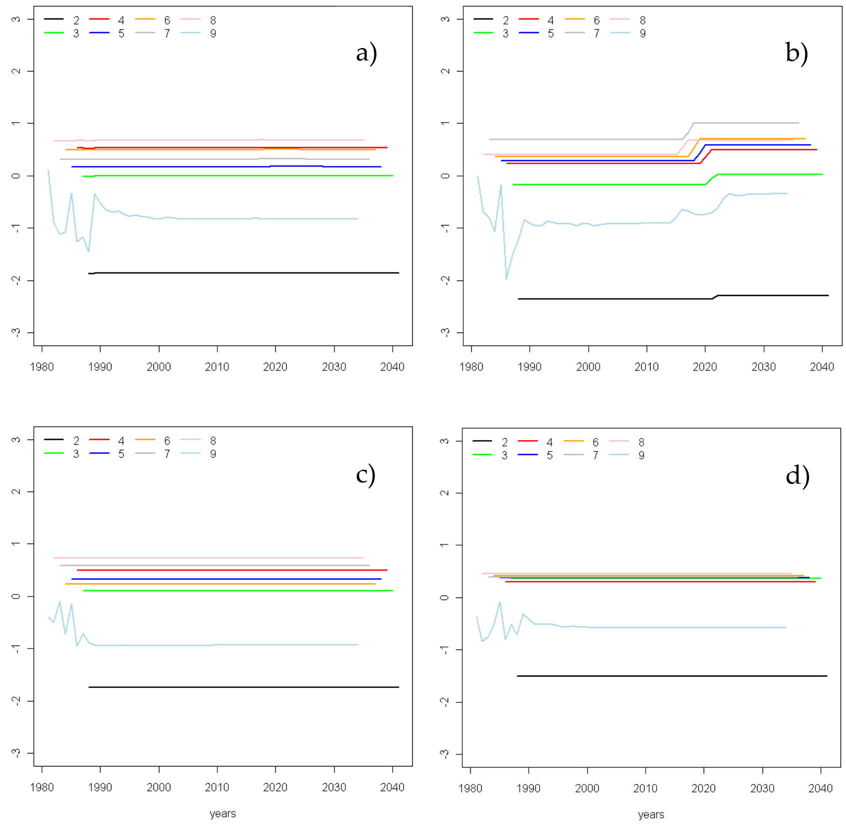

Figure 3.3.2.4. Log-catch ratios obtained from the fishery data. Each succeeding age-pair is presented with a different colour, e.g. the log-catch ratios of ages 1 and 2 are represented in black as (2). Run 3, Availability Scenario A. Panels a to d respectively, populations 1 to 4.

To fully evaluate alternative management strategies for herring stocks west of the British Isles, it is recommended to adapt the model setup to reflect current knowledge of the biological status of these populations. Therefore, the model should be adjusted to a year-by-year management strategy evaluation (MSE) platform. Using this approach, the efficacy of different management strategies could, be evaluated. Therefore, the current XSA assessment tool should be replaced by the ICA assessment tool, as currently used within most of these fisheries. Further, the model should be able to simulate both changes in fishing effort and in reproductive success.

The group also needs to consider alternative diagnostics, as these were currently limited and proved to be insufficient during the first meeting. The changes in log-catch ratios as shown in Figure 3.3.2.3 are marginal, and hard to identify in the stochastic situation. Note that these types of figures do not indicate whether a stock is over- or underexploited either. In designing robust harvest control rules reliable indicators of the state of the stock need to be identified.

3.4 Comments on the best way to maintain each spawning component in a healthy state, while managing the fish of that component when they are in a neighbouring area

This term of reference was not addressed during the first meeting as all modelling was preliminary and not enough conclusions were available to allow discussion of these issues.

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Annex 2: SGHERWAY: proposed Terms of Reference for 2009

The **Study Group on the evaluation of assessment and management strategies of the western herring stocks** [SGHERWAY] (Chair: Emma Hatfield, UK) will continue and will meet in Belfast, UK from 7–11 December 2009 to:

a) evaluate the utility of a synoptic acoustic survey in summer for the Hebrides, Malin and Irish shelf areas, in conjunction with PGIPS surveys of VIaN and the North Sea;

b) explore a combined assessment of the three stocks and investigate its utility for advisory purposes;

c) evaluate, through simulation, alternative management strategies for the metapopulation of VIaN, VIaS and VIIaN and the best way to maintain each spawning component in a healthy state.

SGHERWAY will report by 1 March 2010 to the attention of the SCICOM.

Supporting Information

Priority:	It is expected that this work will resolve issues surrounding the assessment and management of the herring stocks to the west of the British Isles. Its impact is expected to be high and consequently this work is considered to have a very high priority.
Scientific Justification and relation to Action Plan:	The EU funded project WESTHER evaluated the uncertain stock identity of herring stocks to the west of the British Isles. Its results suggested a rearrangement of the stocks as they are currently assessed and these results now need to be taken forward into the assessment and management process. We recognize the need to provide sound management advice for the western herring areas, and in particular the importance of ensuring as far as possible that there is no depletion of local components. HAWG noted that WESTHER was not funded to evaluate the extent of mixing in the fisheries or to evaluate alternate management strategies for the area. Currently it is unclear what management regime would provide the most cost-effective method for successful management and what data would be needed to support this management. We consider that it is necessary to move towards an integrated management plan for this area through a series of iterations involving the following steps :- Investigation of combined assessment of the three currently assessed stocks, VIaN, VIaS and VIIaN (to be called the Malin Shelf stock), including an investigation of the utility of a combined acoustic survey. Examination of alternative management strategies based on their ability to deliver protection to local populations and provide cost-effective information applicable for management of the two proposed stock units of herring to the west of the British Isles (Malin Shelf and Celtic Sea). Amendment of existing, or development of new, cost-effective assessment and data collection schemes which will be required to support this management. SGHERWAY supports directly ICES Goals 1, 3 and 4 in the action plan, specifically 1.11, 3.4, 4.1, 4.2, 4.3 and 4.15.
Resource Requirements:	It is proposed that this would be the second of two meetings of SGHERWAY. It is intended that there would be 8–10 –participants, meeting for a week each time, with intersessional work required.
Participants:	Herring biologists and scientists experienced in assessment and

	management strategy evaluation, from Ireland, Norway, The Netherlands, and the UK have agreed to attend the Study Group.
Secretariat Facilities:	None, other than formatting and publishing of the final report.
Financial:	There are virtually no financial implications
Linkages To Advisory Committees:	The Study Group will provide information to ACOM. This group feeds into the advisory process.
Linkages To other Committees or Groups:	This SG is essential to the work of HAWG and will have clear links to PGIPS..
Linkages to other Organisations:	None