instituto português do mar e da atmosfera

RELATÓRIOS CIENTÍFICOS E TÉCNICOS

SÉRIE DIGITAL

REPORT OF THE WORKSHOP ON SAMPLING DESIGN AND OPTIMIZATION OF FISHERIES DATA – WKSDO

Manuela Azevedo, Cristina Silva, Jon Helge Vølstad, Nuno Prista, Ricardo Alpoim, Teresa Moura, Ivone Figueiredo, Marina Dias, Ana Cláudia Fernandes, Pedro Lino, Mónica Felício, Corina Chaves, Eduardo Soares, Sandra Dores, Patrícia Gonçalves, Ana Maria Costa and Cristina Nunes

2014

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RELATÓRIOS CIENTÍFICOS E TÉCNICOS DO IPMA – SÉRIE DIGITAL

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Workshop on Sampling Design and Optimization - WKSDO

IPMA, 17-20 November 2014

Report of the Workshop on Sampling Design and Optimization of fisheries data - WKSDO

Manuela Azevedo, Cristina Silva, Jon Helge Vølstad, Nuno Prista, Ricardo Alpoim, Teresa Moura, Ivone Figueiredo, Marina Dias, Ana Cláudia Fernandes, Pedro G. Lino, Mónica Felício, Corina Chaves, Eduardo Soares, Sandra Dores, Patrícia Gonçalves, Ana Maria Costa and Cristina Nunes

IPMA - Divisão de Modelação e Recursos da Pesca (DivRP)
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RESUMO

Título: Relatório do workshop sobre o planeamento da amostragem e optimização de dados da pesca

O "**Workshop on Sampling Design and Optimization** (WKSDO)", presidido pelas investigadoras Cristina Silva e Manuela Azevedo (IPMA) e o investigador Norueguês Jon H. Vølstad (IMR), decorreu no IPMA-Algés, de 17 a 20 de Novembro de 2014, para analisar o actual Programa Nacional de Amostragem Biológica (PNAB/Data Collection Framework) com o objectivo de optimizar o programa de amostragem em lota para estimação da composição por comprimento da captura/desembarque das espécies capturadas pela frota nacional, de amostragem das capturas a bordo e da amostragem biológica para estudos de crescimento e reprodução. O Workshop, organizado no âmbito do projecto de investigação nacional GesPe (Planos de Gestão Pesqueira, PROMAR) e do PNAB/DCF, foi planeado e calendarizado tendo em conta o início do processo de revisão do programa Europeu de recolha de dados da pesca de suporte à avaliação e gestão dos recursos pesqueiros (DFC). Foram analisados e discutidos vários métodos e abordagens que resultaram num conjunto de instruções e recomendações para trabalho futuro, relevantes para assegurar uma elevada qualidade e optimização do futuro programa de amostragem.

Palavras chave: Amostragem a bordo, Amostragem em lota, Chaves comprimento-idade, Ogiva de maturação, Programa Nacional de Amostragem Biológica.

ABSTRACT

The **Workshop on Sampling Design and Optimization** (WKSDO), chaired by Cristina Silva and Manuela Azevedo (IPMA-PT) and Jon H. Vølstad (IMR-NO) met in Lisbon, 17–20 November 2014, to focus on the analysis of the current Portuguese sampling designs under PNAB/DCF (Programa Nacional de Amostragem Biológica/Data Collection Framework) with the aim to optimize the current market sampling design to estimate the species length composition of landings, the onboard sampling for catches and the biological sampling for growth and maturity. The Workshop was organized within the scope of the national research project - GesPe (Planos de Gestão Pesqueira, PROMAR) and the PNAB/DCF and the planning and timing of the workshop took into account the initiated review process of EU fisheries data collection for stock assessment and management (DCF - Data Collection Framework). During the workshop several approaches and methods were analysed and discussed, resulting in a set of guidelines and recommendations for future work which are relevant to ensure a high quality and optimized future data collection programme.

Key words: Age-length keys, Market sampling, Maturity ogive, National Biological Sampling Programme, Onboard sampling.

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AZEVEDO, M.; SILVA, C.; VØLSTAD, J.H.; PRISTA, N.; ALPOIM, R.; MOURA, T.; FIGUEIREDO, I.; DIAS, M.; FERNANDES, A.C.; LINO, P. G.; FELÍCIO, M.; CHAVES, C.; SOARES, E.; DORES, S.; GONÇALVES, P.; COSTA, A.M.; NUNES, C. 2014. Report of the Workshop on Sampling Design and Optimization of fisheries data. ***Relat. Cient. Téc. do IPMA(http://ipma.pt)***, ***nº 2***, **79** pp.

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1 Introduction

1.1 Terms of reference

The **Workshop on Sampling Design and Optimization** (WKSDO), chaired by Cristina Silva and Manuela Azevedo (IPMA-PT) and Jon H. Vølstad (IMR-NO) took place in Lisbon, 17–20 November 2014, to focus on the analysis of the current Portuguese sampling designs under PNAB/DCF (Programa Nacional de Amostragem Biológica/Data Collection Framework) and their optimization:

1) Market sampling design to estimate the length composition of landings: concurrent sampling and species focus sampling.
2) On-board sampling for catches: objectives, sampling design, sampling effort, constraints, approaches for raising, improving the precision of estimates.
3) Sampling for biological parameters used in stock assessment.

1.2 Background

The Workshop was organized within the scope of the national research project - GesPe (Planos de Gestão Pesqueira, PROMAR) and the national biological sampling programme - PNAB/DCF.

1.3 Conduct of the meeting

The workshop participants made available several documents prepared in advance to the meeting, including a glossary of statistical terms to be used during the workshop (Annex 3), as well as several presentations (Annex 4) which subsequently formed the basis of the workshop's investigations and discussions during the week.

The following speakers presented the talks indicated:

P01 - Manuela Azevedo: Portuguese Fleets and Fisheries. M. Azevedo, C. Silva, M. Dias

ToR 1) Market sampling design to estimate the length composition of landings: concurrent sampling and species focus sampling.

P02 - Nuno Prista: Present sampling design. N. Prista, M. Dias

P03 - Ricardo Alpoim: Anglerfishes. R. Alpoim, T. Moura, N. Prista

P04 - Ivone Figueiredo: Rays. I. Figueiredo, C. Maia

P05 - Manuela Azevedo: Catch length composition estimated from commercial size-categories: does it improve accuracy? M. Azevedo, C. Silva

P06 - Jon H. Vølstad: Sampling designs

ToR 2) On-board sampling for catches: objectives, sampling design, sampling effort, constraints, approaches for raising, improving the precision of estimates.

P07 - Ana Cláudia Fernandes: Sampling design in Div. IXa. A. C. Fernandes, N. Prista

P08 - Pedro Lino: Sampling design in Indian Ocean. P. G. Lino, R. Coelho, M. N. Santos

P09 - Jon Vølstad: Framework for assessing monitoring effort to support stock assessment.

ToR 3) Sampling for biological parameters used in stock assessment.

P10 - Jon Vølstad: Sampling/precision ALKs.

P11 - Eduardo Soares: Sampling for age / ALKs: sardine Case-study.

P12 - Ana Maria Costa: Sampling for maturity / maturity ogive: hake case-study. A. M. Costa, C. Nunes, J. Pereira

During the workshop the participants were divided into three subgroups dealing with each of the ToRs.

2 Market sampling for length composition (ToR 1)

2.1 Background information and description of current sampling design

Market sampling for length composition in ICES Division IXa is carried out by IPMA and its design has evolved through time. Before 2009 the sampling plan was species-focused following the requirements of the former DCF (Commission Regulation (EC) No. 1639/2001). From 2009 onwards the design was changed to focus on métiers conforming new DCF requirements (Commission Decision No. 2010/93/UE). Following preparatory discussions on probability-based sampling held at the ICES Planning Group on Commercial Catches, Discards and Biological Sampling (PGCCDBS) and the Workshop on Practical Implementation of Statistical Sound Catch Sampling Programs (WKPICS), IPMA decided to test a new market sampling plan in 2014. This new sampling plan draws on the preparatory work carried out by several ICES Workshops and Study Groups dealing with sampling design (e.g. WKACCU, 2008; WKMERGE, 2010; SGPIDS, 2011-2013; WKPICS, 2011-2013; several PGCCDBS meetings) and available preparatory documents for the new DC-MAP where growing emphasis is put on the development of statistically sound probability-based sampling schemes that move away from previous quota sampling practices. The goal of the new sampling plan is therefore to improve the quality of data sent for ICES stock assessments and the overall quality of fisheries data collected from the Portuguese coast and its ecosystems.

The Portuguese fleet that operates in waters of ICES Division IXa comprises ~85 trawlers and ~115 purse-seiners (medium to large sizes) with the remainder (~6400 vessels) being considered "polyvalent" (Azevedo *et al.*, P01 - Annex 4). The "polyvalent" fleet includes a large set of fishing vessels, highly variable in length (from a few meters to over 30 meters) and daily catch volume, and is typically multi-gear (i.e., each vessel can have more than one fishing license) and multi-species (i.e., individual vessels frequently target multiple species in each trip and/or throughout the year).

The Portuguese sampling design targeting fish lengths in 2014 is stratified multistage, with auction*day as the Primary Sampling Unit (PSU) and vessel landing events as the Secondary Sampling Unit (SSU). The PSUs are stratified by quarter and port and their selection is quasi-systematic. SSU selection is approximately random. Concurrent sampling is carried out and all size categories available at market are targeted. Box and fish selection are quasi-random (Figure 2.1.1, Prista and Dias, P02 – Annex 4).

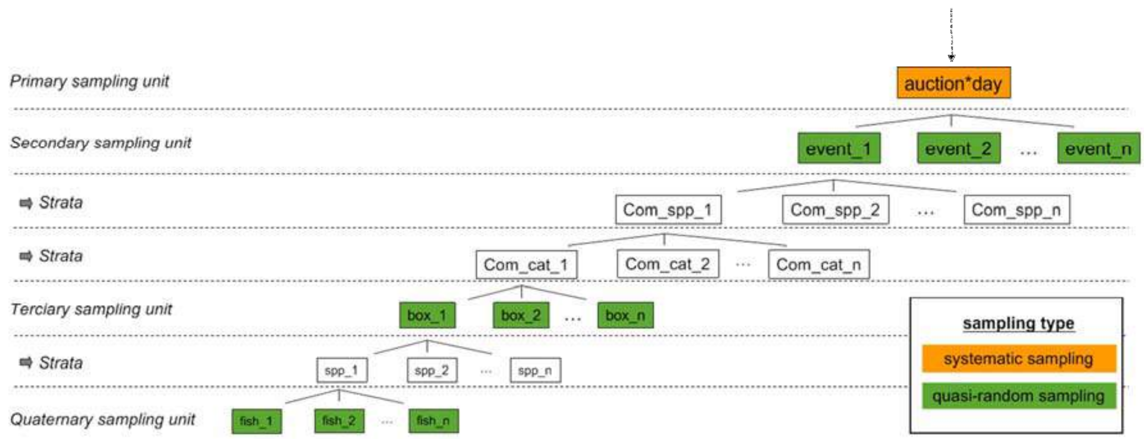

Figure 2.1.1 Concurrent sampling design for species length distribution.

In Portuguese auctions, some commercially important species currently subjected to TAC may appear misassigned to commercial species or included in supra-specific commercial species. That is the case of blackbellied angler (*Lophius budegassa*, FAO code: ANK) and anglerfish (*Lophius piscatorius*, FAO code: MON) that may appear confounded or aggregated into a monkfish nei category (*Lophius* spp., FAO code: MNZ) (Alpoim *et al.*, P03 – Annex 4) and the wide diversity of skates and rays (Figueiredo and Maia, P04 – Annex 4). IPMA's market sampling plan addresses species misassignement by undertaking concurrent sampling, i.e., sampling all commercial species and commercial size categories present in individual trips and identifying the exact species composition of each one of them. However, species misassignement creates several difficulties to sampling and estimation of length composition that urge a better solution because their existence requires complex estimators (Figueiredo and Maia, P04 – Annex 4) and significant increases in sample size. For species like the anglerfishes, where the vast majority of vessels land few amounts, species misassignment makes it particularly difficult to obtain good proportions and length frequencies at trip level (Alpoim *et al.*, P03 – Annex 4), greatly limiting the accuracy and precision of final length composition estimates.

2.2 Analysis of current concurrent sampling program

Given the limiting time and the importance of species misidentification in sampling and estimation processes, the workshop focused on ways to improve the current market sampling plan in order to improve the present situation. A possible solution involves the separate sampling of a primary fleet (composed by the vessels that most contribute to total landings of a species aggregate) and a secondary fleet (vessels that contribute little to total landings of a species aggregate) (Alpoim *et al.*, P03 – Annex 4). This solution was considered useful for future pilot studies but unfeasible for implementation in the current PNAB/DCF sampling plan because the vast number of species requiring sampling would lead to undesirable over-stratification. The workshop thus focused on means to articulate the present concurrent sampling with the need to increase the number of trips and volume of anglerfish and rays and skates sampled by IPMA's observers in each visit to auctions.

The problems associated with species discrimination of the commercial categories of anglerfish (FAO codes: ANK, MON, MNZ), hereby named together as ANF, and rays and skates (FAO codes: RJB, RJC, RJH, RJM, RJN, RJU, RJA, JAI, RJE, RJI, RJO, RJY), hereby named together as SKA, led to the selection of the gillnet/trammel segment (hereby coded as GNS/GTR) and the following auctions: Matosinhos, Póvoa de Varzim, Peniche and Olhão. For comparative purposes Hake (FAO code: HKE), Octopus (FAO code: OCC and OCT, hereby coded as OCC), pout (FAO code: BIB) and horse-mackerel (FAO code: HOM) were also added to the list. All other species landed were aggregated into code OTHER. The aim was to develop a simulation framework that allowed future testing of alternative sampling designs in a broader range of fleet segments, auctions and species.

Considering daily landings of all vessels belonging to GNS/GTR port the following questions were raised:

- Are the numbers of daily landings equally distributed along the different quarters of the year?
- Are the numbers of daily landings equally distributed along the different days of the week?
- Is the total landed weight equally distributed along the different quarters of the year?
- Is the total landed weight equally distributed along the different days of the week?

Using the Peniche auction as a case study the following questions were also raised:

- Are the total landed weights of the species HKE, HOM, OCC, group of species ANF, SKA and the remaining ones (OTHER) equally distributed along the different quarters of the year?
- Are the total landed weights of the species HKE, HOM, OCC, group of species ANF, SKA and the remaining ones (OTHER) equally distributed along the different days of the week?

Analyses were carried out to answer all these questions using sales data from 2012.

No major differences were detected in terms of total number of sale events (≈ trips) and landed weight between quarters (Tables 2.2.1 and 2.2.2). However differences were found between the days of the week, with Monday registering more sale events and weight landed than the rest of weekdays in nearly all quarter*auction combinations (Tables 2.2.3 and 2.2.4). A similar pattern is observed when individual species and species groups were considered (Tables 2.2.5 to 2.2.8). Based on these results one can anticipate that there may be little efficiency gained in using stratification by quarter and that a more efficient allocation might be obtained by stratifying by weekday, e.g., two strata ("Monday", "Remaining Days"). A full analysis of these aspects should involve an evaluation of variance within the putative strata as it is possible that despite differences in number of trips and landings, lengths are more variable among quarters than among weekdays.

Table 2.2.1 Number of trips registered in each auction and quarter. In bold the quarter that registered the highest number of sale events.

	Q1	Q2	Q3	Q4
Póvoa de Varzim	1223	972	**1396**	914
Matosinhos	**2089**	1503	1640	1573
Peniche	2155	1780	**2239**	2052
Olhão	**1492**	1376	1152	1343

Table 2.2.2 Total landed weight (kg) registered in each auction and quarter. In bold the quarters that registered the highest weight landed

	Q1	Q2	Q3	Q4
Póvoa de Varzim	350785.6	233549.2	**363575.1**	273442.3
Matosinhos	**481541.7**	397507.0	451542.0	410642.7
Peniche	666872.9	454249.5	547811.2	**682154.3**
Olhão	105725.2	**115603.3**	91261.6	104446.4

Table 2.2.3 Number of trips registered in each auction and quarter by weekday. In bold the weekdays that registered the highest number of sale events

Q1	Mon	Tue	Wed	Thu	Fri
Póvoa de Varzim	253	217	265	**285**	203
Matosinhos	**461**	380	453	448	347
Peniche	**505**	319	418	500	413
Olhão	**357**	256	299	339	241
Q2	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**
Póvoa de Varzim	**444**	208	169	151	---
Matosinhos	**736**	312	240	215	---
Peniche	**815**	321	303	341	---
Olhão	**603**	291	284	174	24
Q3	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**
Póvoa de Varzim	**605**	248	271	272	---
Matosinhos	**757**	319	310	254	---
Peniche	**1010**	398	376	455	---
Olhão	**468**	206	227	213	38
Q4	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**
Póvoa de Varzim	**282**	191	193	180	68
Matosinhos	**554**	333	297	283	106
Peniche	**590**	424	368	390	280
Olhão	**357**	301	257	258	170

Table 2.2.4 Total landed weight (kg) registered in each auction and quarter by weekday

Q1	Mon	Tue	Wed	Thu	Fri
Póvoa de Varzim	64479.6	63421.7	75830.9	**89354.5**	57698.9
Matosinhos	102986.1	99261.4	**108954.9**	106138.3	64201.0
Peniche	**210887.5**	82363.7	122166.2	145478.5	105977.0
Olhão	23114.2	19667.7	22007.9	**24986.7**	15948.7
Q2	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**
Póvoa de Varzim	**102274.1**	47983.7	47061.8	36229.6	---
Matosinhos	**201050.2**	88109.8	60399.8	47947.2	---
Peniche	**279985.9**	64404.4	70275.5	39583.7	---
Olhão	**46459.5**	24890.2	23835.9	18666.7	1751.0
Q3	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**
Póvoa de Varzim	**159442.7**	61042.9	82480.0	60609.5	---
Matosinhos	**219642.0**	96488.0	87390.4	48021.6	---
Peniche	**281023.3**	74655.4	96879.2	95253.3	---
Olhão	**36498.9**	17204.4	17769.9	15868.6	3919.8
Q4	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**
Póvoa de Varzim	**90794.4**	45321.1	55569.7	62861.7	18895.4
Matosinhos	**150074.8**	92414.8	70338.8	72470.9	25343.4
Peniche	**249693.0**	119616.0	91131.4	127497.0	94216.9
Olhão	**30126.6**	23138.9	19256.3	19320.4	12604.2

Table 2.2.5 Number of trips that registered each species (or group of species) by quarter at Peniche landing port

Peniche	Q1	Q2	Q3	Q4
HKE	**497**	339	402	431
HOM	**183**	128	146	162
BIB	**930**	535	619	835
SKA	**1100**	506	725	795
OCC	1003	892	**1262**	946
ANF	67	181	**196**	76
OTHERS	**2003**	1548	1704	1895

Table 2.2.6 Total landed weight (kg) by species (or group of species) by quarter at Peniche landing port

Peniche	Q1	Q2	Q3	Q4
HKE	33806.0	31685.3	**46594.8**	39475.0
HOM	**26284.5**	12385.1	11437.8	4985.7
BIB	11240.2	4629.5	9475.3	**14455.9**
SKA	**51596.7**	24510.4	34796.5	36424.0
OCC	33487.0	29856.0	**102677.7**	79791.9
ANF	6345.4	**14856.9**	10827.4	4792.4
OTHER	**504113.1**	336326.3	332001.7	502229.4

Table 2.2.7 Number of trips that registered each species (or group of species) by weekday at Peniche landing port

Peniche	Mon	Tue	Wed	Thu	Fri
HKE	**575**	270	335	338	151
HOM	**230**	104	115	119	51
BIB	**1000**	532	504	594	289
SKA	**1067**	525	537	662	335
OCC	**1509**	740	718	847	289
ANF	**233**	68	93	113	13
OTHER	**2509**	1245	1258	1481	657

Table 2.2.8 Total landed weight (kg) by species (or group of species) by weekday at Peniche landing port

Peniche	Mon	Tue	Wed	Thu	Fri
HKE	**77550.0**	13384.7	30407.4	27964.7	2254.3
HOM	**26368.5**	3580.0	9812.8	12542.7	2789.1
BIB	**14811.8**	7377.2	6620.1	7439.6	3552.2
SKA	**56018.1**	23417.7	25135.3	28770.7	13985.8
OCC	**98092.8**	42589.1	40632.1	49442.1	15056.5
ANF	**16981.6**	3094.1	8393.9	7177.2	1175.3
OTHER	**731766.9**	247596.7	259450.7	274475.5	161380.7

2.3 Evaluation of the feasibility to accommodate concurrent sampling and sampling directed at trips that landed monkfish or skates and rays

The gillnet/trammel segment of the polyvalent fleet was further evaluated by analyzing the possibility of increasing the precision of species composition estimation of SKA or ANF without jeopardizing the present concurrent sampling carried out under IPMA sampling design.

Under this design the PSUs correspond to visit dates to auction which in turn include a quasi-random selection of SSUs (landing events ≈ vessels' trips).

To evaluate the question a simulation framework was established in R whereby the present sampling plan, namely the number of PSUs and SSUs planned for each quarter*auction (Table 2.3.1), was replicated once. The objective of the exercise was to check the increase in number of trips sampled and weight sampled that could be expected if directed sampling (i.e., species focused) for monkfishes or skates and rays would supplement the concurrent sampling currently carried out during visits to the auctions.

Table 2.3.1 Present sampling effort assigned to the landing ports of Póvoa de Varzim, Matosinhos, Peniche and Olhão, gillnet/trammel segment.

	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter	
	PSU	SSU	PSU	SSU	PSU	SSU	PSU	SSU
Póvoa de Varzim	7	2	8	2	8	2	7	2
Matosinhos	9	2	9	2	9	2	10	2
Peniche	14	2	15	2	12	2	12	3
Olhão	3	2	3	2	3	2	3	2

Results show that up to 10 trips with monkfish landings (up to ~2500 kg) and up to 30 trips with skates and rays landings (up to ~2500 kg) may be registered per day, depending on the auction (Figure 2.3.1 and Figure 2.3.2). However, such high numbers and weights are only rarely registered with the vast majority of days registering lower numbers and volumes (Figure 2.3.1 and Figure 2.3.2). As a consequence numbers and weight of trips sampled under current sampling are also very low and can be significantly increased if a supplementary sampling directed to monkfishes and rays and skates during the selected days is carried out (Figure 2.3.3 and 2.3.4). As the weight sampled has some relationship to the number of specimens it is likely that direct sampling will improve the overall estimation of species proportion and length frequencies at each auction*day. We note that the latter should still verify if some individual trips maintain low numbers of individuals dispersed over a wide size range hence not achieving the typical continuous appearance of length frequencies of smaller pelagic fish (Alpoim *et al.*, P03 – Annex 4). We note however that:

- it will not always be possible to sample all trips present that register a species because, e.g., a) there are work and time limits to the amount of sampling that can be achieved in each sampling day and, b) length composition of a vast array of species other than ANF and SKA are also targeted by market sampling. In cases when not all trips can be sampled, trips with the species may be randomized and a subset selected.
- further investigation on estimators that combine concurrent and directed sampling is still needed because the sampling probabilities for non-targeted species during directed sampling are technically 0.

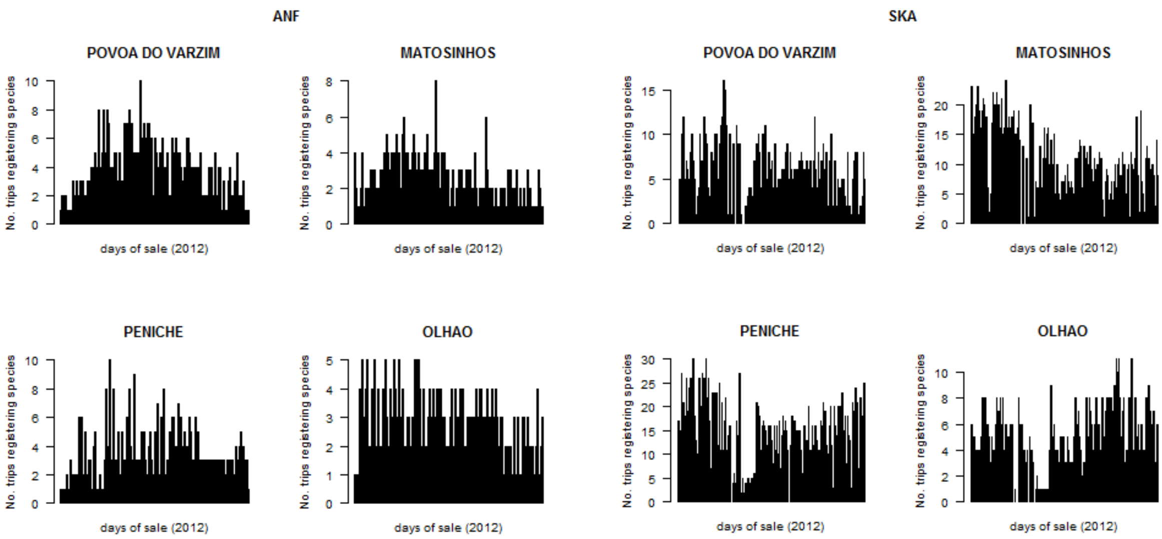

Figure 2.3.1 Number of trips per day that registered monkfishes (ANF, left) and skates and rays (SKA, right) during 2012.

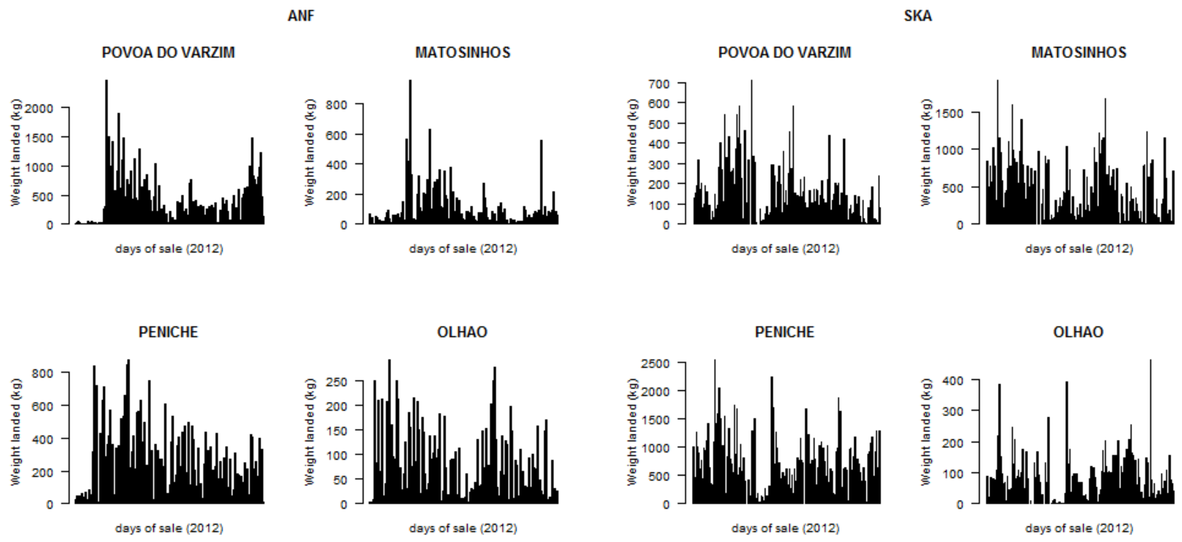

Figure 2.3.2 **Weight landed per day at different auctions during 2012: monkfishes (ANF, left) and skates and rays (SKA, right).**

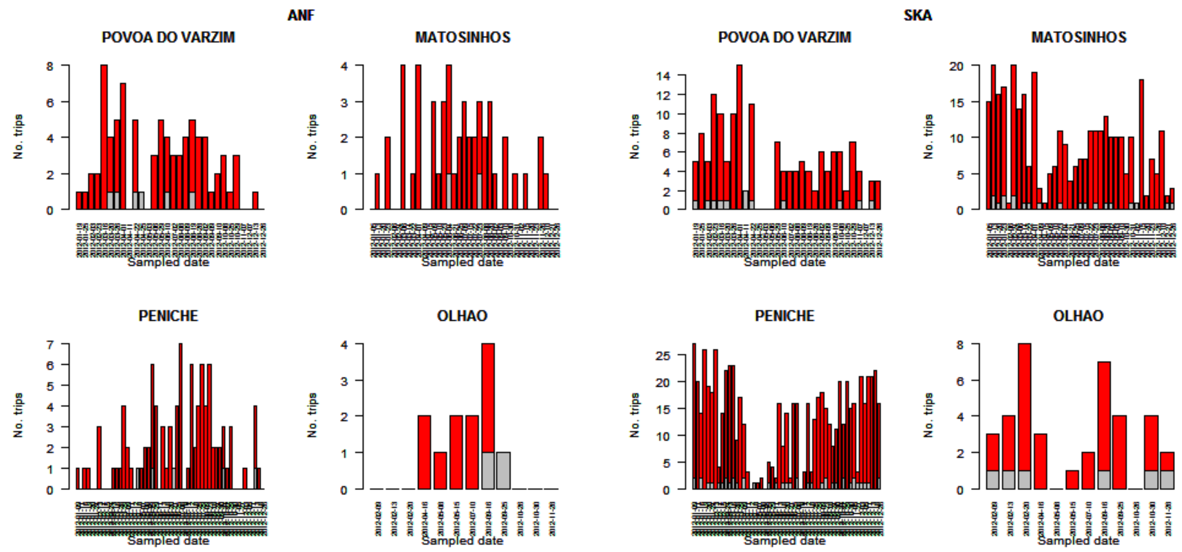

Figure 2.3.3 **Number of trips registering monkfishes (ANF, left) and skates and rays (SKA, right) in randomly selected sampling days and landing events under concurrent sampling plan (grey bars) and directed sampling plan (red bars). Note: n=1 replicate.**

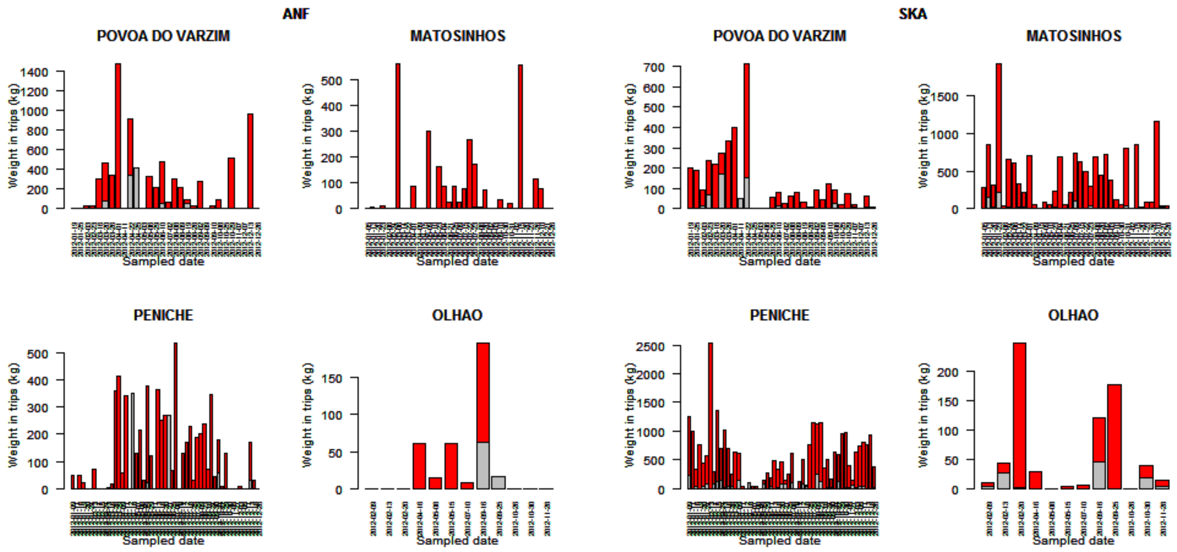

Figure 2.3.4 Weight of monkfishes (ANF, left) and skates and rays (SKA, right) registered in randomly selected sampling days and landing events under a concurrent sampling plan (grey bars) and directed sampling plan (red bars). Note: n=1 replicate.

The main conclusions are that:

- Extra sampling effort directed to the studied groups of species (ANF and SKA) can be made compatible with present concurrent sampling to improve the precision of species composition and length composition;
- The estimation procedure adopted to estimate the variables at trip level needs to take into consideration the sampling strategy adopted in those two sampling procedures: simple random sampling of all trips (concurrent sampling) and simple random sampling of trips registering a specific species;
- Factor "Quarter" appears to have a minor effect on the variability of number of trips and total landed weight. Using it to stratify sampling may be lowering the efficiency of the sampling plan.
- "Monday" is the weekday when most of the trips take place and consequently when Mondays are selected for sampling there is an increased chance of finding vessels with ANF or SKA. Finding more trips with a particular species is advantageous because it may improve estimation of species proportion and length composition. One possibility to increase the chance of sampling Mondays is to consider two strata: "Monday" and "Rest of the days of the week". A systematic sampling strategy is recommended for the stratum "Monday" while a random sampling strategy could be used for the "Rest of the days of the week" making work schedules more operational. A preliminary check on length and species composition of Mondays and Remaining days is advisable before such changes are considered.
- The Portuguese fleet is dominated by small-scale vessels so random selections of vessels present at an auction*date will include mostly small vessels. Small vessels may fish differently (or in different areas) compared to larger vessels and therefore display different length composition in their landings. Stratification by vessel size is therefore also a future option to reduce bias and increase precision of length estimates of some species. If

implemented, such stratification scheme must be taken into account within raising procedures.

2.4 Improving accuracy of estimated length composition

Most of the fish species landed in Portuguese fishing ports or auctions are sorted into size categories due to their different commercial value. For these species, landing statistics (weight) are also compiled by size-category. The number of categories varies depending on species. For example, horse mackerel (*Trachurus trachurus*) has 6 size-categories (category 1 for large fish and category 6 for small fish) whereas hake (*Merluccius merluccius*) has 5 categories.

The length composition of annual landings by species and main fleet segments is obtained by raising the length distribution of the sampled trips by fleet segment to the total landings of the segment, by quarter and area, which is hereinafter referred to as "trip" approach. The estimated annual length composition may be based on a low number of sampled trips which may result in imprecise and biased landings length composition.

Azevedo and Silva (P05 – Annex 4) presented a different method to estimate total annual length composition, based on a "size-category" approach. The method was applied to the Portuguese landings of southern horse-mackerel (hom-9a) in 2012 and of the Iberian stock of hake (hke-8c9a) in 2013 by fleet segment. The underlying assumption of the "size-category" approach is that species mean size is significantly different among size-categories. The mean length by size-category was estimated from the port samples collected in the period 2010-2013, after a pre-screening by fleet segment and port to remove outliers and unrepresentative samples.

Figure 2.4.1 shows the estimated Portuguese catch length composition of horse-mackerel in 2012 by fleet using the "size-category" and the "trip" approach (Azevedo and Silva – P05 Annex 4).

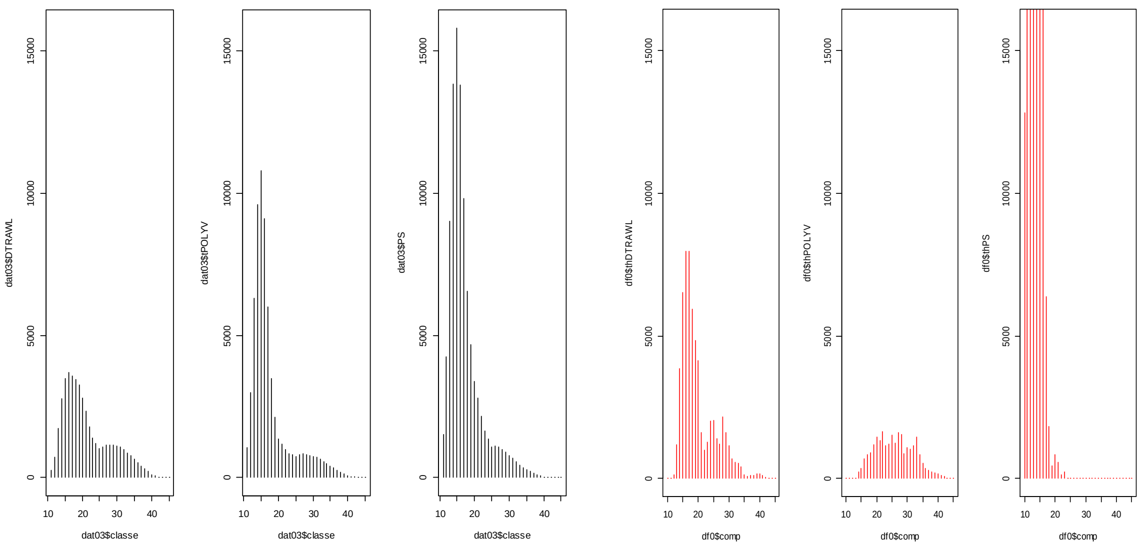

Figure 2.4.1 Horse-mackerel estimated catch length composition in 2012 by fleet using the "size-category" (left) and the "trip" (right) approaches.

Large differences are observed between the estimated catch length compositions by fleet using the two approaches, which may be explained by the low number of trips sampled from the polyvalent and purse-seine fleets and not covering all sizes caught during the year. The differences in the estimated length composition for the polyvalent fleet illustrate the bias caused by the lack of small size categories in trip samples although these sizes were present in landing records.

The two approaches give similar results in the case of the estimated length composition for hake in 2013, due to a better coverage of all landed categories in the trips sampled from the two fleet segments catching this species, the trawl and the polyvalent fleets.

The overall opinion was that the "size-category" approach may increase the precision and accuracy of the estimated catch/landings length composition by species and since the "size-category" approach may require lower sampling effort (and consequently lower costs: human resources, budget) than the "trip" approach, the following question was raised: should sampling focus on characterizing / monitoring the species size-categories?

The discussion focused on further analysis to explore and evaluate the robustness of this approach and on recommendations for future work, such as:

- Evaluate the effect of the approach on stock assessment;
- Apply the approach to other species in order to support changing the sampling scheme (sampling directly for size categories instead of sampling trips), if it proves to be cost effective;
- Ponder the development of a pilot study (including field experiments) to evaluate the implementation feasibility of such a sampling strategy.

2.5 Discussion and conclusions

Substantial discussions on the case-studies and analyses presented provided suggestions of research for the revision of PNAB sampling program, namely:

- Randomization of landing events within sampling days should be improved. One possibility will be to systematically sample vessels instead of the present quasi-random selection.
- The simulation framework undertaken to evaluate the feasibility of combining concurrent sampling and species-focus sampling should be extended to analysis of the precision of the length estimates. Such extension may yield substantial reductions in the time spent in concurrent sampling and thus allowing directed sampling in larger numbers. The extension shall consider:
    - (i) Number of PSU and SSU to be sampled and,
    - (ii) Number of individuals measured within each SSU.
- Explore the information available for the set of landing ports other than the major ones in relation to landed weight and number of trips. The review of the NOAA Recreational US sampling program (Sullivan *et al.*, 2006) offers several alternatives on how to best sample smaller components.
- Explore different sampling strategies (e.g., sampling directly for size categories instead of sampling trips) and ponder the development of a pilot study including field experiments.
- Compare the different raising methods (e.g., current, design-based, by categories), particularly in relation to the updated design where the SSU are trips.

The need to estimate species proportions in grouped commercial categories or categories that have been misassigned seriously limits the accuracy of estimation and the degree of optimization that can be achieved by IPMA's sampling plan with effects extending to several other species than the ones directly involved. Also, there are evidences of non-compatibility between strata used for sampling and the strata considering used for raising causing unknown bias in the estimation of length composition but also species composition (when proportions have to be estimated). Recommendations are made to the Portuguese Administration (DGRM) and DOCAPESCA to address this issue, namely:

- To DGRM and DOCAPESCA: At the landing port anglerfish and skates and rays (but also other species e.g. sole and plaice, megrim and four-spot-megrim and whiting and pollock) need to be correctly identified and discriminated at species level;
- To DOCAPESCA: SLV daily landing database should include the discrimination of the fishing gear(s) used at the box level (preferably).

We emphasize that these two measures are not only useful to improve stock assessment but actually envisaged to be mandatory under provisions on consumer information will enter into force in 13th December 2014 (Regulation (EU) 1379/2013).

3 On-board sampling for catches (ToR 2)

3.1 Sampling designs

3.1.1 Sampling design in Division IXa

The current sampling design used by IPMA observers onboard fishing vessels operating in the ICES Division IXa was presented (Fernandes and Prista, P07 – Annex 4) and discussed. The sampling units and strata are shown in Figure 3.1.1.1. The overall opinion was that it followed the best procedures given practical and logistical constraints.

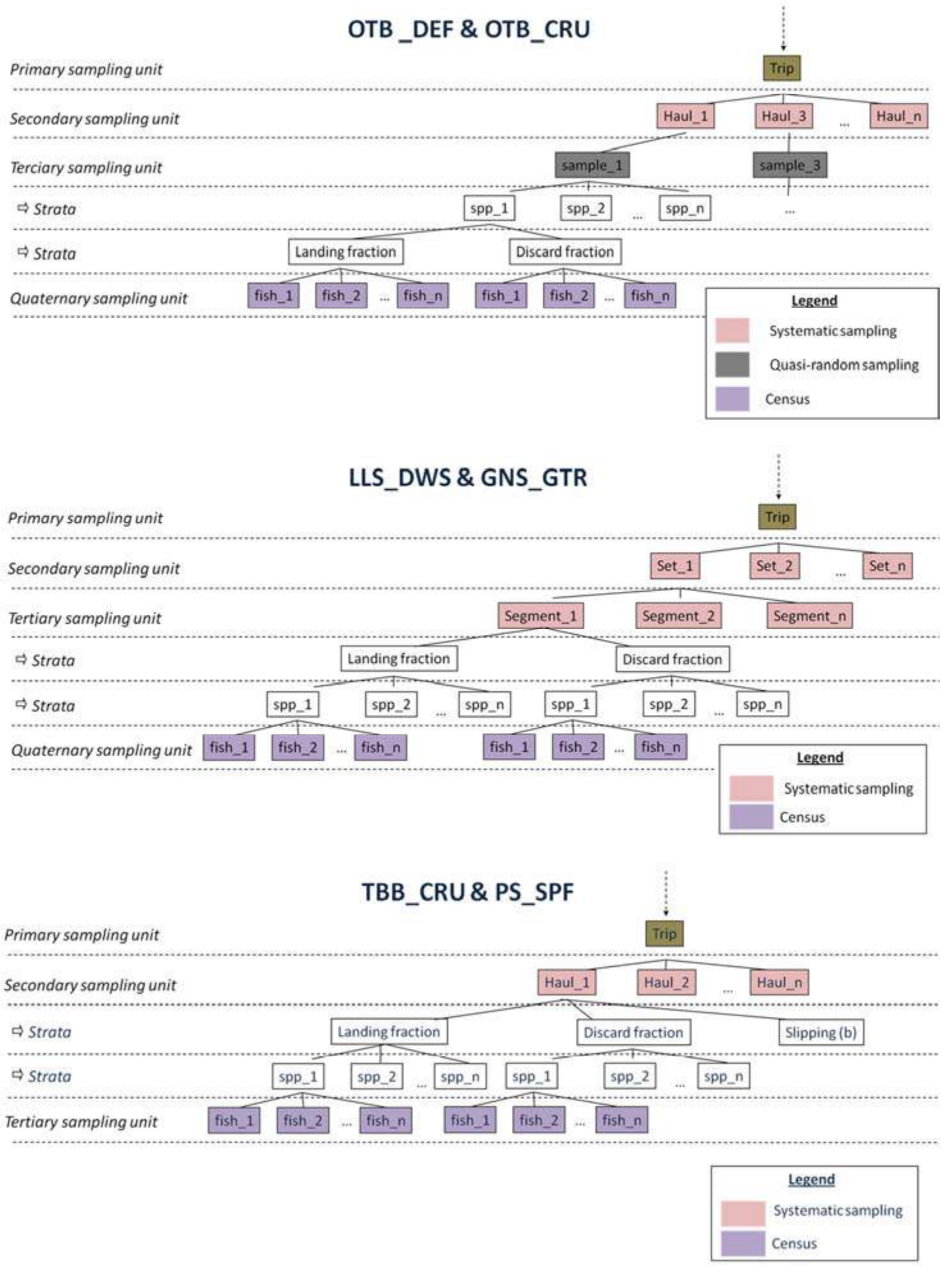

Figure 3.1.1.1 Onboard sampling design by gear type in Division IXa. (OTB_DEF-Bottom otter trawl for demersal fish; OTB_CRU- Bottom otter trawl for crustaceans; LLS_DWS- Deep-water longline; GNS_GTR- Gill and trammel net; TBB_CRU- Beam trawler for crustaceans; PS_SPF- Purse seine).

The following improvements were discussed:

(i) Additional control over potential biases can be obtained by implementing a log of contacts and the calculation of refusal rates.

(ii) Randomization of trips and ports of departure: a list of vessel owners/masters contacts is needed and the feasibility of randomizing the port of departure and vessel must be tested.

(iii) Sampling onboard trawlers might be improved by collecting 3 sample boxes from the haul (beginning, middle and end sections) in order to avoid size and species separation in the codend. Records from these boxes may be recorded separately in order to future evaluation of the need of such practice. IPMA observers reported that this approach is already in place but limited to 2 sample boxes due to time limitations for the final box sampling.

3.1.2 Sampling design in the Indian Ocean

The current onboard sampling design used by IPMA observers on fishing vessels operating in the Indian Ocean was presented (Lino *et al.*, P08 – Annex 4) and discussed.

Figure 3.1.2.1 presents the distribution of the Portuguese longline fleet and the observer sets in 2013 (Lino *et al.*, P08 – Annex 4). The current design includes a single observer trip per year. It was suggested that the observer should ideally switch from vessel to vessel during the trip to cover a higher representation of the fleet. However given the extension of the fishing area it was recognized that this procedure is impractical.

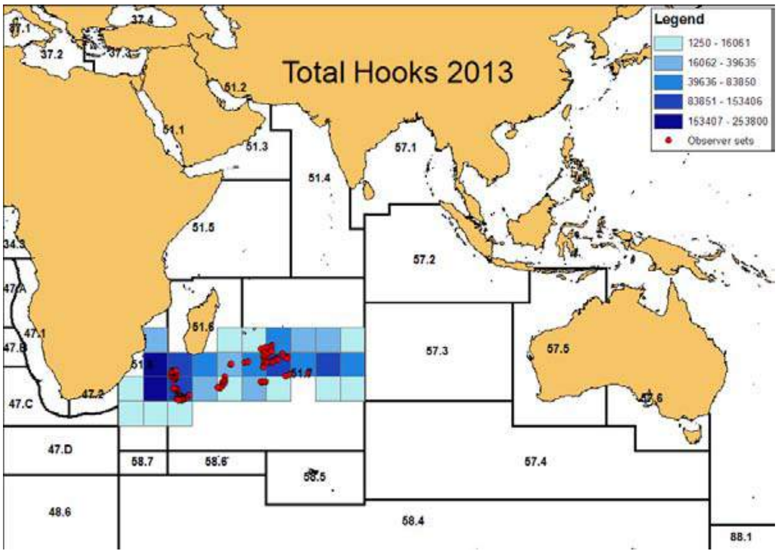

Figure 3.1.2.1 Fishing effort distribution of the Portuguese long-distance longline fleet in the Indian Ocean and observers coverage in 2013.

Given that the number of vessels effectively fishing during 2011 (when the observer program started) and 2012 was only 3, this allowed to cover 10-18% of the fished hooks (the *de facto* measure of effort for longline gears). However, the number of effective fishing vessels more than doubled (to 8 vessels) in 2013 and it is expected to increase further in 2014.

Given the possibility of the fishing area be expanded to the East, with two core areas, it was recommended the coverage of the two areas. However, if only one observer can be allocated, a switch between areas is advised starting with the area with less coverage.

3.2 Sources of bias on onboard sampling

3.2.1 Literature review

The Vølstad and Fogarty (2006) report focuses on the sources of bias based on 24 observer programs representing all regions covered by the US National Observer Program. The report identifies major sources of bias and suggests methodological approaches for evaluating and minimizing bias in vessel selection in observer programs. The major sources identified were: (1) errors in the sampling frame,

(2) vessel selection and observer deployment, (3) bias caused by changes in fishing behaviour in the presence of observers.

Table 3.2.1.1 elaborated during WKSDO presents the criteria for vessel selection within a sampling frame. During the workshop a case study was selected aiming to assess if the currently onboard sampled vessels would conform to a reference fleet.

Table 3.2.1.1 Criteria used for vessel selection within a sampling frame

Criteria	Average Fleet	Average for Vessel1	Vessel1 with Observer	Source
Vessel length				Fleet
Main gear used				Logbooks
Fishing effort (lenght/hooks/duration)				Logbooks
Trip duration (days)				Logbooks
Number of fishing operations				Logbooks
Total catch/trip				Landings
Depth of observed tows/sets				VMS
Species composition				
SpeciesA ()				Landings
SpeciesB ()				Landings
SpeciesC ()				Landings
Fishing days/year				Logbooks
Fishing area				VMS
Fishing season				Logbooks
Contribution to total catch landed				Landings

Some methods to analyze sources of bias on onboard sampling are suggested in Rago *et al.* (2005) where they also compare several measures of performance for vessels with and without the presence of observers, testing hypotheses for comparing observable properties (e.g. trip duration, fishing areas, total trip landings, etc.) in vessels´ strata. If observed and unobserved trips, within a stratum, measure the same underlying process, one could expect no statistical differences between variable means (and standard deviations) measured from the Vessel Trip Report (VTR or logbooks) and the observer data sets. Examining these differences may indicate if there is evidence of systematic bias. They used a paired t-test to infer about the correlation between the two sources of data, showing that the mean difference of the average catch between the two data sets were not significantly different from zero. Concerning measures of spatial coherence two different approaches are presented: one using information from VTR and the other using VMS data. Murawski *et al.* (2005) found that spatial resolution of traditional data sources (e.g. VTR or logbooks) was insufficient to discern detailed analysed effects, as revealed by high-resolution vessel positions from VMS and catch data obtained by observers. Their results showed that effort concentration profiles deduced from VMS data coincide almost exactly with the profiles derived from the observed trips. Overall, these comparisons suggested strong coherence between these two independent measures of fishing locations and should be used.

3.2.2 Case study on Fish Otter Trawl (>=24m)

Bottom otter trawl for fish (OTB_DEF) in 2012 was the fleet segment selected for this case study and only vessels with overall length above 24 meters were considered. The study was performed in order to analyze if the group of sampled vessels in the Portuguese mainland waters (6 vessels) were representative of the sampling frame (target fleet – 25 vessels) and could be considered as a reference fleet. Logbook, market sales and vessel monitoring system (VMS) information were used for the analysis of the fleet activity. Table 3.2.2.1 shows the total number of fishing days and total landings for each of the analysed components (target fleet, group of vessels sampled and each sampled vessel). Percentages of landings by the sampled group in relation to the total target fleet were also calculated.

Table 3.2.2.1 Official landings and number of fishing trips for each of the analysed components (Fleet - target fleet; Group SV - observed group of vessels; V –vessels) in 2012.

General information	Source	Fleet (25 v)	Group SV (6 v)	Vessel1	Vessel2	Vessel3	Vessel4	Vessel5	Vessel6
Mean vessel length (m)	Fleet register	29	30	28	28	28	31	29	35
Number of fishing trips/year/vessel	Market sales	152	161	200	202	184	183	146	48
Number of fishing trips/year	Market sales	3792	963	5 (a)	9 (a)	2 (a)	12 (a)	2 (a)	1 (a)
Mean annual landings per vessel (t)	Market sales	363	365	311	364	537	377	460	142
Total annual landings (t)	Market sales	9,084	2,191						
Contribution to total catch landed	Market sales	-----------	24%	3%	4%	6%	4%	5%	2%

(a) number of sampled trips

The results show that the group of sampled vessels present similar ranges for annual number of trips per vessel and annual landings. They are also responsible for a high proportion of the total landings for the sampling frame. This is a good indicator that the selected vessels could be part of a reference fleet.

The criteria used to compare fishing activity of sampling frame and sampled vessels included fishing effort, trip duration, number of fishing operations, total landings per trip, fishing depth, fishing area and also total landings and landings of selected species per trip. Table 3.2.2.2 summarizes the results for all the criteria analysed. The values obtained for the sampled vessels and for the trips with observers onboard have the same ranges that those obtained for the fleet. Further statistical analysis should be performed to confirm these results.

The analysis of spatial distribution of the target fleet versus onboard observed vessels fishing activities was performed by plotting VMS information. Maps were produced to show the spatial distribution of the fishing activity for the three studied components (target fleet; group of sampled vessels; and locations of sampled trips) and also to infer on a possible observers' effect (bias caused by changes in fishing behaviour in the presence of observers). Results are presented per quarter to analyze possible seasonal changes in those distributions (Figure 3.2.2.1). The visual inspection of these plots shows that the spatial distribution of the group of sampled vessels covers the same areas as the target fleet (Figure 3.2.2.1a). This is a good indicator that the sampled vessels are representative of the sampling frame and therefore, they could be used as a reference fleet for this stratum.

In what concerns to observers' effect on fishing behaviour, Figure 3.2.2.1(b) shows that the spatial distribution of trips with onboard observer (quarter and area) are within the fishing area of the group of sampled vessels, indicating that the characteristics of the observed fishing trips do not differ from the regular operation of the vessel. However, it is not possible to conclude anything on the observers′ effect in the SW and S areas in quarters 2-4, due to lack of observers' coverage.

Table 3.2.2.2 - Results obtained, median and 1st and 3rd quartile values (in brackets), when comparing study fleet and onboard data: vessels with the same characteristics (OTB_DEF, overall length above 24m), for year 2012. (SV – sampled vessels; WO – with observer; NW – Northwest coast; SW – Southwest coast; S – South coast)

Criteria	Source (fleet)	Target fleet	Group SV	Vessel1	Vessel1WO	Vessel2	Vessel2 WO
Fishing effort (fishing hours)	Logbooks	9.6 (7.1-12.1)	8 (6-10)	10 (8-12)	10 (10-10)	8.0 (6-10)	8.0 (5.9-8.5)
Trip duration (days)	Logbooks	0.65 (0.58-0.73)	0.61 (0.53-0.69)	0.66 (0.63-0.71)	0.65 (0.6-0.66)	0.58 (0.54-0.65)	0.58 (0.56-0.64)
Number of fishing operations	Logbooks	4 (3-5)	4 (3-5)	4 (3-5)	4 (4-4)	4 (3-5)	4 (4-4)
Total landings/trip (ton)	Landings	1856 (1191-3019)	1840 (1259-2790)	1225 (803-1852)	1214 (1107-1731)	1528 (1098-2100)	1209 (891-1391)
Depth of observed tows/sets	VMS	81 (58-134)	92 (60-121)	113 (68-128)	122 (91-126)	104 (68-132)	128 (120-139)
Fishing area	VMS	All coast	All coast	NW	NW	SW	SW
Species composition							
SpeciesA (HKE)	Market sales	106 (46-229)	114 (49-226)	26 (12-56)	13 (11-17)	177 (68-306)	209 (137-290)
SpeciesB (HOM)	Market sales	744 (349-1333)	802 (418-1328)	892 (522-1429)	1019 (765-1378)	814 (388-1268)	471 (213-899)
SpeciesC (MAS)	Market sales	68 (20-204)	80 (22-252)	19 (7-52)	19 (17-48)	105 (27-251)	102 (19-214)

Criteria (cont.)	Vessel3	Vessel3 WO	Vessel4	Vessel4 WO	Vessel5	Vessel5 WO	Vessel6	Vessel6 WO
Fishing effort (fishing hours)	7.9 (6-9.5)	9.0 (8.6-9.4)	6.7 (5.3-8.6)	6.9 (5.4-7.2)	8.3 (6.0-10.6)	8.5 (7.9-9.1)	8.0 (6.7-10.0)	10 (10-10)
Trip duration (days)	0.51 (0.47-0.64)	0.48 (0.48-0.48)	0.61 (0.57-0.65)	0.59 (0.58-0.62)	0.62 (0.54-0.71)	0.66 (0.64-0.68)	0.65 (0.55-0.70)	0.58 (0.58-0.58)
Number of fishing operations	5 (4-7)	4.5 (4.25-4.75)	4 (3-4)	4 (3-4)	5 (4-7)	5 (5-5)	3 (3-4)	3 (3-3)
Total landings/trip (ton)	2614 (1821-3571)	2687 (2628-2746)	1740 (1271-2312)	1694 (1393-2243)	2378 (1881-3550)	1493 (1273-1714)	2556 (1723-3975)	1825 (1825-1825)
Depth of observed tows/sets	69 (57-105)	79 (75-128)	80 (52-133)	117 (76-137)	105 (63-126)	128 (101-137)	123 (100-157)	79 (75-128)
Fishing area	S	S	NW	NW	S	S	NW; SW	NW
Species composition								
SpeciesA (HKE)	138 (82-228)	65 (57-72)	123 (60-201)	88 (63-120)	84 (41-141)	82 (56-109)	369 (126-602)	608 (608-608)
SpeciesB (HOM)	610 (265-1007)	185 (144-227)	1192 (731-1690)	1338 (1058-1815)	580 (262-968)	74 (73-76)	1036 (590-1274)	1001 (1001-1001)
SpeciesC (MAS)	236 (98-771)	143 (111-176)	28 (14-71)	22 (11-38)	213 (73-634)	377 (196-558)	132 (30-273)	30 (30-30)

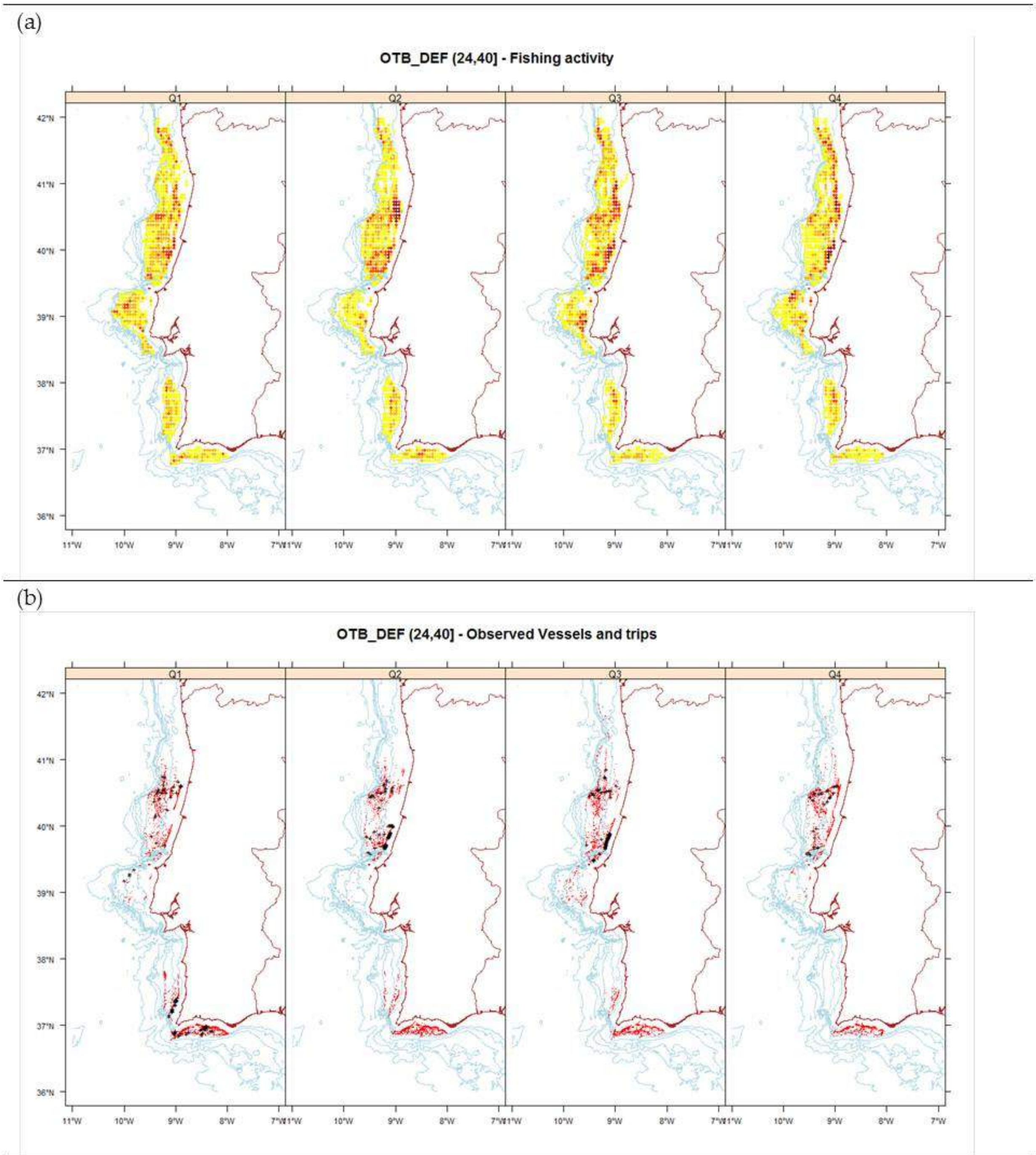

Figure 3.2.2.1 Spatial distribution of fishing activity based on VMS records from: (a) all vessels of the target fleet (gradient of density: yellow for low to red for high); (b) the group of sampled vessels (red dots) and the trips with observers onboard (black dots), for year 2012.

3.3 Discussion and conclusions

Regarding the sampling onboard the Portuguese long-distance fleet operating in the Indian Ocean and when only one observer is assigned to this task, a switch between West and East areas is advised, starting with the area with less coverage.

From the analyses and discussions on the onboard sampling in Division IXa, several outlines for future work were drawn:

- Information on refusals and reasons for not deploying observers (e.g. lack of working/rest conditions for the observer, lack of security, etc.) should be collected in a systematic way.
- The criteria used in the workshop for vessels selection can be applied to all fleet segments to identify a reference fleet by segment.
- The onboard program may be switched to reference fleet based sampling only for segments where random sampling is not possible due to high refusal rate and where a reference fleet can be positively identified. Cluster analysis of landings and effort data in the population (based on sales and logbooks) may allow the identification of vessels with specific behaviour pattern that may constitute strata within the reference fleet;
- Actions to disseminate information from onboard sampling must be developed to increase the number of vessels on which the operators agree to take observers.

Finally, some recommendations were addressed to external bodies:

- To DGRM and SWWAC: Facilitate updated list of contacts of masters and skippers.
- To SWWAC: Indicate the type of information the skippers /masters /associations find relevant and would like to receive from PNAB-IPMA onboard sampling programme.

4 Sampling for biological parameters – Growth and Reproduction (ToR 3)

4.1 Age-length Keys

4.1.1 Sampling effort: how much is enough?

The sampling of fish for estimating age-composition of fish population and of commercial landings is expensive, and it is therefore important to use efficient estimators, as well as cost-effective sub-sampling strategies. The work by Aanes and Vølstad (Vølstad, P10 – Annex 4), "Efficient statistical estimators and sampling strategies for estimating the age composition of fish", to appear in Canadian Journal of Fisheries and Aquatic Sciences deals with the issue of estimating the age-composition of fish, including the quantification of uncertainty, based on sample data from commercial catch sampling programs and scientific trawl surveys. In recent years there has been an increasing focus on the statistical aspects of sample surveys and the quantification of uncertainty in input-data to stock assessments. Aanes and Vølstad (in review) focused on the design-based estimators of proportions-at-age and the accuracy (precision and bias) of such estimates derived from complex cluster sampling, which is the norm. Aanes and Vølstad show how estimators (Age-Length-Keys and design-based estimators) and subsampling strategies can be evaluated through simulation studies, and provide advice on the choice of estimators and level of age-sampling from primary sampling units (e.g., vessel-trips). Many years of effort by expert groups in ICES have revealed the need for statistically sound survey designs and estimation methods for quantifying the age-composition of commercial catches both nationally and regionally. This paper provides guidance on the evaluation and choice of estimators and sampling strategies that is relevant for large sampling programs of fish worldwide. The approach was used during the workshop to explore otoliths sampling design optimization for age data collection and age-length keys, with application to the sardine case-study (Section 4.1.2).

4.1.2 Sardine case-study

4.1.2.1 Introduction

The Atlantic Iberian sardine, *Sardina pilchardus*, (ICES Divs. VIIIc+IXa) is considered as a single stock for management purposes. The fishing fleet for this resource is mainly composed by purse-seiners (99% of landings) (Portugal: 160, of which around 115 are medium to large size vessels; Spain: 332).

Catches sharply decreased since the middle of the 80´s due to successive low recruitment years. There was a 60% abundance decrease in the last 10 years and since 2011 landings dropped from about 72000 tons to around 41000 tons in 2013 (the lowest value within the historic series since 1954), raising serious concern for the resource sustainability.

High variability of stock abundance is mainly due to direct influence of environmental factors on annual recruitments.

The fishery management measures since 1998 (Portugal and Spain) involve limitation of fishing boats in activity, TAC and catch ban periods. Presently the fishery is interdicted till the end of this year, as the TAC of 20 thousand tons for 2014 was exceeded.

Within the sardine case-study a presentation was carried out based on the 2012 and 2013 sampling data for growth parameters estimation and considering the discussion on otoliths sampling design optimization for age data collection and age-length keys (ALK's) construction (Soares, P11 – Annex 4). The collection of sardine otoliths is based on a two stage stratified sampling programme (PNAB – National Biological Sampling Programme): fish sampling with quarterly periodicity in landing harbours (North – Matosinhos and Póvoa-de-Varzim; Centre - Peniche and South – Olhão and Portimão) involving otolith collection from 10 individuals in each length class by sample. Additional sampling is carried out in research surveys at sea.

4.1.2.2 Sampling design optimization for age data collection and age-length keys - exploratory analysis

The selected samples for the ALK's construction must represent the population, and considering that the 2013 ALK's estimated values are accurate and precise, different numbers of otoliths' pairs by length class in each sample were tested in order to check if their representativeness of the population was preserved. Samples/fishing vessels were used as PSU, randomly selecting in each sample respectively 10, 5, 2 and 1 pairs of otoliths by length class and for length class intervals of 0.5 cm and 1.0 cm. Whenever a length class did not comprise the required number of otoliths, the existing ones were used.

The analysis of the sardine ALK´s for 2013 (Soares, P11 – Annex 4) showed that the average fish total length by age group varied among the four quarters of 2013 and also between areas (North, Centre and South), hence "quarter" and "area" variables were used in the tests.

In order to detect any differences between market samples from the same landing ports in the North area and from the same time period (quarters 3 and 4, data monthly compared) a Tukey HSD test comparing the mean length by each age group was carried out.

Table 4.1.2.2.1 shows the mean length, standard deviation, number of otoliths and length range in each age group in the whole year in each area for the sampling conditions involving 10, 5, 2 and 1 pairs of otoliths by length class and for length class intervals of 0.5 and 1.0 cm.

Figure 4.1.2.2.1 shows the boxplots with fish average length in each age group, by area for each of the four sampling test conditions (10, 5, 2 and 1 pairs of otoliths by length class) and the length intervals of 0.5 and 1.0 cm.

Figures 4.1.2.2.2 to 4.1.2.2.4 show the boxplots with fish average length in each age group, by quarter and area for each of the four sampling test conditions (10, 5, 2 and 1 pairs of otoliths by length class) and the length intervals of 0.5 and 1.0 cm.

Figure 4.1.2.2.5 shows the fishing sites geographic positions in the North area from which samples were used for comparing the mean length at age group from samples from different vessels fishing in different areas.

Figure 4.1.2.2.6 presents the Tukey HSD test results comparing the mean length of the samples collected from catches undertaken in the sites/quarters shown in figure 4.1.2.2.5.

Table 4.1.2.2.1 Mean length (cm), standard deviation, number of otoliths and length range in each age group in the whole year in each area for 10, 5, 2 and 1 otoliths' pairs by length class and length class intervals of 0.5 and 1.0 cm. These variables are also shown for original ALK's as a reference (yellow columns). (ALK's were built based on 0.5 cm length class intervals).

Total_2013_OTOLITOS																	
		Age 0			Age 1			Age 2			Age 3			Age 4			Age 5
		0.5 cm	1 cm	ALK_2013	0.5 cm	1 cm	ALK_2013	0.5 cm	1 cm	ALK_2013	0.5 cm	1 cm	ALK_2013	0.5 cm	1 cm	ALK_2013	0.5 cm
10 OTO	Mean Lt(cm)	15.1	15.2	15.6	18.4	18.3	18.6	19.8	19.8	19.6	20.3	20.3	20.4	21.3	21.2	21.0	21.3
	s.d.	1.64	1.59	1.61	1.51	1.51	1.41	1.24	1.24	1.29	1.31	1.33	1.23	1.02	1.07	1.05	1.09
	nº otoliths	278	141	447	1298	678	1967	1089	528	2182	849	432	1618	471	249	998	288
	LT(cm) min	10.5	11.0	10.5	13.0	13.0	13.0	15.5	16.2	15.5	16.5	17.0	16.5	18.0	18.0	17.2	18.6
	LT(cm) max	18.8	18.4	19.7	22.9	22.3	22.9	23.2	23.2	23.2	24.3	24.3	24.3	23.6	23.4	24.0	24.3
5 OTO	Mean Lt(cm)	15.2	15.4	15.6	18.3	18.3	18.6	19.8	19.8	19.6	20.3	20.4	20.4	21.3	21.3	21.0	21.5
	s.d.	1.71	1.66	1.61	1.53	1.55	1.41	1.30	1.30	1.29	1.38	1.37	1.23	1.01	1.16	1.05	1.14
	nº otoliths	171	82	447	751	382	1967	619	299	2182	481	245	1618	255	143	998	169
	LT(cm) min	10.5	11.0	10.5	13.0	13.0	13.0	15.5	16.2	15.5	16.5	17.0	16.5	18.2	18.0	17.2	18.6
	LT(cm) max	18.3	18.4	19.7	22.9	22.3	22.9	23.2	22.3	23.2	24.3	24.3	24.3	23.6	23.4	24.0	24.3
2 OTO	Mean Lt(cm)	15.2	15.3	15.6	18.1	18.2	18.6	19.7	19.6	19.6	20.4	20.4	20.4	21.3	21.5	21.0	21.7
	s.d.	1.87	1.72	1.61	1.53	1.67	1.41	1.34	1.31	1.29	1.47	1.41	1.23	1.08	1.06	1.05	1.18
	nº otoliths	87	41	447	328	180	1967	265	133	2182	201	90	1618	120	56	998	72
	LT(cm) min	10.5	11.0	10.5	13.0	13.0	13.0	15.5	16.2	15.5	17.1	17.3	16.5	18.0	18.3	17.2	19.5
	LT(cm) max	18.3	18.3	19.7	22.3	22.1	22.9	23.2	22.3	23.2	24.3	24.3	24.3	23.6	23.2	24.0	24.3
1 OTO	Mean Lt(cm)	15.4	15.3	15.6	18.1	17.9	18.6	19.7	19.6	19.6	20.3	20.5	20.4	21.4	21.5	21.0	21.9
	s.d.	1.92	1.79	1.61	1.65	1.59	1.41	1.46	1.35	1.29	1.43	1.50	1.23	1.13	1.08	1.05	1.16
	nº otoliths	52	25	447	181	88	1967	127	65	2182	105	66	1618	64	30	998	49
	LT(cm) min	10.6	11.0	10.5	13.0	13.0	13.0	15.5	16.2	15.5	17.3	17.1	16.5	18.0	20.0	17.2	19.7
	LT(cm) max	18.4	18.2	19.7	21.5	20.3	22.9	22.6	22.3	23.2	24.3	24.3	24.3	23.6	23.4	24.0	24.3

Matosinhos_2013_OTOLITOS																	
		Age 0			Age 1			Age 2			Age 3			Age 4			Age 5
		0.5 cm	1 cm	ALK_2013	0.5 cm	1 cm	ALK_2013	0.5 cm	1 cm	ALK_2013	0.5 cm	1 cm	ALK_2013	0.5 cm	1 cm	ALK_2013	0.5 cm
10 OTO	Mean Lt(cm)	16.7	16.8	16.4	19.0	18.9	19.1	20.3	20.3	20.0	21.1	21.1	21.0	21.8	21.7	21.7	22.2
	s.d.	0.63	0.68	0.88	1.39	1.42	1.26	1.17	1.17	1.36	1.06	1.09	1.09	0.81	0.85	0.90	1.04
	nº otoliths	72	39	132	501	256	879	427	203	812	239	117	524	199	104	277	62
	LT(cm) min	15.5	16.0	14.5	15.3	15.3	15.3	17.0	17.0	16.0	17.8	19.0	16.5	19.4	19.4	18.3	18.6
	LT(cm) max	18.4	18.4	19.3	22.9	22.3	22.9	23.2	23.2	23.2	24.3	24.3	24.3	23.6	23.4	23.8	23.9
5 OTO	Mean Lt(cm)	16.7	16.9	16.4	18.9	18.9	19.1	20.3	20.2	20.0	21.1	21.2	21.0	21.9	21.9	21.7	22.3
	s.d.	0.66	0.72	0.88	1.43	1.49	1.26	1.19	1.23	1.36	1.14	1.17	1.09	0.77	0.88	0.90	1.04
	nº otoliths	47	25	132	276	140	879	224	112	812	138	66	524	107	56	277	38.00
	LT(cm) min	15.5	16.0	14.5	15.3	15.3	15.3	17.1	17.0	16.0	17.8	19.0	16.5	20.2	19.4	18.3	18.6
	LT(cm) max	18.3	18.4	19.3	22.9	22.3	22.9	23.2	22.3	23.2	24.3	24.3	24.3	23.6	23.4	23.8	23.9
2 OTO	Mean Lt(cm)	16.7	16.9	16.4	18.9	18.9	19.1	20.3	20.2	20.0	21.1	21.2	21.0	21.9	21.9	21.7	22.3
	s.d.	0.66	0.72	0.88	1.43	1.49	1.26	1.19	1.23	1.36	1.14	1.17	1.09	0.77	0.88	0.90	1.04
	nº otoliths	47	25	132	276	140	879	224	112	812	138	66	524	107	56	277	38
	LT(cm) min	15.5	16.0	14.5	15.3	15.3	15.3	17.1	17.0	16.0	17.8	19.0	16.5	20.2	19.4	18.3	18.6
	LT(cm) max	18.3	18.4	19.3	22.9	22.3	22.9	23.2	22.3	23.2	24.3	24.3	24.3	23.6	23.4	23.8	23.9
1 OTO	Mean Lt(cm)	17.0	16.7	16.4	18.9	18.6	19.1	20.4	20.2	20.0	21.2	21.7	21.0	22.0	22.2	21.7	22.4
	s.d.	0.78	0.65	0.88	1.44	1.34	1.26	1.23	1.21	1.36	1.19	1.18	1.09	0.94	0.86	0.90	1.07
	nº otoliths	13	6	132	58	28	879	49	25	812	27	18	524	23	10	277	12
	LT(cm) min	15.9	16.0	14.5	15.4	15.3	15.3	17.3	17.3	16.0	18.7	20.0	16.5	20.2	21.0	18.3	19.7
	LT(cm) max	18.4	17.4	19.3	21.5	20.3	22.9	22.6	22.3	23.2	24.3	24.3	24.3	23.6	23.4	23.8	23.9

Table 4.1.2.2.1 Mean length (cm), standard deviation, number of otoliths and length range in each age group in the whole year in each area for 10, 5, 2 and 1 otoliths' pairs by length class and length class intervals of 0.5 and 1.0 cm. These variables are also shown for original ALK's as a reference (yellow columns). (ALK's were built based on 0.5 cm length class intervals). (continued)

Peniche_2013_OTOLITOS																	
		Age 0			Age 1			Age 2			Age 3			Age 4			Age 5
		0.5 cm	1 cm	ALK_2013	0.5 cm	1 cm	ALK_2013	0.5 cm	1 cm	ALK_2013	0.5 cm	1 cm	ALK_2013	0.5 cm	1 cm	ALK_2013	0.5 cm
10 OTO	Mean Lt(cm)	14.3	14.4	15.2	18.9	18.9	18.9	20.2	20.2	19.9	20.9	20.9	20.7	21.3	21.5	21.3	21.8
	s.d.	1.58	1.47	1.85	1.14	1.15	1.13	1.08	1.07	1.07	1.00	1.03	0.98	0.84	0.85	0.82	0.84
	nº otoliths	141	70	244	390	201	602	381	184	782	306	164	629	172	83	373	106
	LT(cm) min	10.5	11.0	10.5	13.0	13.0	13.0	16.5	17.0	16.5	18.0	18.0	17.7	19.5	20.0	18.7	19.9
	LT(cm) max	18.8	18.2	19.7	21.2	21.2	21.3	22.8	22.4	22.8	23.3	23.3	23.3	23.3	23.3	24.0	19.9
5 OTO	Mean Lt(cm)	14.3	14.5	15.2	18.8	18.8	18.9	20.2	20.1	19.9	20.9	20.9	20.7	21.4	21.5	21.3	22.1
	s.d.	1.71	1.57	1.85	1.17	1.22	1.13	1.15	1.13	1.07	1.11	1.08	0.98	0.86	0.87	0.82	0.83
	nº otoliths	84	40	244	241	119	602	223	106	782	161	90	629	88	49	373	57
	LT(cm) min	10.5	11.0	10.5	13.0	13.0	13.0	16.5	17.0	16.5	18.0	18.4	17.7	19.7	20.1	18.7	20.3
	LT(cm) max	18.2	18.2	19.7	21.1	21.1	21.3	22.6	22.3	22.8	23.3	23.3	23.3	23.3	23.1	24.0	24.3
2 OTO	Mean Lt(cm)	14.6	14.8	15.2	18.6	18.7	18.9	20.1	20.0	19.9	21.1	20.9	20.7	21.4	21.7	21.3	22.3
	s.d.	1.96	1.76	1.85	1.20	1.39	1.13	1.16	1.19	1.07	1.08	1.12	0.98	0.98	0.81	0.82	0.99
	nº otoliths	45	23	244	108	61	602	96	46	782	67	26	629	44	24	373	27
	LT(cm) min	10.5	11.0	10.5	13.0	13.0	13.0	16.8	17.2	16.5	18.4	19.3	17.7	19.5	20.2	18.7	20.0
	LT(cm) max	18.2	18.2	19.7	21.0	21.1	21.3	22.3	22.3	22.8	23.3	23.1	23.3	23.3	23.1	24.0	24.3
1 OTO	Mean Lt(cm)	14.8	15.1	15.2	18.5	18.3	18.9	20.1	20.1	19.9	20.8	20.8	20.7	21.5	21.5	21.3	22.5
	s.d.	2.08	1.91	1.85	1.46	1.51	1.13	1.38	1.12	1.07	1.11	1.14	0.98	0.93	1.09	0.82	1.01
	nº otoliths	26	15	244	64	31	602	40	18	782	37	25	629	26	13	373	17
	LT(cm) min	10.6	11.0	10.5	13.0	13.0	13.0	17.0	18.3	16.5	18.8	18.3	17.7	19.7	20.1	18.7	20.3
	LT(cm) max	18.2	18.2	19.7	21.0	20.3	21.3	22.6	22.3	22.8	23.3	23.1	23.3	23.1	23.3	24.0	24.3

Portimao_2013_OTOLITOS																	
		Age 0			Age 1			Age 2			Age 3			Age 4			Age 5
		0.5 cm	1 cm	ALK_2013	0.5 cm	1 cm	ALK_2013	0.5 cm	1 cm	ALK_2013	0.5 cm	1 cm	ALK_2013	0.5 cm	1 cm	ALK_2013	0.5 cm
10 OTO	Mean Lt(cm)	15.1	15.1	15.3	17.1	17.2	17.3	18.7	18.7	18.6	19.2	19.1	19.3	20.1	20.1	20.2	20.5
	s.d.	1.09	1.03	1.16	1.19	1.17	1.20	0.80	0.83	0.93	0.89	0.93	0.91	0.73	0.78	0.77	0.63
	nº otoliths	65	32	71	407	221	486	281	141	588	304	151	455	100	62	348	120
	LT(cm) min	12.2	12.2	12.2	14.3	14.3	14.3	15.5	16.2	15.5	16.5	16.5	16.5	18	18	17.2	19.2
	LT(cm) max	17.6	17.1	17.6	20.3	20.3	20.3	20.8	20.4	21.7	21.4	21.4	21.6	21.6	21.4	22.1	22.5
5 OTO	Mean Lt(cm)	15.1	15.1	15.3	17.1	17.0	17.3	18.7	18.6	18.6	19.2	19.3	19.3	20.3	20.0	20.2	20.6
	s.d.	1.27	1.19	1.16	1.22	1.14	1.20	0.85	0.88	0.93	0.97	0.97	0.91	0.72	0.92	0.77	0.69
	nº otoliths	40	17	71	234	123	486	172	81	588	182	89	455	60	38	348	74
	LT(cm) min	12.2	12.2	12.2	14.3	14.3	14.3	15.5	16.2	15.5	16.5	17	16.5	18.2	18	17.2	19.2
	LT(cm) max	17.6	17.1	17.6	20.3	20.3	20.3	20.6	20.4	21.7	21.4	21.3	21.6	21.6	21.4	22.1	22.5
2 OTO	Mean Lt(cm)	14.8	15.0	15.3	17.0	16.9	17.3	18.6	18.6	18.6	19.1	19.3	19.3	20.3	20.0	20.2	20.9
	s.d.	1.39	1.49	1.16	1.26	1.18	1.20	0.91	0.98	0.93	0.96	0.91	0.91	0.83	0.79	0.77	0.77
	nº otoliths	20	8	71	114	57	486	71	39	588	76	39	455	29	11	348	33
	LT(cm) min	12.2	12.2	12.2	14.3	14.3	14.3	15.5	16.2	15.5	17.1	17.3	16.5	18	18.3	17.2	19.5
	LT(cm) max	17.1	17.1	17.6	20.3	19.3	20.3	20.6	20.4	21.7	21.3	21.1	21.6	21.6	21.1	22.1	22.5
1 OTO	Mean Lt(cm)	15.0	14.4	15.3	16.9	16.7	17.3	18.5	18.5	18.6	19.1	19.2	19.3	20.3	20.5	20.2	21.0
	s.d.	1.56	1.69	1.16	1.31	1.24	1.20	0.96	0.96	0.93	0.97	1.08	0.91	0.98	0.40	0.77	0.77
	nº otoliths	13	4	71	59	29	486	38	22	588	41	23	455	15	7	348	20
	LT(cm) min	12.2	12.2	12.2	14.3	14.3	14.3	15.5	16.2	15.5	17.3	17.1	16.5	18	20	17.2	20
	LT(cm) max	17.1	16.2	17.6	20.3	20.3	20.3	19.7	20.1	21.7	21.3	21.4	21.6	21.5	21.1	22.1	22.5

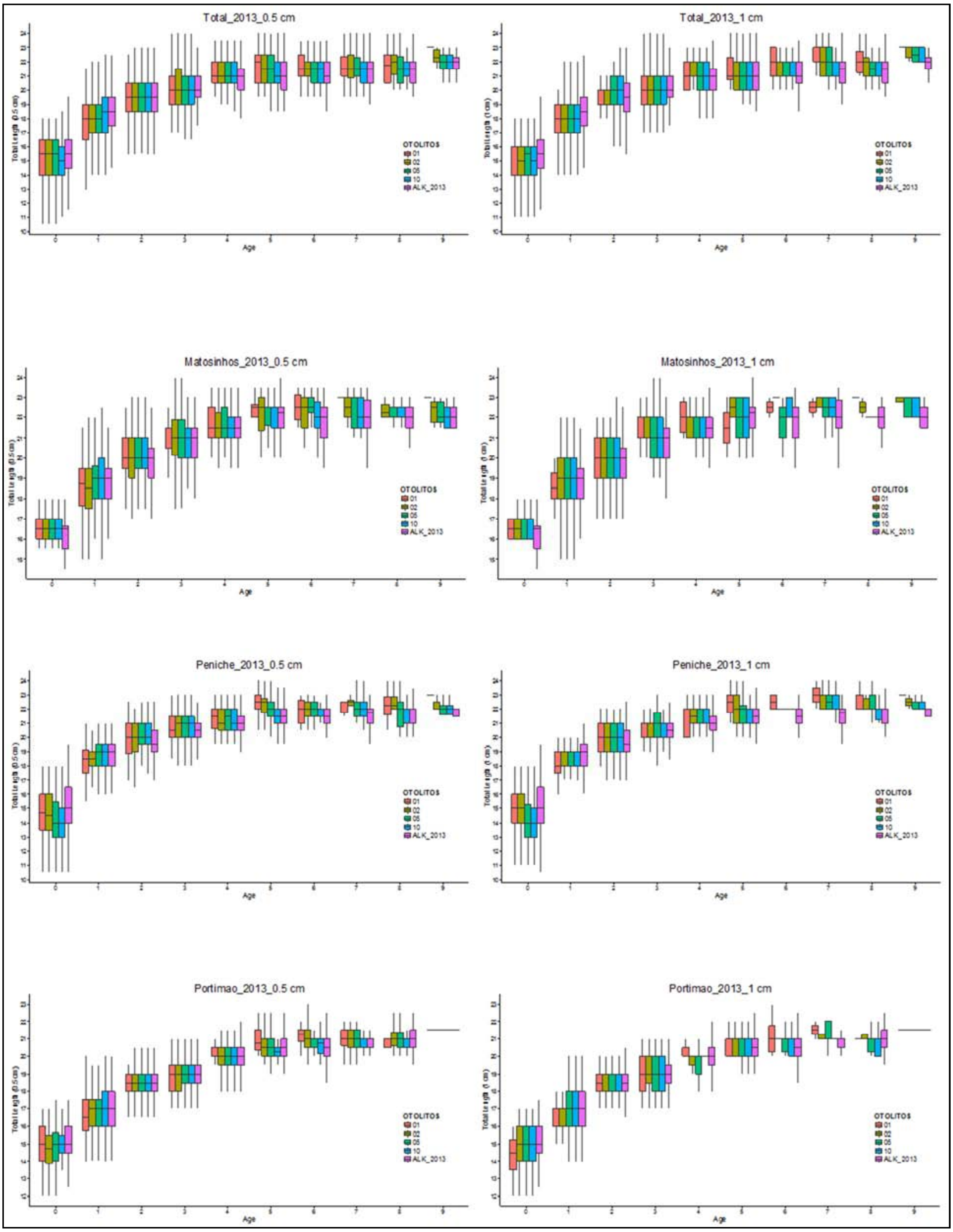

Figure 4.1.2.2.1 Fish average length (cm) in each age group, for the whole year and by area for each of the four sampling test conditions (10, 5, 2 and 1 otoliths' pairs by length class) and the length intervals of 0.5 and 1.0 cm.

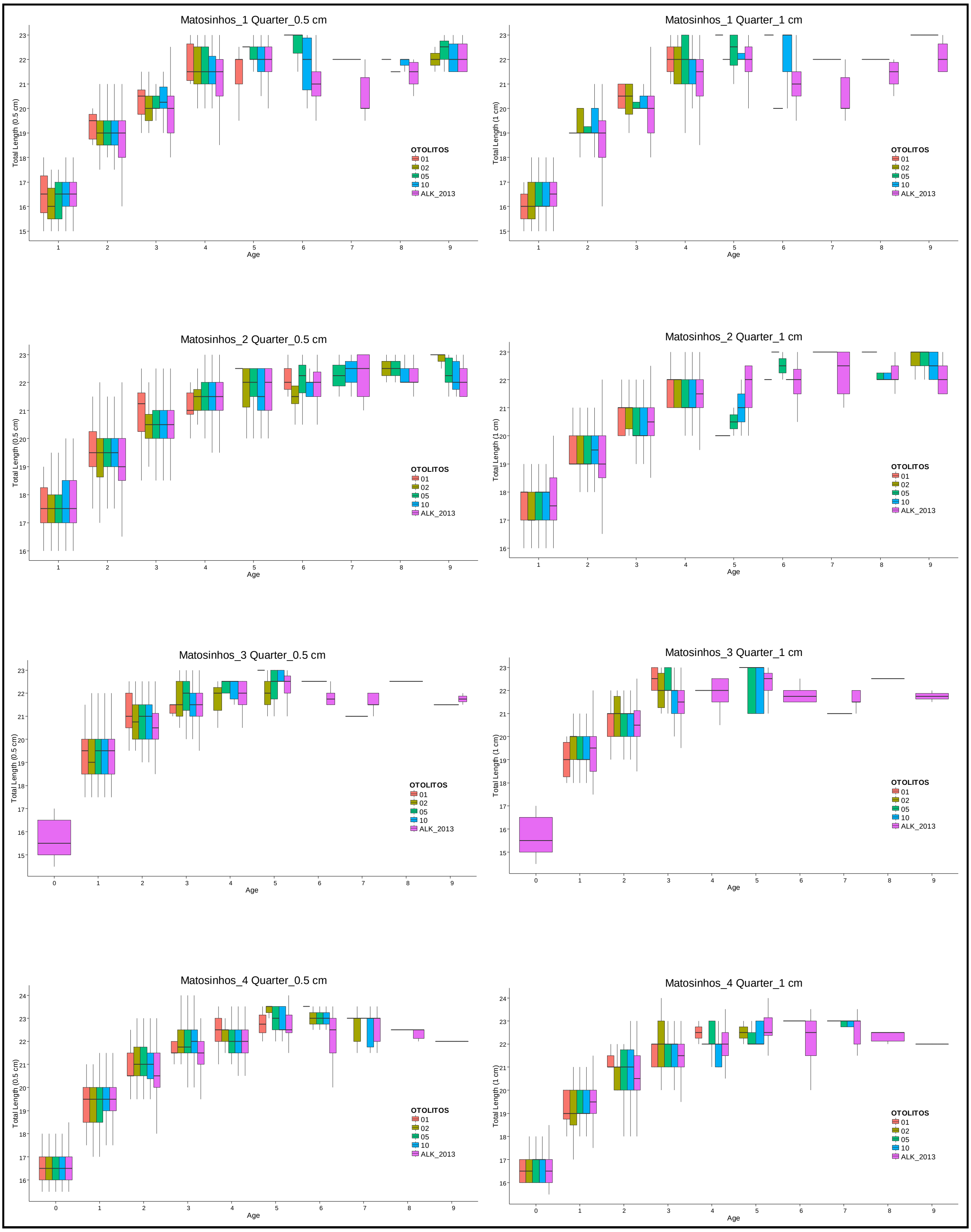

Figure 4.1.2.2.2 North (Matosinhos): fish average length (cm) in each age group, by quarter and area for each of the four sampling test conditions (10, 5, 2 and 1 otoliths' pairs by length class) and for the length intervals of 0.5 and 1.0 cm.

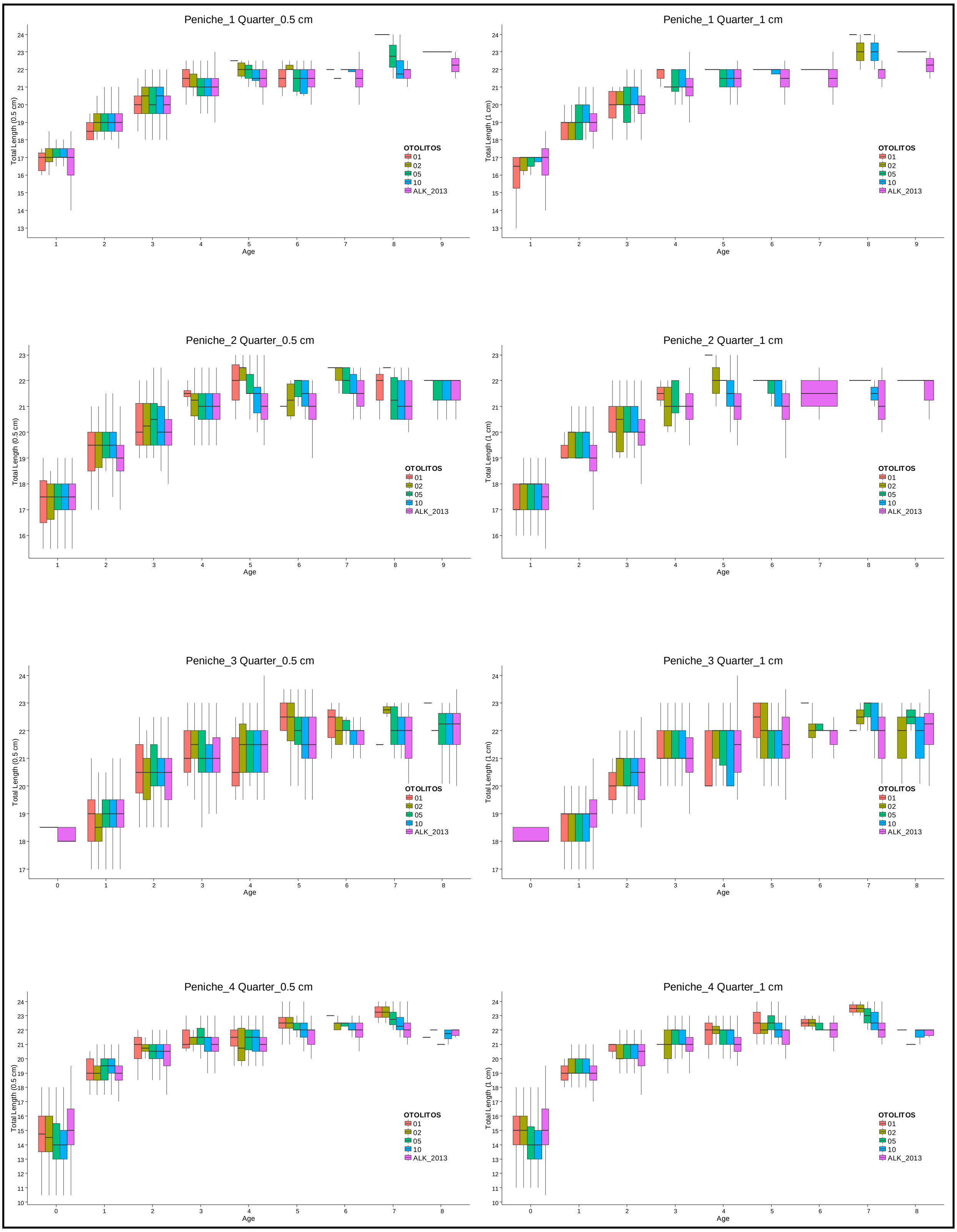

Figure 4.1.2.2.3 **Centre (Peniche): fish average length (cm) in each age group, by quarter and area for each of the four sampling test conditions (10, 5, 2 and 1 otoliths' pairs by length class) and the length intervals of 0.5 and 1.0 cm.**

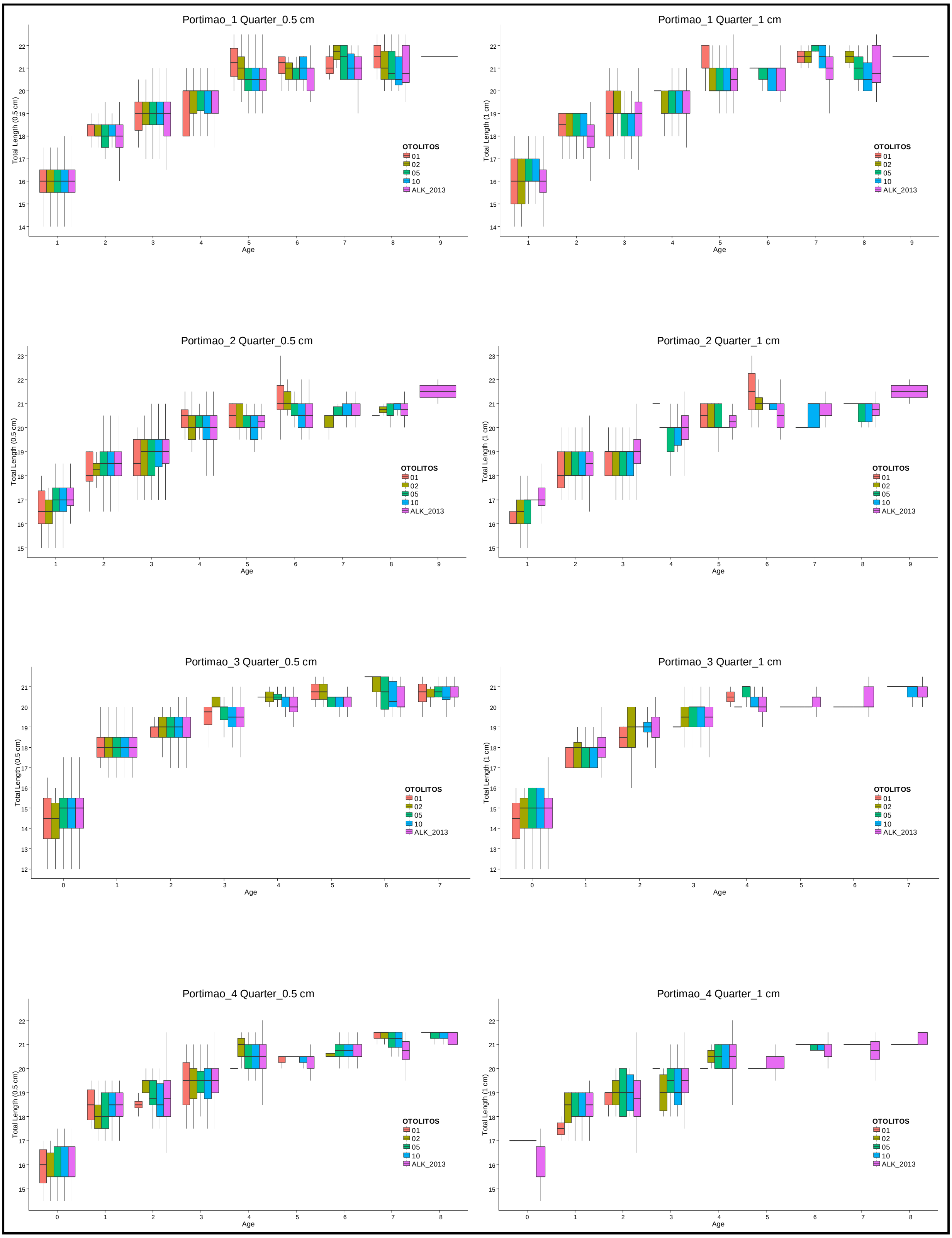

Figure 4.1.2.2.4 **South (Portimão): fish average length (cm) in each age group, by quarter and area for each of the four sampling test conditions (10, 5, 2 and 1 otoliths' pairs by length class) and the length intervals of 0.5 and 1.0 cm.**

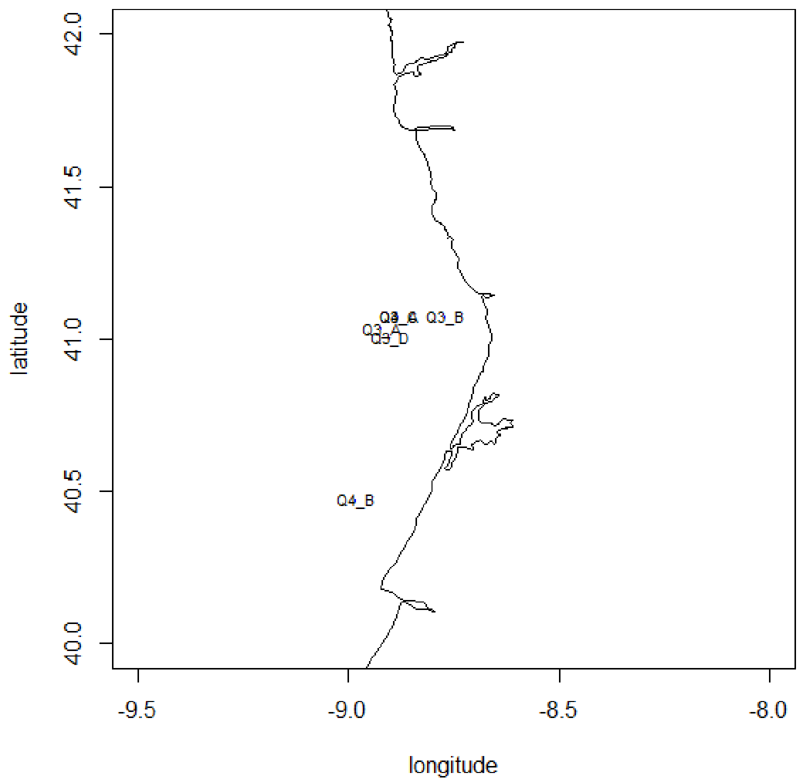

Figure 4.1.2.2.5 Fishing sites in the North area (Q3_C and Q4_A sites are overlapped).

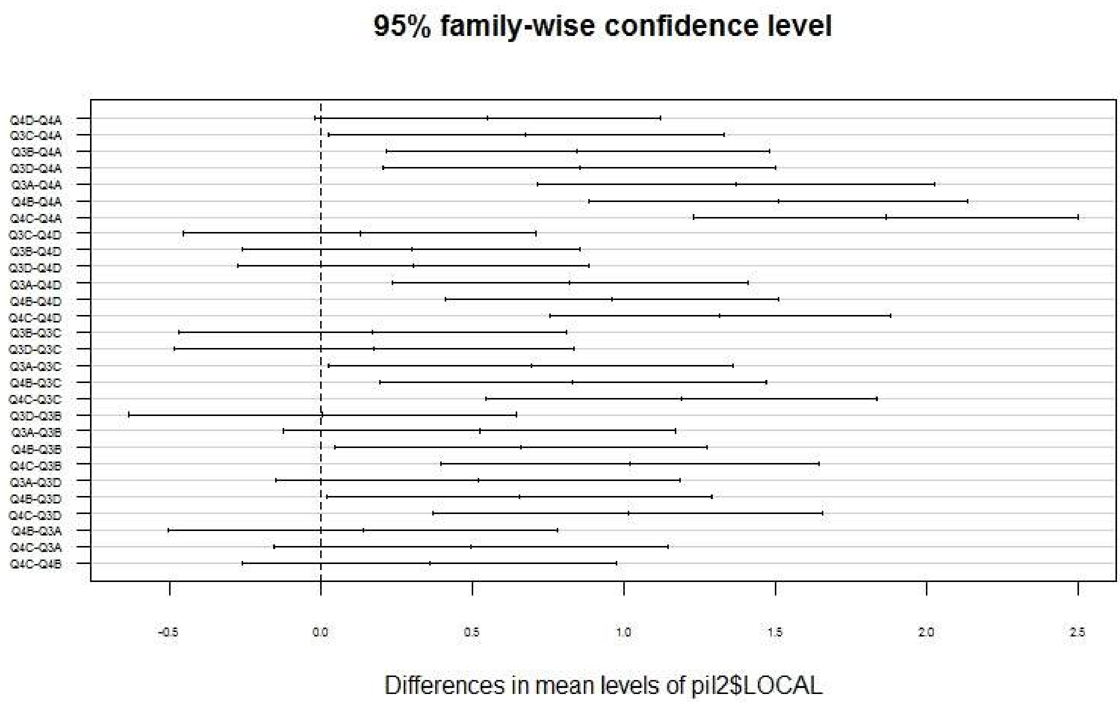

Figure 4.1.2.2.6 Tukey HSD test comparison between mean length by age group from each fishing site and quarters 3 and 4 (see Figure 4.1.2.2.5).

4.2 Maturity ogives

4.2.1 Introduction to hake case-study

The presentation from Costa *et al*. (P12 – Annex 4) raised several issues related to sampling and estimation of the maturity ogive (MO) for hake (*Merluccius merluccius*). The main questions raised were related to the time of sampling and the source of hake samples, given the sampling constraints because the species shows a sexual dimorphism in terms of growth and maturation (sex-ratio is 1:1 till ~ 35 cm of length, whereas at bigger sizes females are predominant in relation to males), and likely also presents ontogenetic and sexual changes in spatial distributions. However, MOs in assessment are sex combined.

Pros and cons of current sampling concerning the time of the year and the source of sampling off the Portuguese coast are (Costa *et al*., P12 – Annex4):

- If samples are taken during Autumn IBTS demersal surveys, the main advantage is that a larger range of sizes is sampled and proportions of mature fish at length can be more accurately raised to the abundances estimated during the surveys. The disadvantages are: the survey takes place out of the main spawning season, there is an increased probability of macroscopic misidentification of immature/resting individuals (no histological validation).
- If samples are taken from commercial catches: it is difficult to obtain non eviscerated fish, smaller individuals (<27 cm) are unavailable (with the consequent limitations for the logistic model fitting), the size distribution of the fish landed depends on the gear used (different selectivity between polyvalent and bottom trawl). The main advantage is that it is possible to obtain samples during the main spawning season. However, are the market samples representatives of the population? Can the spatial distribution of males and females and the proportion of mature fish be inferred without bias from market samples?

4.2.2 Improving the estimation of maturity ogive

Following the discussions on this subject during the workshop additional analyses were carried out in order to clarify the effect of the timing and source of sampling, and to identify the potential sources of bias in the estimation of the MOs, namely:

- Analyse the sex-ratio distribution along the coast for the demersal research surveys (PNAB): Autumn 2004.
- Use the data from microscopic gonad stage classification to obtain a proportion of immature/resting to apply to MO.

Preliminary results showed that sex ratio is similar along the coast, with a slight increase in the offshore stations (Figure 4.2.2.1).

The length-at-first maturity, L_{50} (estimated from the fitting of the MO) does not differ when using macroscopic data from samples collected during the 2007 Winter demersal survey (March), during the main spawning season (L_{50}=28.73 cm), or the ones from market, collected in the same season (L_{50}=28.80 cm) (Figure 4.2.2.2).

The use of data from histological gonad stage classification to obtain a proportion of immature/resting to apply to MO also gives close values of L_{50} (L_{50}=31.75 cm) when compared with the same data from macroscopic identification (L_{50}=32.92 cm) (Figure 4.2.2.3).

The MOs estimated from the 2004 Autumn and the 2005 Winter surveys revealed slight differences in L_{50} (Figure 4.2.2.4).

The analysis of the MOs estimated with a 1:1 proportion of males and females *vs* the real observed sex ratio shows that the L_{50} is slightly higher when the proportion 1:1 of both sexes is considered (Figure 4.2.2.5).

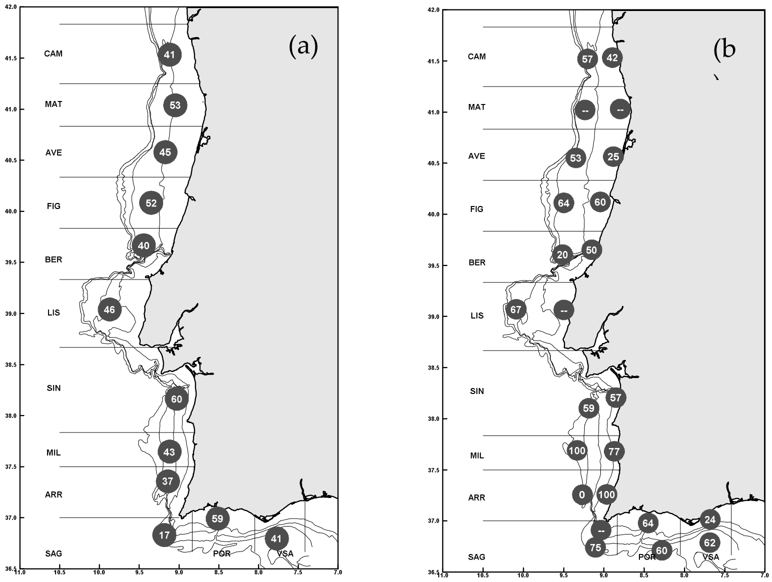

Figure 4.2.2.1 Sex ratio by (a) region and (b) near the coast vs off-shore from the 2004 Winter demersal survey.

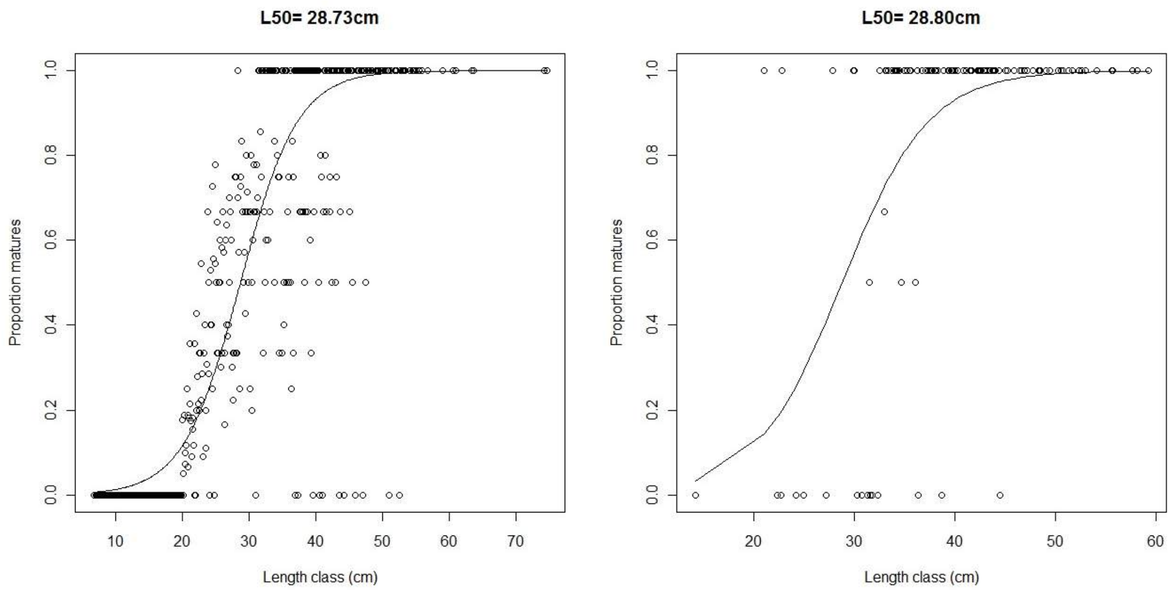

Figure 4.2.2.2 Maturity ogives (macroscopic staging) from samples collected during the Winter demersal survey (left panel) and from the market sampling in Feb-Apr (right panel), in year 2007.

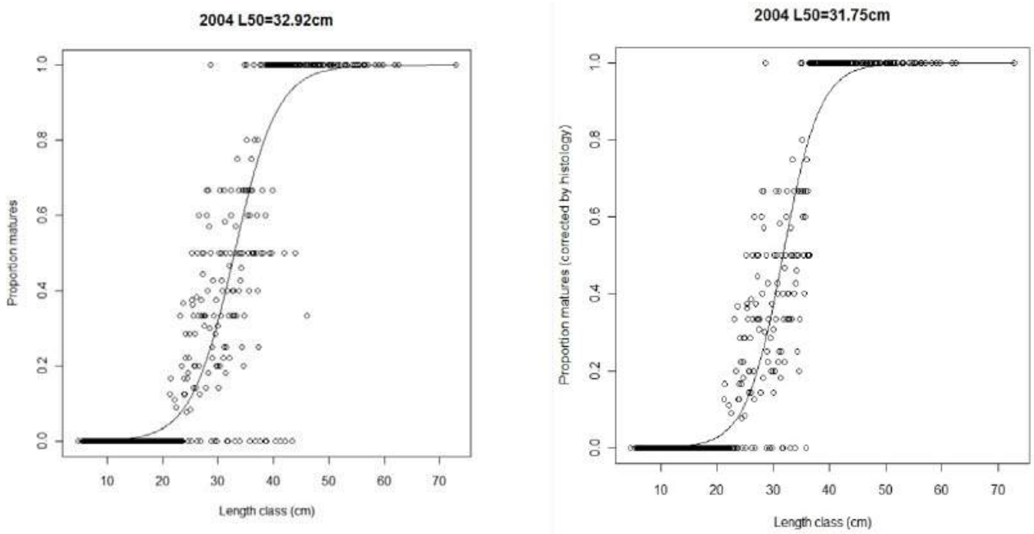

Figure 4.2.2.3 Maturity ogives estimated with GLM fit based on macroscopic (left panel) and histological staging (right panel).

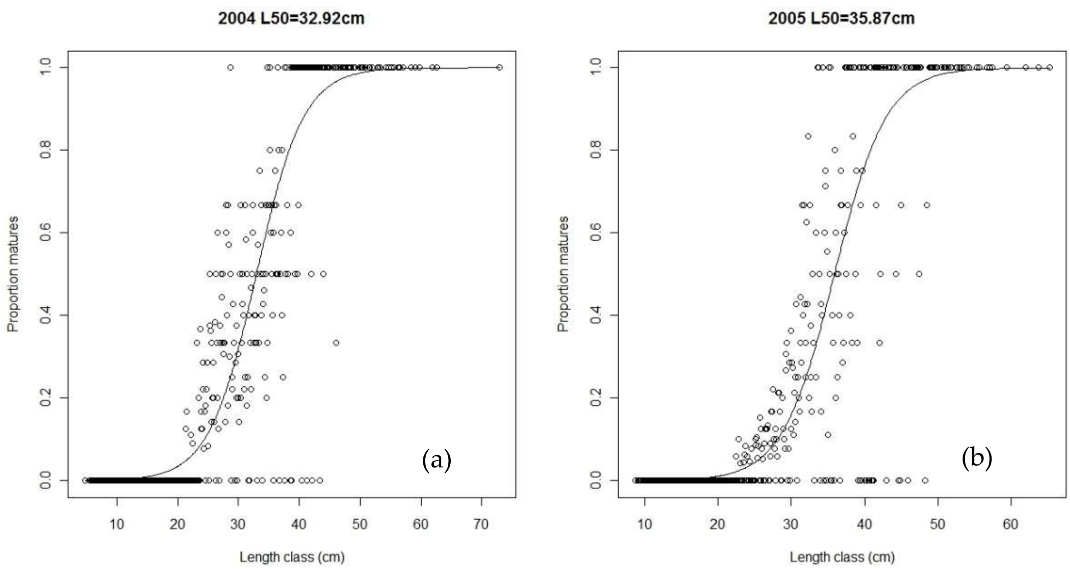

Figure 4.2.2.4 Maturity ogive (macroscopic staging) estimated with GLM from (a) 2004 Autumn survey and (b) 2005 Winter survey.

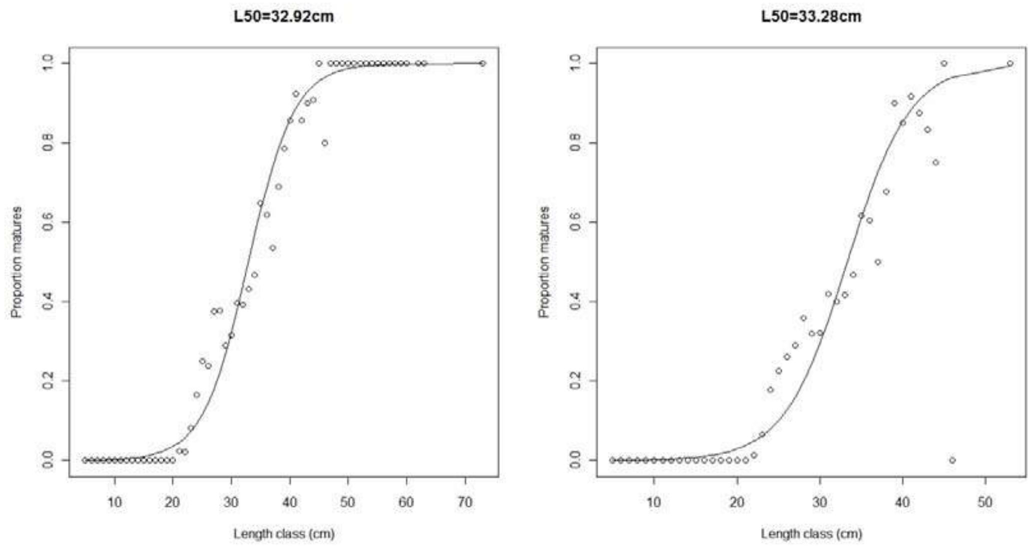

Figure 4.2.2.5 Maturity ogives (macroscopic staging) considering (a) all data and (b) a 1:1 sex-ratio based on samples collected during the 2004 Autumn survey.

4.3 Discussion and Conclusions

4.3.1 Growth

The analyses of the sardine case-study (Section 4.1.2) indicate that there will be no significant differences in the length distribution by age-group if the number of otoliths selected in each length class is reduced. At the age group composition and length distribution the results obtained reducing to 5 the otoliths selected by length class were similar to what is the present situation, considering the ALK's only regarding 2013. The reduced number of samples usually collected from age group 6+, may explain bigger differences found in average length at age observed in older age groups in the different tests undertaken.

The analysis of the number of otoliths by sample in each area and quarter pointed out that satisfactory results can be achieved with 5 or even 2 otoliths by length class.

From the quarter analyses, a 1.0 cm length class interval option is not advisable due to a higher variability observed. However, when considering the total by year and area the results assuming 1.0 cm length class interval do not show so obvious differences in comparison to 0.5 cm length class interval.

Sardine case-study was a first approach to the Portuguese species sampling design optimization for age data collection to estimate age-length keys. The mean length by age group varies among areas (Soares, P11 Annex 4) despite sardine being caught mostly with one "fishing-gear" (purse-seine). A comparison of the mean length from samples collected in the North area, by port and month, was performed. Despite the very low number of samples, there are significant differences in combinations of sites/quarters (Figure 4.1.2.2.6), which suggest that the samples selection must consider these factors. This analysis should be performed for other areas and years to confirm the observed variability before any change to the current otoliths sampling design.

The analysis performed for sardine should be extended to other species and should include factors like "fishing gear", "fishing site stratum" (depth), "landing harbour" which may be particularly important for species with wider distribution and caught by several fleet segments. The effects of using a stratified design by port and quarter (or other variables) should be accounted for in the estimation of the final age-length keys for the overall Portuguese landings. The possibility of taking advantage of probability-based market sampling to obtain probability-based age sampling may be considered in the future as a means to obtain a more design-based sampling scheme.

4.3.2 Reproduction

The analysis of the hake case-study (Section 4.2) indicated that sex and maturity data from the Autumn demersal surveys could be used to predict the maturity ogive (MO) of the following year. This approach should be further explored given the absence of demersal surveys during the peak of hake spawning season (January-March) and market sampling constraints (hake is landed gutted). Therefore, it is recommended to perform a comparison between the macroscopic maturity data from the 2011 Autumn demersal survey and the 2012 macroscopic and microscopic maturity data from market samples during the spawning season. However, it is emphasized that predicting MO requires additional assumptions, namely on growth and mortality rates during the period between the Autumn demersal survey and the spawning season in the following year. Hence, it is highly recommended to estimate MO from in-year market samples.

The sampling design should be based on the analysis of available data from port sampling, in particular to: investigate the distribution of lengths/sexes/mature fish per gear and fishing area to better characterize the spatial distribution of mature fish. It was also suggested that efforts be doubled to obtain representative samples from the fleet, randomizing the sampled trips. Additionally, samples of smaller fish (< 27 cm, not landed) could be obtained from onboard sampled trips. It is noted that the upcoming "landing obligation" may allow these specimens to be sampled on-shore.

Further, bottom-trawl stations conducted during the triennial horse-mackerel DEPM (daily egg production method) surveys, carried out in January-February, might be explored to collect additional data on hake maturity.

5 Recommendations and Future Work

ToR 1)

- Randomization of landing events within sampling days should be improved.
- Extend the feasibility evaluation of combining concurrent sampling and species-focus sampling to the analysis of precision of the mean length estimates.
- Explore other sampling strategies (e.g., sampling directly for size categories instead of sampling trips) and ponder the development of a pilot study including field experiments.
- Compare the different raising methods (e.g., current, design-based, by categories), particularly in relation to the updated design where the SSU are trips.

The following recommendations to improve fishery data are addressed to DGRM and DOCAPESCA:

- At the landing port several species need to be correctly identified and discriminated at species level.
- Include in the daily landing database of SLV (Serviços de Lota e Vendagem, DOCAPESCA) the discrimination of the fishing gear(s) used at the trip level.

ToR 2)

Sampling onboard long-distance longline fleet operating in the Indian Ocean:

- If only one observer can be allocated to the onboard sampling programme, it is recommended a switch between fishing areas (West and East), starting with the area with less coverage.

Sampling onboard vessels in Division IXa:

- Collect information on refusal rates by fleet segment.
- Investigate the existence of reference fleets for segments where random sampling is not possible due to high refusal rates.

The following recommendations are addressed to DGRM and SWWAC:

- Facilitate updated list of contacts of masters and skippers and indicate the type of information skippers /masters /associations would like to receive from PNAB-IPMA onboard sampling programme.

ToR 3)

- The approach used in the sardine case-study to optimize the sampling design for age data collection should be applied to other species.
- The sardine analysis suggested a significant reduction on the number of otoliths required to estimate the ALK´s used in the stock assessment. However, additional analyses should be performed before any change to the current sampling design.
- Following the analyses and discussions on hake reproduction and maturity ogives, it is suggested to explore the use of the microscopic gonad stage classification to estimate the proportion of immature/resting in the length range where macroscopic staging can be misidentified.
- Analyse the available data from port sampling to investigate the distribution of lengths/sexes/mature fish per gear and fishing area to better characterize the spatial distribution of mature fish and base the maturity market/onboard sampling design.
- Explore the effects of different raising procedures on ALK´s and maturity ogive estimates.

Imprecise and biased stock assessment input data, like those analysed and discussed in the workshop, strongly affect the quality of key parameter estimates, like fishing mortality (F) and spawning stock biomass (SSB). A framework for cost-efficient sampling to support stock assessment was presented by Vølstad (Vølstad et al, P09 – Annex 4). An Open Source software (StoX) currently under development at IMR will support reproducible stock assessments, where estimates of parameters such as spawning stock (biomass and numbers) and fishing mortality (F) can be presented with associated measures of precision (e.g., relative standard errors or confidence intervals). In particular, the StoX programs will allow the quantification of the propagation of sampling errors in input data obtained from catch-sampling surveys and scientific trawl surveys (i.e., fishery dependent or independent data) to the stock assessment results used in quota advice. The tool will include methods for quantifying sampling errors in swept-area estimates and acoustic estimates of numbers-at-age and numbers-at-length using data, based on methods in Aanes and Vølstad (in review) and Stenevik *et al*. (2014), as well as sampling errors in estimates of catch in numbers-at-age or numbers-at-length from catch sampling surveys, using the model ECA (Hirst *et al*. 2012).

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Annex 1: List of participants

List of participants:

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Annex 2: Meeting Agenda

WORKSHOP ON SAMPLING DESIGN AND OPTIMIZATION (WKSDO)

IPMA, 17 – 20 November 2014 (4 days)

Objectives:

- Analysis of current sampling designs and their optimization:
  - market sampling for length composition
  - onboard sampling for catches
  - sampling for biological parameters

Agenda

Day 1	
09:00 – 09:30	Startup procedures. Presentation of participants. Workshop TORs Introductory presentation: Portuguese fleets and fisheries – M. Azevedo, C. Silva, M. Dias
09:30 – 10:30	TOR 1: Market sampling design to estimate the length composition of landings. Concurrent sampling and species focus sampling. Presentations: - Present sampling design (10+5 min) – N. Prista, M. Dias - Rays (10+5 min) – I. Figueiredo, C. Maia - Anglerfishes (10+5 min) – R. Alpoim, T. Moura, N. Prista
10:30 – 10:50	Coffee break
10:50 – 12:30	Presentations: - Catch length composition estimated from commercial size-categories: does it improve accuracy? – M. Azevedo, C. Silva - Sampling designs – J. H. Vølstad Discussion: Market sampling design, sampling effort and precision. Approaches and definition of case studies to be discussed in working groups.
12:30 – 14:00	Lunch
14:00 – 16:00	Working groups
16:00 – 16:20	Coffee break
16:20 – 17:30	Presentation of WGs results. Summary of the discussions.

Day 2	
09:00 – 10:30	TOR 2: Catch sampling onboard Presentations: - Sampling design in Div. IXa (10+5 min) – A. C. Fernandes, N. Prista - Sampling design in Indian Ocean (10+5 min) – P. G. Lino, R. Coelho, M. N. Santos Discussion: Objectives, sampling design, sampling effort, constraints, raising, how to improve the precision of estimates.
10:30 – 10:50	Coffee break
10:50 – 12:30	Discussion (continuation)
12:30 – 14:00	Lunch
14:00 – 16:00	Presentation: - Framework for assessing monitoring effort to support stock assessment - J. H. Vølstad Working groups
16:00 – 16:20	Coffee break
16:20 – 17:30	Summary of the discussions.

Day 3	
09:00 – 10:30	TOR 3: Biological sampling Presentations: - Sampling/precision ALKs – J. H. Vølstad - Sampling for age / ALKs, CS Sardine (10+5 min) – E. Soares - Sampling for maturity / maturity ogive, CS Hake (10+5 min) – A. M. Costa, C. Nunes, J. Pereira
10:30 – 10:50	Coffee break
10:50 – 12:30	Discussion
12:30 – 14:00	Lunch
14:00 – 17:30	Working groups and summary of discussions

Day 4	
09:00 – 10:30	Working groups
10:30 – 10:50	Coffee break
10:50 – 12:30	Working groups
12:30 – 14:00	Lunch
14:00 – 17:30	Report writing (Discussion and Conclusions). End

Annex 3: Glossary of statistical terms

Statistics

POPULATION (População): complete set of items from which we may collect data.

TARGET POPULATION (População alvo): is the entire group about which the researcher wishes to draw conclusions.

STUDY POPULATION (População de estudo): is the *group* from which sample is to be drawn.

SAMPLE (Amostra): is a group of units selected from a larger group (the population). By studying the sample one expects to draw valid conclusions about the larger group.

SAMPLING UNIT[1] **(Unidade de amostragem):** In order to take a sample from a population, the population must consist of, or be divided into non-overlapping parts (units). Sampling can then be conducted by selecting units according to a defined sampling scheme. The units that can be selected in catch sampling schemes are typically groups, e.g. the group of fish landed from a fishing trip or group of fish caught in a fishing operation.

PRIMARY SAMPLING UNIT[1] **(Unidade de amostragem primária):** A sampling unit in the first stage in a multi-stage sampling scheme is called a primary sampling unit. Examples of primary sampling units in the most common catch sampling schemes are trips, vessels, landing places or site-days.

NON-PROBABILITY SAMPLING (Amostragem não-probabilística): sampling units are selected deliberately (based on attributes), because they are convenient (easily accessed) or haphazardly (one cannot guarantee that the sampling units are selected independently of their measurement values). An example of non-probability sampling is quota sampling.

PROBABILITY SAMPLING (Amostragem probabilística): sampling units are selected so that every sampling unit has non-zero probability of being present in the sample and no unit is guaranteed to be selected (execpt in very unusual instances), Sampling strategies for probability sampling include simple random, stratified, systematic or cluster.

SAMPLING FRAME[1] **(Lista de amostragem)**: In statistics, a sampling frame is the list of sampling units or device from which a sample can be drawn. The sampling frame comprises all the sampling units and any stratification of these, and may be based, e.g., on a vessel registry or list of ports.

SAMPLING DESIGN (Desenho amostral): The set of rules that govern the sampling.

SAMPLING STRATEGIES (Estratégias de amostragem): there are several methods for selecting a sample:

> **RANDOM SAMPLI**NG (**Amostragem aleatória**) – Each individual is chosen entirely by chance and each element of the population has a known, but possibly non-equal, chance of being included in the sample.
>
> > **SIMPLE RANDOM SAMPLING (Amostragem aleatória simples)** [3] **–** each individual is chosen entirely by chance and each element of the population has the same probability of being selected. There are two ways of selecting a simple random sample, **with replacement** or **without replacement** of the sampling units selected.
> >
> > **UNEQUAL PROBABILITY RANDOM SAMPLING (Amostragem aleatória com probabilidades desiguais) –** each individual is chosen entirely by chance and but elements of the population have different probabilities of being selected. There are two ways of selecting a simple random sample, **with replacement** or **without replacement** of the sampling units selected.

STRATIFIED SAMPLING (Amostragem estratificada) – the whole population is divided into non-overlapping subpopulations, called *strata* (singular: *stratum*), from which samples are taken. Stratification can used be to achieve designated precision levels at stratum level, for convenience of implementation and/or to obtain overall gains in precision of final population-level estimates. In general, gains in precision are obtained when strata are internally homogeneous/similar but heterogenous/dissimilar between each other. Samples can be selected from each stratum using random sampling (with or without replacement) or unequal probability sampling.

CLUSTER SAMPLING (Amostragem por conglomerados) [3] – the whole population is partitioned into groups called clusters, each containing one or more elements, but the sampling units are the clusters. As opposed to the strata, the clusters are preferably based on heterogeneity/dissimilarity within cluster and homogeneity/similarity among clusters. Clusters may be selected using, e.g., simple random sampling. In some books cluster sampling is considered to include multistage sampling-

MULTISTAGE SAMPLING(Amostragem multietápica) [3] **–** several sampling methods are combined into successive sampling stages. At each stage, there is probability-based selection of sampling units, which can be clusters (initial phase) or elements (final stage)or clusters. Stratification can also be used in multistage sampling. In some books multistage sampling is included in cluster sampling.

SYSTEMATIC SAMPLING (Amostragem sequencial)[3] – The population elements are ordered and a first element is randomly selected. Subsequent elements are selected every k*th* element from the starting point.

QUOTA SAMPLING (Amostragem por quotas) – Sampling is carried out from a random starting element until a pre-defined quota is attained (the designated sampling effort). This strategy suffers from a number of methodological flaws, the most basic of which is that the sample is not a random sample and therefore the sampling distributions of any statistics are unknown.

STRATIFICATION[1] **(Estratificação):** The advance decomposition of a **finite population** of sampling units of size N into k non-overlapping subpopulations (*strata*) of size N_i.

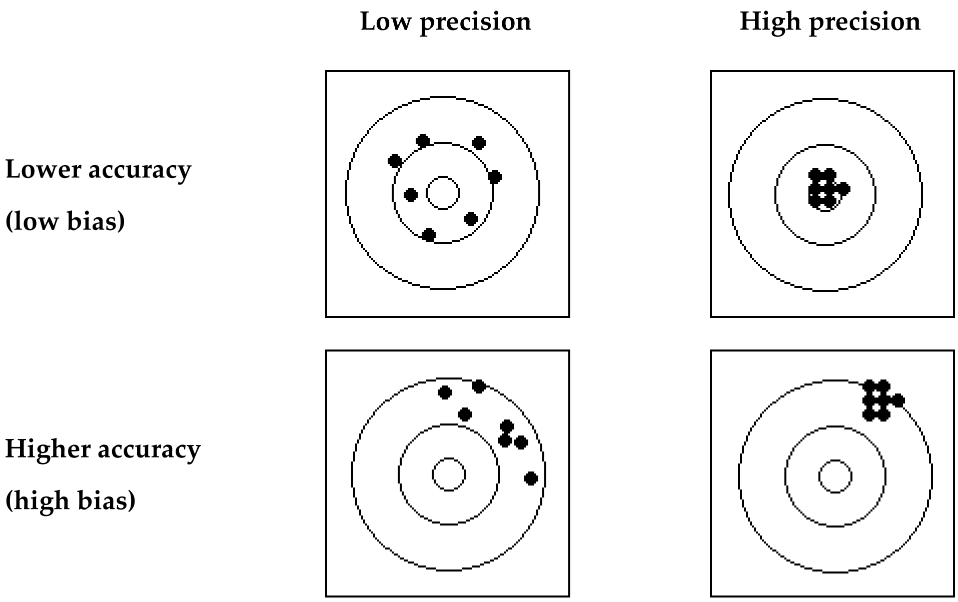
POST-STRATIFICATION or STRATIFICATION AFTER SELECTION[1] **(Pós-estratificação):** If a simple random sample is taken from a **finite population** of sampling units of size N the sample may be treated as a stratified sample during the analysis if the post-strata sizes N_i are know. Stratification after selection (post-stratification) is usually applied if the strata to which the selected sampling units belong are only known after the sample is taken or one is interested in estimates for different subpopulations than the originally envisioned. This is often the case for métiers. Standard stratified estimators may have to be weighed when a métier crosses sampling strata.

SAMPLING EFFORT (Esforço de amostragem): Number of samples to collect. Sampling effort can be optimized to achieve the precision levels required for a certain estimate, taking into account the costs of sampling and the variance of the samples/strata.

ACCURACY (Exactidão): an indicator of the closeness of an estimated value (e.g. population parameter) to the actual value.

PRECISION[4] **(Precisão):** is a measure of how close an estimator is expected to be to the true value of a parameter. Precision is usually expressed in terms of imprecision and related to the standard error of the estimator. Less precision is reflected by a larger standard error (or a larger coefficient of variation).

BIAS[4] (Enviesamento): a term which refers to how far the average statistic lies from the parameter it is estimating, that is, the error which arises when estimating a quantity. Errors from chance will cancel each other out in the long run, those from bias will not.



__Fisheries section__

CONCURRENT SAMPLING[2] (Amostragem simultânea): Sampling all or a predefined group of species that are simultaneously present in landings (or catches) of a certain fishing trip.

FLEET[1] (Frota): A physical group of vessels sharing similar characteristics in terms of technical features and/or major activity.

FISHERY[1] (Pescaria): A group of trips targeting the same species assemblage and/or stocks, using similar gear, during the same period of the year and within the same area.

FLEET SEGMENT[2] (Segmento de frota): A group of vessels with the same length class (LOA) and predominant fishing gear during the year, e.g. according to the Appendix III of the EU-DCF. Vessels may have different fishing activities during the reference period, but are classified in only one fleet segment.

MÉTIER[1,2]: A group of fishing operations targeting a similar (assemblage of) species, using similar gear, during the same period of the year and/or within the same area and which are characterised by a similar exploitation pattern.

HIERARCHICAL LIST OF SPECIES[2] (Lista hierárquica de espécies): When there is no possibility to do the "concurrent sampling", a list of species with major interest is needed. This list must include species of relevance for management purposes and for which a request is made by an international scientific body or a regional fisheries management organisation (DCF). It can be compiled in accordance to DCF requisites (combination of species groups and sampling schemes adopted).

[1] ICES. 2012. Report of the second Workshop on Practical Implementation of Statistical Sound Catch Sampling Programs, 6 - 9 November 2012, ICES Copenhagen. ICES CM 2012 / ACOM: 52, 71p

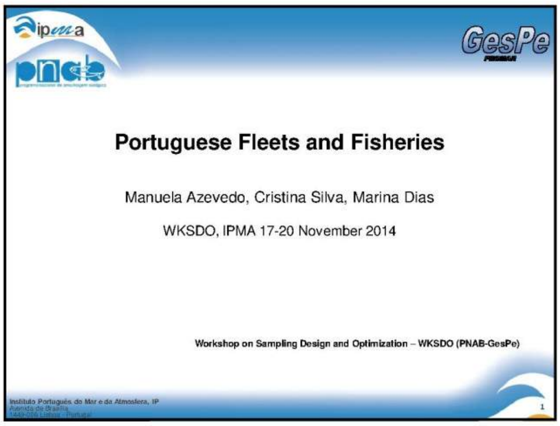
[2] EU Commission Decision (2010/93/EU) of 18 December 2009, adopting a multiannual Community programme for the collection, management and use of data in the fisheries sector for the period 2011-2013 *(notified under document C(2009) 10121)*

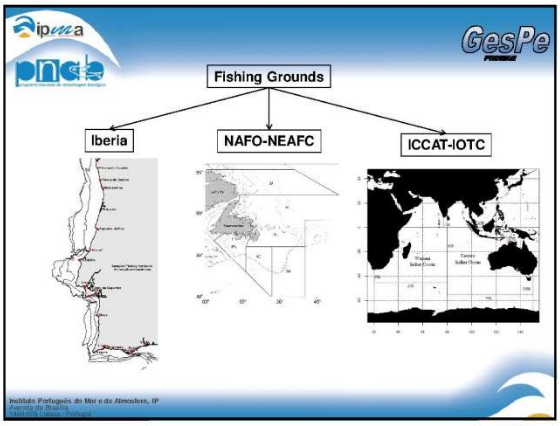
[3] Cadima, E.L.; Caramelo, A.M.; Afonso-Dias, M; Conte de Barros, P.; Tandstad, M.O.; de Leiva Moreno, J.I.. 2005. Sampling methods applied to fishing science: a manual. FAO Fisheries Technical Paper. No. 434. Rome, FAO. 88p.

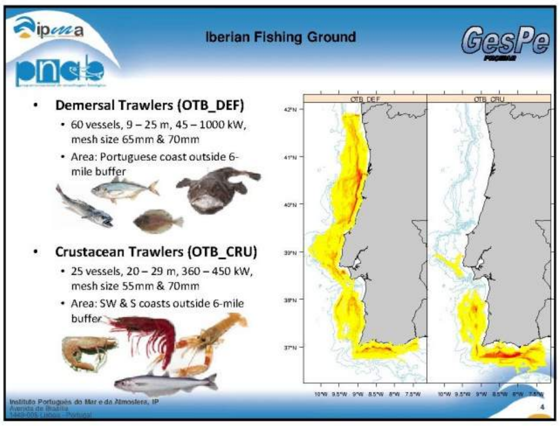
[4] Statistics Glossary (STEPS internet site)

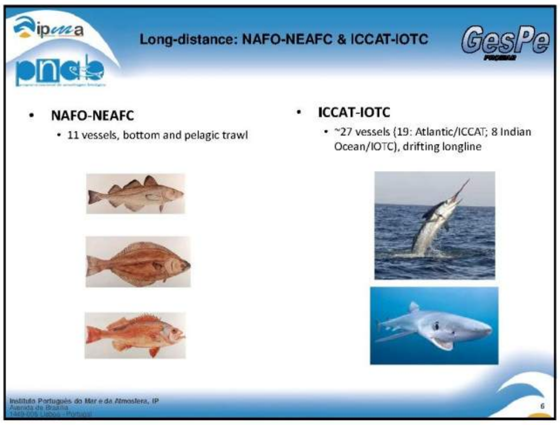
Annex 4: Presentations

P01









Sampling Strategy
Species Priorities (under DCF)

Each species within a region shall be classified within a group according to the following rules[(a)]:

Group 1
Species that drive the international management process including species under EU management plans, EU recovery plans, EU long term multi-annual plans, EU action plans for conservation and management.

Group 2
Other internationally regulated species and major non-internationally regulated by-catch species.

Group 3
All other by-catch species. List established at regional level.

[(a)] Decision 2010/93/UE adopting a multiannual Community programme for the collection, management and use of data in the fisheries sector for the period 2011-2013

Sampling Strategy
Species Priorities (under DCF)

NS&EA + NAFO areas

Fishing ground	Species (Latin)	Species (Eng.)	Species (Port.)	Species Group
Eastern Artic	*Gadus morhua*	Cod	Bacalhau	1
	Sebastes mentella	Deap sea Redfish	Peixe-vermelho-da-fundura	1
	Reinhardtius hippoglossoides	Greenland halibut	Alabote-da-Gronelândia	1
	Sebastes marinus	Golden Redfish	Peixe-vermelho	1
NAFO Areas	*Gadus morhua*	Cod	Bacalhau	1
	Hippoglossoides platessoides	American plaice	Solha-Americana	1
	Raja spp.	Rays and skates	Raias	1
	Reinhardtius hippoglossoides	Greenland halibut	Alabote-da-Gronelândia	1
	Sebastes spp.	Redfish	Peixes-vermelhos	1
	Glyptocephalus cynoglossus	Witch flounder	Solhão	2
	Limanda ferruginea	Yellowtail flounder	Solha-de-pinta-amarela	2
	Macrouridae	Greanadier	Granadeiros	2
Iceland, Greenland and Irminger Sea	*Sebastes mentella*	Deap sea Redfish	Peixe-vermelho-da-fundura	1

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Sampling Strategy
Species Priorities (under DCF)

Other Regions: ICCAT & IOTC

Fishing ground	Species (Latin)	Species (Eng.)	Species (Port.)	Species Group
ICCAT (ATL)	*Istiophoridae*	Billfish	Espadins e veleiros	1
	Isurus oxyrinchus	Shortfin mako	Tubarão-anequim	1
	Katsuwonus pelamis	Skipjack tuna	Gaiado	1
	Prionace glauca	Blue shark	Tintureira	1
	Squaliformes	Other sharks	Tubarões	1
	Thunnus alalunga	Albacore	Atum-voador	1
	Thunnus albacares	Yellowfin tuna	Atum-albacora	1
	Thunnus obesus	Bigeye tuna	Atum-patudo	1
	Thunnus thynnus	Bluefin tuna	Atum-rabilho	1
	Xiphias gladius	Swordfish	Espadarte	1
	Auxis rochei	Frigate tuna	Judeu	2
	Euthynnus alleteratus	Atlantic back skipjack	Merma	2
IOTC (FAO 51+57)	*Isurus oxyrinchus*	Shortfin mako	Tubarão-anequim	1
	Prionace glauca	Blue shark	Tintureira	1
	Thunnus alalunga	Albacore	Atum-voador	1
	Thunnus albacares	Yellowfin tuna	Atum-albacora	1
	Thunnus obesus	Bigeye tuna	Atum-patudo	1
	Xiphias gladius	Swordfish	Espadarte	1

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Sampling Strategy
Species Priorities (under DCF)

North Atlantic: Iberian Fishing Ground

Species (Latin)	Species (Eng.)	Species (Port.)	Species Group
Anguilla anguilla	European eel	Enguia	1
Aphanopus carbo	Black scabbardfish	Peixe-espada-preto	1
Lepidorhombus boscii	Four-spot megrim	Areeiro-de-quatro manchas	1
Lepidorhombus whiffiagonis	Megrim	Areeiro	1
Lophius budegassa	Black -bellied angler	Tamboril-sovaco-preto	1
Lophius piscatorious	Anglerfish	Tamboril	1
Merluccius merluccius	Hake	Pescada	1
Micromesistius poutassou	Blue whiting	Verdinho	1
Nephrops norvegicus	Norway lobster	Lagostim	1
Leucoraja naevus	Cukoo ray	Raia-de-dois-olhos	1
Raja brachyura	Blonde ray	Raia-pontuada	1
Raja clavata	Thornback ray	Raia-lenga	1
Raja montagui	Spotted ray	Raia-manchada	1
Rajidae	Other rays and skates	Raias	1
Sardina pilchardus	Sardine	Sardinha	1
Scomber scombrus	Mackerel	Sarda	1
Solea solea	Sole	Linguado-legítimo	1

Species (Latin)	Species (Eng.)	Species (Port.)	Species Group
Conger conger	Conger	Safio	2
Dicentrarchus labrax	Sea bass	Robalo	2
Loligo vulgaris	Common squid	Lula-vulgar	2
Octopus vulgaris	Common octopus	Choco-vulgar	2
Parapenaeus longirostris	White shrimp	Gamba-branca	2
Scomber colias	Spanish mackerel	Cavala	2
Sepia Officinalis	Cuttlefish	Choco-vulgar	2
Trachurus trachurus	Horse mackerel	Carapau	2
Trisopterus spp.	Pouting	Fanecas	2

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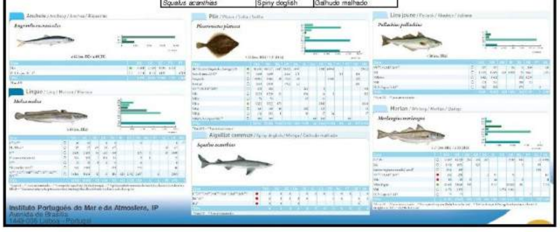
Sampling Strategy
Other Species (TAC & Quotas)

North Atlantic: Iberian Fishing Ground

Species (Latin)	Species (Eng.)	Species (Port.)
Engraulis encrasicolus	Anchovy	Biqueirão
Pleuronectes platessa	Plaice	Solha
Pollachius pollachius	Pollack	Juliana
Molva molva	Ling	Maruca
Merlangius merlangus	Whiting	Badejo
Squalus acanthias	Spiny dogfish	Galhudo malhado



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Acknowledgments

PNAB/DCF – Programa Nacional de Amostragem Biológica/Data Collection Framework (EU co-financed)

GesPe – Planos de Gestão Pesqueira (PROMAR)

DGRM – Direcção Geral de Recursos Naturais, Segurança e Serviços Marítimos

Thank you !

P02

Market sampling for length distribution (ICES Division IXa)

Nuno Prista, Marina Dias

Workshop on Sampling Design and Optimization
IPMA, Lisboa, 17-20 November 2014

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1449-006 Lisboa - Portugal

DCR/DCF evolution

DCR[a] 2002-2008 Stock-based approach	DCF[b] 2009 onwards Fishing activity based approach
• Biological sampling performed in order to evaluate the composition in length of the landings for specified stocks.	• Data collected by metier in order to evaluate the quarterly length distribution of species in the catches; • Métiers decided based on 90% criteria (landings, effort) • Sampling unit = fishing trip; • When sampling a fishing trip, the species are sampled concurrently.

(a) Commission Regulation (EC) No. 1639/2001 establishing the minimum and extended Community programmes for the collection of data in the fisheries sector and laying down detailed rules for the application of Council Regulation (EC) No. 1543/2000.
(b) Commission Decision 2010/93/UE adopting a multiannual Community programme for the collection, management and use of data in the fisheries sector for the period 2011-2013

2

Recent ICES Work

ICES DCF related Workshops

WKACCU (2008)

Precision in fisheries statistics can be improved by increasing the sample sizes in data collection programs whereas bias should be eliminated by developing and following sound field data collection procedures and analytical methods

WKMERGE (2010)

Highly resolved and temporally dynamic métier definitions are a inneficient basis for stratification (...) [that], can lead to over-stratification and problems of under-sampling or non-sampling of strata, and poor control over sampling probabilities. Rather, MS should specify sampling frames and sample selection schemes with temporally stable strata that are capable of providing sufficient data for the required metiers and fishing grounds. The métiers are treated as domains of interest rather than strata, unless the metier is sufficiently stable over time to act as a stratum with controlled sampling probabilities.

WKACCU: Workshop on Methods to Evaluate and Estimate the Accuracy of Fisheries Data used for Assessment
WKMERGE: Workshop on methods for merging metiers for fishery based sampling

3

Recent ICES Work

ICES DCF related Workshops

WKPICS / SGPIDS (2011-2013)

Recommended the use of probability-based sampling schemes with sampling frames, primary sampling units and strata optimised to deliver the required estimates for species, fleet metiers, fishing grounds or other variables of interest. Emphasised that such schemes allow samples to be easily extrapolated to the target population using weighting factors based on inclusion-probabilities;

Advised against using the alternative and widely adopted sampling method of setting "quotas" for numbers of fishing trips or fish to sample within multiple, highly resolved and dynamic fleet activities (e.g. EU Level-6 métiers). This method involves searching for specific types of trip to sample in order to meet a quota for a specified time period, and as a consequence alters the selection probabilities for all other métiers in the sampling frame. This can lead to bias and reduced precision.

WKPICS: Workshop on Practical Implementation of Statistical Sound Catch Sampling Programs
SGPIDS: Study group on Practical Implementation of Discard Sampling Plans

4

Recent ICES Work

ICES DCF related Workshops

PGCCDBS answer to EU Comission Query (2014)

PGCCDBS considers that sampling effort is better allocated to well-defined and more predictable strata such as vessel lists or port lists where a sufficient sampling rate can be assured and all primary sampling units have a controlled probability of being sampled. Within these strata, more resolved métiers will appear in sampling achievements in proportion to their activity, and unbiased estimates for these can be extracted through post-stratification.

STECF review of proposed DCF 2014:2020-p2 (STECF13-01)

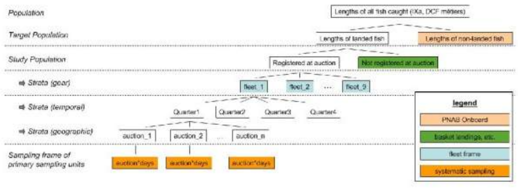
Sampling strategy: MS should perform sampling programmes collect data necessary for evaluation of stocks and fisheries. Sampling should be carried out in accordance to best available practice for statistically sound sampling.

PGCCDBS: Planning Group on Commercial Catches, Discards and Biological Sampling

5

Market sampling design (2014)

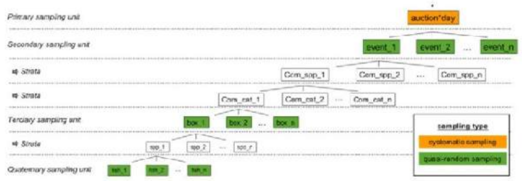
Main statistical concepts and pathway to PSU stratification:



6

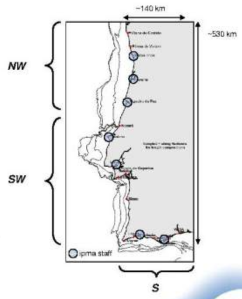
Market sampling design (2014)

Within-PSU sampling design: stratified multistage



Making it all operational

- 3 regions, 3 teams
  - NW: 11+ people
  - SW:8+ people
  - S: 2+ people
- Landings vary spatially and quarterly depending on fleet and species
- Sampling effort allocated to the auction*quarter combinations that register the highest landings



Making it all operational

- Sampling effort allocated to the auction*quarter combinations that register the highest landings
- Systematic selection of auction*days

Total PSU per fleet segment (fixed on the 2013 DCF objectives)

Fleet_segment	Total
FPO_0_0_0	202
GNSGTR_0_0_0	659
LLD_0_0_0	36
LLS_0_0_0	55
LLSDWS_0_0_0	47
OTB_>=55_0_0	99
OTB_>=65_0_0	150
PS_>=16_0_0	141
TBB_0_0_0	20
Grand Total	1409

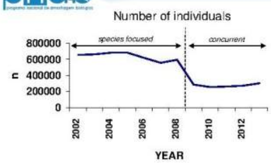
PSUs per auction

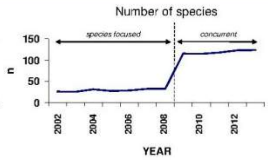
Region	HARBOUR	FPO	GNSGTR	[illegible]	[illegible]	[illegible]	[illegible]	PS	TBB	Grand Total
NW	VIANA DO CASTELLO	8	29					2		39
	POVOA DO VARZIM	9	61							70
	MATOSINHOS	6	76				17	31	4	133
	AVEIRO	10	89				33	4	8	144
	FIGUEIRA DA FOZ	12	40				14	16	8	90
SW	NAZARE	8	39	4			21			72
	PENICHE	16	111	14			36	18		215
	COSTA DA CAPARICA	6	22	2						30
	SESIMBRA	19	37	6	47		11	30		150
	SETUBAL		31					4		35
	SINES	4	16	6		25		15		70
S	[illegible]	6	30	4		6				46
	LAGOS	8	15					2		25
	PORTIMAO	22	10			2	18	8		60
	QUARTEIRA	14	30	8				8		60
	OLHAO	20	30	8			6	8		64
	[illegible]	28								28
	VRSA		2			66	4			72
	Grand total	202	658	55	47	99	150	141	20	1408

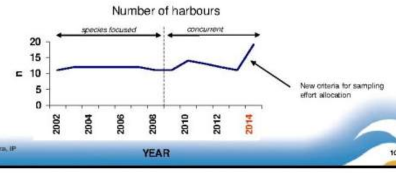
Final PSUs per auction*quarter

VESSEL LIST	AUCTION	QUARTER Q1	Q2	Q3	Q4	TOTAL
GNSGTR_0_0_0	AVEIRO	20	21	22	26	89
	FIGUEIRA DA FOZ	7	9	15	9	40
	MATOSINHOS	21	19	18	20	78
	POVOA DO VARZIM	14	16	17	14	61
	VIANA DO CASTELO	6	6	7	10	29
	COSTA DA CAPARICA	5	7	5	5	22
	NAZARE	9	8	10	12	39
	PENICHE	27	26	26	32	111
	SESIMBRA	10	8	9	10	37
	SETUBAL	8	10	6	7	31
	SINES	4	4	6	5	19
	LAGOS	3	4	3	3	13
	OLHAO	6	5	5	4	20
	PORTIMAO	2	3	2	3	10
	QUARTEIRA	7	7	7	7	28
	SAGRES	7	9	8	6	30
	VRSA		2			2

Some results







Project Execution/Quality Control

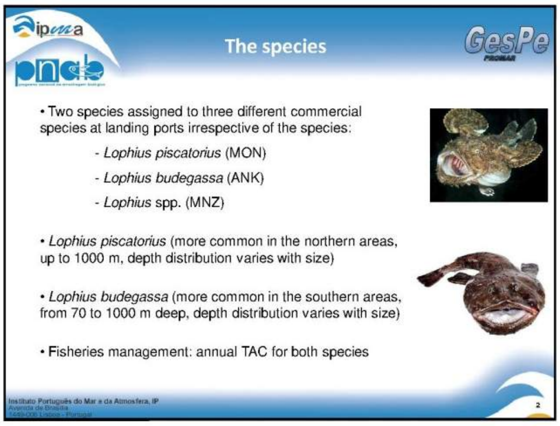
- R+Google calendar used for execution control
  - Enhances regional coordination
  - Records changes to annual plan
- Quality control assurance
  - Random checks on trip records (annual runs, *implemented*)
  - Semi-automated R and SQL scripts (quarterly and annual runs, *in development*)
- Execution and quality control reports to end users *(in development)*:
  - Programme management
  - Regional coordinators (NW, SW, S)
  - Stock coordinators

Suggested topics for discussion

- Can auction coverage be improved while maintaining precision and operational costs?
- Impacts of random sampling on lists crowded with small vessels: Is it worth to further stratify? what about overstratification?
- How to conjugate concurrent sampling with directed species sampling under a probability-based design?
- Is it really worth to sample 100 fish per size category vs. sampling less fish on more trips per PSU.

P03

Case Study
Anglerfish (*Lophius* spp.)
IPMA Workshop on Sampling Design and Optimization
17-20 November 2014
Instituto Português do Mar e da Atmosfera, IP



The species
• Two species assigned to three different commercial species at landing ports irrespective of the species:
- *Lophius piscatorius* (MON)
- *Lophius budegassa* (ANK)
- *Lophius* spp. (MNZ)
• *Lophius piscatorius* (more common in the northern areas, up to 1000 m, depth distribution varies with size)
• *Lophius budegassa* (more common in the southern areas, from 70 to 1000 m deep, depth distribution varies with size)
• Fisheries management: annual TAC for both species
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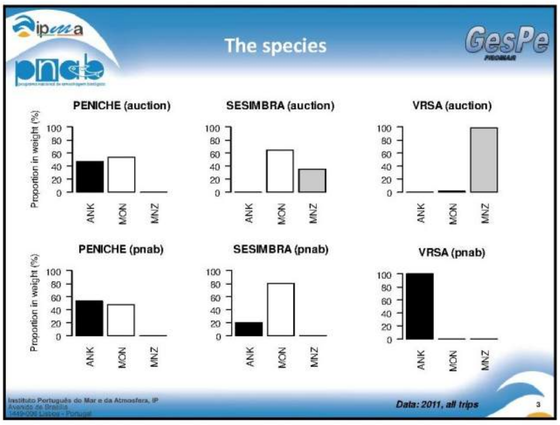

The species
PENICHE (auction)
SESIMBRA (auction)
VRSA (auction)
PENICHE (pnab)
SESIMBRA (pnab)
VRSA (pnab)
Proportion in weight (%)
ANK
MON
MNZ
Data: 2011, all trips
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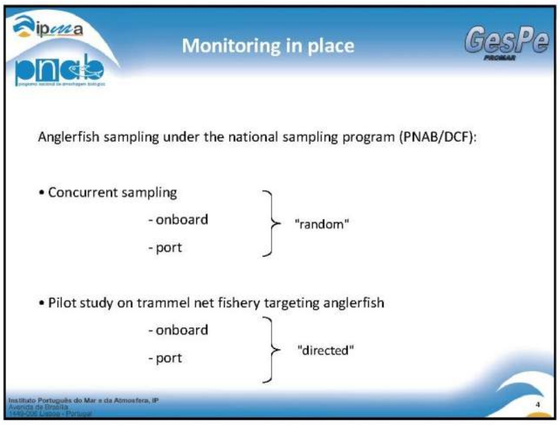
3



Monitoring in place
Anglerfish sampling under the national sampling program (PNAB/DCF):
• Concurrent sampling
- onboard
- port
"random"
• Pilot study on trammel net fishery targeting anglerfish
- onboard
- port
"directed"
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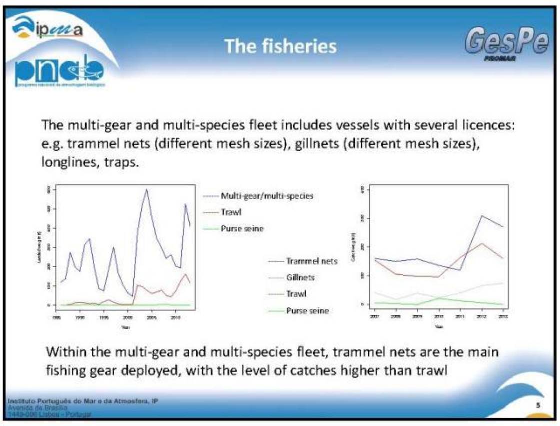
4



The fisheries
The multi-gear and multi-species fleet includes vessels with several licences: e.g. trammel nets (different mesh sizes), gillnets (different mesh sizes), longlines, traps.
Multi-gear/multi-species
Trawl
Purse seine
Trammel nets
Gillnets
Trawl
Purse seine
Within the multi-gear and multi-species fleet, trammel nets are the main fishing gear deployed, with the level of catches higher than trawl
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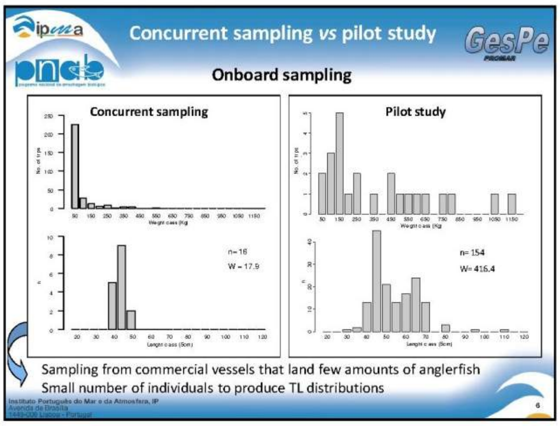

Concurrent sampling *vs* pilot study
Onboard sampling
Concurrent sampling
Pilot study
n= 16
W= 17.9
n= 154
W= 416.4
Sampling from commercial vessels that land few amounts of anglerfish
Small number of individuals to produce TL distributions
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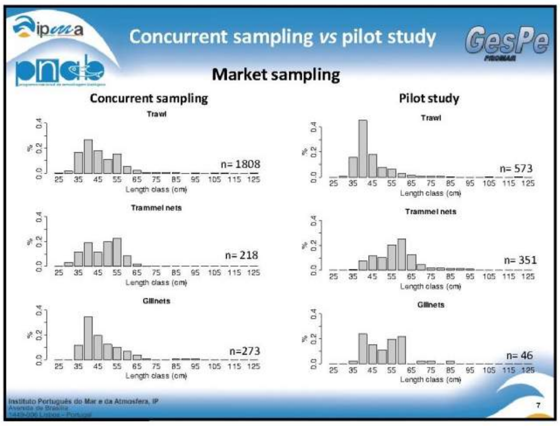
6



Concurrent sampling vs pilot study
GesPe
Market sampling
Concurrent sampling
Pilot study
Trawl
n= 1808
n= 573
Trammel nets
n= 218
n= 351
Gillnets
n=273
n= 46
Length class (cm)
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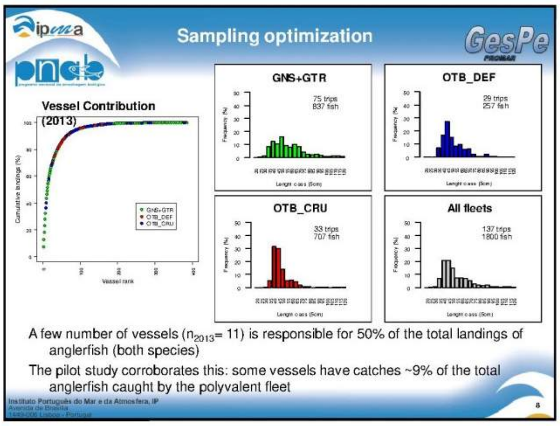
7



Sampling optimization
GesPe
Vessel Contribution (2013)
GNS+GTR
75 trips
837 fish
OTB_DEF
29 trips
257 fish
OTB_CRU
33 trips
707 fish
All fleets
137 trips
1800 fish
Vessel rank
A few number of vessels (n_{2013}= 11) is responsible for 50% of the total landings of anglerfish (both species)
The pilot study corroborates this: some vessels have catches ~9% of the total anglerfish caught by the polyvalent fleet
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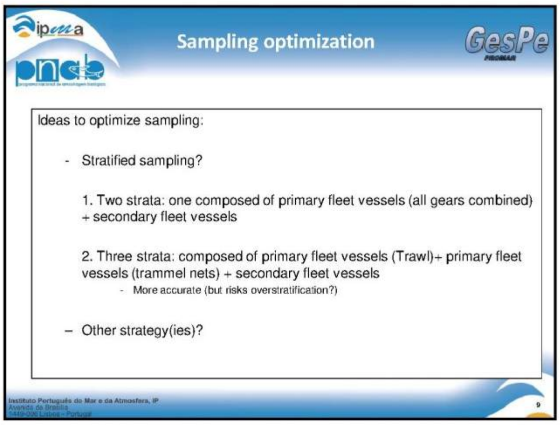
8



Sampling optimization
GesPe
Ideas to optimize sampling:
- Stratified sampling?
1. Two strata: one composed of primary fleet vessels (all gears combined) + secondary fleet vessels
2. Three strata: composed of primary fleet vessels (Trawl)+ primary fleet vessels (trammel nets) + secondary fleet vessels
- More accurate (but risks overstratification?)
– Other strategy(ies)?
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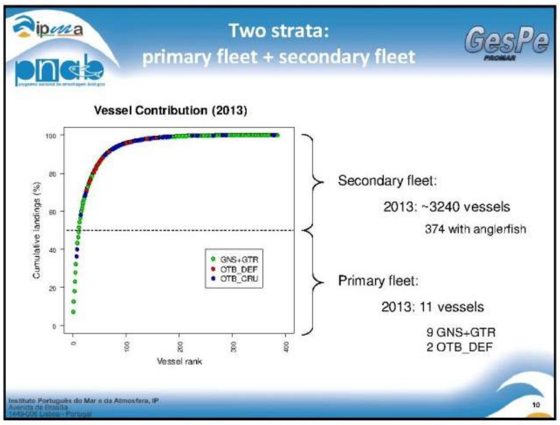

Two strata:
primary fleet + secondary fleet
GesPe
Vessel Contribution (2013)
Cumulative landings (%)
GNS+GTR
OTB_DEF
OTB_CRU
Vessel rank
Secondary fleet:
2013: ~3240 vessels
374 with anglerfish
Primary fleet:
2013: 11 vessels
9 GNS+GTR
2 OTB_DEF
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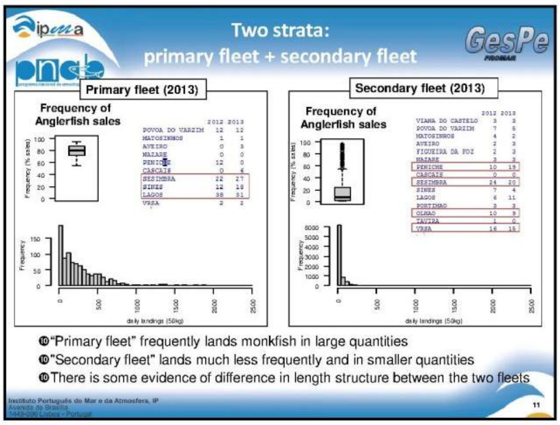
10



Two strata:
primary fleet + secondary fleet
GesPe
Primary fleet (2013)
Frequency of Anglerfish sales
Secondary fleet (2013)
Frequency of Anglerfish sales
daily landings (50kg)
"Primary fleet" frequently lands monkfish in large quantities
"Secondary fleet" lands much less frequently and in smaller quantities
There is some evidence of difference in length structure between the two fleets
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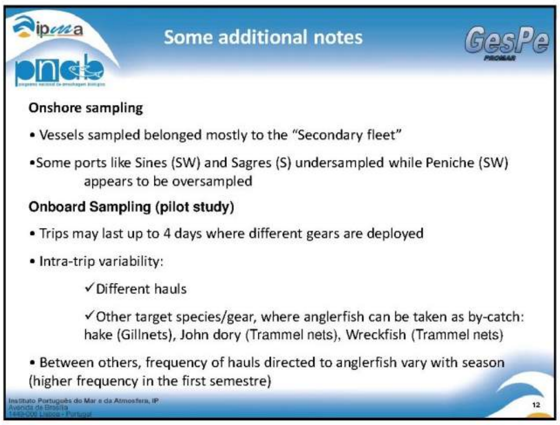
11



Some additional notes
GesPe
Onshore sampling
• Vessels sampled belonged mostly to the "Secondary fleet"
•Some ports like Sines (SW) and Sagres (S) undersampled while Peniche (SW) appears to be oversampled
Onboard Sampling (pilot study)
• Trips may last up to 4 days where different gears are deployed
• Intra-trip variability:
✓Different hauls
✓Other target species/gear, where anglerfish can be taken as by-catch: hake (Gillnets), John dory (Trammel nets), Wreckfish (Trammel nets)
• Between others, frequency of hauls directed to anglerfish vary with season (higher frequency in the first semestre)
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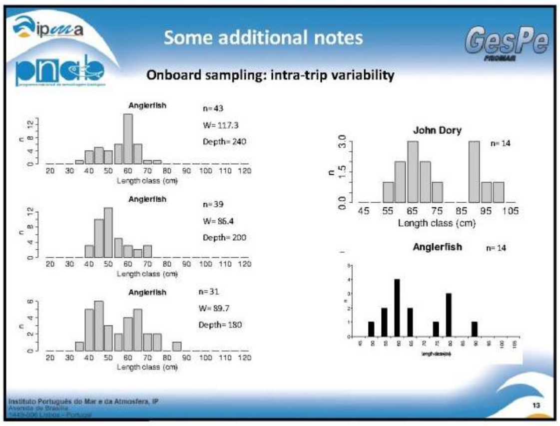
12


Some additional notes
GesPe
PROMAR
Onboard sampling: intra-trip variability
Anglerfish
n= 43
W= 117.3
Depth= 240
Length class (cm)
Anglerfish
n= 39
W= 86.4
Depth= 200
Length class (cm)
Anglerfish
n= 31
W= 89.7
Depth= 180
Length class (cm)
John Dory
n= 14
Length class (cm)
Anglerfish
n= 14
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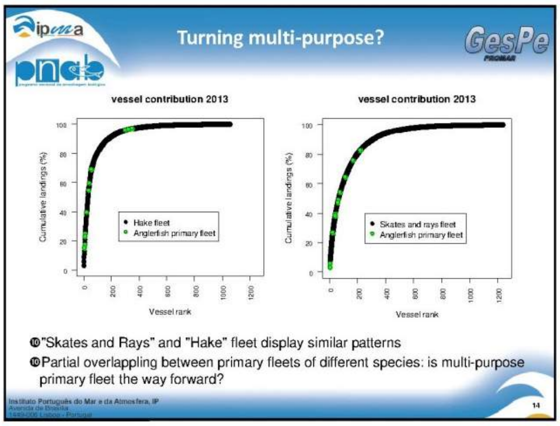
13


Turning multi-purpose?
GesPe
PROMAR
vessel contribution 2013
Cumulative landings (%)
Hake fleet
Anglerfish primary fleet
Vessel rank
vessel contribution 2013
Cumulative landings (%)
Skates and rays fleet
Anglerfish primary fleet
Vessel rank
"Skates and Rays" and "Hake" fleet display similar patterns
Partial overlappling between primary fleets of different species: is multi-purpose primary fleet the way forward?
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14

P04

SKATE LANDINGS BY SPECIES SAMPLING REQUIREMENTS

PNAB/DCF PILOT PROJECT ON RAYS AND SKATES

Ivone Figueiredo and Catarina Maia

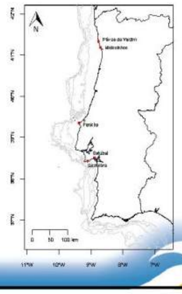
Instituto Português do Mar e da Atmosfera, IP

IPMA, 7- November - 2014

1

SKATE LANDINGS BY SPECIES – SAMPLING REQUIREMENTS

- Skates are mainly by-catches from multispecies mixed fisheries
- Most of the landings are derived from the polyvalent segment.
- During the period 2008- 2013, Peniche, Sesimbra, Setúbal, Matosinhos and Póvoa de Varzim have been the most important landing ports of skates.



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2

SKATE LANDINGS BY SPECIES – SAMPLING REQUIREMENTS

At the Portuguese landing ports

Despite the EU regulations (Regulation EC No 43/2009; EC No 39/2013) that settled the obligation of recording skates landed weight by species

↓

the problems on species identification persist

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3

SKATE LANDINGS BY SPECIES – SAMPLING REQUIREMENTS

- Under the PNAB/DCF skate pilot study that took place from 2011 to 2013 the Portuguese landings by skate species were estimated based on sampling fishery data collected at the main landing ports.

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4

SKATE LANDINGS BY SPECIES – SAMPLING REQUIREMENTS

The methodology adopted to estimate the landed weight by species at each landing port includes the following steps:

1) identification of vessel´s group sharing similar vessel size (S) and seasonality (Sz);
2) to each sampled trip the fishing gear (G) was allocated to the group identified in Step 1 (each level of the factor represented by combined of the three variables S, Sz and G is considered as a stratum) used to each sampled trip and;
3) estimation of the total number of trips;
4) estimation of skate landed weight by species and by stratum.

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SKATE LANDINGS BY SPECIES – SAMPLING REQUIREMENTS

Estimators

Proportion of the landed weight of species, a, in year, y, at the landing port, p and stratum s

$$\widehat{pa}_{(a,y,p,s)} = \sum_{i=1}(pa_{(a,y,p,s)i} \times w_{(y,p,s)i}) \Big/ wt_{(y,p,s)}$$

Total landed weight of the species a, in year, y at the landing port p

$$\widehat{W}_{(a,y,p)} = \sum_{s} \widehat{pa}_{(a,y,p,s)} \times \widehat{W}_{(y,p,s)}$$

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SKATE LANDINGS BY SPECIES –
SAMPLING REQUIREMENTS

Results

Stratum	$W_{(y,p)}$	$\hat{N}_{(y,p,s)}$	$\hat{W}_{(y,p,s)}$	$var(\hat{W}_{(y,p,s)})$	$w_{(y,p,s)}$	$\widehat{pa}_{(a,y,p,s)}$	$var(\widehat{pa}_{(a,y,p,s)})$

For year y, at the landing port, p

W(y,p) - skate (overall species) total landed weight;

$\hat{N}_{(y,p,s)}$ - skate (overall species) total number of trips at *stratum*, s (estimated);

$\hat{W}_{(y,p,s)}$ - skate (overall species) total landed weight at *stratum*, s (estimated);

$var\left(\hat{W}_{(y,p,s)}\right)$ - variance of the skate (overall species) total landed weight at *stratum*, s

w(y,p,s) - skate (overall species) total sampled landed weight at *stratum*, s;

n(y,p,s) - skate (overall species) total sampled number of trips at *stratum*, s;

$\widehat{pa}_{(a,y,p,s)}$ - sampling proportion of species, a, at the stratum, s; and

$var\left(\widehat{pa}_{(a,y,p,s)}\right)$ - variance of the sampling proportion of species, a, at the stratum, s

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SKATE LANDINGS BY SPECIES –
SAMPLING REQUIREMENTS

Sampling requirements

Landing port: XXXX

Year: XXXX

For each *stratum* (vessel´s size, vessel´s seasonality and gear), what is the optimal sampling size (number of trips) to estimate the total landed weight of species ?

Given a significant level of XX% and an error of YY.

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P05

Catch length composition estimated from commercial size-categories: does it improve accuracy?

Manuela Azevedo & Cristina Silva

WKSDO, IPMA 17-20 November 2014

Workshop on Sampling Design and Optimization – WKSDO (PNAB-GesPe)

Why?

- size matters! €€€€€€€
- catch (landing) statistics are compiled by commercial size-category
- fishing trip approach to estimate the length composition of the catch is (maybe) based on low number of samples
- characterizing the size-category by species requires lower number of samples (< €€€) compared to trip approach
- size-category approach can be used to estimate the length composition of the catch/landings for (several) species/stocks with few/low number of sampled trips

Application

2 stocks:

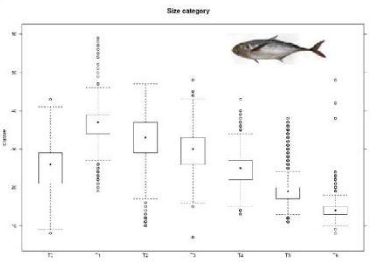
- southern horse-mackerel (hom-9a), Portuguese catch by fleet, 2012
- southern hake (hke-8c9a), Portuguese landings by fleet; 2013

H_0: There are significant differences between the commercial mean size-category

Steps:

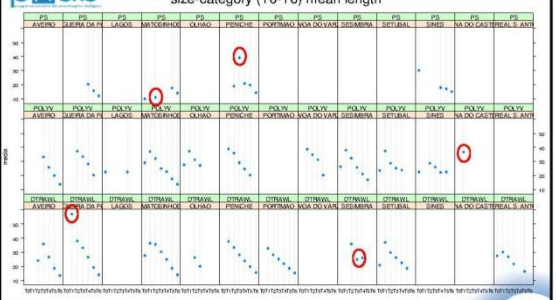
1) data screening
2) test differences between the mean size by commercial category
3) estimate the length composition by size-category & compute length probability distribution by size-category
4) estimate the catch/landing length composition by fleet & total

Step (1)
data screening



Step (1)

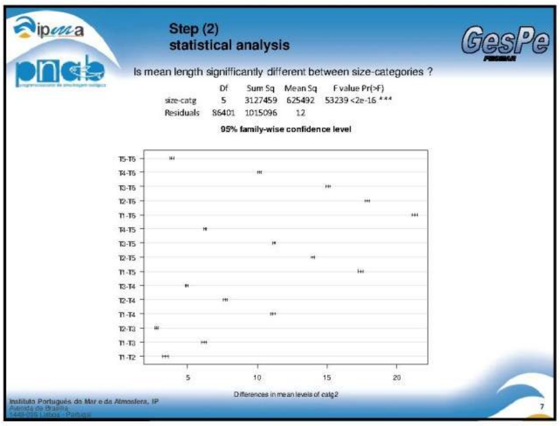
size-category (T0-T6) mean length



Step (1)

data: 2010-2013

	T0	T1	T2	T3	T4	T5	T6
DTRAWL_AVEIRO	0	0	1	21	32	39	8
DTRAWL_FIGUEIRA DA FOZ	0	1	9	31	38	44	21
DTRAWL_MATOSINHOS	1	9	25	28	25	18	7
DTRAWL_OLHAO	0	0	1	1	0	0	0
DTRAWL_PENICHE	0	16	25	39	42	28	18
DTRAWL_PORTIMAO	0	11	36	43	42	45	22
DTRAWL_SESIMBRA	0	0	1	1	1	0	0
DTRAWL_SETUBAL	1	1	2	3	3	2	0
DTRAWL_VILA REAL S. ANTONIO	11	10	3	2	0	1	0
POLYV_AVEIRO	0	0	0	10	10	3	1
POLYV_FIGUEIRA DA FOZ	0	0	3	12	11	3	0
POLYV_LAGOS	1	0	0	0	1	0	0
POLYV_MATOSINHOS	2	11	6	7	11	13	1
POLYV_OLHAO	1	1	7	5	0	0	0
POLYV_PENICHE	0	8	11	13	14	4	0
POLYV_POVOA DO VARZIM	0	13	16	11	3	0	0
POLYV_SESIMBRA	12	5	4	5	4	1	0
POLYV_SETUBAL	10	1	1	3	2	0	0
POLYV_SINES	12	0	5	22	18	1	0
POLYV_VIANA DO CASTELO	0	1	0	0	0	0	0
PS_FIGUEIRA DA FOZ	0	0	0	0	1	10	2
PS_MATOSINHOS	1	0	1	0	0	6	1
PS_PENICHE	0	0	3	1	5	5	4
PS_SINES	2	0	0	0	6	5	3


Step (2)
statistical analysis
GesPe
Is mean length signifficantly different between size-categories ?
Df Sum Sq Mean Sq F value Pr(>F)
size-catg 5 3127459 625492 53239 <2e-16 ***
Residuals 86401 1015096 12
95% family-wise confidence level
T5-T6
T4-T6
T3-T6
T2-T6
T1-T6
T4-T5
T3-T5
T2-T5
T1-T5
T3-T4
T2-T4
T1-T4
T2-T3
T1-T3
T1-T2
5
10
15
20
Differences in mean levels of catg2
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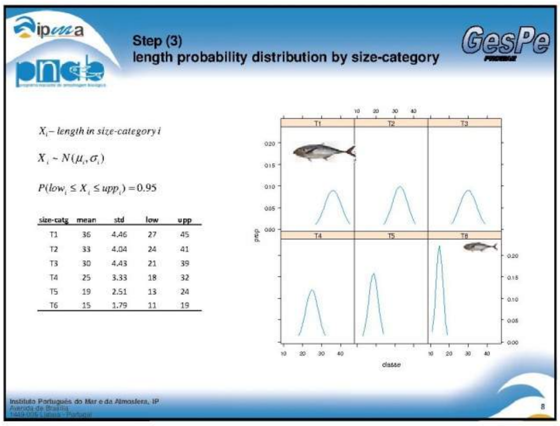
Step (3)
length probability distribution by size-category
GesPe
X_i – length in size-category i
$X_i \sim N(\mu_i, \sigma_i)$
$P(low_i \le X_i \le upp_i) = 0.95$
size-catg mean std low upp
T1 36 4.46 27 45
T2 33 4.04 24 41
T3 30 4.43 21 39
T4 25 3.33 18 32
T5 19 2.51 13 24
T6 15 1.79 11 19
T1
T2
T3
T4
T5
T6
classe
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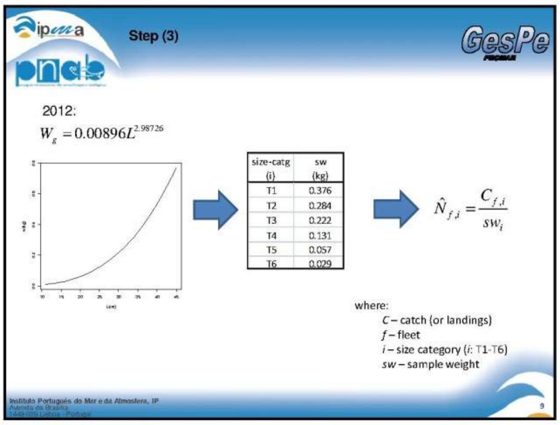
Step (3)
GesPe
2012:
$W_g = 0.00896L^{2.98726}$
size-catg (i) sw (kg)
T1 0.376
T2 0.284
T3 0.222
T4 0.131
T5 0.057
T6 0.029
$\hat{N}_{f,i} = \frac{C_{f,i}}{sw_i}$
where:
C – catch (or landings)
f – fleet
i – size category (i: T1-T6)
sw – sample weight
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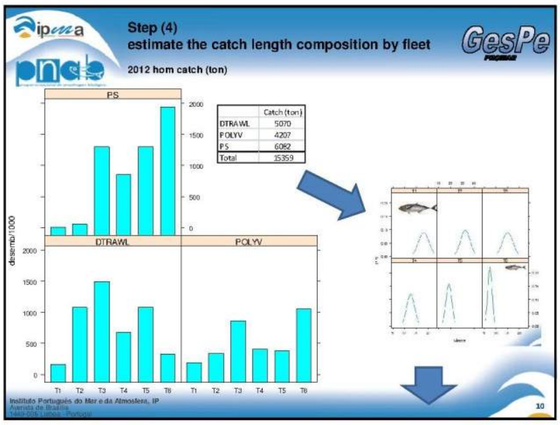
Step (4)
estimate the catch length composition by fleet
GesPe
2012 hom catch (ton)
PS
DTRAWL
POLYV
desemp/1000
Catch (ton)
DTRAWL 5070
POLYV 4207
PS 6082
Total 15359
T1 T2 T3 T4 T5 T6
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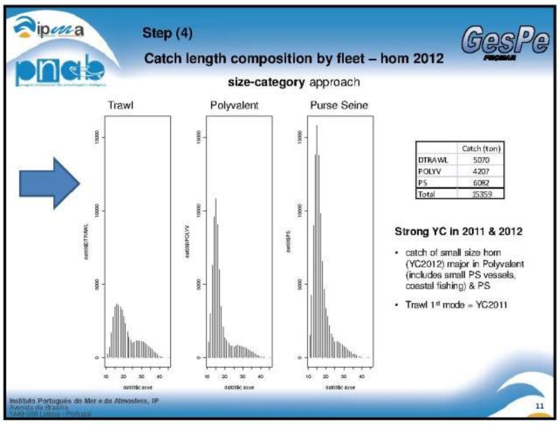
Step (4)
Catch length composition by fleet – hom 2012
GesPe
size-category approach
Trawl
Polyvalent
Purse Seine
Catch (ton)
DTRAWL 5070
POLYV 4207
PS 6082
Total 15359
Strong YC in 2011 & 2012
catch of small size hom (YC2012) major in Polyvalent (includes small PS vessels, coastal fishing) & PS
Trawl 1st mode = YC2011
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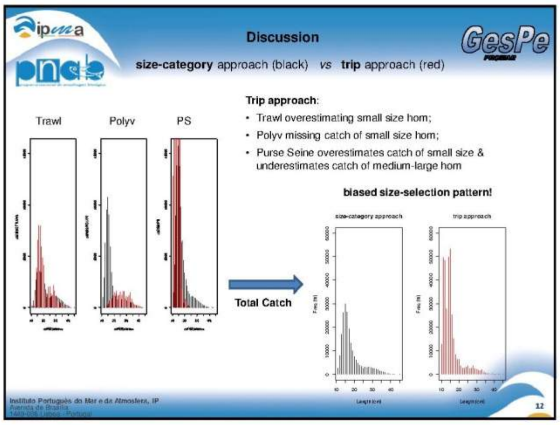
Discussion
GesPe
size-category approach (black) vs trip approach (red)
Trawl
Polyv
PS
Trip approach:
Trawl overestimating small size hom;
Polyv missing catch of small size hom;
Purse Seine overestimates catch of small size & underestimates catch of medium-large hom
biased size-selection pattern!
Total Catch
size-category approach
trip approach
Length (cm)
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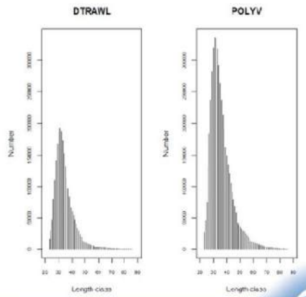
Application to Hake

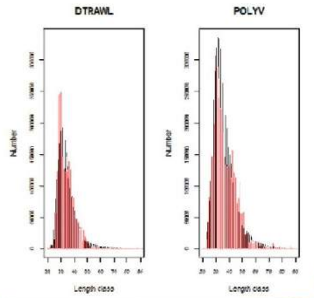
2013 – Raising by categories



Application to Hake

2013 – Raising by categories

2013 – Raising by trip

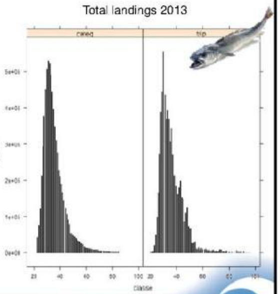


Application to Hake

size-category *vs* **trip** approach

arte	porto	T0	T1	T2	T3	T4	T5
DTRAWL	AVEIRO	2	33	24	26	38	35
	FIGUEIRA DA FOZ	0	15	20	27	39	29
	MATOSINHOS	2	26	24	17	15	4
	NAZARE	3	0	0	0	0	0
	OLHAO	0	0	3	3	2	0
	PENICHE	0	18	29	33	39	28
	PORTIMAO	30	22	20	29	50	48
	SESIMBRA	5	0	1	2	2	2
	SETUBAL	0	1	0	3	3	2
	VILA REAL S. ANTONIO	25	17	18	20	13	5
POLYVALENT	AVEIRO	0	16	7	12	12	17
	FIGUEIRA DA FOZ	0	10	17	18	27	18
	LAGOS	1	0	1	1	0	0
	MATOSINHOS	1	30	38	44	54	34
	OLHAO	10	19	37	49	49	49
	PENICHE	1	21	33	32	43	16
	POVOA DO VARZIM	3	17	22	35	44	24
	SAGRES	0	0	1	2	0	0
	SESIMBRA	31	6	19	21	22	4
	SETUBAL	32	0	0	0	1	1
	SINES	34	10	7	10	18	12
	VIANA DO CASTELO	0	2	0	1	0	0

Total landings 2013



Conclusions

- Catch/landings length composition is as much (hke) or more (hom) accurate when estimated with "size-category" approach than with "trip" approach
- Lower sampling effort (< €€€) with size-category approach
- Should sampling focus on characterizing/monitoring species size-categories**?**

Future work

- Apply the approach to other species/stocks;
- Evaluate the effect of the size-category approach for fish stock assessment and management

Acknowledgments

PNAB/DCF – Programa Nacional de Amostragem Biológica/Data Collection Framework (EU co-financed): for sampling data

GesPe – Planos de Gestão Pesqueira (PROMAR): for analysis & workshop

DGRM – Direcção Geral de Recursos Naturais, Segurança e Serviços Marítimos: for catch/landings statistics

Thank you !

P06

Statistical principles of survey sampling design applied to catch sampling programs

Jon Helge Vølstad

INSTITUTE OF MARINE RESEARCH
HAVFORSKNINGSINSTITUTTET

Major theoretical challenges in survey design

- Design the survey so that it will meet adequate precision requirements
  - within budgetary, administrative, and practical constraints
- Estimate the precision actually obtained for several important catch characteristics
  - Due to the complexity of survey designs that can actually be implemented this is not always straight forward

Steps in the planning of surveys

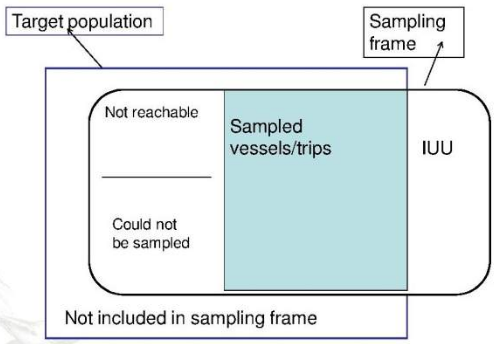
- Define the universe (target population) to be studied
  - E.g., total commercial annual landings of NEA cod from Barents Sea (by Norwegian vessels)
- Define what statistical information is needed
  - E.g., numbers of NEA cod by age-class in annual landings

Steps in the planning of sample surveys

- Decide what type of sample survey that could provide the information that is needed
  - At-sea sampling versus on-shore
  - Frequency of coverage, allocation of sampling effort over the year
  - Should a large survey be conducted at rare intervals, or would a series of smaller surveys at frequent intervals be better?
  - Consider available resources
  - Consider difficulties of obtaining the information (non-response etc.)

Steps in the planning of surveys

- Define the study population
  - E.g., all vessels/trips with catches of NEA cod
- Define the sampled population
  - All vessels/trips that it is actually possible to sample



Steps in the planning of surveys

- Lay out several rough alternative sample designs to evaluate costs
- Decide maximum allowable sampling errors
  - E.g., based on pilot studies
- Develop field sampling procedures

At-sea surveys

- Sampling frame may be based on a vessel registry
- Primary sampling units (PSUs)
  - Vessels (e.g., Reference Fleet, where all sampled trips are nested within a fixed set of vessels)
  - Trips (Observer programs where trips are selected across all vessels in the frame)
- Secondary sampling units (SSUs)
  - Fishing operations (Sets, Hauls, …)

On-shore surveys

- Sampling frame may be a matrix of sites-days (e.g., ports X days)
- Hierarchical sampling
  - Stage 1 sampling units (PSUs)
    - Site-days
  - Stage 2 sampling units
    - Vessels/trips
  - Stage 3 sampling units
    - Boxes (e.g., stratified by species and market-category)
  - Stage 4 sampling units
    - Individual fish sampled and measured for length and age

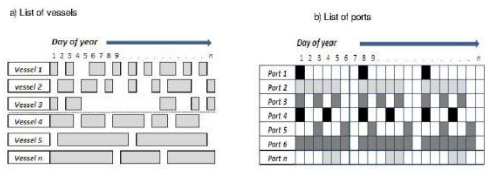
Multi-stage sampling for biological data is the norm

- The PSUs will generally contain complex clusters of individuals
  - e.g., hierarchy where catches are clustered within site-days and trips
  - Fish that are caught together tend to be more similar than fish in the entire target population (e.g., annual landings)

Principal design classes for at sea and on-shore commercial catch sampling. The primary sampling units may be sub-sampled in multiple stages, using simple random, stratified random, or systematic sampling.

Design class	Sampling frame of *PSU*s	Comment, example	Examples of stratification of *PSU*s	Case study
A	Vessel*time	Sample a number of trips or fishing operations across all vessels. In the analysis, trips or fishing operations are treated as PSUs	Vessel-characteristics (length), quarter	NL case study Skagerrak regional study NO case studies
B	Vessels	Sample a group of vessels Special case: If all vessels are sampled, each vessel is effectively a stratum, and trips are sampled over time from each vessel	Fleets (offshore/coastal), gear, target fishery	NO case study
C	Sites * time	Random sample of port-days	Geographic (markets), Quarter	SE case study
D	Sites	Sample a group of ports Special case: If all ports are sampled, each port is effectively a stratum, and vessels/trips are sampled over time from each port	Geographic, quarter, effort, or landings at the sites	ES case studies Scottish study

Example of sampling frames



Stratification

- Stratification is the process of dividing units in the sampling frame population into non-overlapping subgroups before sampling.
  - Can be done for multiple sampling stages
  - Sample sizes within strata are fixed in advance
  - For proper weighted estimation across strata, the strata sizes must be known!

Why stratify?

- Administrative and cost benefits
  - E.g., local field staff may sample from a group of ports with reduced travel time
- Improve overall precision for fixed cost
  - Create strata of homogeneous units
  - Optimize allocation of samples
- Control sample sizes for strata of particular importance
  - To help achieve precision targets

Stratification to maximize precision of estimation

- The principle is to construct strata so that their averages are as different as possible, and their variances are as small as possible
- Allocation of samples ~proportional to strata size is safe when the survey has multiple objectives

Allocation of samples to strata

- Optimum:

$$n_h = n \times \frac{A_h \hat{\sigma}_h}{\sum A_h \hat{\sigma}_h}$$

- Proportional:

$$n_h = n \times \frac{A_h}{\sum A_h}$$

- Proportional allocation works well for multi-objective surveys

Limitations of stratification

- Cannot normally stratify catch samples by métiers (e.g., statistical area and gear combinations) because the trips and catch operations in each are not known in advance
- Sample sizes (#PSUs) may preclude
  - stratification by all major gears
  - stratification be vessel size, etc.

MÉTIERS versus STRATA

- **MÉTIER:** A group of fishing operations targeting a similar (assemblage of) species, using similar gear, during the same period of the year and/or within the same area and which are characterised by a similar exploitation pattern.
  - The catches for such a sub-population of fishing operations in a fishery (domain) cannot generally be sampled with known probability since a list of PSUs within metiers is not available in advance.
  - Estimates of catch characteristic for a métier (domain) are therefore often based on stratification after selection of PSUs (post-stratification.)

Domains

- Estimates may be desired for subpopulations (domains) of the general target population
  - Obtaining precise estimates for many domains (e.g., métiers) can be costly!
- The sample sizes for domains cannon generally be fixed in advance
  - Cannot identify in advance the population units of each domain

Domains

- The sample sizes for catch surveys should be sufficient to produce estimates of reasonable precision for major domains;
- Precision requirements for domains present a major challenge
  - May require oversampling in some strata, resulting in overall loss in precision for fixed cost

Examples of domains

- Quarterly estimates of discard by fishing ground
- Catch composition of gear type * target species * fishing areas
- Quarterly estimates of landings and discards numbers at age, by species, area (subdivision), mesh-size range, Loa of vessels

A caution on quota sampling

- Sampling to achieve a given sample size for a particular métier (e.g., when sampling trips in a port) will often result in bias
  - Métiers will not be sampled in their right proportion
  - Inclusion-probabilities are unknown
  - Overall precision may be reduced

Precision requirements versus achieved precision

- Advance calculations of the expected variance for some key characteristics to be obtained from the survey are useful for planning
  - This calculation is based on incomplete knowledge (from pilot studies, other catch sampling programs etc.)
  - Important to estimate the precision actually achieved, and adjust design if necessary

Estimation principles for clustered data – At-sea sampling

- Observations are expanded in reverse order
  - Means and frequencies from a sub-sample of the catch is expanded to the total catch of a haul
  - Averages across hauls within each trip are expanded to the trips
  - For observer programs with trips as PSUs, averages for trips are expanded to all trips

Estimation principles for clustered data

- In practice, catch sampling programs will only collect data from a very small fraction of PSUs
- Variances can therefore be calculated from the PSUs only
  - For small sampling fractions (< 10%) we can assume sampling with replacement
  - Number of PSUs sampled will often drive the achieved effective sample sizes

Role of post-stratification and model-based estimation

- Post-stratification can take advantage of census data to balance the sample
  - Complete trip-ticket data crossed with vessel registry can be used to re-weight samples
  - Sample data may be more representative for the general fleet within statistical areas and vessels groups
  - Improve spatially balance to reduce vessel/trip selection bias

Methods for evaluating surveys

- The efficiency of each survey design can be evaluated by comparing the respective design-based variance of the estimated characteristics with the expected variance obtained under simple random sampling.

Some measures of the efficiency of surveys

- Design effect:

$$deff = \hat{\sigma}^2_{complex} / \hat{\sigma}^2_{sr}$$

- Effective sample size:

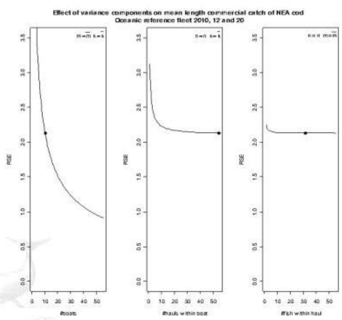
$$n^*_{eff} = n / deff$$

- The effective sample size is the number of observation units selected by simple random sampling that would be required to achieve the same precision obtained under the actual complex (hierarchical) sampling design.

Effective sample sizes

- Effective sample size are often close to # of PSUs
- Individual fish cannot be assumed SRS

Projected precision in estimated mean length of cod given sample size in each sampling stage



Kilde: Sondre Aanes

Onboard Sampling in Division IXa

Ana Cláudia Fernandes and Nuno Prista

Workshop on Sampling Design Optimization

Lisbon 17-20 November 2014

Objectives

General: Collect data necessary for the evaluation of stocks and fisheries

Onboard:

- estimate discards produced by Portuguese fisheries, concerning species under regulation (TAC, quotas, MLS, recovery plans)
- characterize the catch (landings+discards) composition in different fisheries (species, lengths)

Fleet segments - I

DCF Métiers	Fleet Segments	Denomination
OTB_DEF_>=55_0_0	OTB_DEF	Otter bottom trawl - demersal fish
OTB_CRU_>=55_0_0	OTB_CRU	Otter bottom trawl - crustaceans
LLS_DWS_0_0_0	LLS_DWS	Deepwater set longline
FPO_MOL_0_0_0	GNS_GTR	Gill and trammel nets
GNS_DEF_>=100_0_0		
GNS_DEF_60-79_0_0		
GNS_DEF_80-99_0_0		
GTR_DEF_>=100_0_0		
GTR_DEF_80_99_0_0		
PS_SPF_0_0_0	PS_SPF	Purse seine
TBB_CRU_<55_0_0	TBB_CRU	Beam trawl - crustaceans

Vessels combine métiers in a same trip

Fleet segment - II

Fleet segment	Targets	Region	Sampling Data
OTB_DEF	horse-mackerel, cephalopods and other finfish	NW; SW; S	2004-2014
OTB_CRU	deep-water rose shrimp, Norway lobster and blue whiting	SW; S	2004-2014
LLS_DWS	black scabbardfish	NW; SW	2005-2014
PS_SPF	sardine, horse-mackerel, chub-mackerel	NW; SW; S	2009-2014
GNS_GTR	Demersal fish	NW; SW; S	2011-2014
TBB_CRU	Crustaceans	NW	2010-2014

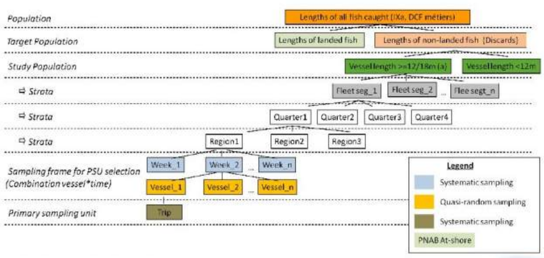
Sampling effort

Fishing effort distribution is used to allocate sampling effort into three regions:

Fleet	NW	SW	S	Total
OTB_CRU	-	2	16	18
OTB_DEF	18	15	5	38
LLS_DWS	3	9	-	12
PS_SPF	9	9	6	24
GNS_GTR	13	8	3	24
TBB_CRU	12	-	-	12

Logbook data: OTB and LLS_DWS
Auction sales data: PS_PSF; GNS_GTR and TBB_CRU

Sampling scheme



(a) Vessels operating in Portuguese ports

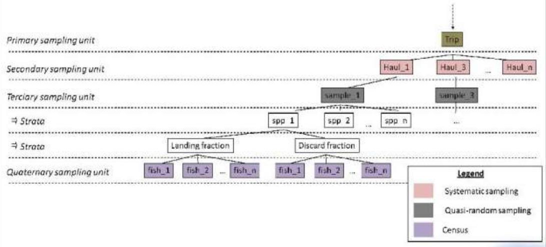
List of cooperant vessels for each fleet segment (mutually exclusive)

Trip selection

- Quasi-systematic distribution of trips in quarter*region
- Quasi-random selection of vessel from the list of cooperative vessels
- Contact a vessel and ask shipmaster if he is working that week and if observers can go onboard
  - **Yes** – try to go in a trip (that same week)
  - **No** – contact another vessel from the list

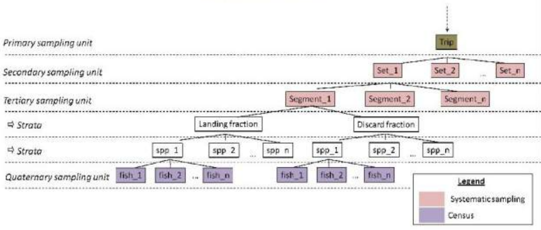
Trip sampling design

OTB _DEF & OTB_CRU



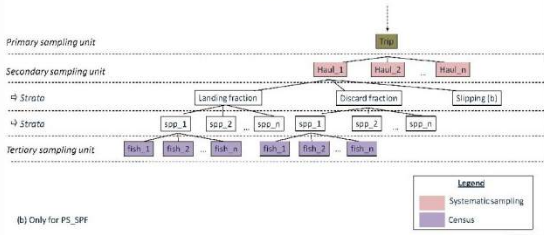
Trip sampling design

LLS_DWS & GNS_GTR



Trip sampling design

TBB_CRU & PS_SPF



Sampling coverage (2013)

Fleet	Vessel length (m)	% nr vessels	% trips
OTB_DEF	>= 24	15	0.53
OTB_CRU	>= 18	13	0.37
LLS_DWS	>= 12	12	0.10
PS_SPF	>= 12	20	0.23
GNS_GTR	>= 12	2	0.02
TBB_CRU*	>= 12	30	0.90

* Some vessels under 12 m were sampled

- Way forward
  - Register refusal rates in a database
  - Find a way to overcome the low cooperation of industry, taking into account the "Landing obligation"
- Topics for discussion
  - Is there a problem with the overlap of vessels lists between regions?
  - How to cope with "Landing obligation"?

Sampling design in the Indian Ocean

Pedro G. Lino, Rui Coelho and Miguel N. Santos

WORKSHOP ON SAMPLING DESIGN AND OPTIMIZATION (WKSDO)

Lisboa, 17-20 Nov 2014

Instituto Português do Mar e da Atmosfera, IP

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Historical information

- Portuguese fleet has been fishing with longline in the Indian Ocean since 1998
- On-board sampling since 2011
- No port sampling (transhipment IO ports; landed in Vigo)
- Self-reporting through IPMA scientific electronic logbook (spreadsheet)

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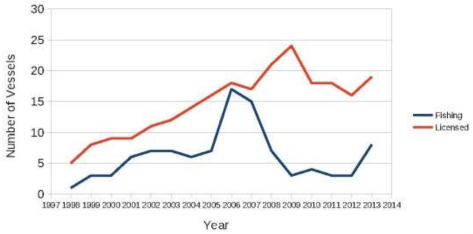
Fleet size



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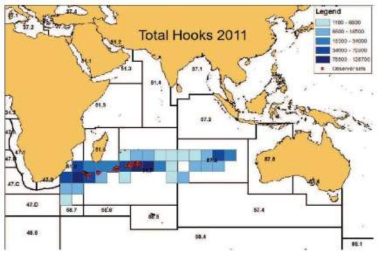
3

Fishing effort 2011



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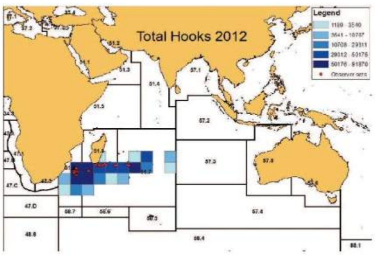
4

Fishing effort 2012



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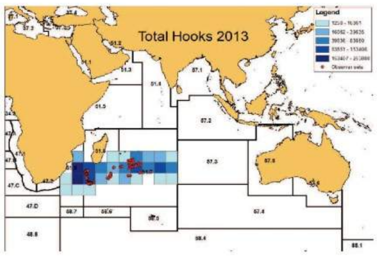
Fishing effort 2013



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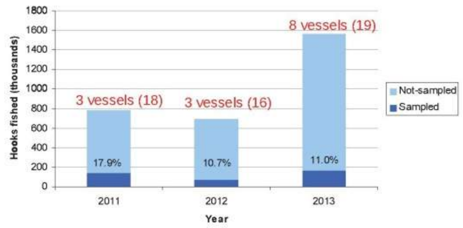
Portuguese active fleet and effort in IOTC



7

Data for 2013

- 1312 fishing sets with 1557998 hooks fished
- Min hooks: 588; Max hooks: 2180; Avg hooks: 1335
- Observers covered 130 fishing sets (9.9%) for a total of 170924 hooks (11.0%)

8

Sampling strategy

- Observers are boarded on collaborating boats
- Sampling area occurs in the core fishing area (SW Indian Ocean)
- A complete trip is sampled (no boat hopping)
- Fishing data (date, location, effort, bait, depth...)
- All specimens are identified, measured and sexed (if possible)
- At haulback and fate (retained/discarded) status (live/dead) is registered

9

Additional data

- Old paper logbooks
- Self-reporting through IPMA provided scientific electronic logbooks
- Usually all specimens from major commercial species are measured (or at least 20 fish of each species on each set)
- Non-commercial and/or prohibited species are counted and release status registered

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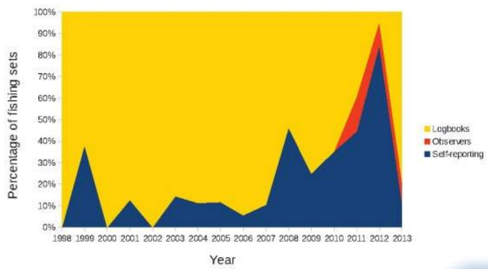
Data collection



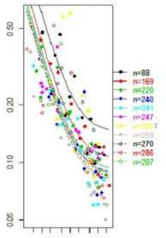
11

Future sampling

- Need to include 2014 data in the analysis: fleet is expanding fishing area to the East (two major areas)
- Need to increase area coverage
- Improve self-reporting which has significantly decreased since shark fin cut ban by EU (fins naturally attached)

12

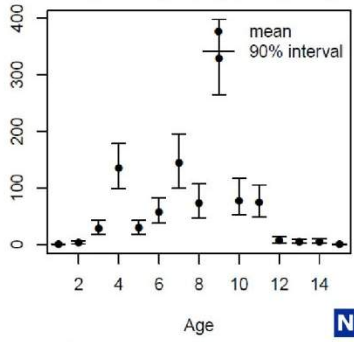
A framework for cost-efficient sampling to support stock assessment



Norsk Regnesentral

Catch at age

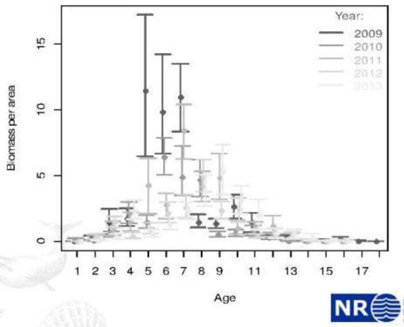
Example: Norwegian spring spawning herring



Norsk Regnesentral

Acoustic survey indices of abundance at age

Example: Norwegian spring spawning herring



Norsk Regnesentral

Statistical model: process

The model in Aanes et al. 2007 with 3 adjustments:

$$N_{a+1,y+1} = N_{a,y}\exp(-Z_{a,y}) \quad \text{for} \quad a_{\min} \le a \le A, 1 \le y \le Y$$

Mortality:

$$Z_{a,y} = F_{a,y} + M_{a,y}$$

fishing natural

1) In Aanes et al 2007: a stochastic process
Here: ≡ 0.2 for fair comparison with XSA

The fishing mortality is modelled as a stochastic process:

$$\log(F_{a,y}) = f_a + e_y + W_{a,y}$$

Separable model

iid ~ $N(0,\sigma_M^2)$

$$e_y = \alpha + \beta e_{y-1} + T_y$$

iid ~ $N(0,\sigma_\varepsilon^2)$

2) In Aanes et al 2007: Random walk
Here: 1. order AR process;
improves retrospective bias in estimates

Statistical model: Observations

Catch at age in numbers:

$$\hat{C}_{a,y} = \frac{F_{a,y}}{F_{a,y}+M_{a,y}} N_{a,y}\left(1-\exp(-F_{a,y}-M_{a,y})\right)\exp\left(\varepsilon_{a,y}^{(C)}\right)$$

$$\varepsilon_{\cdot,y}^{(C)} \sim MVN\left(0,\Sigma_y^{(C)}\right)$$

Variability

Index of abundance at age:

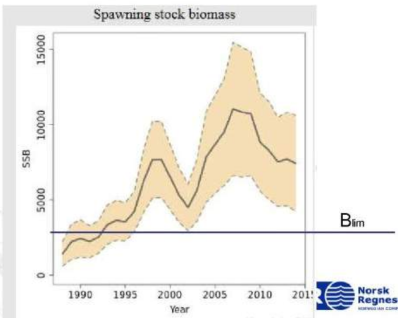
$$\hat{I}_{a,y} = q_a N_{a,y}^{(I)}\exp(\varepsilon_{a,y}^{(I)}) \quad \text{for} \quad a_{\min}^{(I)} \le a \le A^{(I)}, 1 \le y \le Y$$

$$\varepsilon_{\cdot,y}^{(I)} \sim MVN\left(0,\Sigma_y^{(I)}\right)$$

3) In Aanes et al 2007, $\Sigma_y^{(\cdot)} = \sigma^2 I$, i.e. the observations were assumed to be IID, and σ^2 was a estimated. Here, $\Sigma_y^{(\cdot)}$ is taken as input.

Notice:
The observation model is an integrated part of the statistical model; not in XSA

Assessment model output used for quota advice



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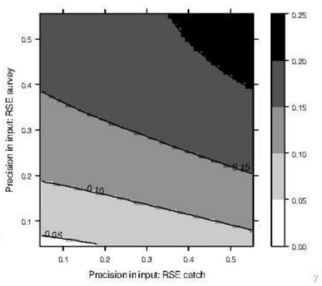
Uncertainty in output depend on uncertainty in input

Work in progress by Aanes and Vølstad

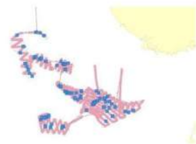


RSE: Relative standard error

7

StoX

- Open source software hosting various types of survey estimation programs
  - Fishery independent surveys
    - Acoustic
    - Trawl surveys
    - ++
  - Fishery dependent surveys
    - Catch at age
    - ++
- User friendly interface and an interactive GIS module
- Fully documented: Reproducible estimates
- Batch mode, linking Java with external R libraries



Framework for estimating catch at age: ECA

- Model-based (peer reviewed)
- Design-based (in progress, cf WKPICS)
- Implemented for 11 species
- Routinely used for ~6 species
- Currently allow for hierarchical sampling (three levels)

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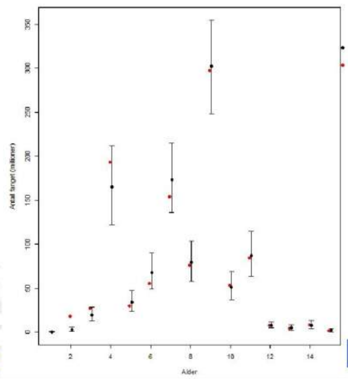
Example: Norwegian spring spawning herring



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P10

ICES CM 2013/J:08

Efficient statistical estimators and subsampling strategies to quantify the age composition of fish

Sondre Aanes (Norwegian Computing Center)
Jon Helge Vølstad (Institute of Marine Research)

NR Norsk Regnesentral

Focus of this talk

- Estimation methods;
  - Age-Length-Keys (ALK);
  - Design-based estimators for multistage cluster sampling
- Assessing common subsampling practices
  - Random versus systematic (length-stratified) subsampling
- Assessing common practices in the use of ALKs
  - Assuming ALK without sampling error
  - Borrowing ALK
- Our analyses are based on extensive empirical data on NEA cod from scientific surveys and catch sampling programs
- Simulations that creates "realistic" population data on numbers at age are used to assess properties of estimators

Approach 1: ALK

Appears as the most common method in practice;

The proportion at age k $p_k^{(a)}$ is estimated by applying the proportion of age k at length j, q_{jk} (the ALK), on the length distribution $p_j^{(l)}, j = 1, \ldots, L$ through

$$\hat{p}_k^{(a)} = \sum_{j=1}^{L} \hat{p}_j^{(l)} \times \hat{q}_{jk}$$

We estimate the ALK based on standard sampling theory. For PSUs $i = 1, \ldots, n$

$$\hat{q}_{jk} = \frac{\sum_i w_{ij} \times \hat{q}_{ijk}}{\sum_i w_{ij}} \quad \text{for 2 different weights } w_{ij} = \begin{cases} \hat{M}_{ij} = M_i \times \hat{p}_{ij}^{(l)} & \text{\# in length cat } j \text{ (ratio to size} \\ 1 & \text{Unweighted} \end{cases}$$

ALK in PSU/trawl station i

And similarly, the length distribution is estimated by

$$\hat{p}_j^{(l)} = \frac{\sum_i w_i \times \hat{p}_{ij}^{(l)}}{\sum_i w_i} \quad \text{for 2 different weights } w_i = \begin{cases} M_i & \text{\# in PSU } i \text{ (ratio to size)} \\ 1 & \text{Unweighted} \end{cases}$$

Proportion in length category j at PSU/trawl station i

Approach 2: Design based approach

The proportion at age k, $p_k^{(a)}$, is estimated by

$$\hat{p}_k^{(a)} = \frac{\sum_i w_i \hat{p}_{ik}^{(a)}}{\sum_i w_i}$$

proportion at age within PSU i

$$\text{for 2 different weights } w_i = \begin{cases} M_i & \text{\# in PSU } i \text{ (ratio to size)} \\ 1 & \text{Unweighted} \end{cases}$$

Estimator for $p_{ik}^{(a)}$ is derived using the general stratified estimator

$$\hat{p}_{ik}^{(a)} = \sum_{j=1}^{L} \frac{m_{ij}}{m_i} \times \frac{m'_{ijk}}{m'_{ij}} = \sum_{j=1}^{L} \hat{p}_{ij}^{(l)} \times \hat{q}_{ijk}$$

# of fish in l-cat j in the subsample m_i measured for length from PSU i

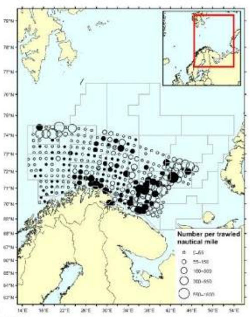
total # of fish subsampled and measured for length from M_i

# of fish in the sub-sample m'_{ij} assigned to age class k

# of fish subsampled for age from the m_{ij} fish in length category j for PSU i

Notice: The Design based approach is the ALK applied within cluster and may be shown to be equivalent to the ALK approach provided the estimators are weighted according to size (ratio to size).

Data: Bottom trawl survey 1991



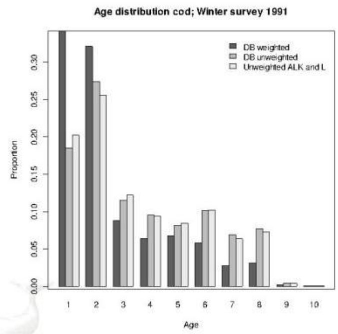
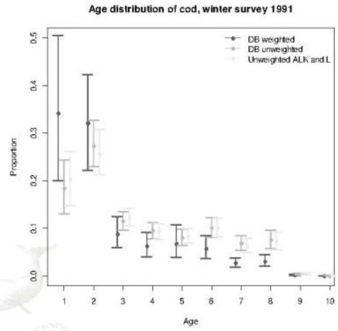
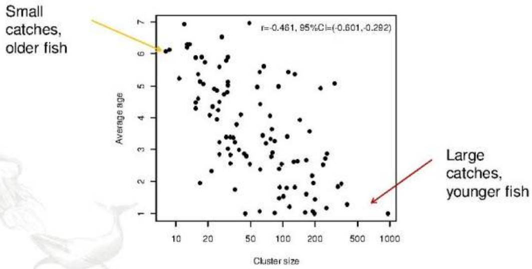


Figure 2. Estimated age distribution of NEA cod in 1991 from the joint Russian Norwegian winter survey by three different estimators, design based estimator utilizing sampling weights (DB weighted), design based estimator weighing PSU's equally (DB weighted), the ALK approach where the ALK is estimated giving PSUs equal weight applied on the unweighted length distribution (unweighted ALK and L).

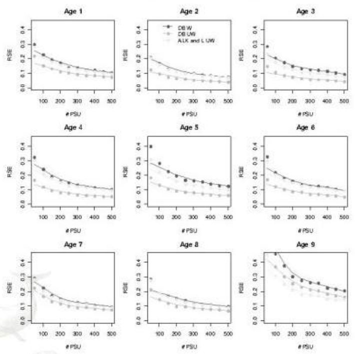
Choice of estimators makes a difference



Why the big difference between weighted and unweighted estimators?



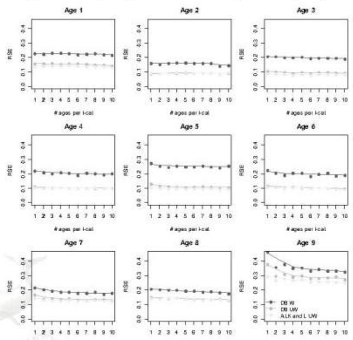
Effect of # PSUs on precision in age-composition



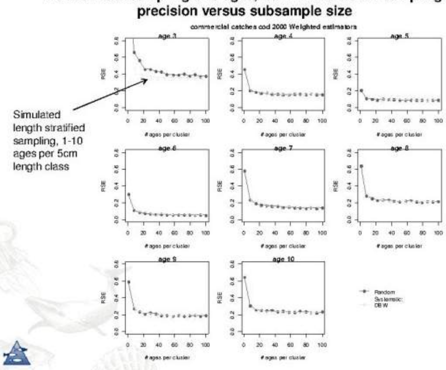
Assessing effects of subsampling for age on the precision of age-compositions

- Subsampling
  - Resample from 1 to 10 ages within each 5-cm length category (scientific survey data)
  - Random subsampling from 1 to 100 ages (length-age sampling in commercial fisheries)
- Compare random subsampling with length-stratified subsampling
  - Use data from commercial catches in 2000 where all fish sampled for length (100) in each PSU were also sampled for age
  - Compare random and length-stratified sampling by simulations (resampling)

Subsampling of ages within 5cm length categories, scientific survey precision (RSE) versus subsample size (1-10)



Random subsampling of # ages, commercial catch sampling precision versus subsample size



Effect of borrowing an ALK for imputations

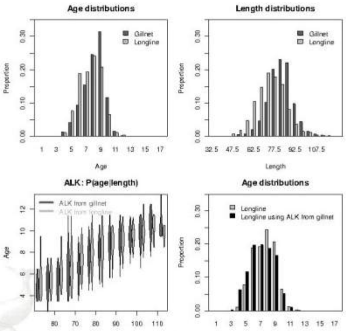


Figure 9. Summary of estimates and data on age distributions of commercial catch of NEA cod in the Lofoten area (0 and 5) in the first quarter in 2000 by gillnet and longline: Estimated age distributions (upper left panel), length distribution (upper right panel) and age-length-keys (lower left panel) by gillnet (dark gray) and longline (light gray), represented by violin plots. The ALK represents a discrete probability distribution, for the sake of visualization the distribution is made continuous by assuming the same probability for age intervals of width 1 year centered at each integer age. The estimated age distribution of the commercial catch by longline compared to estimated age distribution of longline applying the ALK from gillnet on the length distribution of longline. The age and length distributions and the age length keys are estimated using the weighted DB approach. There were 20 PSUs sampled from gillnet and 15 PSUs from longline, each with approximately 80 fish that were both length measured and aged.

- The estimates differ
- Which estimator yields the most accurate estimates?
  - Accuracy = the degree of closeness of an estimate to the quantity's actual (true) value
  - Determined by precision and bias

Evaluating estimators

- Look at accuracy (how close are estimates to the true age-compositions)
- Based on 200 replicates (surveys) of a synthethic population ("the truth") we consider the statistics:
  - Goodness of fit: $F = \sum_{i=1}^{k} \frac{(\hat{p}_i - p_i)^2}{p_i}$
    - How close are the estimates of age-distributions to the "truth"
- Coverage:
  - Does estimated 95% CL of proportions at age include the true value?

$$F = \sum_{i=1}^{k} \frac{(\hat{p}_i - p_i)^2}{p_i}$$

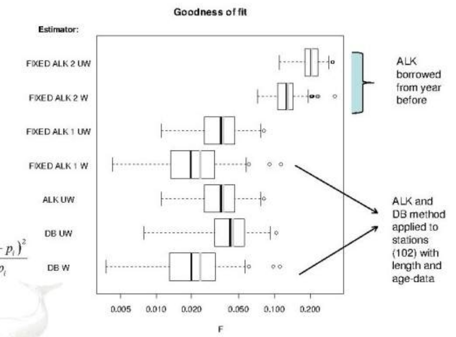
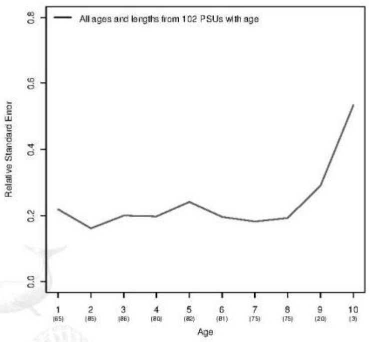
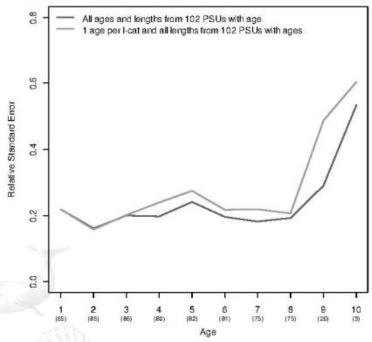


Figure 11. Distribution of the goodness of fit statistic (F) for different estimator and approaches fitted to 200 realizations from a simulated population. The estimators are 1) the weighted design based estimator (DB W), 2) the unweighted design based estimator (DB U), 3) the unweighted ALK applied on the unweighted estimate of the length distribution (ALK UW), 4) estimating ALK using the weighted estimator fixing it and apply it on the weighted estimate of the length distribution, 5) as 4) but unweighted estimates of ALK and length distribution, 6) as 4) but using the ALK estimated using data from the 1999 data, and 7) as 5) but using the ALK estimated using the 1999 data.

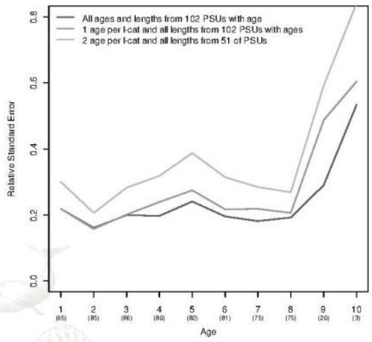
Effect of additional length samples



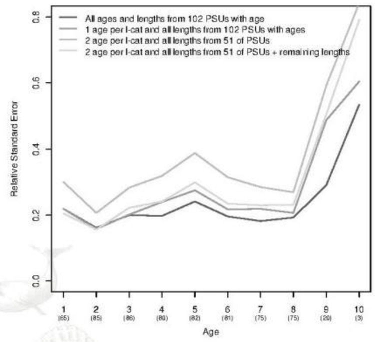
Effect of additional length samples



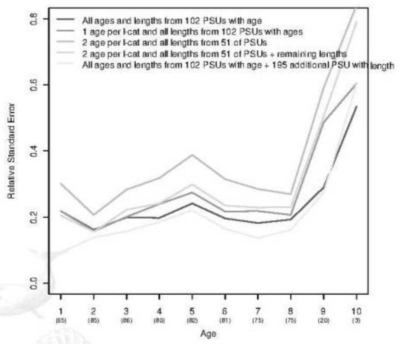
Effect of additional length samples



Effect of additional length samples



Effect of additional length samples



Some conclusions

- The performance of the ALK method and design based estimators are similar when properly weighted
- Variance in proportions-at-age is driven by sample size of PSUs
  - No need to estimate variance in secondary and lower sampling stages
  - Subampling 1 otolith per 5 cm length category is sufficient for NEA cod
- Applying ALK within PSUs (design-based estimator) is preferable:
  - Supports the estimation of precision in proportions and numbers at age
  - Allows for study of spatial variation of age distribution and model-based estimation (whereas standard ALK practice does not)
- The borrowing of ALK for imputations most likely cause bias in age-composition

END—Questions?

"An investigator who gives serious attention to the numerous types of systematic error which may enter into his procedures for sampling fish populations may at times tend to forget that even his best efforts will not make the result anything better than a good *sample*, subject to sampling error."

Ricker, W. E. (1945). Some applications of statistical methods to fishery problems. Biometrics Bulletin 1, 73-79.

Courtesy of Paul Rago, Department of Commerce | National Oceanic and Atmospheric Administration | NOAA Fisheries

P11

GesPe/PNAB Workshop on Sampling Design and Optimization (WKSDO)
17-20 November 2014, IPMA, Lisbon - PORTUGAL

– Study case Sardine –
Sampling for growth parameters estimation
(Sampling scheme; ALK's construction; Problems)

Eduardo Soares

IPMA

INTRODUCTION

Stock
- Atlantic Iberian sardine - single stock;
- Distribution area - ICES Divs. VIIIc+IXa.

Fishing fleet
- Purse seiners (99% of landings): Portugal – 144; Spain – 332.

Fishery data
- Having reached a maximum around 250 thousand tons/year (1961), catches sharply decreased since the middle eighties due to successive low recruitment years. 60% abundance decrease in the last 10 years and since 2011 landings dropped from about 72 thousand tons to around 41 thousand tons in 2013 (the lowest within the historic series since 1954), raising serious concern for the resource sustainability.

INTRODUCTION

Management measures
- Fishery management measures since 1998 (PT and SP): limitation of fishing boats in activity; TAC; catch ban periods.

Presently: fishery interdiction till the end of this year (20 thousand tons TAC for 2014 exceeded!).

Resource dynamics
- High variability of stock abundance - environmental factors direct influence on annual recruitments;

SAMPLING SCHEME

Landing sampling program
- Program: PNAB – Programa Nacional de Amostragem Biológica (National Biological Sampling Program)
- Two stage stratified sampling program
  - Landing harbours (Matosinhos, Póvoa-de-Varzim, Peniche, Olhão, Portimão);
  - Periodicity: quarterly;
  - Fish samples;
  - Otolith collection (from 10 individuals in each length class).

Additional specimens sampling
- Research surveys at sea.

Analysis of 2012 and 2013 age data

Samples data

2012

Area		Month 1	2	3	4	5	6	7	8	9	10	11	12	Total
North	Minimum Length	16.0			16.5	16.5	17.5	18.5	18.5	14.5	18.5	18.1	18.6	14.5
	Maximum Length	22.6			23.1	20.8	24.2	22.9	22.3	22.4	23.4	24.2	22.9	24.2
	Nº Otoliths	164			110	85	153	161	64	133	147	186	82	1285
Centre	Minimum Length	15.7	13.7		16.5	17.5	17.6	18.3	19.2	17.3	14.1	16.2	18.5	13.7
	Maximum Length	23.1	23.4		22.9	22.8	22.4	23.6	24.0	23.1	24.0	22.5	23.0	24.0
	Nº Otoliths	180	176		98	155	146	137	73	142	238	82	142	1569
South	Minimum Length	15.3	15.5			17.0	16.5	17.0	17.0		15.6	16.2		15.3
	Maximum Length	22.8	22.4			22.3	22.2	21.0	20.3		22.5	22.1		22.8
	Nº Otoliths	185	187			165	146	64	63		166	98		1074
Total	Minimum Length	15.3	13.7		16.5	16.5	16.5	17.0	17.0	14.5	14.1	16.2	18.5	13.7
	Maximum Length	23.1	23.4		23.1	22.8	24.2	23.6	24.0	23.1	24.0	24.2	23.0	24.2
	Nº Otoliths	529	363		208	405	445	362	200	275	551	366	224	3928

Analysis of 2012 and 2013 age data

Samples data

2013

Area		Month 1	2	3	4	5	6	7	8	9	10	11	12	Total
North	Minimum Length	18.5		15.3	16.0	17.1	19.1	18.5	17.8	20.0	16.0	15.5	16.0	15.3
	Maximum Length	23.4		21.9	23.6	23.4	23.4	23.4	21.8	23.4	23.2	24.3	23.8	24.3
	Nº Otoliths	175		110	218	111	132	148	141	62	158	208	95	1558
Centre	Minimum Length	13.0		16.7	18.9	15.8	18.8	17.2	18.0	17.7	18.8	10.5	13.5	10.5
	Maximum Length	24.0		22.8	23.1	22.5	22.9	23.0	23.2	23.7	24.3	22.7	24.3	24.3
	Nº Otoliths	172		78	60	151	135	150	164	164	145	220	168	1607
South	Minimum Length	14.5	14.3	15.2	15.3	16.6	16.1	16.2	17.2	12.2	14.8			12.2
	Maximum Length	22.6	22.5	22.4	23.2	21.4	21.8	21.9	21.8	21.5	21.7			23.2
	Nº Otoliths	180	195	190	218	79	138	142	54	116	140			1452
Total	Minimum Length	13.0	14.3	15.2	15.3	15.8	16.1	16.2	17.2	12.2	14.8	10.5	13.5	10.5
	Maximum Length	24.0	22.5	22.8	23.6	23.4	23.4	23.4	23.2	23.7	24.3	24.3	24.3	24.3
	Nº Otoliths	527	195	378	496	341	405	440	359	342	443	428	263	4617

Analysis of 2012 and 2013 age data

ALK 2012

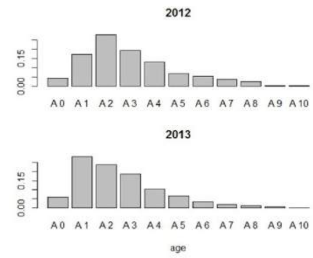
L.Class	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	Total
10.75	0	0	0	0	0	0	0	0	0	0	0	0
11.25	0	0	0	0	0	0	0	0	0	0	0	0
11.75	0	0	0	0	0	0	0	0	0	0	0	0
12.25	0	0	0	0	0	0	0	0	0	0	0	0
12.75	0	0	0	0	0	0	0	0	0	0	0	0
13.25	0	0	0	0	0	0	0	0	0	0	0	0
13.75	0	1	0	0	0	0	0	0	0	0	0	1
14.25	5	1	0	0	0	0	0	0	0	0	0	6
14.75	20	2	0	0	0	0	0	0	0	0	0	22
15.25	20	1	0	0	0	0	0	0	0	0	0	21
15.75	22	1	1	0	0	0	0	0	0	0	0	24
16.25	23	12	9	0	0	0	0	0	0	0	0	44
16.75	22	17	25	1	0	0	0	0	0	0	0	65
17.25	24	23	54	4	1	0	0	0	0	0	0	106
17.75	15	40	71	11	1	0	0	0	0	0	0	138
18.25	10	69	106	14	4	0	0	0	1	0	0	204
18.75	5	133	174	39	11	0	2	0	0	0	0	364
19.25	2	143	160	71	31	10	2	1	0	0	0	420
19.75	1	113	142	120	46	16	7	3	1	0	1	450
20.25	0	73	128	117	79	43	30	17	7	0	1	495
20.75	0	20	104	123	97	52	31	24	16	0	2	469
21.25	0	14	57	95	95	52	49	25	12	1	1	401
21.75	0	4	33	85	64	43	30	29	18	2	0	308
22.25	0	1	18	60	54	31	30	28	25	2	1	250
22.75	0	0	3	20	23	16	14	13	10	1	3	103
23.25	0	0	1	2	6	3	6	7	3	0	0	28
23.75	0	0	0	0	1	1	0	1	1	0	0	4
24.25	0	0	0	0	1	2	0	1	0	0	1	5
Total	169	668	1086	762	514	269	201	149	94	6	10	3928

ALK 2013

L.Class	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	Total
10.75	2	0	0	0	0	0	0	0	0	0	0	2
11.25	1	0	0	0	0	0	0	0	0	0	0	1
11.75	6	0	0	0	0	0	0	0	0	0	0	6
12.25	11	0	0	0	0	0	0	0	0	0	0	11
12.75	12	0	0	0	0	0	0	0	0	0	0	12
13.25	10	1	0	0	0	0	0	0	0	0	0	11
13.75	23	0	0	0	0	0	0	0	0	0	0	23
14.25	32	1	0	0	0	0	0	0	0	0	0	33
14.75	25	7	0	0	0	0	0	0	0	0	0	32
15.25	22	29	0	0	0	0	0	0	0	0	0	51
15.75	30	51	1	0	0	0	0	0	0	0	0	82
16.25	41	72	1	0	0	0	0	0	0	0	0	114
16.75	30	86	5	1	0	0	0	0	0	0	0	122
17.25	19	124	17	9	0	0	0	0	0	0	0	169
17.75	8	120	39	19	0	0	0	0	0	0	0	186
18.25	5	148	82	42	4	0	0	0	0	0	0	281
18.75	1	154	140	54	2	1	0	0	0	0	0	352
19.25	0	171	144	92	12	4	0	0	0	0	0	423
19.75	0	140	165	116	30	20	4	2	0	0	0	477
20.25	0	109	154	125	72	54	15	3	5	0	0	537
20.75	0	56	128	107	70	51	28	19	6	1	0	464
21.25	0	20	103	107	81	37	27	13	9	0	0	397
21.75	0	6	68	81	79	43	30	17	7	8	1	340
22.25	0	3	32	58	73	33	27	13	11	6	0	256
22.75	0	1	16	34	44	40	13	6	6	2	0	162
23.25	0	0	1	10	16	13	7	7	2	4	0	60
23.75	0	0	0	0	1	5	1	1	0	0	1	9
24.25	0	0	0	1	0	1	0	1	1	0	0	4
Total	278	1299	1096	856	484	302	44	82	47	21	2	4617

Analysis of 2012 and 2013 age data

Age distribution



Analysis of 2012 and 2013 age data

Proportions-at-age, standard errors and CV's from age-length keys by year (assuming a two-stage random sampling design of data).

2012

	prop	SE	CV
A0	0.0430	0.0032	0.0755
A1	0.1701	0.0060	0.0353
A2	0.2765	0.0071	0.0259
A3	0.1940	0.0063	0.0326
A4	0.1309	0.0054	0.0412
A5	0.0685	0.0040	0.0590
A6	0.0512	0.0035	0.0688
A7	0.0379	0.0031	0.0807
A8	0.0239	0.0024	0.1023
A9	0.0015	0.0006	0.4088
A10	0.0025	0.0008	0.3197

2013

	prop	SE	CV
A0	0.0602	0.0035	0.0583
A1	0.2814	0.0066	0.0236
A2	0.2374	0.0063	0.0264
A3	0.1854	0.0057	0.0309
A4	0.1048	0.0045	0.0431
A5	0.0654	0.0036	0.0558
A6	0.0325	0.0026	0.0805
A7	0.0178	0.0020	0.1099
A8	0.0102	0.0015	0.1458
A9	0.0045	0.0010	0.2184
A10	0.0004	0.0003	0.7268

Analysis of 2013 age data by quarter

ALK 2013 Q1

L.Class	A1	A2	A3	A4	A5	A6	A7	A8	A9	Total
10.75	0	0	0	0	0	0	0	0	0	0
11.25	0	0	0	0	0	0	0	0	0	0
11.75	0	0	0	0	0	0	0	0	0	0
12.25	0	0	0	0	0	0	0	0	0	0
12.75	0	0	0	0	0	0	0	0	0	0
13.25	1	0	0	0	0	0	0	0	0	1
13.75	0	0	0	0	0	0	0	0	0	0
14.25	1	0	0	0	0	0	0	0	0	1
14.75	7	0	0	0	0	0	0	0	0	7
15.25	27	0	0	0	0	0	0	0	0	27
15.75	49	0	0	0	0	0	0	0	0	49
16.25	56	0	0	0	0	0	0	0	0	56
16.75	51	1	1	0	0	0	0	0	0	53
17.25	51	3	5	0	0	0	0	0	0	59
17.75	20	18	9	0	0	0	0	0	0	47
18.25	4	41	18	3	0	0	0	0	0	66
18.75	1	57	22	1	0	0	0	0	0	81
19.25	0	57	37	7	1	0	0	0	0	102
19.75	1	45	44	7	7	0	0	0	0	104
20.25	0	20	42	26	19	5	0	2	0	114
20.75	0	5	36	19	17	9	6	2	0	94
21.25	0	6	20	24	14	8	5	1	0	78
21.75	0	0	13	23	17	10	3	4	5	75
22.25	0	0	3	19	11	3	8	4	0	48
22.75	0	0	1	11	8	2	0	1	1	24
23.25	0	0	0	7	2	2	0	0	2	13
23.75	0	0	0	0	0	0	0	0	0	0
24.25	0	0	0	0	0	0	0	1	0	1
Total	269	253	251	147	96	39	22	15	8	1100

ALK 2013 Q2

L.Class	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	Total
10.75	0	0	0	0	0	0	0	0	0	0	0
11.25	0	0	0	0	0	0	0	0	0	0	0
11.75	0	0	0	0	0	0	0	0	0	0	0
12.25	0	0	0	0	0	0	0	0	0	0	0
12.75	0	0	0	0	0	0	0	0	0	0	0
13.25	0	0	0	0	0	0	0	0	0	0	0
13.75	0	0	0	0	0	0	0	0	0	0	0
14.25	0	0	0	0	0	0	0	0	0	0	0
14.75	0	0	0	0	0	0	0	0	0	0	0
15.25	1	0	0	0	0	0	0	0	0	0	1
15.75	2	1	0	0	0	0	0	0	0	0	3
16.25	16	0	0	0	0	0	0	0	0	0	16
16.75	33	4	0	0	0	0	0	0	0	0	37
17.25	48	13	4	0	0	0	0	0	0	0	65
17.75	51	13	8	0	0	0	0	0	0	0	72
18.25	44	27	18	1	0	0	0	0	0	0	90
18.75	22	48	25	1	1	0	0	0	0	0	97
19.25	12	56	42	5	3	0	0	0	0	0	118
19.75	4	64	49	13	11	3	1	0	0	0	145
20.25	1	47	49	26	28	7	2	2	0	0	162
20.75	0	30	34	25	22	12	8	4	1	0	136
21.25	0	13	34	36	12	14	3	6	0	0	118
21.75	0	6	16	34	14	9	5	0	2	0	86
22.25	0	2	11	20	6	12	0	4	4	0	59
22.75	0	0	4	6	10	1	3	2	1	0	27
23.25	0	0	0	2	1	2	1	1	2	0	9
23.75	0	0	0	0	0	0	0	0	0	1	1
24.25	0	0	0	0	0	0	0	0	0	0	0
Total	234	324	254	169	108	60	23	19	10	1	1242

Analysis of 2013 age data by quarter

ALK 2013 Q3

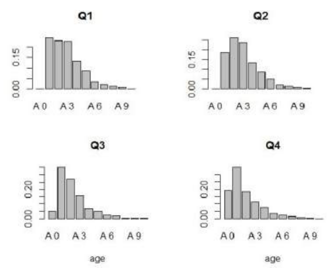
L.Class	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	Total
10.75	0	0	0	0	0	0	0	0	0	0	0	0
11.25	0	0	0	0	0	0	0	0	0	0	0	0
11.75	0	0	0	0	0	0	0	0	0	0	0	0
12.25	1	0	0	0	0	0	0	0	0	0	0	1
12.75	2	0	0	0	0	0	0	0	0	0	0	2
13.25	0	0	0	0	0	0	0	0	0	0	0	0
13.75	3	0	0	0	0	0	0	0	0	0	0	3
14.25	10	0	0	0	0	0	0	0	0	0	0	10
14.75	10	0	0	0	0	0	0	0	0	0	0	10
15.25	10	0	0	0	0	0	0	0	0	0	0	10
15.75	10	0	0	0	0	0	0	0	0	0	0	10
16.25	10	0	1	0	0	0	0	0	0	0	0	11
16.75	1	2	0	0	0	0	0	0	0	0	0	3
17.25	0	22	1	0	0	0	0	0	0	0	0	23
17.75	1	28	3	1	0	0	0	0	0	0	0	33
18.25	0	67	7	2	0	0	0	0	0	0	0	76
18.75	1	70	21	4	0	0	0	0	0	0	0	96
19.25	0	70	23	8	0	0	0	0	0	0	0	101
19.75	0	55	40	14	5	2	1	1	0	0	0	118
20.25	0	42	57	23	15	5	2	1	1	0	0	146
20.75	0	27	49	23	17	6	2	4	0	0	0	128
21.25	0	9	46	34	6	8	2	4	0	0	0	109
21.75	0	4	39	25	9	9	7	4	0	1	1	99
22.25	0	3	16	26	15	8	7	2	1	0	0	78
22.75	0	1	9	16	11	13	3	2	2	0	0	57
23.25	0	0	0	5	1	6	1	2	1	0	0	16
23.75	0	0	0	0	0	1	0	0	0	0	0	1
24.25	0	0	0	0	0	0	0	0	0	0	0	0
Total		400	312	181	79	58	25	20	5	1	1	1141

ALK 2013 Q4

L.Class	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	Total
10.75	2	0	0	0	0	0	0	0	0	0	2
11.25	1	0	0	0	0	0	0	0	0	0	1
11.75	6	0	0	0	0	0	0	0	0	0	6
12.25	10	0	0	0	0	0	0	0	0	0	10
12.75	10	0	0	0	0	0	0	0	0	0	10
13.25	10	0	0	0	0	0	0	0	0	0	10
13.75	20	0	0	0	0	0	0	0	0	0	20
14.25	22	0	0	0	0	0	0	0	0	0	22
14.75	15	0	0	0	0	0	0	0	0	0	15
15.25	12	1	0	0	0	0	0	0	0	0	13
15.75	20	0	0	0	0	0	0	0	0	0	20
16.25	31	0	0	0	0	0	0	0	0	0	31
16.75	29	0	0	0	0	0	0	0	0	0	29
17.25	19	3	0	0	0	0	0	0	0	0	22
17.75	7	21	5	1	0	0	0	0	0	0	34
18.25	5	33	7	4	0	0	0	0	0	0	49
18.75	0	61	14	3	0	0	0	0	0	0	78
19.25	0	89	8	5	0	0	0	0	0	0	102
19.75	0	80	16	9	5	0	0	0	0	0	110
20.25	0	66	30	11	5	2	1	0	0	0	115
20.75	0	29	44	14	9	6	3	1	0	0	106
21.25	0	11	38	19	15	3	3	1	2	0	92
21.75	0	2	23	27	13	3	4	5	3	0	80
22.25	0	0	14	18	19	8	5	3	2	2	71
22.75	0	0	7	13	16	9	7	1	1	0	54
23.25	0	0	1	5	6	4	2	4	0	0	22
23.75	0	0	0	0	1	4	1	1	0	0	7
24.25	0	0	0	1	0	1	0	1	0	0	3
Total		396	207	130	89	40	26	17	8	2	1134

Analysis of 2013 age data by quarter

2013 - Age groups distribution by quarter



Analysis of 2013 age data by quarter

2013 - Proportions-at-age, standard errors and CV's from age-length keys by quarter (assuming a two-stage random sampling design of data)

Q1

	Prop	SE	CV
A1	0.2445	0.0130	0.0531
A2	0.2300	0.0127	0.0554
A3	0.2282	0.0127	0.0557
A4	0.1336	0.0103	0.0773
A5	0.0873	0.0086	0.0982
A6	0.0355	0.0056	0.1586
A7	0.0200	0.0043	0.2125
A8	0.0136	0.0035	0.2584
A9	0.0073	0.0026	0.3577

Q2

	Prop	SE	CV
A1	0.1884	0.0111	0.0591
A2	0.2609	0.0125	0.0480
A3	0.2367	0.0121	0.0512
A4	0.1361	0.0098	0.0719
A5	0.0870	0.0080	0.0924
A6	0.0483	0.0061	0.1268
A7	0.0185	0.0039	0.2083
A8	0.0153	0.0035	0.2297
A9	0.0081	0.0026	0.3201
A10	0.0008	0.0008	0.9996

Q3

	Prop	SE	CV
A0	0.0517	0.0066	0.1273
A1	0.3506	0.0142	0.0404
A2	0.2734	0.0133	0.0485
A3	0.1586	0.0109	0.0685
A4	0.0692	0.0076	0.1091
A5	0.0508	0.0065	0.1288
A6	0.0219	0.0044	0.1991
A7	0.0175	0.0039	0.2233
A8	0.0044	0.0020	0.4514
A9	0.0009	0.0009	1.0046
A10	0.0009	0.0009	1.0046

Q4

	Prop	SE	CV
A0	0.1931	0.0117	0.0608
A1	0.3492	0.0142	0.0407
A2	0.1825	0.0115	0.0632
A3	0.1146	0.0095	0.0832
A4	0.0785	0.0080	0.1025
A5	0.0353	0.0056	0.1576
A6	0.0229	0.0045	0.1959
A7	0.0150	0.0037	0.2462
A8	0.0071	0.0025	0.3546
A9	0.0018	0.0013	0.7114

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Analysis of 2013 age data by area

2013 – ALK's by area

North

L.Class	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	Total
10.75	0	0	0	0	0	0	0	0	0	0	0	0
11.25	0	0	0	0	0	0	0	0	0	0	0	0
11.75	0	0	0	0	0	0	0	0	0	0	0	0
12.25	0	0	0	0	0	0	0	0	0	0	0	0
12.75	0	0	0	0	0	0	0	0	0	0	0	0
13.25	0	0	0	0	0	0	0	0	0	0	0	0
13.75	0	0	0	0	0	0	0	0	0	0	0	0
14.25	0	0	0	0	0	0	0	0	0	0	0	0
14.75	0	0	0	0	0	0	0	0	0	0	0	0
15.25	0	3	0	0	0	0	0	0	0	0	0	3
15.75	6	7	0	0	0	0	0	0	0	0	0	13
16.25	19	20	0	0	0	0	0	0	0	0	0	39
16.75	24	20	0	0	0	0	0	0	0	0	0	44
17.25	16	26	4	0	0	0	0	0	0	0	0	46
17.75	3	41	8	1	0	0	0	0	0	0	0	53
18.25	4	51	14	0	0	0	0	0	0	0	0	69
18.75	0	62	32	3	0	1	0	0	0	0	0	98
19.25	0	75	44	11	1	0	0	0	0	0	0	131
19.75	0	68	76	14	1	1	0	0	0	0	0	161
20.25	0	64	66	35	10	2	1	0	0	0	0	178
20.75	0	39	61	44	19	3	2	0	0	0	0	168
21.25	0	14	53	37	40	6	0	1	0	0	0	151
21.75	0	6	34	37	42	7	3	3	1	5	0	138
22.25	0	3	21	28	41	10	4	3	5	4	0	119
22.75	0	1	13	22	33	21	4	1	3	2	0	100
23.25	0	0	1	6	12	7	4	4	1	3	0	38
23.75	0	0	0	0	1	4	1	1	0	0	1	8
24.25	0	0	0	1	0	0	0	0	0	0	0	1
Total	72	501	427	239	200	62	19	13	10	14	1	1558

Centre

L.Class	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	Total
10.75	2	0	0	0	0	0	0	0	0	0	0	2
11.25	1	0	0	0	0	0	0	0	0	0	0	1
11.75	6	0	0	0	0	0	0	0	0	0	0	6
12.25	10	0	0	0	0	0	0	0	0	0	0	10
12.75	10	0	0	0	0	0	0	0	0	0	0	10
13.25	10	1	0	0	0	0	0	0	0	0	0	11
13.75	20	0	0	0	0	0	0	0	0	0	0	20
14.25	22	0	0	0	0	0	0	0	0	0	0	22
14.75	14	0	0	0	0	0	0	0	0	0	0	14
15.25	12	1	0	0	0	0	0	0	0	0	0	13
15.75	11	1	0	0	0	0	0	0	0	0	0	12
16.25	12	2	0	0	0	0	0	0	0	0	0	14
16.75	4	18	3	0	0	0	0	0	0	0	0	25
17.25	2	25	3	0	0	0	0	0	0	0	0	30
17.75	3	28	1	0	0	0	0	0	0	0	0	32
18.25	1	48	12	4	0	0	0	0	0	0	0	65
18.75	1	62	29	5	0	0	0	0	0	0	0	97
19.25	0	74	42	17	0	0	0	0	0	0	0	133
19.75	0	64	64	33	10	1	0	0	0	0	0	172
20.25	0	44	66	45	18	6	0	0	1	0	0	180
20.75	0	17	63	48	33	10	7	1	2	1	0	182
21.25	0	6	50	64	29	15	7	1	2	0	0	174
21.75	0	0	34	44	35	27	15	8	3	0	1	167
22.25	0	0	11	30	32	21	22	7	5	2	0	130
22.75	0	0	3	12	11	18	9	5	2	0	0	60
23.25	0	0	0	4	4	6	2	3	1	1	0	21
23.75	0	0	0	0	0	1	0	0	0	0	0	1
24.25	0	0	0	0	0	1	0	1	1	0	0	3
Total	141	391	381	306	172	106	62	26	17	4	1	1607

South

L.Class	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	Total
10.75	0	0	0	0	0	0	0	0	0	0	0
11.25	0	0	0	0	0	0	0	0	0	0	0
11.75	0	0	0	0	0	0	0	0	0	0	0
12.25	1	0	0	0	0	0	0	0	0	0	1
12.75	2	0	0	0	0	0	0	0	0	0	2
13.25	0	0	0	0	0	0	0	0	0	0	0
13.75	3	0	0	0	0	0	0	0	0	0	3
14.25	10	1	0	0	0	0	0	0	0	0	11
14.75	11	7	0	0	0	0	0	0	0	0	18
15.25	10	25	0	0	0	0	0	0	0	0	35
15.75	13	43	1	0	0	0	0	0	0	0	57
16.25	10	50	1	0	0	0	0	0	0	0	61
16.75	2	48	2	1	0	0	0	0	0	0	53
17.25	1	73	10	9	0	0	0	0	0	0	93
17.75	2	51	30	18	0	0	0	0	0	0	101
18.25	0	49	56	38	4	0	0	0	0	0	147
18.75	0	30	79	46	2	0	0	0	0	0	157
19.25	0	22	58	64	11	4	0	0	0	0	159
19.75	0	7	25	69	19	18	4	2	0	0	144
20.25	0	1	22	45	44	46	14	3	4	0	179
20.75	0	0	4	15	18	38	17	18	4	0	114
21.25	0	0	0	6	12	16	20	11	7	0	72
21.75	0	0	0	0	2	9	12	6	3	3	35
22.25	0	0	0	0	0	2	1	3	1	0	7
22.75	0	0	0	0	0	1	0	0	1	0	2
23.25	0	0	0	0	0	0	1	0	0	0	1
23.75	0	0	0	0	0	0	0	0	0	0	0
24.25	0	0	0	0	0	0	0	0	0	0	0
Total	65	407	288	311	112	134	69	41	20	3	1452

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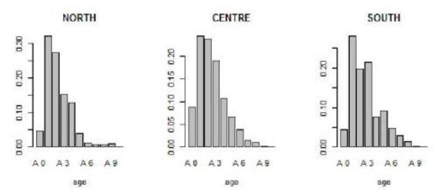
Analysis of 2013 age data by area

2013 – Age groups distribution by area



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Analysis of 2013 age data by area

2013 - Proportions-at-age, standard errors and CV's from age-length keys by area (assuming a two-stage random sampling design of data).

North

	Prop	SE	CV
A0	0.0462	0.0054	0.1160
A1	0.3216	0.0119	0.0369
A2	0.2741	0.0113	0.0414
A3	0.1534	0.0092	0.0597
A4	0.1284	0.0085	0.0663
A5	0.0398	0.0050	0.1253
A6	0.0122	0.0028	0.2300
A7	0.0083	0.0023	0.2792
A8	0.0064	0.0020	0.3168
A9	0.0090	0.0024	0.2676
A10	0.0006	0.0007	1.0604

Centre

	Prop	SE	CV
A0	0.0877	0.0071	0.0807
A1	0.2433	0.0107	0.0441
A2	0.2371	0.0106	0.0449
A3	0.1904	0.0098	0.0516
A4	0.1070	0.0077	0.0723
A5	0.0660	0.0062	0.0944
A6	0.0386	0.0048	0.1251
A7	0.0162	0.0032	0.1970
A8	0.0106	0.0026	0.2448
A9	0.0025	0.0013	0.5036
A10	0.0006	0.0006	1.0027

South

	Prop	SE	CV
A0	0.0448	0.0055	0.1221
A1	0.2803	0.0118	0.0422
A2	0.1983	0.0105	0.0529
A3	0.2142	0.0108	0.0504
A4	0.0771	0.0070	0.0911
A5	0.0923	0.0076	0.0829
A6	0.0475	0.0056	0.1182
A7	0.0296	0.0045	0.1515
A8	0.0138	0.0031	0.2269
A9	0.0021	0.0012	0.5845

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Study case Sardine

Questions/Problems:

- Stratified sampling design (landing port, quarter) should be maintained?
- Optimum Sample size to reach with a precision XXX with an error level.

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Study case Sardine

References

R Software v 3.1.1 (R Foundation for Statistical Computing Platform) 2014: packages ("agricolae"); ("ALKr"); ("fishmethods").

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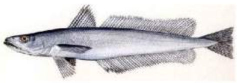
Study case - Hake

Sampling for maturity estimation
(Sampling scheme; maturity ogives construction; sex ratio; problems)



Ana Costa, Cristina Nunes and J. Pereira

Workshop on Sampling Design and Optimization
(WKSDO)
17-20 November 2014, IPMA, Lisbon- PORTUGAL

SAMPLING SCHEME FOR MATURITY OGIVE ESTIMATION

Macroscopic maturity ogive

- Program PNAB/DCF
- Research surveys
- Winter surveys (February/March) - 1992 to 1998 + 2005 to 2009
- Summer surveys (June/July) - 1990 to 1993 + 1997 to 2002
- Autumn surveys (October/November) - 1990 to present
- All individuals are sexed and the macroscopic maturity stage is assigned

SAMPLING SCHEME FOR MATURITY OGIVE ESTIMATION

Microscopic maturity ogive

- Program PNAB/DCF
- Sampling for microscopic maturity ogive (gonads collected for histology) - since 2006
- December to May (spawning season)
- Landing ports: Póvoa do Varzim, Matosinhos, Peniche and Olhão
- Two samplings per month (every 15 days)
- 4 gonads (males and females) per length class, per sex, per month

SAMPLING CONSTRAINTS

➢ If sampling during **autumn demersal surveys**:

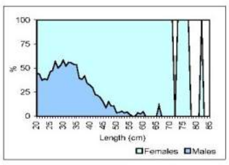
- (-) out of the main spawning season
- (-) increased probability of macroscopic misidentification of immature/resting individuals (no microscopic validation)
- (+) larger range of sizes sampled

➢ If sampling from **commercial catches**:

- (-) difficult to obtain non eviscerated fish
- (-) smaller individuals (<27 cm) unavailable (with the consequent limitations for the logistic model fitting)
- (-) size distribution of the fish landed depending on the gear used (different selectivity)
- (+) possible to do it during the main spawning season

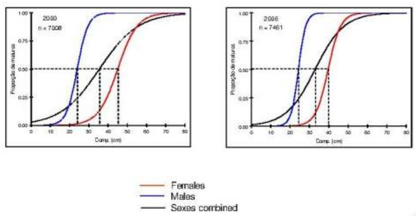
DIFFERENCES BETWEEN MALES AND FEMALES

- Sex ratio:
  Varies with length



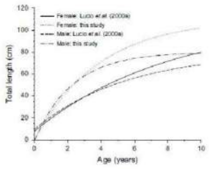
DIFFERENCES BETWEEN MALES AND FEMALES

- Maturity:
  Males mature earlier than females

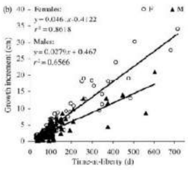


DIFFERENCES BETWEEN MALES AND FEMALES

• Growth:
Females grow faster than males



(Bay of Biscay, de Pontual *et al.*, 2006)



(Tagging experiment - Gulf of Lions, Mellon-Duval *et al.*, 2009)

QUESTIONS RAISED

➢**Autumn demersal surveys** *vs* **commercial fleet samples**?

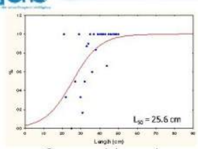
Better have size frequency distribution limited samples during main spawning season or more complete size frequency distribution samples out of the main spawning season?

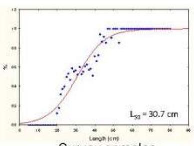
✓**1st option**: will the limiting size frequency distribution of the fish sampled from the commercial fleet no longer be an issue with the "Landing obligation"?

✓**2nd option**: then maturity identification should be validated microscopically to avoid misidentification of the immature/resting fish

Macroscopic maturity ogives – commercial vs survey samples

2007

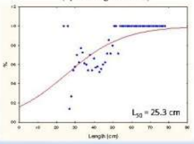


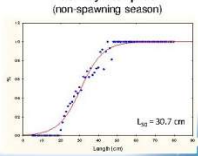


Commercial samples
(spawning season)

Survey samples
(non-spawning season)

2010





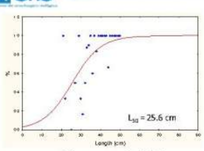
Questions raised (cont.)

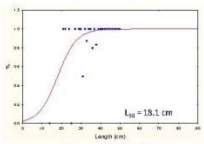
➢Which **period of the year** to be sampled for maturity ogive?

Reproductive season is not fully acknowledged off Portuguese coast but at present main reproductive season is considered to last from Dec. to May

Macroscopic vs microscopic maturity ogives

2007

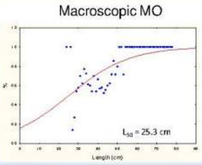


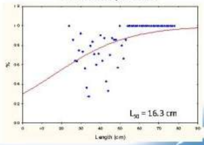


Macroscopic MO

Microscopic MO

2010





QUESTIONS RAISED (cont.)

➢Sex

Ideally, taking into account the biology of hake, assessment should consider sex separated ogives

If not possible, how to consider sampling in order to not bias estimation of sex combined length at first maturity?

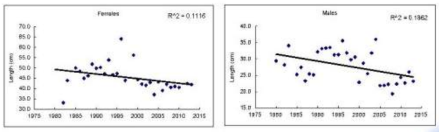
- Consider the observed sex ratio per length class in the samples analysed?
- Consider the sex ratio raised to the catches?
- Always consider a 1:1 proportion of the sexes?

QUESTIONS RAISED (cont.)

- Spatial and temporal variability?

• Spatial: currently, available samples/data insufficient for a spatial stratification analysis.

• Temporal: is maturity ogive estimation necessary annually?



L_{50} time-series from Portugal for females and males separately

QUESTIONS RAISED (cont.)

- If maturity data for maturity ogives are obtained length stratified from market:

• Should samples keep on being obtained in a monthly frequency basis, during the main reproductive season?

• Sampling is adaptative with the purpose of fulfilling the goal of n individuals per length class (~ALKs) during the main reproductive season?

"NEXT STEP": ASSESSMENT

• How to combine maturity ogives from Portuguese coast to maturity ogives from Spanish coast (Southern stock) for inclusion in the assessment mode?

• Evaluate the effect of spatial/temporal/sex ratio variations of the proportions of mature fish at length in the output of the assessment model

Thank you!

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