9-2013

Review of report on the "Status of nearshore finfish stocks in south-western Western Australia: Australian herring and tailor"

Department of Fisheries

Fisheries Occasional Publication No. 116, 2013

Review of report on the "Status of nearshore finfish stocks in south-western Western Australia: Australian herring and tailor"

prepared by Keith Jones,
Sillago Research Pty Ltd for the
Department of Fisheries, Western Australia.

Government of **Western Australia**
Department of **Fisheries**

Fisheries Research Division
Western Australian Fisheries and Marine Research Laboratories
PO Box 20 NORTH BEACH, Western Australia 6920

Fish for the future

Correct citation:

Review of report on the "Status of nearshore finfish stocks in south-western Western Australia: Australian herring and tailor" prepared by Keith Jones, Sillago Research Pty Ltd for the Department of Fisheries, Western Australia. Fisheries Occasional Publication No. 116. Department of Fisheries, Western Australia. 52pp.

Disclaimer

Department of Fisheries
3rd floor SGIO Atrium
168–170 St Georges Terrace
PERTH WA 6000
Telephone: (08) 9482 7333
Facsimile: (08) 9482 7389
Website: www.fish.wa.gov.au
ABN: 55 689 794 771

Published by Department of Fisheries, Perth, Western Australia.
Fisheries Occasional Publication No. 116, September 2013.
ISSN: 1447 - 2058 ISBN: 978-1-921845-65-9

Contents

1.0 Summary of the review of the draft report

"Status of nearshore finfish stocks in south-western Western Australia: Australian herring and tailor" Smith *et al*. 2012.

By Dr. Keith Jones, Sillago Research Pty Ltd, July 2012 for the Department of Fisheries, Western Australia.

This draft report has been reviewed with the objectives

1. Determine if the assessment advice generated for the two nearshore indicator species is appropriate given –
   - the data available,
   - specific circumstances of the stocks and the fisheries operation, and
   - the nature of the 'weight-of-evidence' assessment for nearshore indicator species.
2. Provide any additional scientific comment or advice that may be useful to assist with the future monitoring and assessment of these species.

General comments about the Report (Structure, Style, Methodology)

Firstly, I must commend the work that the team of WA scientists has done to bring together the considerable amount of information available on both these species in south-western WA. Although both species are used as indicator species in their respective bioregions, because the two species have differing life histories', ratios of levels of commercial: recreational fishing effort as well as differing methods to assess their status, I found it easier to structure my review as separate reports for the two species, and I trust this will also make it easier for the reader.

I've assumed that the structure and format of the report is based on a template used for the assessments of all WA fisheries. Overall, I found the report extremely well written, with only a very small number of typo errors. A final spell check will locate these. There were a number of places where I had to revisit previous chapters (eg recruitment dynamics) which were linked with later chapters (eg commercial CPUE's), but this is only natural in such a comprehensive report.

The references quoted in the report have all been checked in the reference list. Several references to recent research on herring in South Australia and which were pertinent to this assessment had not been included, and my review includes these. (see also Appendix 1 of this review). I could only find one reference, where there was a slight misquotation (see Gomon *et al.* 2008, relating to the distribution of tailor in southern Australian waters).

All tables and figures were clearly described with minimal overlap in information. There were only one or two captions to the figures which needed some minor changes (eg Fig. 4.2.3 refers to catch and effort and not catch rates).

The executive summary was well written, although quite long, especially in introducing the reader to the report. However, knowing that this part of the report is directed to those who need comprehensive summaries and who do not have time to wade through the whole document, the summary has achieved its purpose. It adequately reflects the contents of the report.

Scientific Content

The report has successfully used correlation analyses to link oceanographic parameters to recruitment indices (RI's) and RI's to fisheries CPUE's (lagged correlations) for both species. These analyses provide a powerful tool to demonstrate that environmental variability significantly drives short-term variability in the catch rates.

Measures of long-term changes to relative abundance were more dependent on time series of catch rates from commercial and/or recreational sectors; however, interpretations of these long-term changes are hampered by the well documented regulation changes (eg size and recreational bag limits for tailor, commercial netting closures for both species), shifts in economic demand for commercially caught herring and the possible increase in high grading by reduced bag limits. Currently it is not possible to measure these effects on long-term variations in CPUE's, and so this part of the assessment has largely been semi-qualitative. A long-term knowledge of each of the fisheries has assisted this assessment greatly.

In the past, there have been preliminary attempts at modelling the effects of fishing on the Australian herring population (see Ayvazian *et al.* 2000). The current report now provides updated and more detailed biological and fishing mortality information to improve the outcome of modelling.

The weigh-of-evidence assessment is an acceptable form of risk assessment on stock sustainability. It is also a practical means to inform "non-scientists" at the time of the public consultation.

Future research and monitoring

The assessments for both species have shown a) the decreasing dependence on commercial fishery catch and effort analyses (often highlighted by the fact that legislative changes and varying economic demands hamper interpretation of relative abundances) and b) the extremely patchy information on recreational catch and effort (especially shore based). There is considerable uncertainty in the total recreational harvest for both species, because of a single recent estimate of total recreational catch for both species (2000/01) using a survey methodology which substantially differs from other regional on-site surveys. The authors have highlighted the challenges, especially relating to the future funding of research on the shore based component. Total catch information and representative size/age composition data that are collected regularly, are essential to decrease the uncertainties relating to our understanding of the stock status of these two indicator species (currently 4 out of 7 implications for stock status for herring and 2 out of 6 for tailor).

Both assessments have also demonstrated that oceanographic variables (current direction and speeds) influence recruitment to nursery areas and eventually the respective fisheries. Expanding fisheries independent monitoring of juveniles will similarly improve our understanding on the implications for stock status. For example; a) expansion of the volunteer angler tailor sampling program to other sites and b) resurrection of the previous long-term SA beach seine surveys and maintenance of the WA beach seine surveys for newly settled herring are two fishery independent monitoring programs worth pursuing.

Implications for Management

The assessments for both species have highlighted the need to manage them on a whole stock approach, rather than separately, within regions. For Australian herring, because of its relevance to the issue of high juvenile retention, there is the need to include the South Australian component of the stock, and for tailor, the inclusion of both WCB and GCB is required. WCB is the area of relatively high recreational fishing effort, and the GCB appears to be where the most significant tailor spawning biomass occurs.

For herring, the report highlights the unacceptable stock status and shows the main causes are a) juvenile retention along the SCB and in SA, and b) the increasingly high fishing mortality rates, especially in the region where the spawning component is found. This is clear advice for

the future management of this species, without going into details of how future management should take place. That is not the purpose of this report, and I commend the authors for keeping just to the management implications.

Exec Summary

This was the last chapter I read. Having thoroughly digested the other chapters, I found this chapter acceptably summarised the research and assessments.

2.0 Introduction

This report is a review of the information contained in the draft report by Smith *et al*. 2012 "Status of nearshore finfish stocks in south-western Western Australia: Australian herring and tailor", hereafter referred to as the Report.

The complete terms of reference for this review are provided in Appendix 1 but there are two primary objectives:

1. Determine if the assessment advice generated for the two nearshore indicator species is appropriate given –
   - the data available,
   - specific circumstances of the stocks and the fisheries operation, and
   - the nature of the 'weight-of-evidence' assessment for nearshore indicator species.
2. Provide any additional scientific comment or advice that may be useful to assist with the future monitoring and assessment of these species.

This report primarily investigates the status of nearshore finfish resources in the West Coast Bioregion (WCB), but includes the South Coast Bioregion (SCB) and Gascoyne Coast Bioregion (GCB) where stocks are distributed across Bioregions. The nearshore 'suite' of species includes all finfish in coastal waters less than 20 m depth, which are mainly captured by recreational line fisheries and commercial net fisheries.

Consistent with the Department's Ecosystem Based Fisheries Management (EBFM) and Resource Assessment Frameworks (RAF), assessment of the status of the nearshore suite is based on the status of indicator species, including Australian herring (*Arripis georgianus*) which occurs in the WCB and SCB, and tailor (*Pomatomus saltatrix*) which occurs in WCB and GCB.

These indicator species were identified as the best representatives of the WCB nearshore finfish suite using a comprehensive risk-based process that considered the biological vulnerability (e.g. longevity, age-at-maturity, spawning strategy) and fisheries significance of each species.

The stock status of these two indicators is the subject of this report. This report aims to gain a better understanding of the biology of the *indicator* species, determine the current stock status using a 'weight-of-evidence' approach and assess the associated risks to ongoing sustainability. This review, therefore, focuses on the quality of the data, the assessments for these species in which these are used and the validity of the conclusions drawn from them.

3.0 Report review[1]

This review generally follows the same structure as the report, with each chapter (recruitment dynamics, commercial fishery catch and effort trends, recreational fisheries catch and effort trends, biology and assessment, and general discussion and implications) dealing with each of the two indicator species in turn.

Australian herring

3.1 Herring Recruitment Dynamics

This chapter provided a comprehensive set of information on the linkage between the environmental (annual Leeuwin Current strength) effects on recruitment to a) the various herring nursery sites and b) the fisheries in the SW WA regions.

Methods

Environmental data – Three proxies are provided for the relative strength of the Leeuwin Current – annual deviations around Freo sea level, Albany SST and SOI. As recruitment strength varies spatio-temporally, improved correlations may be apparent between recruitment indices and the respective sea level deviation adjacent to the nearest sampling site for recruitment eg Albany sea level and Emu Point and Esperance sea level and Poison Creek (see Fig. 2.1.8).

Results

I agree with the mis-identification of herring in June at Poison Creek in initial years of the survey. It's good that the RI only covers the Sept – April period.

It is a great pity that juvenile sampling didn't occur from 2002 – 04, therefore we missed out in measuring RI's in 2002, 03 & 04, of which 02 & 04 were El Nino years, but there were no "La Nina" years over this period. I would have predicted slightly higher recruitment years to the nursery sites in WCB over this period. Note: El Nino years (low Leeuwin Current strength) occurred in 1997 and 2006, when Warnbro Sound (Perth) RI's were relatively high. Also RI's at Koombana Bay were high in 1997, but not in 2006.

When correlations between RI's and fishery statistics were presented, I found I had to constantly refer to later chapters on catch, effort and CPUE's to fully digest this part of the report. Correlations between RI's with catches and CPUE's could have been placed after the descriptions of the catch and effort in the fisheries, and I'll discuss these correlations later in my review.

Discussion

I agree that 0 gp herring can recruit to any habitat, ranging from sites such as sheltered ones (Mangles Bay) to higher energy coast (Warnbro Sound). We have similar observations in SA (e.g. medium energy James Beach, on the far West Coast and the sheltered Barker Inlet in Gulf St. Vincent). I think you've made a good point about peak juvenile recruitment linked to macrophyte / seagrass abundance (food and shelter). Unfortunately, at times, these sites are difficult to sample juvenile fish with small mesh beach seine nets!

1 The numbering of sections, pages, figures and tables cited by the reviewer here is consistent with the original version of the report. Modified numbering was used in the final version of the report, as outlined in *Department of Fisheries responses and actions to the review* (Section 6) in this document.

You refer to the SA initial time of recruitment as September (Jones *et al.* 1990). You might like to refer to my recent more paper (Jones 2008) which provides more detail to the duration of the recruitment period in Gulf St. Vincent (SA) to reference on peak time of recruitment in SA. The temporal pattern of juvenile recruitment throughout its distribution certainly appears to be related to the distance from the only known spawning area and growth rate.

Variations in juvenile growth – It's useful to include discussion on juvenile growth here. I'm pleased you referred to the length and age at maturity information in the later chapter, as I thought it was a little out of place here.

Variations in annual recruitment – There is no doubt in my mind that the variable strength in the Leeuwin Current plays an important part in directing abundances of juveniles along the southern Australian coast. As previously mentioned, the sampling gap in RI's in 2002 – 04, (not only in WA but SA too), is very unfortunate; however, based on the information available it is plausible that recruitment to all nursery sites has been lower in the 2000's than in the late 1990's, during the periods when sampling took place.

Comments on the influence of RI variation on the year class strengths observed in the various fisheries can be seen later in this review.

3.2 Herring Commercial Fishery

Introduction

Background descriptions of fisheries – The authors provide good historical information on the reasons for changes in legislation (eg spatial closures), licence numbers, prices etc, all of which variously affect the levels of fishing effort in the different fisheries.

Methods

Sources of catch and effort data – I'm happy that voluntary log book data have not been incorporated in the assessment, due to the variability in reporting rates. It is also pleasing that there has been a continuing source of compulsory catch and effort data; however, you may like to indicate whether there has been any formal validation of these data.

Calculation of catch per unit effort (CPUE) – As mentioned, without catch per net shot data in multi-species fisheries, especially in the WCB, assigning effort directed at herring is challenging. In SA, multi-species net fishers undertake between 1 and 4 shots per fishing day, depending on catch rates, relative abundance and price of species. We ask on our compulsory catch and effort forms, which species they will be choosing to target at the start of the fishing day, and that's how we get targeted catch and effort (fisher-day) by species. The problem is that some fishers report they target "any species", and often, because the price of herring is low relative to other net caught species (whiting, garfish), they report higher catches of herring when they report "any species", than as targeted herring. However, this appears to be changing as the av. value (adjusted for CPI) of herring has risen recently, due to the ongoing drop in catches but ongoing demand for human consumption and bait (more about that later). I think you've done the best you can with calculating CPUE's in the WCB fisheries. There's less of a problem with the South Coast trap fishery, as herring is the target species; however, I believe "catch per active team" is the preferable measure of rel. abundance (CPUE).

Results

National and State figures – Commercial herring catch figures for SA between 1951 and 1975 are those from selected fish processors and the Adelaide fish market and are probably underestimates of the total state catch. In those days, there were many small net operators who processed and sold their catches locally. It was in 1975, when licence freezes and compulsory log books were introduced, so therefore since then, we've had one source of commercial fishery data. We haven't validated these data for herring, but have attempted to do it for higher valued species, such as whiting.

The decline in the SA annual commercial catches of herring since the 1980's can be related to a number of legislative changes, especially to the multi-species net fisheries. They have never been directed specifically at herring, but more to resource share reallocation decisions from net fishing to commercial and recreational line fishing. These included: netting closures in sthn Eyre Peninsula in 1983 and mid 1990's and northern Spencer Gulf in 1983 and waters around sthn Yorke Peninsula in 2004/05. With other factors such as net licence freezes and net licence buy backs, the number of multispecies licenced net fishers has decreased from 280 in 1989 to about 40 in 2011. Also, since the 1970's, net fishers have been restricted to depths 5 metres or less.

The history of SA herring commercial catches, targeted catches, targeted effort and targeted catch per unit effort is available in Fowler *et al.* (2011). I have attached the appropriate page for your information. Using these data I've found significant correlations between SA Catch and Targeted Catch and between Targeted Catch and Targeted Effort, suggesting that the decline in herring catch is linked to the decline in fishing effort directed at the species in SA (see table below).

Comparison	Correlation Coefficient (r)	Significance (Zar 1974)
SA Commercial Catch v's SA Target Catch (1990/01 – 2010/11)	0.8981	(2 tailed) P < 0.001 ***
SA Target Catch v's SA Target effort (1990/01 – 2010/11)	0.5864	(2 tailed) 0.005 < P < 0.02 **

Catch and effort in the WA fisheries – The WA report clearly shows a decrease in fishing effort (substantially since the early 2000's in most reported fisheries (Figs. 3.1.6; 3.1.10; 3.1.14; 3.1.16, 3.1.17, 3.18, 3.1.19). The issue when interpreting CPUE trends in any fishery, is whether declines in fishing effort over time are due to a reduction in fish abundance, resulting in fishers increasingly finding it un-economical to fish for herring. However, the reduced economic demand for herring caught in the SC trap fishery would certainly have to had aggravated the reduction in effort (number of active teams).

Catch rates in WA fisheries – *SC Trap fishery.* Since 1994, I believe the "catch per active team" is the best measure of CPUE. The point that the trap nets only work the inshore schools is a good one, therefore indicating that it indirectly only measures relative inshore abundance and not the whole population along the south coast.

Other South Coast Fisheries. Agree that the opening and closures of several of the inlets increase the un-certainty in interpreting CPUE fluctuations for these areas. The sig correlation between Oyster Harbour gill and haul seine CPUE's is probably driven by the earlier years, as, since the late 1990's, gill net fishers targeted more on bream and cobbler, and the correlation is probably weak after that point. The haul seine CPUE's on their own appear the best indicator of relative

abundance for other south coast fisheries. It still shows a slow decline in relative abundance of herring over time. The Fig.3.1.21 plot doesn't give a clear indication of CPUE's on y axis.

Geographe Bay/Bunbury Fishery. Due changes in legislature, CPUE trends possibly not interpretable for herring abundance after 2000/01.

Cockburn Sound Fishery. Catch appears to be related to fishing effort (4 main vessels). Decrease in both in recent years, therefore CPUE's remain about the same. Based on the belief that CPUE is not a good indicator of rel. abundance, it appears that the drop in catch and effort may reflect a drop in local market demand for herring.

Peel-Harvey Fishery. Decline in CPUE since 2000, probably reflects environmental changes in accessibility of the fishery to herring, therefore not an acceptable fishery for investigating trends in herring rel. abundance.

Mandurah Fishery. Not an acceptable fishery to measure rel. abundance of herring.

WCB north of Perth fishery. Possibly the best commercial fishery to measure rel. abundance variation for herring in WCB.

Discussion

Using commercial netting catch and effort information in WA and SA to determine trends in relative abundance is fraught with uncertainty, because of the variable effects of temporal changes in fishing regulations, economic demands or whether the fishery is accessible to the whole or part of the population.

The three WA commercial fisheries that provide greatest confidence in using them as indicators of rel. abundance are the SC trap fishery (where they only have access to the inshore herring population), the Oyster Harbour haul seine fishery (again only inshore) and the WCB north of Perth fishery. Note: There appears to be a significant 1 and 2 yr lagged correlation between the SC trap fishery CPUE and the Oyster Harbour haul seine CPUE – is there any evidence for fish harvested in the Oyster Harbour haul seine fishery to be 1 or 2 yr older than in the SC trap fishery? Or is this an un-interpretable correlation?

Effect of temporal recruitment variation on Catch and CPUE's in the SA fishery – There appears to be a significant direct (non-lagged) correlation between Poison Creek RI and the SA catch and SA target CPUE for the period 1996 – 2010, suggesting that the SA commercial fishery targets 0 – 1 yr old fish. This has shifted, since the 1980's and 1990's, from a significant 3 yr lagged correlation between the Gulf St. Vincent RI and the GSV/KI targeted CPUE (see Jones & Westlake, 2003), suggesting a truncation in age structure of herring caught by the SA commercial fishery, but not necessarily the whole SA herring population. Fairclough *et al.* in Ayvazian *et al.* 2000 showed there were a number of age groups (0 – 3+) in SA waters during 1996 – 99 (Fig. 2.16) and in 2007/08, the size composition of fish caught by recreational fishers in SA, suggest that more than the 0 and 1 yr old fish still occur in these waters (see Appendix 1 of this report). It should be noted that since the early 2000's, substantial netting closures in SA (especially in southern Spencer Gulf and Gulf St. Vincent) have shifted effort on herring (and other netted species) towards the more northern waters of both gulfs, where relatively more juvenile fish occur (this will also be discussed in great detail in the chapter on the recreational fishery). The shift to smaller herring in the commercial net fishery has been enhanced by the rise in demand for small herring as bait in the commercial longline, general recreational and recreational charter boat line fisheries for snapper, all of which have increased substantially in the 2000's (Fowler *et al.* 2009). Therefore, the SA commercial herring fishery is now similar to

the SC trap fishery, where only a restricted age structure of the herring population is harvested by the commercial fishery. The targeted SA CPUE trends during the past 11 years indicate high CPUE's in 2005/06 and 2008/09 through to 2010/11 (Fowler *et al*. 2011), suggesting relatively high recruitment levels to SA about one year previously. However, the absence of juvenile sampling at Poison Creek (and SA) in 2002 – 05 has meant that we are not able to explicitly say whether the high CPUE's in SA in 2005/06 are due to high recruitment a year or so previously.

There is also a significant 2 and 3 yr lagged correlation between the SA target CPUE and the SC trap fishery CPUE (catch per active team) (r = 0.5967 **, r = 0.6047 **; resp.). Taking into account the westward migration of SA fish, this correlation is meaningful.

Finally, without any current recruitment indices available for the SA part of the population, the Poison Creek RI's provide the best indication of recruitment strength in SA; however, it should be noted that in years of relatively strong Leeuwin Current strength (e.g. 1999; see Jones & Westlake, 2003), recruitment strength in SA was higher than at Poison Creek. Conversely, in 1997, an El Nino year, recruitment strength in SA was much lower than at Poison Creek (Jones & Westlake, 2003).

3.3 Herring Recreational Fishery

Introduction

This section highlights the major gaps in catch and effort data for this sector, and especially, the shore based component, which is believed to be the most important, at least in the WCB. Although there have been a number of regional short term surveys, the National survey of 2000/01 has been the only one that provides a one year snapshot of the spatial extent of the recreational herring fishery (not only in WA, but also SA and Vic). The other issue that challenges an interpretation of trends in recreational fishing catch and effort is the variation in survey methodology, eg bus route surveys and voluntary recreational fishing log books. In similarity with the analyses of the commercial fisheries, the authors of this report have successfully attempted to assess the recreational fishery by investigating where and when similarities in catch trends occur.

The analyses have focussed on the WCB, rather than the South and SE coasts, mainly because of the perceived greater recreational catch and effort and number of surveys undertaken in the former bioregion. It should also be pointed out that with the decline in commercial fisheries over the distribution of herring, through re-allocation of the resource towards the recreational sector (e.g. WCB region), as well as diminishing demands for the commercial product (eg SC trap fishery), there is an increasing need to install regular surveys of the recreational sector in the areas where they have replaced the commercial fisheries. The authors point out the uncertainty in funding large scale shore-based recreational surveys in WA; if this is so, the only alternative may be to direct volunteer groups (e.g. angling clubs, volunteer log books) to survey in specific areas which are adjacent to nursery areas that are also monitored.

Methods

Boat-based surveys in the WCB – This give a time series of data (1996/97 and 2005/06 – 09/10) which uses the same survey methodology (bus-route), thereby limiting issues such as inter-method variation in biases. On its own, this method is probably good for estimating total herring retained catch and total boating effort (for all species); however, as mentioned by the authors, assigning effort to herring is problematic, because surveyed fishers were not asked whether herring were targeted on their trip, and therefore CPUE provided in the report, probably under-

estimates targeted herring CPUE. If this survey method is continued, surveyed recreational fishers should be asked their target species when interviewed. Also, experiments to investigate the effects of technologic changes to CPUE's would be valuable.

Individual shore-based angler diaries – A total of three dedicated anglers provided long-term data on retained catch and effort in three different areas of WCB. It is a pity that the data from more than one angler per region were not available, as data from additional experienced anglers in the same area would have enhanced reliability in this survey method. I expect in the future that the use of voluntary angler log books will be substituted for the personal diaries of anglers.

Long-term Melville Amateur Angling Club data – I have four questions relating to these two sets of data (Swan/Canning estuary and Ocean competitions). 1) It appears that effort measurements differ between the two sets, with the estuary effort recorded as fisher-days, and the ocean effort as fisher-trips (see Fig. 4.1.8). Assuming most trips were "weekend" events, should the ocean effort be approximately doubled? 2) In Fig. 4.1.8, it is not clear what the scale for CPUE for herring is. Is the range in the number of herring / trip the same scale as the percentages? 3) The authors point out the issue of high-grading at 'weigh-ins", thereby reducing the estimated CPUE. I'm wondering whether bag limits are adhered to only at 'weigh-ins'. If so, with the reduction in the self imposed bag limits, is there the possibility that the prevalence of high-grading has increased over time? This could result in the weigh-in CPUE's decreasing their usefulness as indicators of relative abundance in these fishing competitions. 4) It appears that the numbers of participants in the MAAC comps have slowly decreased over time. Is there any evidence that we are now left with relatively more highly skilled dedicated club fishers?

Voluntary Recreational logbooks – Does the voluntary log book carry a picture ID of the more commonly caught species? I assume that the size differences between recreationally caught herring and salmon in WA differ greatly enough for most anglers to distinguish between the two. It is a major issue for SA anglers as undersized salmon are often the same size as herring. The only other species in WA which may be mis-identified as herring are juvenile tailor. Again this would not be a problem with the more highly skilled anglers who are voluntary log book recorders. So, some measure of the fish id skills by the volunteer may lead to improved data quality.

It is good that data from only the Perth shore-based "ocean fishery" volunteers are analysed, as inclusion of data from the boat and other areas (e.g. Rottnest Is), may confuse interpretation. Also, comparisons with RI's in the same area (e.g. Warnbro Sound), the other adjacent shore based recreational fisheries would be very meaningful.

Because of the uncertainty as to whether the volunteers represent the "average" herring fisher, it is pleasing that no attempt has been made to estimate total catch. For consistency in measuring average CPUE's over time by these fishers, it would be useful to use the same volunteers' sets of annual / monthly data. I'm uncertain whether this has been done in this analysis.

Results

Previous recreational fishing surveys – Retained catch estimates from surveys of boat or shore based fishers in various areas (estuaries and oceans of SCB and WCB) are provided between the 1970's and recent years, however, it is difficult to investigate any trends because of the different survey methods employed. The 2000/01 peak in estimated herring recreational harvest in WCB and SA (but similar in SCB) using a different survey methodology is highlighted (Fig. 4.1.2), however, the authors also suggest anecdotal evidence from rec fishers confirm relatively high catch rates at that time. This is confirmed from the data from the other rec fisheries in the WCB (see Fig. 4.1.7).

In dot point 10, discussing the SA recreational fishing survey in 2007/08, the second sentence is out of place as it is the same as the third sentence in dot point 7.

Total Catch (SA and Vic) – The authors mention the change in SA recreational herring harvest from 2.5 million in 2000/01 to ~0.6 million in 2007/08. Both estimates are specifically for SA residents, and don't include interstate/overseas residents who fished in SA. There is some information to suggest the proportion of interstate residents fishing in SA is slowly rising (Jones, unpubl. data); however, most interstate fishers target species that are more highly valued (sport and eating) than herring. A drop in recreational fishing effort (especially shore based) could have also contributed to the drop in estimated SA catch between 2000/01 and 2007/08.

Catch Rates – In both the boat- and shore-based fisheries, the only technological changes that may have increased fishing efficiency for herring could be the introduction of chemically sharpened and/or modified small circle hooks in the mid 2000's.

West Coast Boat-based surveys. In para 2 of this section, the catch rates should be changed to 0.379 fish per boating hr etc.

West Coast diary Anglers and MAAC estuary competitions. Acceptable for WC diary angler records.

MAAC ocean beach competitions. Interpretations are hampered due to the reduction in bag limits and possible impact on estimated CPUE's due to a possible increase in high grading (see above). I remain to be convinced that CPUE trends reflect changes in rel. abundance based on this set of data.

West Coast Vol. log books. Although monthly fishing effort for the Perth shore based voluntary fishers is provided in Fig.4.1.9.a, some indication of numbers of anglers who participated each year, i.e. whether the same fishers provided information each year may assist in understanding whether there was any change in rel. skills of fishers over time. Number of fishers participating each year may also assist in understanding the year to fluctuations in effort. In addition to the stable annual CPUE for this group, the autumn /winter peak in CPUE appears stable, too.

Released catch – The authors suggest that the release rate of herring could be related to the spatial variation in average size of herring in the particular area. This is partly true, however, our limited data on lengths of released herring in 2007/08 (from our vol. rec. log books), suggest that release length frequencies are similar to those of the retained lengths; ie there is no preference for releasing smaller fish (in SA there is no min. legal length for herring). I'll expand on retained lengths later in this review.

Discussion

Recreational catch and effort – The authors point out that the herring is a relatively important species (numbers) in the WCB boat fishery, despite being a lightly targeted species. This may be due to the relatively high bag limit for herring compared with the more highly valued sport species targeted by boat fishers. Also, herring may be used as bait when targeting these other species, thereby enhancing the need to keep relatively large numbers. I agree about the relatively higher importance in the shore based fishery than the boat fishery for WCB.

Discarding – See my comments above on SA released sizes.

Seasonal availability of herring in WCB – It seems logical that the peak CPUE's in WCB match the time of the spawning aggregations in this area. Intense feeding may be related to pre-spawning activity too. Interestingly, SA herring CPUE's appear to peak late spring – pre-migration feeding?

Long-term trends in herring availability in WCB – Regarding the trends in the MAAC Ocean CPUE's, until some information is available to say that the possible increase in high grading is not an issue, there is still some doubt in my mind on its usefulness as an indicator for herring availability in this region. The authors suggest these are only a qualitative indicator and I agree. The better long-term CPUE data may be the estuary MAAC and individual anglers (1 & 2) (Fig. 4.1.7) which is similar to the volunteer surveys (1995 – 2007) and the more recent vol. log books (2005 – 2010).

Finally it's good to see some discussion on the link between RI's and Recreational CPUE's for this area, albeit that very unfortunate gap from 2003 – 2005 in RI's. The strong yr class in SCB in 1999, was also apparent in SA (Jones & Westlake, 2003) and recent peaks in the SA commercial targeted CPUE in 2005/06 and 2008/09 onwards (Fowler *et al.* 2011) may suggest higher availability of herring in WCB in these later years.

Future monitoring – See my general comments on this issue above (Introduction). Despite the problems with costs, due to lack of licences for the shore-based fishery I believe it is still important to obtain regular estimates (every 5 yrs) of annual harvest by this sector. Such data would be essential when future population modelling work is done, and if any future decision on formal resource sharing arrangements take place between the commercial and recreational sectors for this and other fisheries. In the meantime, cost effective monitoring of CPUE's by groups of fishers who are assessed as being representative of the fishery should be undertaken in key areas (in WCB and SCB) to validate with beach seine sampling of juvenile fish for RI's. Voluntary log books are probably the way to go, just so long as the same fishers regularly report. Powerful incentive may be needed.

Summary – should be #4.1.4.6. The authors conclude that the CPUE trends from the individual fisheries are similar, including the commercial fisheries. Most fisheries, which have long-term data, certainly do show highest CPUE's during the 1980's then drops in the 1990's, however, the CPUE's in the fisheries appear to diverge in 2000/01, and thereafter, CPUE rises have occurred for the Mandurah/Perth HN, steady CPUE in the Cockburn sound nets, rises for the MAAC estuary, vol. log book fishers, VLFOs, but continued drop in the MAAC ocean fishery data. However, for the fisheries, where there are data going back to the 1970's, the CPUE's of 2000+ are lower than those of the 1980's. The only exception is the individual rec anglers (combined with the MAAC estuary data). Interestingly, the peaks in the SA Commercial targeted CPUE in 2005/06 and 09/10 are lower than the 1997/98 and 98/99 peaks (record highs).

I agree that the CPUE in the WCB is an indicator of spawning stock size, which therefore suggests that recruitment overfishing has been taking place for some time.

3.4 Biology and Assessment of Herring

Introduction

In summarising the previous chapters, the authors mention that the recreational fishery's peak catches occur in Autumn/Winter. I believe peak catches may occur during summer months, when effort and recreational participation are at their highest, but peak CPUE's (herring vulnerability) occur in autumn/winter.

Mention is made on the reduced SA commercial catch since 2000. As mentioned in my review of the commercial fishery chapter, this is mainly due to reduced fishing effort, although the spikes in high targeted CPUE's in later years are slightly lower since the very high peaks in 1998

& 99. I think the poor understanding in the connectivity is due to: a) the fisheries in the WCB more recently may be driven by local recruitment when years of good yr classes occurred and b) a number of poor recruitment years along the SC have been observed, thus minimising the passage of relatively high abundances from the south to the west coast.

The point about shift in recreational effort from demersal species to herring due to management changes is an important one to make, and is a huge issue in managing multispecies fisheries.

In this introduction, mention should be made about the attempt in developing an age-structured spatial model of the herring fishery in WA and SA (Wise & Hall, in Ayvazian *et al.* 2000), pointing out the uncertainties associated with the model, and reasons why it hasn't been updated in this latest stock assessment. With these more recent sets of data now available it may be worth pursuing, as you may eventually be able to estimate and compare current spawning stock size (SSS) with unfished SSS. It the light of this gap, the catch curve analysis is the only possible method of assessing the stock status, and focussing only on the fully recruited spawning population in the lower WCB, and, as mentioned in the report, is best suited for consecutive years of age composition data to smooth out any effects of inter-annual variability in age class strength. Reasons for not undertaking yield per recruit modelling could also be discussed.

Materials and methods

Good to see the old CSIRO data set on length frequencies from the 1940's – 50's mentioned. Mention is made of the model length for the SC of 244 mm TL. This is a valuable piece of information in comparing with more recent length frequencies for the same area in the 80's and 00's.

Validation of length frequencies derived from sample frames donated from recreational fishers could be done using measurements of fish collected from dept. based recreational on-site surveys.

Natural mortality (M) – A possible method of verifying M, may be to find out if there are any angling clubs' record size figures near the beginning of the fishery, then applying a growth equation and estimating max.age when fishing mortality was relatively low.

Biological reference points – The 2/3M target level approach is more precautionary than 0.8M, which is adopted for data-poor species. I believe we are at the stage for herring in having enough both fishery-independent and dependent data indicating historically low stock sizes in the 2000's, to adopt the more precautionary approach. I personally believe that the limit BRP (2M) is too high and could be reduced to 1.5M, in line with the more precautionary 2/3M for target BRP.

Results

Length and age structures – See my comments above on validation of recreational volunteers herring length frequencies, in line with the observation that a small proportion of the volunteers provided the greater proportion of frames. Information on the truncation of lengths and ages over time look acceptable. Taking into account the CSIRO 1940/50's modal length of 244 mm for the south coast commercial fishery (see above), it appears that the truncation of lengths took place after the 1980's.

When reporting on the age structures, it would have been useful to assign spawning years to the ages. For example, in Figs. 5.17 & 5.1.8, for the WCB, there appears to the passage of a relatively strong year class in winter, 2009 (seen as 2^+ fish) through to winter, 2011 (seen as 4^+ fish), and a weaker one immediately afterwards. Based on the growth rate data of juveniles and

later information in this chapter on age-at-1st maturity for WCB females, does this mean that the 2^+ fish observed in winter, 2009, would have come from the 2006 spawning year, ie just beginning their 3rd of life? If so, it fits in with the slightly higher RI observed in Warnbro Sound in that year. If not, I've mis-interpreted the spawning years, or the Warnbro Sound RI doesn't match the strong year class observed in the fishery. Any comments?

The information on truncation of age structure over time is good.

Growth – Happy with this section, however, in some places I had to refer back to the chapter 1 on juvenile growth.

Spawning Period – Although the sample size for females along the SC in June was small (n = 4), and no sign of any females in spawning condition in this region beforehand, it almost indicates to me some sort of a back-run of spent females took place from the WCB to the SC in June, 2009 – 2011. This was not apparent in 1996 – 99 with larger sample sizes (Fairclough *et al.* in Ayvazian *et al.* 2000). Any comments?

The spawning period for Cockburn Sound caught fish appeared to be just on a month's duration (May 12 – June 10, 2010). This coincides nicely with the peak months in CPUE by the recreational sector (Fig. 4.1.10).

Sex ratios – Going from the figures (5.1.24, 5.1.25) it certainly appears females are relatively more vulnerable to fish gear (both rec and commercial) during the spawning period than at other times of the year.

Length& age at maturity – This section look good to me. A decline in size at 1st maturity over time is often sign of over-exploitation, however, the slight but non-significant drop between 1996 and 2009 is still a concern, and that this parameter should be monitored in the future.

Juvenile Retention – I like the term juvenile retention. Later in this review I'll provide information on the size compositions for the SA fisheries, which would be useful in this context.

Mortality – Looks good to me. If there were good data on the relative size of the total catches for the two sectors, over time, the age structures for the two sectors could be weighted accordingly, and an overall estimate of Z and F for the combined fisheries could be calculated. The trend in estimated F for both sectors over the past 15 years is of concern.

Discussion

Representative samples – Mention is made of the 110 recreational fishers who voluntarily provided frames; however, see p. 168, which mentions that the bulk of the samples came from a small number of volunteers.

Length & Age structure – With the fisheries now dominated by a smaller number of year classes, and with the variable strength of the Leeuwin Current fluctuating year to year, it would be expected that catch rates by both sectors should show greater inter-annual variability. I think this is seen in the SC trap fishery.

Very good point about the reduction in egg production due to lower fecundities of smaller fish.

Growth – The decrease in growth constant (k) over time could be a result of the higher rate of capture of the faster growing fish of a particular group, a situation common in heavily fished fisheries. The hypothesis that reduced growth rates are due to warmer temperatures goes against the observation that over the whole distribution of herring from WA to at least SA, it appears

that growth rate increases as water temperature increases (see Fairclough *et al.* in Ayvazian *et al.* 2000, p. 37, Fig. 2.2.).

Spawning – See my previous comments above, about duration of spawning season. You also may like to mention the possible presence of a back-run of spent fish to the SC in the last few years.

Sex ratio – The hypothesis that females are more aggressive feeders, taking baited hooks more avidly than males can successfully be tested by the observation of highest CPUE's during the spawning period, although the overall higher female: male ratios in most of the fisheries in the rest of the year may be due to females generally in areas where the fisheries occur. We still see it in the SCB commercial fisheries – is this from the trap fishery or the inlet fisheries? If it's the trap fishery, the differential spatial distribution of females : males is the reason (males further offshore?)

There again the overall high female : male sex ratio might just be a natural biological characteristic for this species – any evidence with Australian salmon?

Maturity – I had to draw VB growth curves for 1996 and 2009 females for WCB, and based on those curves, I agree that there will be more immature fish caught in more recent times.

Juvenile retention – The figures on relative size of the SA and Vic catch compared with the current WA catch look about right, if we are dealing in harvest weight (tonnage), and the estimated recreational WCB harvest is put at 400 t (as seen in the 2000/01 national survey). The SA/Vic proportion would be even higher, if the WCB harvest is estimated at about 150 tonnes, as proposed for the more recent years (p. 119). The need to reduce the juvenile catch (ie allow more fish to recruit to spawning aggregations) is certainly required, however, the example given to the work by Robinson *et al.* (2011) on the Seychelles trap fishery, is not a good one, as the fishery on spawning aggregations of Siganids was relatively small compared with the other fisheries at other times of the year (18 % of the total catch). This does not appear to be the case for this herring fishery. The old adage "to allow fish to spawn at least once" may need to be considered.

Mortality – Good discussion on the reasons for selecting the Hoenig method for estimating M. The probability that M has increased due to increased predation by Australian salmon after the pilchard mortality events (1995 and 1998) is feasible; however, more recent stock assessments on the SC pilchard fishery suggest that the pilchard spawning biomass at Albany /Bremer Bay in 2002 (WA State of the Fisheries Report 2002/03) is at the stage of recovering. Is there any anecdotal information from the commercial salmon fishers in more recent years of a shift back to pilchards in this area? Recent research on the diet of NZ fur seals along the southern Fleurieu Peninsula coast of SA in 2006, reported yellow-eye mullet as the main teleost species in their diet; "tommy rough" were not found, but, small numbers of herring were reported in the diet of little penguins living in the same areas as the fur seals (Bool *et al.* 2007). Has there been any dietary studies on fur seals in WA?

Stock assessment – I have mentioned previously my concern with the observed truncated age composition especially in the WCB fisheries. In the last paragraph in this section, I would also add that the WCB recreational pre-spawning catch is also relatively high (see Fig. 4.1.10).

Future monitoring – It is critical that monitoring herring age structure from the recreational sector, especially in the WCB is maintained, as 1) it probably samples a spatially better distribution of herring than the commercial fisheries (both in SC WA and SA), and 2) the decline in the commercial fisheries due to economic and legislative reasons. Maintenance of recruitment monitoring programs at key sites in WCB, SC and SA would also assist in predicting yr class strength to the fisheries. The absence of the RI data in 2003 – 2005, especially in the WCB, has

hindered our understanding of linkage between recruitment and catches later on. As the total SA catch has consistently (since the early 2000's) been about 25% of the total harvest, and as the recreational fishery is now a better indicator of size (and probably age) structure than the commercial fishery, ongoing monitoring of the former sector and linkage with recruitment indices would benefit the stock assessment process in both states. Finally, regular estimates of total annual recreational harvest (both platforms) would be essential for future modelling work.

3.5 General Discussion and Implications (Herring)

Introduction

Agree that Level 3 Assessment is suitable for herring.

Summary of stock status

There should be a better recognition of the significance of the SA component of the stock in this assessment, especially in relation to the fishery independent RI's and catch rates.

Fishing Mortality – Agree that F has increased in the WCB.

Fishery Catch Rates – Agree that fishery CPUE's are relatively poor indicators of short-term fluctuations in stock abundance, often because of the external factors, including reductions in bag limits (eg MAAC data), externally driven effort declines in the commercial fisheries (WCB, Sc trap and SA net fisheries). It should be pointed out that the commercial fisheries in SC trap and SA, don't represent the entire population of herring in the areas where they are fished (due to gear and spatial restrictions), and that the recreational fishery probably provides a better indication of the population structure – certainly in SA (see Appendix 1).

Similarly, the lagged correlations between recruitment indices and annual fishery CPUE's which suggest recruitment to the fishery is recruitment driven are seen because of the truncated age structures in the fisheries. Again, this may not necessarily mean that the population size of the stock in the region varies in the same way. For example, the direct correlation between Poison Creek RI and the SA Commercial catch (and targeted CPUE) with no lag means the SA commercial fishery is now only taking 0 & 1 yr old fish, whereas the SA recreational fishery in areas where the commercial fishery does now not work, shows a greater number of length modes (ages?) in SA. I would therefore conclude that the commercial fishery catch rates provide relatively low levels of confidence as indicators of herring abundance. Also, my concern with the MAAC catch rates being influenced by reduced bag limits, and potentially causing increased high grading at weigh-ins, adds to my lowered confidence in this set of data to as an indicator of abundance in the WCB.

The increasing trends in catch rates in northern commercial and recreational WCB fisheries **may be** a function of locally high recruitment indices during 2003 – 2005. RIs were not collected over this period, but should be high as observed in the El Nino oceanographic conditions for this period.

Fishery Catch Composition – The recent contraction of the age structure in the WCB, and the high rate of juvenile retention in the SCB and the SA fisheries (this has probably always been the case) are two good indicators of concern. There is not good evidence for rising water temperature influencing size at 1st maturity, and I would therefore consider higher fishing pressure would be more important.

Recruitment – Despite the lack of RI data in 2003 – 2005, it appears that recruitment emanating from the WCB nursery areas has been lower than for the SCB throughout 1996 – 2010, even in years of high RI in WCB in 1997 – 8. It is therefore critical that enough escapement takes place from the SC and SA fisheries to allow sufficient recruitment to the spawning population in the lower WCB.

Overall Vulnerability – Agree with this level.

Summary – Good summary.

Tailor

3.6 Tailor Recruitment Dynamics

Introduction

This provides a good description of the known recruitment dynamics of tailor in other areas of its distribution (east coast Aust. and Atlantic US) and reviews existing information for WA.

Methods

Seine nets – It appears the sampling sites in the WCB for tailor, with the exception of Bunbury (Koombana Bay), differ. Pinnaroo for tailor and Warnbro Sound for herring. I'm assuming that the respective sites were chosen to reflect consistently highest numbers of newly settled fish of the particular species. Do different habitat characteristics at these respective sites influence the differing recruitment rates for the respective species? In similarity with herring, it was very unfortunate that sampling ceased in 2003 – 2005.

Volunteer Angling – It appears to be a well designed FI sampling program for 9 – 18 month old tailor. As the fish caught were mostly under the MLL, you mention that all fish were released. Do you think there's an issue with potential recapture of released fish, therefore, artificially increasing CPUE's?

However, as this was done consistently, I don't think it should affect the year to year variation. It's good to see such a long set of data, without the 2003 – 05 sampling gap. Hope this survey can be maintained. Keep up the incentives to the voluntary anglers.

Environmental data – A good set of environmental parameters to explore linkages with recruitment strengths.

Results

Seine netting – Overall, the average catch rates of newly recruited tailor appear to be quite low at all sites (at least in comparison with herring and salmon), suggesting to me that either a) tailor recruit to coastal WCB and GCB in small numbers throughout their distribution range, a result of their temporally widespread spawning period, or b) the sampling sites were relatively poor representatives of the optimum habitat that 0 gp tailor recruit to. Is there any evidence from other studies along the Atlantic US or eastern Australian coast?

The back calculated birth months of new recruits at the three sites are key indicators of the spatial divergence of winter v's spring/summer spawned fish. A very helpful set of data that can be nicely linked to the voluntary anglers data. However, there appears to have been no attempt to correlate recruitment indices from the seine netting with the environmental variables. As these fish are younger than the voluntary angled fish, it's possible that a clearer linkage between environmental variables and netted fish may appear.

Voluntary angling – Yes, hook size selectivity influences size of fish caught by anglers. Based on the size composition of newly recruited fish to Perth (seine nets), the small hook sizes used by the volunteer anglers, may not even be small enough to capture fish < 120 mm (see Feb in Fig. 2.2.1). However, there may be a change in diet for tailor about that size.

The sig. correlation between northward wind stress and group 1 fish indicate the southward larval movement from the northern winter spawning area and Geraldton autumn /winter SST and Gp 2 fish. Although IOD tracks water temperature in eastern and western Indian Ocean, I always thought that IOD is more of a predictor of rainfall across southern Australia, including SW WA. Thus, it could indirectly reflect Swan River chemistry, and may not necessarily reflect larval tailor transport mechanisms, hence the non-significance between IOD and Gp 1 or 2 indices. The lack of correlation with FSL and SOI may reflect the relatively long time that the juvenile tailor had been in the Swan/Canning estuary. See my comments above regarding the environmental linkages with the newly settled tailor sampled by the seine nets.

Discussion

In contrast to herring, relative abundances of newly settled tailor appear quite low at all netting sites in all sampling years. Is this a function of the extended spawning season for tailor, with no clearly defined nursery areas? Has there been any work done on the diet of newly settled tailor at sites such as Bunbury? The sizes of tailor during winter months at this site (Fig. 2.2.4) may be conducive for them to prey on smaller newly settled herring (June – Aug) at the same site.

I found it difficult to link the sizes of newly settled tailor at Perth (Fig. 2.2.3) with the sizes of fish caught by the voluntary anglers in the Swan-Canning estuary, and the only reasons I could come up with were due to a) hook size selectivity by the voluntary anglers, or b) change in the preferred diet at about 150 mm to fish (whitebait used as bait).

Finally, I would have liked to have seen some work done on correlation between environmental parameters (FSL etc) and newly settled netted tailor.

3.7 Tailor Commercial Fishery

I would be interested to know whether the commercial fishery data collected by ABS up to the mid 1970's was from voluntary or compulsory reporting. In SA, our ABS catch data was from voluntary reporting in our MSF fishery up to 1975/76, and probably under-estimated commercial harvest levels at the time. Also, the shift to more detailed CAES records in the late 1980's, highlighting the awareness amongst fishers to report more accurately (correctly?), may have caused the rise in catches about this time. Were any commercial management proposals relating to tailor mooted about this time, increasing the possibility that commercial fishers over-, or more accurately reported their catches? I've seen this occur in other fisheries. It's good to see the CPUE analysis of the GCB fishery based on selected vessels.

In the Peel-Harvey net fishery, the many changes to the environment (the 1994 "Cut"), the shift in target species between blue crabs and finfish, and changes in tailor MLL make interpretation of commercial tailor catches quite challenging. However, the point that tailor has always (?) been a by-product species in this net fishery, with little, if any targeting, and little change in demand as a fresh fish product, may mean that this net fishery could be an acceptable one to measure relative abundance of tailor in this area. As mentioned, the other commercial fisheries catch and effort is diminishing through management changes to areas, and more reliance on fisheries-independent and recreational fisheries data will be needed.

The lagged negative correlations between SOI, FSL and the GCB CPUE, and the inference that high CPUE's in the 1990's were related to suitable tailor reproduction can be enhanced with the relatively high RI's at Perth and Bunbury during those years.

I look forward to seeing the completed 2011 Peel/Harvey catch and effort data. As it is, the large 2011 CPUE may be related to the rel. high RI's at Bunbury in 2010/11? Any data on size/age composition for this fishery?

3.8 Tailor Recreational Fishery

As with so many of our other important shore-based recreational fisheries across southern Australia, it is very unfortunate that this part of the tailor assessment is hampered by having minimal long-term total catch data. The individual angler diaries and the voluntary logs are adequate for indices for relative abundance, however, not suitable for estimating total harvest. The recreational boat fishery data seems to have enough information long-term data but is hampered by the fact that tailor is a minor target species in this fishery. Is there any targeted fishing in the WA charter boat fishery, and are there any data from this fishery to assist in future assessments?

Results

Regarding the high estimate of the total rec harvest in 2000/01 from the NRIFS, the authors consider that it may be an over-estimate. Lyle *et al.* (2010) have developed an enhanced method to analyse the data from this survey, taking into account issues about drop-in/drop-out rates. We've re-analysed our SA 2000/01 survey data (see page 57 of my survey report; Jones, 2009), so a similar exercise may be possible for the WA NRIFS data set. Karina Ryan may be able to assist you there. The other issue, is that other boat- and shore-based surveys undertaken during the 1990's and 2000's admit that their estimates may be slightly under-estimated, due to surveys not being undertaken after dark (eg, see Sumner *et al.* 2008). As we know that tailor can be caught after dusk (voluntary anglers in the Swan-Canning survey), the "after-dusk" catch could be a factor in underestimated on-site surveyed catches. The truer estimate may therefore be somewhere between the phone-dairy and the on-site estimates. I would certainly not disregard the 2000/01 total catch estimate at this stage, as it's the only available one you have. The best available information.

I agree that increasing the MLL will increase the release rate. We've found this in our whiting fisheries.

Catch Rate – It appears that angler 1 and 2 CPUE's show the closest connection (both are Perth shore based fishers. Angler 3's (Geraldton) CPUE's appear to peak 1 year earlier than the Perth based shore fishers, however, I may be drawing a long bow. Because of the patchy nature of the data in the 2000's for all anglers, it's hard to say, just from these fishers, that CPUE's have improved in recent years. The voluntary log book data appears to be a better indicator, if we assume that the same voluntary log book fishers are reporting over time, and that there is no change in catching efficiency over time.

Length composition – Clearly, for future estimates of recreational harvest weights for tailor, because of the regional and fishing platform based differences in sizes of fish caught, adequate sample sizes of measurements are required for each sector. This assessment has highlighted these complexities.

Discussion

I agree that the shift in target species between demersal and pelagic species for boat fishers could have altered the boat-based tailor catch in recent years. The added recent restrictions in the demersal fishery could shift effort back to tailor and other pelagics. However, this could be outweighed by the reduction in max size limit. A complex set of variables which make interpretation of changes in catches very difficult.

Future monitoring – The shore based fishery is the critical sector to monitor regularly, and using the same survey methodology. Interpretation of the recreational fishery has been hampered by the different survey methods used in the past.

Summary – Good summary as it links the recreational fishery with recruitment variation.

Note. Caption for figure 4.2.3 should be catch and effort, not catch rates. Also shore based diary angler 3 and boat based angler 4 should be c) and d), respectively.

3.9 Biology and Assessment of Tailor

Introduction

Reference is made of tailor found as far as the WA/SA border (Gomon *et al.* 2008). This is incorrect as Gomon *et al.* (2008) shows the distribution of tailor from mid coast of WA, throughout southern Australia and into southern Queensland. I can confirm that on occasions, small schools of tailor are seen on some of the ocean beaches of southern Eyre Peninsula, Port Lincoln bays and KI ocean beaches. Recreational fishers have reported them in SA for many years, albeit in small numbers compared with Australian salmon. Whether the SA fish are related to the WA population rather than the eastern Australian population is pure speculation.

There is mention that the WA recreational catch of tailor in the 1980's and 1990's was of the order of 500 – 1,000 tonnes (Lenanton *et al.* 1996). This is the first reference to this figure and should be put in the context with the NRIFS harvest estimate of 187 tonnes in 2000/01. This should be discussed in the chapter on the recreational fishery.

The introduction provides a good summary of the biology of tailor in other waters (US).

Methods

If commercial fishery data are going to be used in future assessments of this fishery, sampling of size and age composition of harvested numbers is required. The current information on the biology has only come from the recreational fishery, and therefore, gaps in biology in places like the GCB are apparent. Also, as rec fishers often only provide frames, length/weight data are minimal.

Methods for estimating mortalities and yield and eggs per recruit are acceptable for this species. However, there's a need to mention that the YPR and EPR models assume constant recruitment – something which appears to not occur for tailor.

Results

Juvenile and adult age and growth – As mentioned previously, it would have been good to provide an age/length graph linking juvenile and adult growth (ie Perth sampled new recruits and the Swan-Canning juvenile fish).

Is the truncation in size composition from the 1990's to 2009/10 also due to the implementation and reduction in the max size limit?

Spawning Period – It appears the GSI information confirms the winter and spring/summer spawning periods, observed in the otoliths of the newly recruited fish.

Mortality – The total mortality estimates are clearly dependent on the presence or otherwise of the single 10 yr old fish and the small sample sizes in the southern and northern parts of the WCB. Your most certain estimates could be from the mid-west and metro parts and an overall estimate based on these 469 fish might be the way to go. Also, as the single 10 yr old fish came from the SW region, with the small sample size, I would leave out the SW and Kalbarri fish. The total mortality rates may be over-estimated, as sampling was biased towards the smaller shore based recreational caught fish.

Yield and egg per recruit analyses – The effects of max size limit on yield and egg per recruit appear logical. You've had to assume 100% survival of released fish.

Discussion

Age and growth – see my comments in the results section, regarding the effect of max limits truncating size and age composition over time.

Reproduction – The large differences in L50 between the two sampling periods clearly indicates the need for extreme caution in interpretation of any sets of data which have a low sample size.

Assessment – I think you're correct in using the max age of 10 for estimating M, despite the fact that recreational fishers under-sampled larger older fish. If you go down that track, your estimated F values will contain inshore fishing mortality and migration of fish to offshore, under-sampled areas. Therefore, there is a need to sample those offshore fish and include them with inshore sampled fish (weighted by relative levels of harvest) to obtain more accurate values of F. At this stage, I think your best estimate for Z and F will come from the combined metro and mid west areas, due to the low sample sizes elsewhere in the WCB.

3.10 General Discussion and Implications (Tailor)

The current view is that commercial and recreational catches are of a similar magnitude. Based on catch data from previous years, the recreational share appears to have dropped. Reported annual recreational catches of 500 – 1,000 t in the 1980's – early 90's (Lenanton *et al.* 1996) and approx. 50 t for the commercial sector during the same period.

Summary of stock status

Stock structure – The single stock structure with spawning occurring in both the GCB and WCB is the most plausible hypothesis at this stage. Backed up by good recruitment information for WCB.

Recruitment – The statement on recent improvement in recruitment stems from the Swan-Canning volunteer angler surveys and the Peel Harvey commercial fishery data. However, the seine netting surveys don't quite show this. It appears that with the exception of the Bunbury Jan – May data set, all other ones, show either similar or reduced recruitment in recent years. Some explanation on the divergence of these results would assist.

Fishery Catch rates – The correlations between catch rates and environmental parameters (SOI, FSL) give good evidence that oceanographic processes (Leeuwin and Capes Currents)

significantly influence the recruitment strength and ultimately the catch rates in these fisheries for tailor. Separating the influences of fishing effort on catch rates from environmental factors is not possible at this stage.

Fishery catch composition – Clearly the effect of increased size limits has affected the release rates.

Fishing Mortality – Biased sampling towards shore based recreational catches influences the upwardly biased estimates of F.

Yield and egg per recruit – The estimated EPR is much higher than for the F (threshold), and therefore confirms no evidence of recruitment overfishing.

Overall Vulnerability – Acceptable.

Summary – Agreed, however, my only proviso is the need to explain the divergence between the netted recruitment indices and the volunteer angler derived recruitment indices.

Implications for management

Tailor. This is a safe view, in the light of the need for additional stock status information.

Future monitoring and assessment

Agree that the current Swan-Canning volunteer angler survey is currently the best indicator of recruitment index for the Metro WCB region. If the newly recruited netting surveys at Carnarvon, Perth and Bunbury are maintained, some investigation of the relationship between these RI's and the Volunteer angler RI's needs to be reconciled. If this isn't done, there seems to be no need for maintaining these nettings surveys. Volunteer angler surveys at other sites may need to be undertaken to confirm the present observed increase in recruitment strength. Ultimately, when fishery independent sampling of the whole population in WCB and GCB is undertaken, some indication of the relative importance of winter and spring/autumn spawning recruitment to the fishery (ies) could be achievable though otolith chemistry research, however, it's need is dependent on how spatially fine the fishery is to be managed. My view is that the stock should be managed in its entirety, taking into account both the GCB and WCB.

4.0 References cited

Ayvazian, S.G., Jones, G.K., Fairclough, D., Potter, I.C., Wise, B.S. and Dimmlich, W.F. (2000). Stock assessment of Australian herring. Fisheries Research and Development Corporation, Project No. 96/105. Department of Fisheries, Western Australia. Fisheries Research Report, 163. 130pp.

Bool, N., Page, B. and Goldsworthy, S. (2007). What is causing the decline of little penguins (*Eudyptula minor*) on Granite Island, South Australia. SARDI Research Report Series No. 217. 55pp.

Fairclough, D.V., Potter, I.C. and Platell, M.E. (2000). Reproduction, age and growth of Australian herring (*Arripis georgiana*) 28 – 73pp. In (Eds) Ayvazian, S.G., Jones, G.K., Fairclough, D., Potter, I.C. Wise, B.S. and Dimmlich, W.E. Stock assessment of Australian herring. Final Report. Project 96/105 Fisheries Research and Development Corporation, Canberra. 223pp.

Fowler, A.J., Lloyd, M.T. and Schmarr, D. (2009). A Preliminary Consideration of By-Catch in the Marine Scalefish Fishery of South Australia. SARDI Aquatic Sciences Publication No. F2009/000097-1. SARDI Research Report Series No. 365.

Fowler, A.J., McGarvey, R., Steer, M.A. and Feenstra, J.E. (2011). The South Australian Marine Scalefish Fishery Stock Status Report – 2011. SARDI Research Report Series. No. 586. 29pp.

Gomon, M., Bray, D. and Kuiter, R. (2008). Fishes of Australia's southern coast. Museum Victoria, Melbourne. 928pp.

Jones, G.K., Hall, D.A., Hill, K.L. and Staniford, A.J. (1990). The South Australian marine scalefish fishery. Stock Assessment, Economics, Management. Green Paper. South Australian Department of Fisheries. 187pp.

Jones, G.K. and Westlake, M. (2003). Marine scalefish and miscellaneous fisheries. South Australian Fisheries Assessment Series Report No. 01/18. SARDI Aquatic Sciences, Adelaide. 47pp.

Jones, G.K. (2008) Australian salmon and herring. Chapter 30. In: Natural History of Gulf St. Vincent. (ed: S. Shepherd, S. Bryars, I. Kirkegaard, P. Harbison, J.T. Jennings). Occasional Publications of the Royal Soc. of South Australia Inc. p. 415 – 36.

Jones, K. (2009). South Australian Recreational Fishing Survey 2007/08. South Australian Fisheries Management Series Paper No. 54. PIRSA Fisheries, Adelaide. 84pp.

Lenanton, R.C., Ayvazian, S.G., Pearce, A.F., Steckis, R.A. and Young, G.C. (1996). Tailor (*Pomatomus saltatrix*) off Western Australia: where does it spawn and how are the larvae distributed? Marine and Freshwater Research, 47: 337-346.

Lyle, J.M., Wotherspoon, S. and Stark, K.E. (2010). Developing an analytical module for large-scale recreational fishery data based on phone-diary survey methodology. FRDC Project No. 2007/064. 105pp.

Robinson, J., Samoilys, M.A., Grandcourt, E., Julie, D., Cedras, M. and Gerry, C. (2011). The importance of targeted spawning aggregation fishing to the management of Seychelles' trap fishery. Fisheries Research, 112: 96-103.

Sumner, N.R., Williamson, P.C., Blight, S. and Gaughan, D.J. (2008). A 12-month survey of recreational boat-based fishing between Augusta and Kalbarri on the west coast of Western Australia 2005–06. Fisheries Research Report No. 177. Department of Fisheries, Western Australia. 44pp.

Wise, B. and Hall, N. (2000). Stock assessment of Australian herring (*Arripis georgiana*) 165 – 201pp. In (Eds) Ayvazian, S.G., Jones, G.K., Fairclough, D., Potter, I.C. Wise, B.S. and Dimmlich, W.E. Stock assessment of Australian herring. Final Report. Project 96/105 Fisheries Research and Development Corporation, Canberra. 223pp.

5.0 Appendices

5.1 Appendix 1. Terms of Reference

Terms of reference for the review of stock assessments for the nearshore indicator species (Australian herring and tailor) for the West Coast and South Coast Bioregions.

Scope

To review the scientific stock assessment provided in the draft document, "Status of nearshore finfish stocks in south-western Western Australia: Australian herring and tailor", funded by the State NRM. The format for the review shall consist of:

1. General comments – "Overview" comments about the publication, including advice on how the document could be better structured, issues about the broad methodology or design, or general comments on writing style.
2. Comments in relation to management advice and recommendations – their appropriateness, and within the ambit of WA Research Laboratories.
3. Specific comments – Review key elements of the document, including: executive summary, introduction, analysis of commercial fishery(ies), analysis of recreational fishery(ies), review of fishery biology, modelling, recruitment monitoring, literature content.
4. Figures and tables – Appropriate number, redundancy of information, information captions.
5. Final recommendations – Suitability for publication (as is; minor editorial correction; minor revision of substance; not suitable without substantial revision; not suitable).

Background

This report investigates the status of two key nearshore finfish indicator species in the West Coast Bioregion:

- Australian herring (*Arripis georgianus*)
- Tailor (*Pomatomus saltatrix*)

The report also assesses the SCB and GCB where stocks are distributed across Bioregions. The nearshore 'suite' of species includes all finfish in coastal waters less than 20 m depth, which are mainly captured by recreational line fisheries and commercial net fisheries.

Objectives:

1. Determine if the assessment advice generated for the two nearshore indicator species is appropriate given–
    - the data available,
    - specific circumstances of the stocks and the fisheries operation, and
    - the nature of the 'weight-of-evidence' assessment for nearshore indicator species.
2. Provide any additional scientific comment or advice that may be useful to assist with the future monitoring and assessment of these species.

Operations

Department staff will be available for the reviewer to answer questions pertaining to any aspect of the stock assessment (e.g. data collection, data processing, analyses, spatial dynamics, fleet behaviour, management objectives). If required, any relevant data can be provided.

Report

In addition to the formal report, the reviewer is to provide a brief "stand alone" report which explains the conclusions in a format that can be understood by key stakeholders (e.g. members of RecFishWest, WAFIC).

Extension

As the Department of Fisheries will be the client of the review, DoF will have sole responsibility for managing any subsequent extension of the results of the review to interested parties.

6.0 Department of Fisheries responses and actions to the review

Although both species are used as indicator species in their respective bioregions, because the two species have differing life histories', ratios of levels of commercial : recreational fishing effort as well as differing methods to assess their status, I found it easier to structure my review as separate reports for the two species, and I trust this will also make it easier for the reader.

AGREED. ACTION: The report has been restructured into two separate reports, one for each indicator species. Therefore each separate report now follows the format of

1. Introduction
2. Recruitment dynamics
3. Commercial fishery catch and effort trends
4. Recreational fishery catch and effort trends
5. Biology and assessment
6. Weight-of-evidence assessment and implications

NOTE: The sections, figures and tables in the final version of the report were re-numbered to fit this new format. The numbering of sections, figures and tables referred to below is consistent with the final version of the report. Where the reviewer has cited a section, figure or table, the numbering has been changed to be consistent with the final version.

Australian herring

6.1 Herring Recruitment Dynamics

Methods

Environmental data – Three proxies are provided for the relative strength of the Leeuwin Current – annual deviations around Freo sea level, Albany SST and SOI. As recruitment strength varies spatio-temporally, improved correlations may be apparent between recruitment indices and the respective sea level deviation adjacent to the nearest sampling site for recruitment eg Albany sea level and Emu Point and Esperance sea level and Poison Creek (see Fig. 2.8).

NOTE: Since sea level deviations along the lower West Coast and the South Coast of WA are highly correlated (Caputi *et al*. 1996[2]), recruitment trends were initially compared with sea level at Fremantle (Perth) only.

AGREED. ACTION: We have followed the reviewer's suggestion and expanded the analysis to include correlations with Esperance sea level. The text (Methods, Results & Discussion) in Section 2 and also Figure 2.8 have been modified accordingly. Correlations between recruitment and Esperance sea level yielded higher *r* values than with Perth sea level, although the nature of the relationships at all sites were similar, including no relationship between sea level and recruitment at Poison Creek.

2 Caputi N, Fletcher WJ, Pearce A and Chubb CF. 1996. Effect of the Leeuwin Current of the fish and invertebrates along the Western Australian coast. Marine and Freshwater Research 47: 147-155.

Results

When correlations between RI's and fishery statistics were presented, I found I had to constantly refer to later chapters on catch, effort and CPUE's to fully digest this part of the report. Correlations between RI's with catches and CPUE's could have been placed after the descriptions of the catch and effort in the fisheries, and I'll discuss these correlations later in my review.

AGREED. ACTION: Text and figures describing correlations between RI's and fishery CPUE's have been deleted from the recruitment Section and inserted into the relevant Sections on commercial and recreational fisheries.

Discussion

You refer to the SA initial time of recruitment as September (Jones *et al.* 1990). You might like to refer to my recent more paper (Jones 2008) which provides more detail to the duration of the recruitment period in Gulf St. Vincent (SA) to reference on peak time of recruitment in SA.

AGREED. ACTION: Additional reference has been inserted and text updated. Text now reads: "*In South Australia (SA), juveniles are usually first observed at a length of >60 mm in October/November (Jones et al. 1990, Jones 2008).*"

6.2 Herring Commercial Fishery

Methods

Sources of catch and effort data – It is also pleasing that there has been a continuing source of compulsory catch and effort data; however, you may like to indicate whether there has been any formal validation of these data.

AGREED. ACTION: We have followed the reviewer's suggestion and inserted into Section 3.2.1 the following: *"Catch and effort data reported by fishers are checked for errors/ inconsistencies prior to entry into the CAES database. Data are again checked for errors/ inconsistencies after extraction from the database and prior to any analysis."*

And inserted into Section 3.2.2 the following: "*None of the fishery catch rates discussed below have been formally validated by fishery-independent surveys*."

Results

National and State landings – Commercial herring catch figures for SA between 1951 and 1975 are those from selected fish processors and the Adelaide fish market and are probably underestimates of the total state catch.

AGREED. ACTION: We have inserted into Section 3.3.1 the following: *"The reported commercial catches of Australian herring in SA between 1951 and 1975 are probably underestimates of the total state catch. During these years, catches handled by selected fish processors and the Adelaide fish market were recorded, but catches by many small netting operators who processed and sold their catches locally were not included (K. Jones, pers. comm.). Catch records are more accurate in SA after 1975, when compulsory logbooks were introduced for all fishers."*

The decline in the SA annual commercial catches of herring since the 1980's can be related to a number of legislative changes... ….Also, since the 1970's, net fishers have been restricted to depths 5 metres or less.

AGREED: We agree that it is important to document the histories of the WA and SA fisheries because this is critical to the interpretation of catch and effort trends. We have included only a small amount of historical information in this report because it has been published elsewhere.

ACTION: To ensure that readers of the stock assessment report are aware of the availability of this historical information, we have included additional sentences in (Section 3), as follows: "*Details of recent annual commercial catches, targeted catches, targeted effort and targeted catch per unit effort in SA are available in Fowler et al. (2011).*" and, "*The histories of the herring fisheries in WA, SA and Victoria are described in detail by Walker and Clarke (1987), and Ayvazian et al. (2000).*"

The history of SA herring commercial catches, targeted catches, targeted effort and targeted catch per unit effort is available in Fowler *et al.* (2011). I have attached the appropriate page for your information. Using these data I've found significant correlations between SA Catch and Targeted Catch and between Targeted Catch and Targeted Effort, suggesting that the decline in herring catch is linked to the decline in fishing effort directed at the species in SA (see table below).

AGREED: We agree in part with the point being made by the reviewer, i.e. the decline in effort in each fishery could have contributed to the observed reduction in catch level.

ACTION: To acknowledge that this is a potential contributing factor, we have inserted into Section 3.4 the following: *"In both WA and SA, reductions in effort, including spatial closures and licence buy-backs, may also have contributed to declines in catch levels."*

Catch rates in WA fisheries – The Fig. 3.19 plot doesn't give a clear indication of CPUE's on y axis.

AGREED. ACTION: The font size of the y axis label has been increased in this Figure.

Discussion

There appears to be a significant 1 and 2 yr lagged correlation between the SC trap fishery CPUE and the Oyster Bay haul seine CPUE – is there any evidence for fish harvested in the Oyster Bay haul seine fishery to be 1 or 2 yr older than in the SC trap fishery? Or is this an un-interpretable correlation?

AGREED: Although we tested for these (and other) lagged correlations, our analyses did not identify any significant lagged correlation between these CPUE series.

Effect of temporal recruitment variation on Catch and CPUE's in the SA fishery – There appears to be a significant direct (non-lagged) correlation between Poison Creek RI and the SA catch and SA target CPUE for the period 1996 – 2010, suggesting that the SA commercial fishery targets 0 – 1 yr old fish. This has shifted, since the 1980's and 1990's, from a significant 3 yr lagged correlation between the Gulf St. Vincent RI and the GSV/KI targeted CPUE (see Jones & Westlake, 2003), suggesting a truncation in age structure of herring caught by the SA commercial fishery, but not necessarily the whole SA herring population.

NOTE: Although not shown in the report we did find a positive relationship between the unlagged (i.e. within the same year) SA catch and the Poison Creek recruitment index (r^2 = 0.4945, n=11, $p<0.02$). It is interesting to learn that this relationship is consistent with the recent SA fishery catch composition (i.e. 0–1 year olds). Also, the targeting of 0–1 yr old fish in SA is consistent with the strong correlation between the SC Bioregion catch (which is mainly comprised of 2–3 y old fish) and SA catch 2 y earlier (Fig. 3.4).

AGREED. ACTION: We have inserted this extra information into last paragraph of Section 3.3.1: *"The lagged relationships between WA and SA annual landings are consistent with the progressive migration of Australian herring between Bioregions, with fish migrating from SA to the SCB and then to the WCB. This trend is reflected in the age structure of commercial landings from each region. The age at capture was typically 1–2 y in SA during the 1990s (Ayvazian et al. 2000) and 0–1 y in more recent years in SA (K. Jones, pers. comm.), 2–3 y in the SCB and 2–4 y in the WCB (see Section 5)."*

There is also a significant 2 and 3 yr lagged correlation between the SA target CPUE and the SC trap fishery CPUE (catch per active team) (r = 0.5967 **, r = 0.6047 **; resp.). Taking into account the westward migration of SA fish, this correlation is meaningful.

AGREED: The 2 y lagged correlation between SC Bioregion catch and SA catch shown in Fig 3.4A, which is stronger (r = 0.85) than the one mentioned by the reviewer, is also illustrating this relationship.

Without any current recruitment indices available for the SA part of the population, the Poison Creek RI's provide the best indication of recruitment strength in SA; however, it should be noted that in years of relatively strong Leeuwin Current strength (eg 1999; see Jones & Westlake, 2003), recruitment strength in SA was higher than at Poison Creek. Conversely, in 1997, an El Nino year, recruitment strength in SA was much lower than at Poison Creek (Jones & Westlake, 2003).

AGREED: We agree that it would be useful to have empirical information about recent recruitment trends in SA waters. The Poison Creek index is probably not a precise measure of SA recruitment. It is unfortunate that annual surveys of SA recruitment ceased in 2000, providing only 5 years where both indices overlap, making it difficult to confirm the relationship.

6.3 Herring Recreational Fishery

Methods

Long-term Melville Amateur Angling Club data – I have four questions relating to these two sets of data (Swan/Canning estuary and Ocean competitions). 1) It appears that effort measurements differ between the two sets, with the estuary effort recorded as fisher-days, and the ocean effort as fisher-trips (see Fig. 4.7). Assuming most trips were "weekend" events, should the ocean effort be approximately doubled ?

NOTE: The weekend events were referred to as 'field days' or 'trips' by the club. They were held over a 24 hour period, encompassing 2 half days : Saturday afternoon plus Sunday morning. The units of effort referred to in this report ('day' in the estuary and 'trip' in the ocean competition) are actually of equivalent duration (24 hours).

The key point is that these weekend events were of the same duration throughout the history of the club, and so provide a constant unit of effort used in the calculation of CPUE. The actual levels of effort are not important – we have used CPUE only as a relative index of abundance.

AGREED. ACTION: We have expanded the Methods Section to clarify these details: *"Weekend fishing events (referred to by the club as 'trips' or 'field days') were typically of a standard duration (~24 hours). The duration of weekend fishing events has remained constant throughout the history of the club."*

2) In Fig. 4.7, it is not clear what the scale for CPUE for herring is. Is the range in the number of herring / trip the same scale as the percentages?

AGREED. ACTION: Figure will be amended to make this clearer.

3) The authors point out the issue of high-grading at 'weigh-ins', thereby reducing the estimated CPUE. I'm wondering whether bag limits are adhered to only at 'weigh-ins'. If so, with the reduction in the self imposed bag limits, is there the possibility that the prevalence of high-grading has increased over time? This could result in the weigh-in CPUE's decreasing their usefulness as indicators of relative abundance in these fishing competitions.

AGREED: This club awards points for all fish caught, irrespective of size, which provides an incentive to retain all fish until the bag limit is reached. As illustrated in Fig 4.7, participants in the ocean competition almost never attained their bag limit. High-grading of herring is likely to have been very rare in the ocean competition and would have had a negligible impact on ocean CPUE trends. Self-imposed bag limits were much lower in the estuary competition and so high-grading may have had some constraining effect on the estuary CPUE.

4) It appears that the numbers of participants in the MAAC comps have slowly decreased over time. Is there any evidence that we are now left with relatively more highly skilled dedicated club fishers?

AGREED: This is possible although there is no evidence of it. Pember (2009) investigated this possibility by calculating the average CPUE of the 'top 5 fishers' during each year, i.e. those with the highest catches (not shown). The average CPUE of these more highly skilled fishers displayed a similar trend to the average CPUE of all fishers. This suggested that any change in skill level did not strongly influence the trend. However, if the average skill level of the membership did increase over time, then the decline in herring availability would be even greater than that implied by Fig 4.7.

Voluntary Recreational logbooks – Does the voluntary log book carry a picture ID of the more commonly caught species? I assume that the size differences between recreationally caught herring and salmon in WA differ greatly enough for most anglers to distinguish between the two. It is a major issue for SA anglers as undersized salmon are often the same size as herring. The only other species in WA which may be mis-identified as herring are juvenile tailor. Again this would not be a problem with the more highly skilled anglers who are voluntary log book recorders. So, some measure of the fish id skills by the volunteer may lead to improved data quality.

AGREED: This was a potential issue identified in the early stages of the logbook project and has been the focus of several recreational fishing guides (including photographs) distributed by the Department in previous years. Herring and tailor are reasonably distinct in appearance. We are unaware of any case of misidentification between these species by any recreational fishers. There could be some confusion among inexperienced recreational fishers in the identification of herring and young salmon. However, most logbook anglers are relatively experienced and are unlikely to mis-identify herring/salmon. As mentioned, the Department has put a considerable effort into communication to ensure this problem is avoided in recent years. Identification guides are regularly distributed by the Department of Fisheries to the general community via various media (newspaper, web, brochures, etc). Also the RAP logbook newsletter has previously included an ID guide on distinguishing between herring and juvenile salmon, with annotated photographs. In general, distinguishing between herring and juvenile salmon is part of the WA recreational fishing culture – recreational fishers in WA refer to juvenile salmon by the common name 'salmon trout' and they are recognised as distinct to herring. Overall, level of misidentification of these key species among logbook anglers is likely to be a negligible.

It is good that data from only the Perth shore-based "ocean fishery" volunteers are analysed, as inclusion of data from the boat and other areas (eg Rottnest Is), may confuse interpretation. Also, comparisons with RI's in the same area (eg Warnbro Sound), the other adjacent shore based recreational fisheries would be very meaningful.

AGREED: These comparisons were all considered and explored. Unfortunately the Warnbro Sound recruitment index was not considered robust due to extremely small sample sizes (an average of <1 fish per haul in most years). The reason for not including Warnbro Sound (i.e. lack of robustness) is mentioned in the Methods Section.

There is no similar type of data available from any other adjacent shore-based fishery for comparison with data provided by volunteer logbook fishers in the Perth region. The logbook is the only source of recent herring catch and effort data from the shore-based recreational fishing sector in WA.

For consistency in measuring average CPUE's over time by these fishers, it would be useful to use the same volunteers' sets of annual / monthly data. I'm uncertain whether this has been done in this analysis.

AGREED: We agree that consideration should be given to creating a 'standardised' set of consistent/regular fishers from which to calculate CPUE in future. In the initial analysis all available logbook catch and effort data was used, subject to meeting specified criteria. Although a substantial proportion of the data was provided by fishers who had a lengthy participation in the logbook program over the period examined, very few (n=4) had participated over the entire period (reflecting the fact that the RAP program was still in an establishment phase, with new fishers registering over the period examined). Thus the exclusion of new/infrequent fishers would have removed most of the data.

ACTION: At the reviewer's suggestion, we have also calculated an annual CPUE based on the catch and effort of the four logbook fishers who participated over the whole period (see below).

Results

Previous recreational fishing surveys – In Section 4.3.1, in dot point 6, discussing the SA recreational fishing survey in 2007/08 the second sentence is out of place as it is the same as the third sentence in dot point 3.

AGREED. ACTION: This is a typographic error. Sentence has been deleted.

West Coast Boat-based surveys – In para 2 of this section, the catch rates should be changed to 0.379 fish per boating hr etc.

AGREED. ACTION: The decimal place was missing from each number quoted in this paragraph. These typographic errors have been corrected.

MAAC ocean beach competitions. Interpretations are hampered due to the reduction in bag limits and possible impact on estimated CPUE's due to a possible increase in high grading (see above). I remain to be convinced that CPUE trends reflect changes in rel. abundance based on this set of data.

AGREED: It is now restated in the text of this section that changes in bag limits hamper the interpretation of these data – we also stated this limitation in the original report. However, as explained in response to the earlier comment, high grading of herring is likely to have been very rare in the ocean and would have had negligible impact on the ocean CPUE trend.

We agree that MAAC ocean CPUE is a qualitative indicator of trends in herring abundance. We have not attempted to use this data to quantify changes in abundance. However, given the dearth of historical information available to indicate trends in herring abundance along the west coast, we feel that this data does provide some important insights into long-term trends. For example, as stated in the report, "*During the 1980s, a bag limit of 50 Australian herring per fisher per trip was attained during 15–25% of trips. In contrast, a bag limit of 20 was attained during only 5–10% of trips during 2001–2006*." This type of evidence is consistent with anecdotal reports from club members and other recreational fishers that suggest a decrease in the availability of herring along the west coast over this period.

West Coast Vol. log books. Although monthly fishing effort for the Perth shore based voluntary fishers is provided in Fig. 4.8.a, some indication of numbers of anglers who participated each year, i.e. whether the same fishers provided information each year may assist in understanding whether there was any change in rel. skills of fishers over time. Number of fishers participating each year may also assist in understanding the year to fluctuations in effort. In addition to the stable annual CPUE for this group, the autumn /winter peak in CPUE appears stable, too.

AGREED. ACTION: We have provided the additional information about number of participants. Also, in response to the reviewer's suggestion, we have calculated a second version of logbook CPUE based on the catch and effort of a 'stable group' of regular fishers. This has then been compared with the trend in the original CPUE based on all logbook data. Figure 4.8 has been modified to include the extra CPUE information and the text modified accordingly.

Released catch – The authors suggest that the release rate of herring could be related to the spatial variation in average size of herring in the particular area. This is partly true, however, our limited data on lengths of released herring in 2007/08 (from our vol. rec. log books), suggest that release length frequencies are similar to those of the retained lengths; ie there is no preference for releasing smaller fish (in SA there is no min. legal length for herring). I'll expand on retained lengths later in this review.

AGREED: In WA, volunteer logbook data (see Figure 1 in Appendix 1) provides evidence that recreational fishers in WA are more likely to release small fish. Specifically, at total lengths of <20 cm, the rate of release increases with decreasing fish size. The recreational fishing survey in SA in 2007/8 indicated that fish caught were considerably smaller than those caught in WA, with about 50% of the catch <20 cm. The survey also found the release rate to be much higher than in WA. While we are unable to demonstrate the same motivation for discarding among SA recreational fishers, it seems plausible that more fish would be discarded in SA than in WA because SA fish are typically smaller. The average weight of individual retained fish estimated in the 2007/8 survey (155g) is quite large, much higher than that estimated to be retained in WA (125g), which suggests that some discarding of small fish is occurring.

Discussion

Long-term trends in herring availability in WCB – Regarding the trends in the MAAC Ocean CPUE's, until some information is available to say that the possible increase in high grading is not an issue, there is still some doubt in my mind on its usefulness as an indicator for herring availability in this region. The authors suggest these are only a qualitative indicator and I agree. The better long-term CPUE data may be the estuary MAAC and individual anglers (1 & 2) (Fig. 4.6) which is similar to the volunteer surveys (1995 – 2007) and the more recent vol. log books (2005 – 2010).

AGREED: This is being considered in future monitoring and assessment plans but is beyond the scope of the current project.

NOTE: As explained in response to an earlier comment, high-grading is not an issue in the MAAC ocean competition. High-grading was mentioned in the Methods section because it may be an issue in the MAAC estuary competition.

Summary – "should be #4.4.7"

AGREED. ACTION: This typographic error has been corrected.

6.4 Biology and Assessment of Herring

Introduction

In summarising the previous chapters, the authors mention that the recreational fishery's peak catches occur in Autumn/Winter. I believe peak catches may occur during summer months, when effort and recreational participation are at their highest, but peak CPUE's (herring vulnerability) occur in autumn/winter.

AGREED: The available data does suggest an equally high recreational catch level in summer as in autumn.

ACTION: The sentence referred to by the reviewer Section 5.1 has been modified as follows: *"Catch and effort in the recreational sector peaks during summer and autumn, encompassing pre- and post-spawning periods (see Section 4)."*

Mention is made on the reduced SA commercial catch since 2000. As mentioned in my review of the commercial fishery chapter, this is mainly due to reduced fishing effort, although the spikes in high targeted CPUE's in later years are slightly lower since the very high peaks in 1998 & 99.

AGREED. ACTION: We agree that declines in commercial catches in SA and the SCB may be partly due to declines in effort, which are a consequence of management (licence buy-backs, etc) and poor market demand (and we have inserted text into Section 3 to acknowledge this – see previous comment).

NOTE: Indeed, until recently we were willing to attribute almost all herring catch declines in the SCB to these factors. However, a more rigorous investigation of the evidence (this report) indicates that the decline is probably mainly recruitment-driven.

The relatively stable 'targeted CPUE' in SA has been used in recently SA assessments to suggest stable herring availability in this region (Fowler *et al.* 2011). However, for the reasons outlined in response to the reviewer's earlier comment on this issue, we are very sceptical that 'targeted CPUE' in the multi-species netting fisheries in SA provides a meaningful index of herring availability.

In this introduction, mention should be made about the attempt in developing an age-structured spatial model of the herring fishery in WA and SA (Wise & Hall, in Ayvazian *et al.* 2000), pointing out the uncertainties associated with the model, and reasons why it hasn't been updated in this latest stock assessment. With these more recent sets of data now available it may be worth pursuing, as you may eventually be able to estimate and compare current spawning stock size (SSS) with unfished SSS.

AGREED. ACTION: We have now included information about this earlier model and why it was not applied in the current study. We have inserted into Introduction (Section 5.1): *"An age-structured population dynamics model was previously developed to assess the stock status of Australian herring (Wise and Hall 2000). This model required numerous assumptions to overcome the gaps in knowledge that existed at that time, including information about stock structure, biological parameters and recreational catch levels. The model output was inconclusive and it was subsequently recognised that knowledge gaps would need to be addressed and a new model structure would be required before a modelling approach could again be applied (B. Wise pers. comm.)."*

We have inserted into Discussion (Section 5.4.10): *"This study has successfully determined the key biological parameters for Australian herring and substantially advanced our understanding of population structure. However, there still remain significant gaps in knowledge about recreational catch levels and the extent of connectivity between regions and the absence of a long-term index of spawning stock abundance that would enable the development of an age-structured population dynamics model. Future research should be focused on addressing these issues."*

Reasons for not undertaking yield per recruit modelling could also be discussed.

AGREE: Per recruit modelling was undertaken for herring but not included in the report.

ACTION: We have now included results from yield-per-recruit and egg-per-recruit models. These results do not alter the stock status. These results provide further support for our assessment of stock status.

Materials and methods

Validation of length frequencies derived from sample frames donated from recreational fishers could be done using measurements of fish collected from dept. based recreational on-site surveys.

AGREED. This was done in regions where comparative data was available. The length structure of donated frames was compared with length data from on-site surveys and volunteer logbooks in Appendix 1.

Appendix 1 states, "*The length composition of the Australian herring retained by WCB shore-based logbook fishers was almost identical to that of herring measured during recreational fishing surveys and of donated frames (Section 5). Samples of herring donated by recreational fishers in the Perth region from 2009 to 2011 indicated a normal distribution, with an average length of 23 cm and a range of approximately 19 to 27 cm (Fig. 5.3e in Section 5). A recent on-site survey in the Perth region also indicated that the lengths of shore-caught Australian herring are approximately normally distributed with a median length of 23 cm TL (Smallwood et al. 2011a)."*

ACTION: Text was added stating the similarity in length data between the various surveys mentioned above: *"The mean length of the WCB recreational Metropolitan Zone catch was 230 mm (Fig 5.3). This mean length is exactly the same as that observed in recent shore-based surveys (Smallwood et al. 2011a) and from recreational angler logbooks (Appendix 1)."*

Natural mortality (M) – A possible method of verifying M, may be to find out if there are any angling clubs' record size figures near the beginning of the fishery, then applying a growth equation and estimating max. age when fishing mortality was relatively low.

AGREED: This is something that has been achieved for other species in other jurisdictions and was considered during the project. Unfortunately this method cannot be applied to Australian herring, due to the asymptotic growth curve. Specifically, there is a minimal increase in length after 4 years, such that length cannot be used to predict age among fish aged 4 y or older. For example, the largest ocean caught female recorded by the DoF was 355 mm TL with an age of 6.95 yrs, whilst the oldest female, at 10.5 yrs, was 315 mm TL.

Biological reference points – I personally believe that the limit BRP (2M) is too high and could be reduced to 1.5M, in line with the more precautionary 2/3M for target BRP.

AGREED: The selection of appropriate reference levels is a difficult issue and has generated much discussion within our Department and the broader scientific community. A limit reference point of 1.5M for this species was initially considered, to be consistent with the limit reference points previously applied to demersal species in WA. However, we adjusted the limit for herring upwards to 2M because we believed this shorter-lived species was probably not as vulnerable as a long-lived demersal species. On the other hand, the outputs of yield-per-recruit and egg-per-recruit analyses (which have been included in the report in response to the reviewers suggestion) support the selection of 1.5M as a suitable limit reference point for herring, despite its inherently lower vulnerability. We have adjusted the limit reference point for herring downwards to 1.5M. This has not altered the stock status – the current F level is still above the limit reference point.

Results

Length and age structures – When reporting on the age structures, it would have been useful to assign spawning years to the ages. For example, in Figs. 5.12 & 5.13.

AGREED. ACTION: We have assigned spawning years to the age classes in these two figures and inserted an additional sentence in Results Section that refers to this additional information.

For example, in Figs. 5.12 & 5.13, for the WCB, there appears to be the passage of a relatively strong year class in winter, 2009 (seen as 2^+ fish) through to winter, 2011 (seen as 4^+ fish), and a weaker one immediately afterwards. Based on the growth rate data of juveniles and later information in this chapter on age-at-1^{st} maturity for WCB females, does this mean that the 2^+ fish observed in winter, 2009, would have come from the 2006 spawning year, ie just beginning their 3^{rd} of life ? If so, it fits in with the slightly higher RI observed in Warnbro Sound in that year. If not, I've mis-interpreted the spawning years, or the Warnbro Sound RI doesn't match the strong year class observed in the fishery. Any comments?

AGREED: The strong year class to which the reviewer refers was spawned in 2007 and is beginning their 3rd year of life in winter 2009. The dominance of this year class in WCB fishery landings can be seen in Figures 5.12 and 5.13.

NOTE: There is no evidence from our available recruitment indices of strong 0+ recruitment in this year.

Spawning Period – Although the sample size for females along the SC in June was small (n = 4), and no sign of any females in spawning condition in this region beforehand, it almost indicates to me some sort of a back-run of spent females took place from the WCB to the SC in June, 2009 – 2011. This was not apparent in 1996 – 99 with larger sample sizes (Fairclough *et al.* in Ayvazian *et al.* 2000). Any comments?

NOTE: All available evidence, including tagging studies and many decades of observation by commercial fishers, indicates that a 'back run' (i.e. a reverse migration from the West Coast to the South Coast) does not occur in herring.

It is possible that a low level of spawning does occur along the south coast, particularly at the western end. Alternatively, these stage 7 and 8 fish may have been in the process of resorbing their gonads after failing to spawn. We also note that the sample size is too small to support any biological interpretation.

Discussion

Representative samples – Mention is made of the 110 recreational fishers who voluntarily provided frames; however, see p. 121, which mentions that the bulk of the samples came from a small number of volunteers.

AGREED: In Results (Section 5.3.1) we previously stated, *"More than 110 recreational anglers donated frames of Australian herring in 2009–11, although a small number of anglers provided most of the frames."* Specifically, a total of 116 fishers donated a total of 4,532 herring samples, with 48% of these frames donated by 10 fishers. However, the corollary of this is that a relatively large sample (n=2,363), representing 52% of frames, were donated by 106 fishers. Also, anglers who did not provide a name donated a large number of samples, and while location and date was provided, these samples were assigned to the 'other' category for donations. This group, counted as just one person for this tally, donated 406 herring (or 9%) from numerous locations and dates, and is likely to comprise many anglers.

Overall, we believe that the number of fishers was sufficient to provide a representative sample of the recreational catch in each zone. The representativeness of these donated frames has been verified by comparison with the length composition of herring reported by volunteer logbook fishers and observed during onsite recreational fishing surveys (see Appendix 1).

ACTION: In Results (Section 5.3.1) we have deleted the above sentence and replaced it with, *"In 2009–11, more than 116 recreational fishers donated a total of 4,532 herring samples. The representativeness of these donated frames was verified by comparison with the length composition of herring reported by volunteer logbook fishers and observed during onsite recreational fishing surveys (see Appendix 1)."*

Growth – The hypothesis that reduced growth rates are due to warmer temperatures goes against the observation that over the whole distribution of herring from WA to at least SA, it appears that growth rate increases as water temperature increases (see Fairclough *et al.* in Ayvazian *et al.* 2000, p. 37, Fig. 2.2.).

AGREED: This is also our belief however we have attempted to present all possibilities.

ACTION: We have re-written this section to present a more coherent argument.

"*A decrease in growth could be caused by high levels of fishing mortality and the removal of fast growing individuals (Neuheimer and Taggart 2010) or by environmental changes (Enberg et al. 2012). Temperature and salinity in shelf waters of the WCB have followed a warming trend over the past 5 decades, although it is unclear whether the magnitude of change (e.g. 0.6–1.0 ºC) is biologically significant (Pearce and Feng 2007). A decline in growth rate in response to increasing temperatures is inconsistent with the observed higher growth of both sexes in the WCB compared to the SCB, suggesting faster growth occurs in more northern (and warmer) waters."*

Spawning – See my previous comments above, about duration of spawning season. You also may like to mention the possible presence of a back-run of spent fish to the SC in the last few years.

AGREED: We have modified the text in this section to acknowledge the possibility of a low level of spawning occurring in the SCB. As discussed above, there is no evidence of a 'back-run' in this species.

Sex ratio – The hypothesis that females are more aggressive feeders, taking baited hooks more avidly than males can successfully be tested by the observation of highest CPUE's during the spawning period, although the overall higher female: male ratios in most of the fisheries in the rest of the year may be due to females generally in areas where the fisheries occur. We still see it in the SCB commercial fisheries – is this from the trap fishery or the inlet fisheries? If it's the trap fishery, the differential spatial distribution of females : males is the reason (males further offshore?) There again the overall high female : male sex ratio might just be a natural biological characteristic for this species – any evidence with Australian salmon?

AGREED: There are numerous potential reasons, which are outlined in the Discussion (Section 5.4.5), for the bias towards females. However, despite spending a considerable amount of time pondering this question, we have been unable to draw any conclusions about which factor(s) are responsible for the bias in each fishery.

ACTION: As suggested by the reviewer, it may simply be a biological characteristic of this species. We have inserted this suggestion at the end of Section 5.4.5, as follows, *"Alternatively, female dominance may be a natural characteristic of Australian herring populations."*

Juvenile retention – The need to reduce the juvenile catch (ie allow more fish to recruit to spawning aggregations) is certainly required, however, the example given to the work by Robinson *et al.* (2011) on the Seychelles trap fishery, is not a good one.

AGREED. ACTION: The original reference has been deleted and replaced with a more appropriate one. This paragraph has also been re-written, as follows, *"Despite such uncertainties, it is clear that juvenile fish are a substantial component of the national catch of Australian herring. When coupled with the high level of mortality currently being experienced by the stock, the harvest of juveniles increases the risk of recruitment overfishing by reducing spawning biomass and yield, thereby increasing the risk of stock collapse (Enberg 2005). Reducing the proportion of juveniles in the catch should be considered as a future management target. In some fisheries, a reduced harvest of juvenile fish may be more beneficial to the sustainability of the stock than the protection of spawning adults (Pelletier and Magal 1996)."*

Mortality – The probability that M has increased due to increased predation by Australian salmon after the pilchard mortality events (1995 and 1998) is feasible; however, more recent stock assessments on the SC pilchard fishery suggest that the pilchard spawning biomass at Albany /Bremer Bay in 2002 (WA State of the Fisheries Report 2002/03) is at the stage of recovering. Is there any anecdotal information from the commercial salmon fishers in more recent years of a shift back to pilchards in this area?

AGREED. ACTION: We have inserted a sentence into Section 5.4.8 to note that the pilchard stock has since recovered.

NOTE: Unfortunately we have no quantitative dietary information for salmon and so the effect on herring cannot currently be assessed.

Recent research on the diet of NZ fur seals along the southern Fleurieu Peninsula coast of SA in 2006, reported yellow-eye mullet as the main teleost species in their diet; "tommy rough" were not found, but, small numbers of herring were reported in the diet of little penguins living in the same areas as the fur seals (Bool *et al.* 2007). Has there been any dietary studies on fur seals in WA?

AGREED. ACTION: A dietary study of fur seals in WA has just been completed (Hara 2012). In Discussion (Section 5.4.8) we have inserted a reference to this study, which found a negligible amount (<1%) of Australian herring in the diet.

Stock assessment – In the last paragraph in this section, I would also add that the WCB recreational pre-spawning catch is also relatively high (see Fig. 4.9).

AGREED. ACTION: We have inserted a reference to the recreational catch in this sentence.

6.5 General Discussion and Implications (Herring)

Summary of stock status

Fishery Catch Rates – It should be pointed out that the commercial fisheries in SC trap and SA, don't represent the entire population of herring in the areas where they are fished (due to gear and spatial restrictions), and that the recreational fishery probably provides a better indication of the population structure – certainly in SA (see Appendix 1).

AGREED: We have inserted into Section 6.4 the following, *"The WCB hosts the Australian herring spawning stock and so catch rates in this bioregion are likely to provide a better index of adult stock abundance than those in the SCB or SA."*

My concern with the MAAC catch rates being influenced by reduced bag limits, and potentially causing increased high grading at weigh-ins, adds to my lowered confidence in this set of data to as an indicator of abundance in the WCB.

AGREED: As explained above, we agree that changes in bag limits hamper the interpretation of this data. However, high grading of herring is likely to have been very rare in the ocean and would have had negligible impact on the ocean CPUE trend.

Fishery Catch Composition – There is not good evidence for rising water temperature influencing size at 1st maturity, and I would therefore consider higher fishing pressure would be more important.

AGREED. There is no direct evidence of water temperature affecting maturity. However, we can't exclude the possibility that there may be some as yet unidentified environmental factors that have altered growth patterns.

ACTION: In Section 6.2 we have removed the reference to water temperature and instead referred more generally to "environmental factors" as follows, *"The significance of an apparent decline in the length-at-maturity is unclear but could represent impacts of high exploitation and/or shifts in growth and maturity in response to environmental factors."*

6.6 Tailor Recruitment Dynamics

Methods

Seine nets – It appears the sampling sites in the WCB for tailor, with the exception of Bunbury (Koombana Bay), differ. Pinnaroo for tailor and Warnbro Sound for herring. I'm assuming that the respective sites were chosen to reflect consistently highest numbers of newly settled fish of the particular species. Do different habitat characteristics at these respective sites influence the differing recruitment rates for the respective species?

AGREED: The optimal sites and sampling times for monitoring of recruitment were determined during a previous project (Gaughan *et al*. 2006). High catch rates were an important factor used by this project to select sites and sampling times for each species. Slight differences in the characteristics of each site presumably do influence the abundance of fish of each species although biologically significant differences are difficult to identify. For example, Pinnaroo and Warnbro Sound appear to be relatively similar habitats (in terms of wave energy, orientation, vegetation, etc), yet tailor is consistent more abundant at Pinnaroo.

Volunteer Angling – As the fish caught were mostly under the MLL, you mention that all fish were released. Do you think there's an issue with potential recapture of released fish, therefore, artificially increasing CPUE's? However, as this was done consistently, I don't think it should affect the year to year variation.

AGREED: There is always the potential to recapture recently released fish. However, this issue was investigated in the mid-1990s by Young *et al*. (1999), who caught and tagged 2,933 tailor at Point Walter (Swan-Canning Estuary). A total of 50 tagged fish (1.7%) were recaptured within the estuary, although only 17 fish (0.8%) were recaptured at Point Walter (Young *et al*. 1999[3], DoF unpubl. data). All recaptures occurred within a year of tagging. Additional tagging was also conducted at Point Walter during 2006–09. A total of 289 tailor were tagged during this period and no fish were recaptured (DoF unpublished data). These results indicate that the probability of recapture is very low. In addition, all tailor caught by volunteers are examined by research staff for evidence of recent hooking injuries. The absence of such injuries suggests that there are no short-term (within the same day) recaptures of fish.

Results

Seine netting – Overall, the average catch rates of newly recruited tailor appear to be quite low at all sites (at least in comparison with herring and salmon), suggesting to me that either a) tailor recruit to coastal WCB and GCB in small numbers throughout their distribution range, a result of their temporally widespread spawning period, or b) the sampling sites were relatively poor representatives of the optimum habitat that 0 gp tailor recruit to. Is there any evidence from other studies along the Atlantic US or eastern Australian coast?

AGREED: The abundance and/or density of 0+ tailor in these sheltered inshore nursery sites is typically lower than herring or salmon. A smaller stock size of tailor is probably a contributing factor. However, the greater mobility and shorter residency by tailor is also probably important – we believe that tailor spend relatively short periods (up to a few weeks)

3 Young GC, Wise BS and Ayvazian SG. 1999. A tagging study on tailor (*Pomatomus saltatrix*) in Western Australian waters: their movement, exploitation, growth and mortality. Marine and Freshwater Research 50:633-642.

in these nursery habitats because they grow very rapidly and quickly move to other sites more suitable for larger juveniles. In contrast, herring appear to remain at these sites for at least a year. This accumulation of 0+ herring at each site, along with their strong schooling behaviour, results in high catch rates.

Catch rates of tailor in eastern Australia are also typically low. Some studies in the US have achieved higher catch rates of tailor, which probably reflects a stock abundance that is 1–2 orders of magnitude larger than WA.

There appears to have been no attempt to correlate recruitment indices from the seine netting with the environmental variables. As these fish are younger than the voluntary angled fish, it's possible that a clearer linkage between environmental variables and netted fish may appear.

AGREED: We considered correlating tailor recruitment indices derived from seine netting with environmental variables using a similar approach to that taken with herring. However, as noted in the previous comment, the catch rates of 0+ tailor during seine netting were extremely low and we believe these are unlikely to provide robust annual indices of recruitment. Due to concerns about the quality of the indices, and several missing years of data, we did not examine linkages with environmental variables.

Voluntary angling – Although IOD tracks water temperature in eastern and western Indian Ocean, I always thought that IOD is more of a predictor of rainfall across southern Australia, including SW WA. Thus, it could indirectly reflect Swan River chemistry, and may not necessarily reflect larval tailor transport mechanisms, hence the non-significance between IOD and Gp 1 or 2 indices.

AGREED: The Indian Ocean Dipole (IOD) is simply another index of large scale climatic/oceanographic condition, like Fremantle sea level (FSL, index of Leeuwin Current strength) and the Southern Oscillation Index (SOI). There is some preliminary research suggesting that currents and winds off south-western Australia might be related to IOD, as well as rainfall in southern Australia.

Discussion

In contrast to herring, relative abundances of newly settled tailor appear quite low at all netting sites in all sampling years. Is this a function of the extended spawning season for tailor, with no clearly defined nursery areas? Has there been any work done on the diet of newly settled tailor at sites such as Bunbury? The sizes of tailor during winter months at this site (Fig. 2.5) may be conducive for them to prey on smaller newly settled herring (June – Aug) at the same site.

AGREED: The reasons for the very low catch rates of tailor are discussed in response to the earlier comment on this issue (see above). There have been no studies of local juvenile tailor diet, but it is conceivable that larger juveniles consume herring. In June–August, the typical size of 0+ tailor (60 – 80 mm) in samples from Bunbury is only marginally larger than the typical size of 0+ herring (30 – 70 mm), and so these fish are unlikely to be predating on herring.

I found it difficult to link the sizes of newly settled tailor at Perth (Fig. 2.4) with the sizes of fish caught by the voluntary anglers in the Swan-Canning estuary, and the only reasons I could come up with were due to a) hook size selectivity by the voluntary anglers, or b) change in the preferred diet at about 150 mm to fish (whitebait used as bait).

AGREED: The two cohorts or 'pulses' of recruitment that are evident from the lengths of older juveniles from the Swan Estuary (Table 2.1 and Fig. 2.2) are not evident from the lengths of young juveniles in Figure 2.4. Therefore, these two figures alone cannot be used to deduce a link. It is only when the estimated birth dates of young juveniles and older juveniles are compared that a link becomes clear. Both have birth dates that group into two main periods – winter and summer.

I would have liked to have seen some work done on correlation between environmental parameters (FSL etc) and newly settled netted tailor.

AGREED: (see above comments). The catch rates of 0+ tailor during seine netting were extremely low and we believe these are unlikely to provide robust annual indices of recruitment. Due to concerns about the quality of the indices, and several missing years of data, we did not examine linkages with environmental variables.

6.7 Tailor Commercial Fishery

I would be interested to know whether the commercial fishery data collected by ABS up to the mid 1970's was from voluntary or compulsory reporting. In SA, our ABS catch data was from voluntary reporting in our MSF fishery up to 1975/76, and probably under-estimated commercial harvest levels at the time. Also, the shift to more detailed CAES records in the late 1980's, highlighting the awareness amongst fishers to report more accurately (correctly?), may have caused the rise in catches about this time. Were any commercial management proposals relating to tailor mooted about this time, increasing the possibility that commercial fishers over-, or more accurately reported their catches? I've seen this occur in other fisheries. It's good to see the CPUE analysis of the GCB fishery based on selected vessels.

AGREED: In WA, commercial catch and effort returns have been compulsory since 1941. Unlike for herring, which was taken by some fishers as bait and therefore not included in returns, there is no evidence of historical underreporting of catches of tailor in data prior to 1975. Apart from the issues already mentioned in the report, we are unaware of any other management-related factors that may have affected the reported catch level of tailor.

The lagged negative correlations between SOI, FSL and the GCB CPUE, and the inference that high CPUE's in the 1990's were related to suitable tailor reproduction can be enhanced with the relatively high RI's at Perth and Bunbury during those years.

AGREED. ACTION: We have inserted into Section 3.4, *"High spawning stock levels in the GCB in the 1990s may have contributed to the high levels of recruitment to the Perth area by winter-spawned juveniles in 1996 and 1997 (see Fig. 2.9 in Section 2). These winter-spawned juveniles were probably spawned in the GCB or northern zone of the WCB (see Section 2)."*

I look forward to seeing the completed 2011 Peel/Harvey catch and effort data. As it is, the large 2011 CPUE may be related to the rel. high RI's at Bunbury in 2010/11? Any data on size/age composition for this fishery?

AGREED. ACTION: The 2011/12 Peel-Harvey data in Figures 3.6 and 3.7 have been updated. This did not alter the CPUE trends. We have no recent (i.e. post-2000) data regarding size/age composition of commercial landings of tailor in the Peel-Harvey estuary. We aim to obtain this information in future.

6.8 Tailor Recreational Fishery

Is there any targeted fishing in the WA charter boat fishery, and are there any data from this fishery to assist in future assessments?

AGREED: We considered this and searched the database. However, the charter boat fishery in WA does not capture tailor (Telfer 2010[4]).

ACTION: Have added the above statement to this chapter.

Results

Regarding the high estimate of the total rec harvest in 2000/01 from the NRIFS, the authors consider that it may be an over-estimate. Lyle *et al.* (2010) have developed an enhanced method to analyse the data from this survey, taking into account issues about drop-in/drop-out rates. We've re-analysed our SA 2000/01 survey data (see page 57 of my survey report; Jones, 2009), so a similar exercise may be possible for the WA NRIFS data set. Karina Ryan may be able to assist you there.

AGREED. ACTION: This re-analysis has been planned by the Department. Data from all previous recreational surveys in WA will be re-analysed using a standard approach. This is beyond the scope of the current project.

The other issue, is that other boat- and shore-based surveys undertaken during the 1990's and 2000's admit that their estimates may be slightly under-estimated, due to surveys not being undertaken after dark (eg, see Sumner *et al.* 2008). As we know that tailor can be caught after dusk (voluntary anglers in the Swan-Canning survey), the "after-dusk" catch could be a factor in underestimated on-site surveyed catches. The truer estimate may therefore be somewhere between the phone-dairy and the on-site estimates. I would certainly not disregard the 2000/01 total catch estimate at this stage, as it's the only available one you have. The best available information.

AGREED: This issue has been discussed at length within the Department.

ACTION: We have modified the text and inserted a sentence into Results (Section 4.3.1) to acknowledge this, as follows, *"The estimates of the annual WCB boat-based catch of tailor derived from on-site surveys were substantially lower than that estimated by the 2000/01 phone survey. The onsite surveys may have underestimated tailor landings because they were conducted during daylight hours (9am to 5pm) and did not included night-time catches. The difference in estimated catch is probably also an artefact of differences in the survey method. Problems with the phone survey methodology have been identified (Lyle et al. 2010). Comparison with other surveys suggests that a total catch of 187 t in 2000/01 was a substantial over-estimate (Henry and Lyle 2003). The results of onsite surveys suggest that the actual catch may have been as little as 8 – 37% of this value."*

Discussion

Summary – Caption for figure 4.3 should be catch and effort, not catch rates. Also shore based diary angler 3 and boat based angler 4 should be c) and d), respectively.

AGREED. ACTION: The caption has been corrected.

4 Telfer C. 2010. The Western Australian charter boat industry: working towards long-term sustainability. Unpubl. MSc thesis. Edith Cowan University, Perth.

6.9 Biology and Assessment of Tailor

Introduction

Reference is made of tailor found as far as the WA/SA border (Gomon *et al.* 2008). This is incorrect as Gomon *et al.* (2008) shows the distribution of tailor from mid coast of WA, throughout southern Australia and into southern Queensland.

AGREED: The distribution of tailor extends further east than the WA/SA border. The sentence refers only to the distribution within WA. The previous sentence lists the worldwide distribution of tailor, including the eastern and western coasts of Australia. However, this paragraph on tailor distribution has now been removed from Section 5.1 and the distribution of tailor can be found in section 2.1.

There is mention that the WA recreational catch of tailor in the 1980's and 1990's was of the order of 500 – 1,000 tonnes (Lenanton *et al.* 1996). This is the first reference to this figure and should be put in the context with the NRIFS harvest estimate of 187 tonnes in 2000/01. This should be discussed in the chapter on the recreational fishery.

AGREED: While a correct citation of the reference, it is now believed that the preliminary figure presented in Lenanton *et al*. (1996) is incorrect. We were not able to find any evidence to verify this catch estimate. Using survey data from the time (see Section 4), our 'best guesses' suggest annual recreational catches during the 1990s were an order of magnitude lower than this.

ACTION: We have removed the reference to Lenanton *et al*. (1996) and re-written the paragraph. It is now contains information consistent with recreational catch estimates quoted in Section 4.

Methods

If commercial fishery data are going to be used in future assessments of this fishery, sampling of size and age composition of harvested numbers is required. The current information on the biology has only come from the recreational fishery, and therefore, gaps in biology in places like the GCB are apparent. Also, as rec fishers often only provide frames, length/weight data are minimal.

AGREED: We lack information about the current age/length structure of tailor landings in the GCB commercial fishery. This is a knowledge gap that adds uncertainty to our assessment of the stock.

NOTE: We do have some length-weight data which was not presented in this report. Length-weight relationships will be included in a biological synopsis on tailor that is currently being prepared and due for publication in 2013. The synopsis, which also includes information on Australian herring, will be a companion report to the stock assessment report.

Methods for estimating mortalities and yield and eggs per recruit are acceptable for this species. However, there's a need to mention that the YPR and EPR models assume constant recruitment – something which appears to not occur for tailor.

AGREED. ACTION: We have inserted into Section 5.4.3, *"The YPR and EPR analyses are based on an assumption of constant annual recruitment, which is clearly not the case for tailor (Section 2). Variable recruitment is characteristic of many fish species and is a common source of uncertainty when conducting per recruit analyses."*

Results

Juvenile and adult age and growth – As mentioned previously, it would have been good to provide an age/length graph linking juvenile and adult growth (ie Perth sampled new recruits and the Swan-Canning juvenile fish).

AGREED. ACTION: A graph (see Figure 5.8) containing the raw age-length data for both juveniles and adults, with an average growth curve superimposed, has now been included.

Is the truncation in size composition from the 1990's to 2009/10 also due to the implementation and reduction in the max size limit?

AGREED: Yes, the introduction of a maximum size limit in 2003 may have contributed to the truncation of the length distribution of samples from the Metropolitan Zone in 2009 – 10. However, lengths of retained and released fish reported by volunteer logbook fishers in the WCB (many of whom fish in the metropolitan zone) indicate that a negligible number of fish >500 mm have been taken in recent years (Fig. 4.4). This suggests that, even in the absence of the maximum size limit, the 2009 – 10 length distribution would be truncated. These issues are discussed in Section 5.4.

Mortality – The total mortality estimates are clearly dependent on the presence or otherwise of the single 10 yr old fish and the small sample sizes in the southern and northern parts of the WCB. Your most certain estimates could be from the mid-west and metro parts and an overall estimate based on these 469 fish might be the way to go. Also, as the single 10 yr old fish came from the SW region, with the small sample size, I would leave out the SW and Kalbarri fish. The total mortality rates may be over-estimated, as sampling was biased towards the smaller shore based recreational caught fish.

AGREED: At the reviewer's suggestion, we have used various combinations of samples to calculate five different values of F. This includes samples with/without the single 10 y old fish. It also includes a sample based on metro/mid-west fish only, although we believe this results in an overestimate of F and the sample based on fish collected in all zones yields a more realistic (lower) value of F.

ACTION: Figure 5.16 has been modified to illustrate all five of the F estimates.

NOTE: The available evidence (including that presented in Section 4 and a large number of anecdotal reports from recreational fishers) indicates a net northward migration of tailor along the WA coast, resulting in a higher proportion of larger/older fish in the Kalbarri Zone and the Gascoyne Coast Bioregion. These northern areas are believed to host a significant proportion of the breeding stock. It is therefore appropriate to include the Kalbarri sample in the catch curve analysis. The inclusion of older fish in the Kalbarri sample partly compensates for the under-sampling of older fish in offshore areas of the Metro and mid-west zones. Mortality calculated from the Metro/Mid-west age structure alone is almost certainly an overestimate.

The age structure in the South-west Zone is more difficult to interpret because of our limited understanding of the stock structure. We agree that it may be appropriate to exclude South-west Zone samples until we can resolve this uncertainty.

6.10 General discussion and implications (Tailor)

The current view is that commercial and recreational catches are of a similar magnitude. Based on catch data from previous years, the recreational share appears to have dropped. Reported annual recreational catches of 500 – 1,000 t in the 1980's – early 90's (Lenanton *et al.* 1996) and approx. 50 t for the commercial sector during the same period.

AGREED: The available evidence suggests that the recreational catch level has dropped, perhaps substantially, but it is impossible to quantify this decline because there are no reliable catch estimates for tailor, either historically or recently. The citing of a preliminary catch estimate of 500 – 1000 t by Lenanton *et al*. (1996) in Section 5 was an error and has now been removed (see response to earlier comment). The catch level at that time is unknown but we believe it was probably an order of magnitude lower than that cited by Lenanton *et al*. (1996). The recreational catch share may not have changed greatly, because the commercial catches in the WCB have been reduced due to a managed reduction in commercial fishing effort.

Summary of stock status

Recruitment – The statement on recent improvement in recruitment stems from the Swan-Canning volunteer angler surveys and the Peel Harvey commercial fishery data. However, the seine netting surveys don't quite show this. It appears that with the exception of the Bunbury Jan – May data set, all other ones, show either similar or reduced recruitment in recent years. Some explanation on the divergence of these results would assist.

AGREED: It was mentioned in the Results (see end of Section 2.3.1) that we considered the seine netting catch rate to be a unreliable measure of tailor abundance due to low catch rates, high variability within years and missing data. However, we agree that a clearer statement is need to explain that we rejected the seine netting as an index of recruitment for these reasons, and that our recruitment index is based on the volunteer angling catch rate.

ACTION: We have inserted in Section 2.4 (Discussion: Annual trends in recruitment and implications for stock status), *"Seine netting catch rates of tailor are relatively low (<20 fish/month) and display high variability within years. The seine netting program also suffers from multiple years of missing data. For these reasons, seine netting does not provide a reliable index of recruitment for tailor. In contrast, volunteer angling catch rates of tailor are very high (up to 800 fish/month) and display relatively low variability within years. Thus, volunteer angling catch rates have been used to indicate trends in annual recruitment of tailor since this program commenced in 1996."*

Summary – Agreed, however, my only proviso is the need to explain the divergence between the netted recruitment indices and the volunteer angler derived recruitment indices.

AGREED: See response to previous comment.

Future monitoring and assessment

Agree that the current Swan-Canning volunteer angler survey is currently the best indicator of recruitment index for the Metro WCB region. If the newly recruited netting surveys at Carnarvon, Perth and Bunbury are maintained, some investigation of the relationship between these RI's and the Volunteer angler RI's needs to be reconciled. If this isn't done, there seems to be no need for maintaining these nettings surveys. Volunteer angler surveys at other sites may need to be undertaken to confirm the present observed increase in recruitment strength.

AGREED: The usefulness of the current sampling regime will be reviewed when the result of the stock status report and proposed sampling are presented to and discussed with management. However, the netting surveys capture dozens of species (including juvenile herring, whiting, salmon, mullet). Although not particularly efficient at capturing tailor, the netting surveys are likely to be maintained because they provide valuable information on many other species, e.g. the recruitment index for herring.

7.0 Comment on the response

Comment on the Department of Fisheries, WA response to the review of "Status of nearshore finfish stocks in south-western Western Australia: Australian herring and tailor" Smith *et al*. 2012.

by Keith Jones, Sillago Research Pty Ltd for the Department of Fisheries, Western Australia.

The authors have responded to all the issues raised in my review of the report and I have fully accepted all their responses.

I consider that the revised report contains the best available information on the status and biology of the two species for the south-western Western Australian region and is appropriate for the IFM process.

Finally, it is pleasing to note, that the publication of the review and associated responses ensure full transparency in the fisheries assessment process.

G.K. Jones

SILLAGO RESEARCH PTY LTD

25 Coppin Street, Glengowrie, South Australia 5044

Ph: 08 82955625, Mob: 0439295990

Email: docjones@bigpond.net.au