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Fisher survey of muscle melanisation in Sand Flathead (*Platycephalus bassensis*)

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EXECUTIVE SUMMARY

Flathead are an important component of Tasmania's recreational and commercial fisheries, with flathead accounting for more than 60% of the total recreational finfish catch by numbers taken. While several species of flathead are taken in Tasmanian waters, Sand Flathead (*Platycephalus bassensis*) alone represents more than 90% all flathead caught by recreational fishers.

Reports of black pigmentation in the usually white fillets of Sand Flathead have been common for many years and is due to a phenomenon known as melanisation. Most commonly melanisation occurs when the naturally occurring pigment melanin becomes concentrated in small areas of the body.

In an effort to connect the practical knowledge of the Tasmanian recreational fishing community with the current scientific understanding of muscle melanisation in Sand Flathead, the Institute for Marine and Antarctic Studies conducted an on-line questionnaire-based survey of recreational fishers during 2018. A total of 437 completed surveys were received, of which 95% indicated that respondents had observed areas of blackened muscle in their catches, with the vast majority (99%) having observed the phenomenon in Sand Flathead. A small number of respondents (8%) also reported having observed melanisation in other Tasmanian fish species, including Tiger Flathead, Jackass Morwong, and Bastard Trumpeter, although this has yet to be confirmed.

Based on locations where fishers had observed muscle melanisation in Sand Flathead, a total of 225 locations across Tasmania were identified, suggesting that the phenomenon is geographically widespread. However, 37 locations in particular attracted multiple reports and confirm that the phenomenon is relatively common within the Tamar River and areas of south-eastern Tasmania, including the Derwent Estuary, D'Entrecasteaux Channel, Norfolk-Frederick Henry Bays and the Tasman Peninsula. Furthermore, four locations of specific interest were identified as having a particularly high proportion of affected Sand Flathead, with "extensive" (large) areas of melanisation in some fillets and/or an apparent increase in the incidence of melanisation in recent years. These locations included: Bell Bay (Tamar), Carnarvon Bay (Tasman Peninsula), Simpsons Bay (D'Entrecasteaux Channel) and Southport.

Although the cause and origin of muscle melanisation in Sand Flathead remains elusive at this stage, a variety of avenues for future research have been established, including continued investigation into heavy metals, type of melanin present, site specificity and environmental histories and conditions in locations where melanisation had been observed.

INTRODUCTION

In Tasmania, flathead (fam *Platycephalidae*) account for 61% of the total recreational finfish catch by numbers, of which almost 90% are Sand Flathead (*Platycephalus bassensis*) (Lyle *et al.*, 2014). Sand Flathead is a benthic species found over sandy and muddy substrata throughout Tasmania's coastal and inshore waters (Jordan, 2001; Bani *et al.*, 2009). The species is iconic and highly targeted by the Tasmanian recreational fishing community (Frijlink and Lyle, 2013). There have been persistent inquiries over many years from recreational fishers regarding the presence of blackened spots in the fillets of Sand Flathead (Fig. 1), in particular regarding its cause and implications for human health if consumed.



Fig. 1. Fillets showing muscle melanisation from a Sand Flathead caught at Deceitful Cove, Tamar River. (From Ware, 2015)

Dark pigmented areas in the usually white fillets of Sand Flathead is a phenomenon known as muscle melanisation. Similar examples of muscle melanisation have been recorded in various northern hemisphere fish species, for example in Atlantic cod (*Gadus morhua*) (Cooper *et al.*, 2011), Pouting (*Trisopterus luscus*) (Esteves *et al.*, 2009) and Atlantic salmon (*Salmo salar*) (Bjorgen *et al.*, 2015). In these species the causes of muscle melanisation have been case specific, including excessive levels of dietary copper (Cu) (Cooper *et al.*, 2011), parasitic infection (Esteves *et al.*, 2009), response to vaccination in farmed fish (Larsen *et al.*, 2014; Bjorgen *et al.*, 2015), and increased immune response to bacterial or viral infection (Bjorgen *et al.*, 2015; Krasnov *et al.*, 2016).

Preliminary investigations based on histology of affected Sand Flathead from the Tamar River have indicated that melanin deposits are present in the skeletal muscles, around individual muscle fibres and/or associated with blood vessels (Ware, 2015). A concurrent parasitological investigation provided no evidence that the melanisation was linked to parasitic infection. Site specificity has also been observed within the Tamar River, with the prevalence of muscle melanisation significantly higher in Deceitful Cove than at nearby Inspection Head. An examination of heavy metal levels in Sand Flathead from the Tamar River exhibiting evidence of melanisation has established that zinc concentrations are significantly higher in areas of melanised tissue than in unaffected areas (Ooi, 2016). Although previous studies have attributed fluctuations of zinc to the biochemistry and physiology of melanin, this relationship requires further research and is being explored in an

on-going study at the University of Tasmania. A more recent study has investigated a variety of potential relationships with muscle melanisation. Site specificity previously described in the Tamar River has been further emphasised, with Deceitful Cove having a significantly higher proportion of affected Sand Flathead than the nearby areas of Inspection Head, Middle Island and West Arm (Stocker, 2019). Histological and image analyses established no obvious relationships between the coverage of melanisation on Sand Flathead fillets and melano-macrophage centres (clusters of pigmented cells) in internal organs, age, sex, maturity stage, weight and length of Sand Flathead in the Tamar River.

While documented cases of muscle melanisation in fish have been mainly from the northern hemisphere, research into the phenomenon in Sand Flathead is quite recent and has produced an initial scientific understanding of the phenomenon (Ware, 2015; Ooi, 2016; Stocker, 2019). However, the practical knowledge present in the recreational fishing community has not been explored and thus the Institute for Marine and Antarctic Studies (IMAS) implemented a fisher-based survey in 2018, intending to connect this fundamental scientific understanding with the practical knowledge, perceptions and experiences of Tasmanian recreational fishers.

MATERIALS AND METHODS

Questionnaire Scope

An on-line questionnaire was implemented to investigate the recreational fishing community's knowledge and observations regarding muscle melanisation in Sand Flathead. The target audience were those recreational fishers 18 years and older, who had observed muscle melanisation in fish from Tasmanian waters, specifically in Sand Flathead. A structured questionnaire was administered and conducted through SurveyMonkey (SurveyMonkey Inc., 2018) between the 25th of July and 3rd of September, 2018. The questionnaire distribution involved strategic targeting and self-selection, with promotion occurring through social media (Facebook) and website pages for IMAS, the Department of Primary Industries, Parks, Water and Environment (DPIPWE), the Tasmanian Association of Recreational Fishing Inc., and Redmap. In addition, DPIPWE promoted the survey through their recreational fishing email list. A clear example of Sand Flathead muscle melanisation was incorporated within the questionnaire invitation to reduce false reports of muscle melanisation (Appendix 1).

Questionnaire Design

The questionnaire incorporated two main sections covering (i) respondent profiling and (ii) respondent observations and perceptions regarding melanisation in Tasmania (Appendix 2). Profiling included questions on general fishing experience (years), avidity (days fished), fishing methods used, age, gender and residence (postcode). Although including a general question about the observations of the phenomenon occurring in other species, the section on melanisation predominately focused on Sand Flathead. Locations (up to 5) where respondents had caught melanised Sand Flathead were of significant focus, with emphasis on the proportion of affected individuals, extent of melanisation within the fillets and the incidence of the phenomenon at each location. Furthermore, questions were implemented to explore a range of general observations and experiences regarding muscle melanisation in Sand Flathead. Respondents were also able to provide further comments relevant to the subject matter, a summary of these additional comments can be found in Appendix 3.

Data Analysis

Quantitative analysis was based on responses to closed survey questions and reported as percentages of the total number of valid responses. Data management was completed by conducting internal consistency checks between key questions and (where relevant) by categorising open-ended questions for qualitative analysis. Responses that did not meet internal consistency checks, or where specific questions were unanswered, have been excluded from the analysis (the total number of valid responses for each question providing the denominator when calculating proportions).

Individual locations were considered of interest if they had five or more independent reports of melanisation in Sand Flathead. Furthermore, locations where respondents reported more than 50% of the fish as being affected by melanisation, "extensive" (large) coverage of melanisation on the fillets and/or an increased incidence of melanisation over the preceding five years, were flagged as locations of 'specific interest'. Conversely, locations that were reported to have no evidence of Sand Flathead muscle melanisation were identified where

there were five or more independent reports suggesting no observations of melanisation and a greater number of independent reports suggesting the absence of Sand Flathead muscle melanisation than those reporting the presence of the phenomenon.

As survey respondents were self-selected, extrapolation of findings to represent the experiences of the general recreational fishing community was not possible. However, within the context of collating observations about the occurrence and prevalence of Sand Flathead muscle melanisation caught within Tasmanian waters, the survey method was appropriate to provide meaningful and valuable insights into this phenomenon and an understanding of the recreational fisher perceptions of melanisation.

This study was approved by the Tasmanian Social Sciences Human Research Ethics Committee (Ethics reference: H0017513).

RESULTS

A total of 439 questionnaire responses were received, with two being omitted from further analysis due to the respondents only providing profiling information and failing to answer any questions on muscle melanisation. A summary of the respondent profiling information can be found in Appendix 4. A total of 415 (95%) respondents indicated they had observed areas of blackened muscle in the fillets of fish that they had landed in Tasmania. Of these respondents, 413 (99%) had observed the phenomenon in Sand Flathead. There were relatively few respondents (37) who reported observing muscle melanisation in other species, with the most common species being Jackass Morwong (10 reports), Bastard Trumpeter (5 reports), Australian Salmon (4 reports) and Tiger Flathead (4 reports).

Reports of muscle melanisation in Sand Flathead

There were 961 reports identifying where fishers had observed melanisation in Sand Flathead, representing a total of 225 unique locations across Tasmania. Locations were reported at a range of spatial scales, from a general area/region to a specific site. Recognising this variability, each report was classified using a hierarchical approach based on increasing spatial resolution; namely (1) region (e.g. Central-East Coast), (2) sub-region (e.g. Mercury Passage/Maria Island), and (3) specific location (e.g. Spring Bay). Individual reports were categorised to the highest spatial resolution possible.

Locational reports were assigned to one of 16 regions (Fig. 2) and regions with more than 50 reports of melanisation were identified as areas of interest; these included the Tamar River in the north, the Central-East Coast and in the south-east the Derwent River, D'Entrecasteaux Channel, Norfolk and Frederick Henry Bays, Storm Bay, and Tasman Peninsula (Fig. 2). An extensive overview of data relevant to each of these eight regions can be found in Appendix 5, Table A3. The summary of results for the remaining regions can be found in Table A3. There were additional 20 reports where the precise location was unclear or ambiguous, these reports have not been included in the analysis.

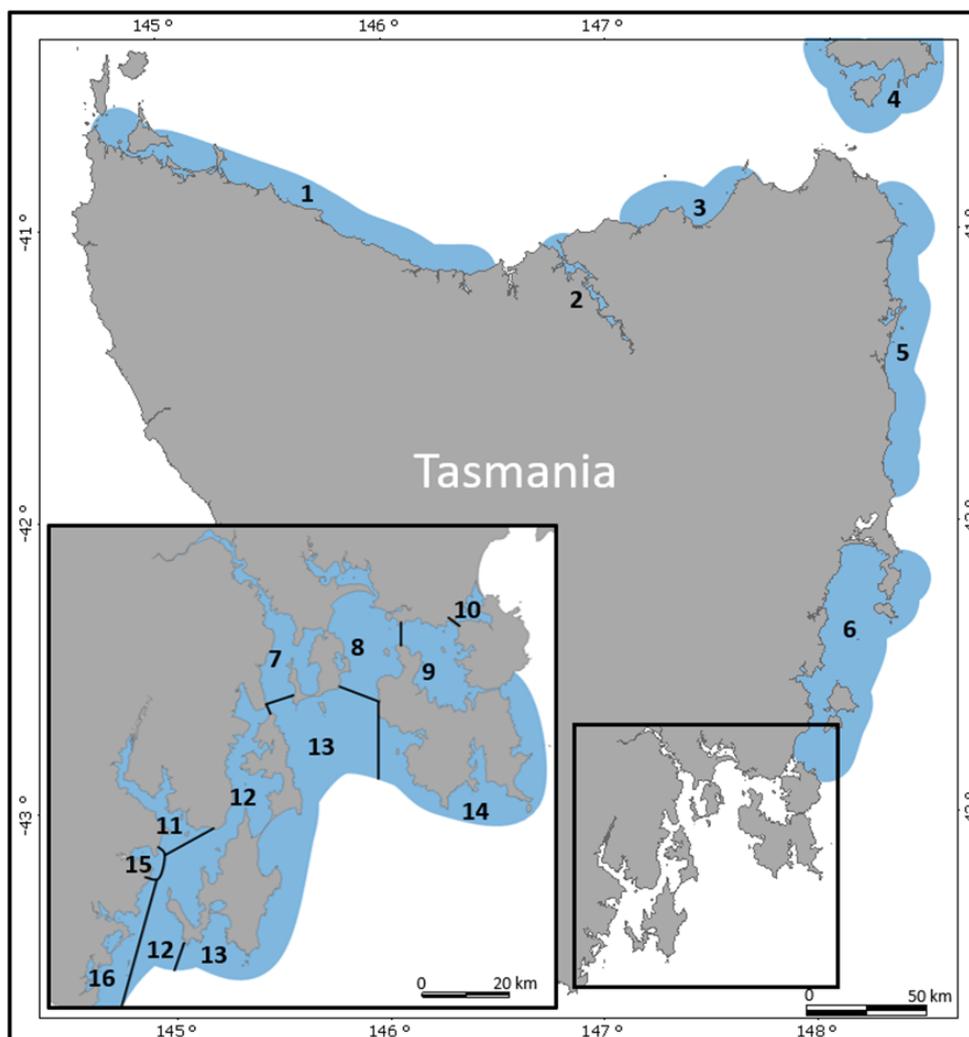


Fig. 2. Map highlighting key regions where recreational fishers have observed muscle melanisation in Sand Flathead. 1. North-West Coast; 2. Tamar River; 3. North Coast; 4. Flinders Island; 5. North-East Coast; 6. Central-East Coast; 7. Derwent River; 8. Frederick Henry Bay; 9. Norfolk Bay; 10. Dunalley; 11. Huon River; 12. D'Entrecasteaux Channel; 13. Storm Bay; 14. Tasman Peninsula; 15. Port Esperance; 16. Southport.

Overall, it was evident that the most common perceptions regarding Sand Flathead muscle melanisation, was that the proportion of fish affected was < 5%, there was a moderate extent of muscle melanisation on the fillets, and that the incidence of muscle melanisation has remained largely unchanged over the last 5 years (Appendix 5, Table A3).

However, a further comparison revealed that a high proportion (> 50% of individuals) with muscle melanisation were more frequently reported for Southport, Port Esperance and the D'Entrecasteaux Channel (>15% of reports), followed by the Derwent River, Port Arthur and North-East Coast regions, each with more that 10% of reports (Fig. 3, Appendix Table A3). When melanisation occurred, coverage within affected fillets that was judged as “extensive” (large areas of the fillet) was most prevalent in catch reports from the Huon and Derwent Rivers (>20% of reports), followed by Frederick Henry Bay, Eagle Hawk Neck, Storm Bay and Great Oyster Bay (>15% of reports) (Fig. 4, Appendix Table A3). Lastly, two regions

stood out with the highest proportion of reports (>40%) suggesting that the incidence of muscle melanisation had increased over the past 5 years, they were the Huon River and Port Arthur (Fig. 5, Appendix Table A3). The D'Entrecasteaux Channel and Port Esperance also had a relatively proportion of reports (>25%) suggesting an increase in the incidence of melanisation in recent years.

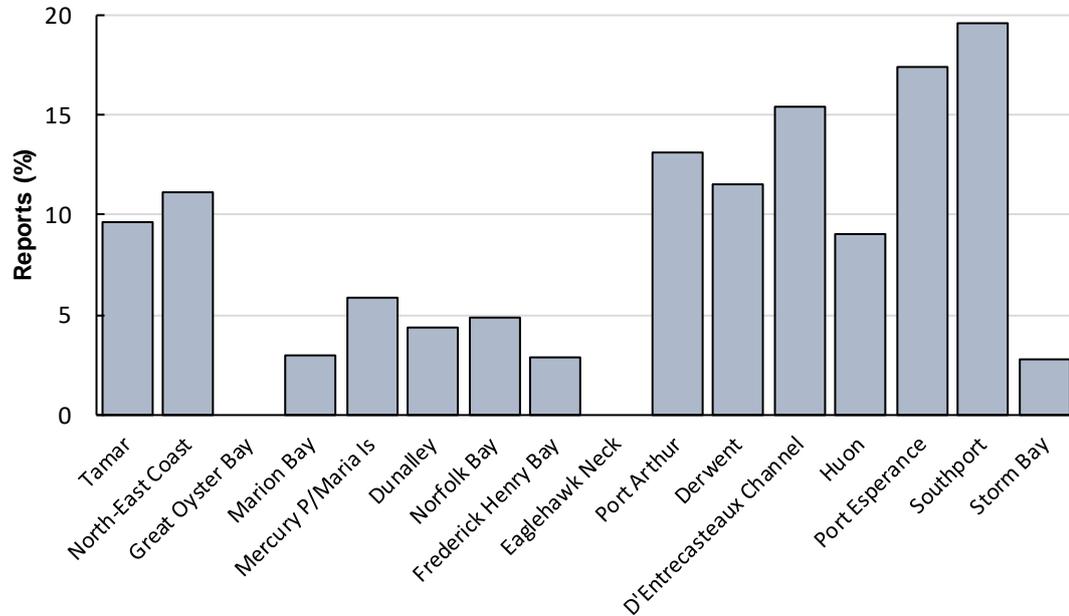


Fig. 3. Percentage of reports for key regions/locations suggesting > 50% proportion of muscle melanisation in Sand Flathead. (Regions with fewer than 17 responses are not shown).

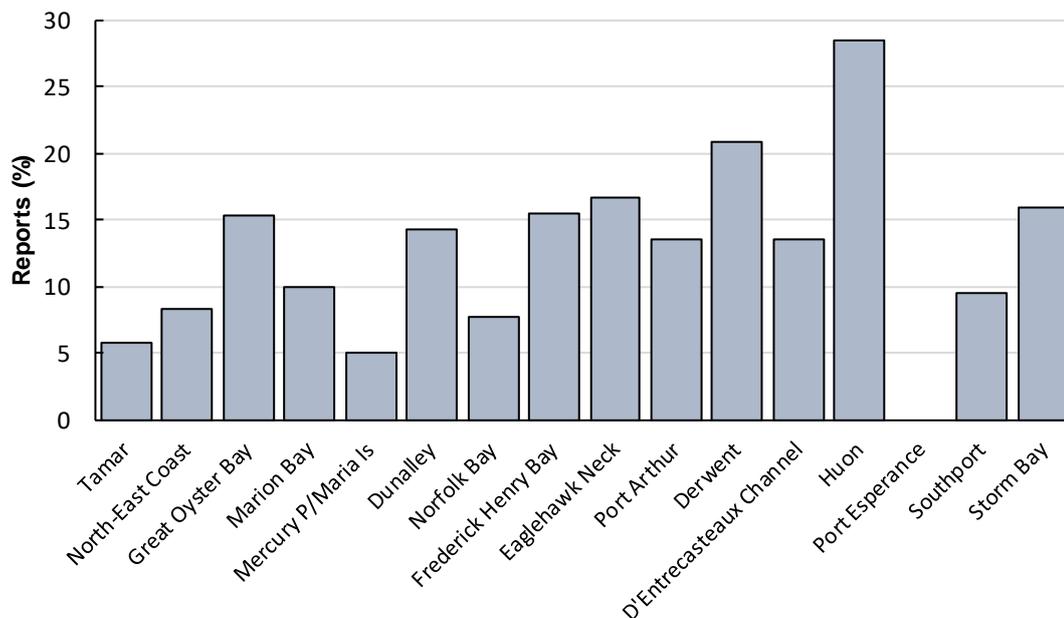


Fig. 4. Percentage of reports for key regions/locations suggesting "extensive" muscle melanisation in Sand Flathead. (Regions with fewer than 17 responses are not shown).

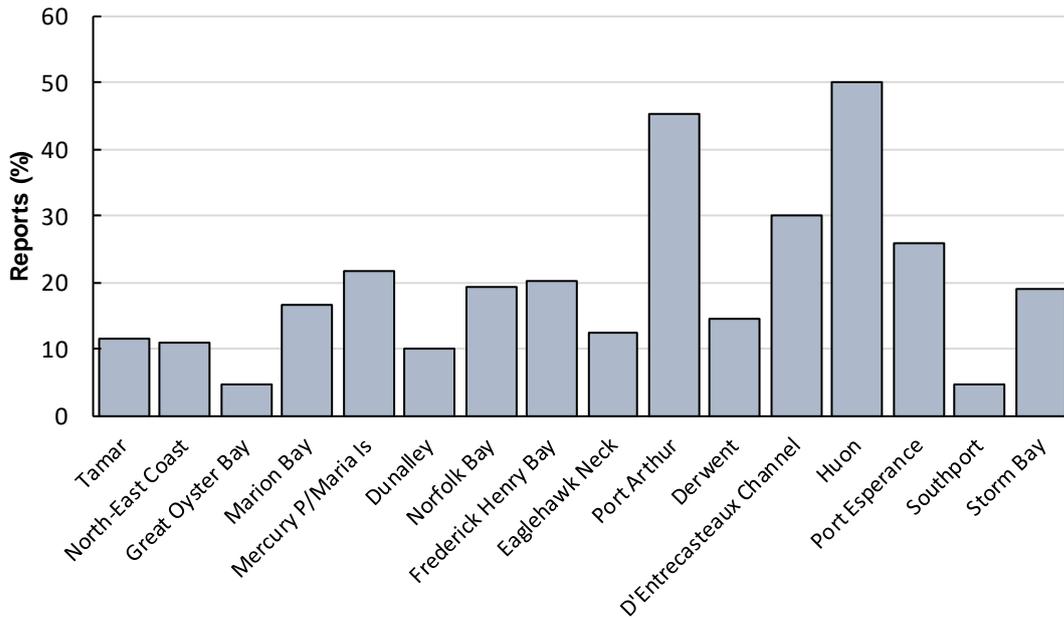


Fig. 5. Percentage of reports for key regions/locations suggesting increased incidence of muscle melanisation in Sand Flathead. (Regions with fewer than 17 responses are not shown).

Locations with more than five independent reports of Sand Flathead affected by melanisations include multiple sites within the Tamar River, Georges Bay in the North-East Coast region, around Orford/Spring Beach in the Central-East Coast region and multiple sites throughout the south-east of Tasmania (Fig. 6). Overall, there were four sites of specific interest identified including Bell Bay (Tamar River), Carnarvon Bay (Port Arthur), Simpsons Bay (D'Entrecasteaux Channel) and Southport Lagoon (Fig. 6).

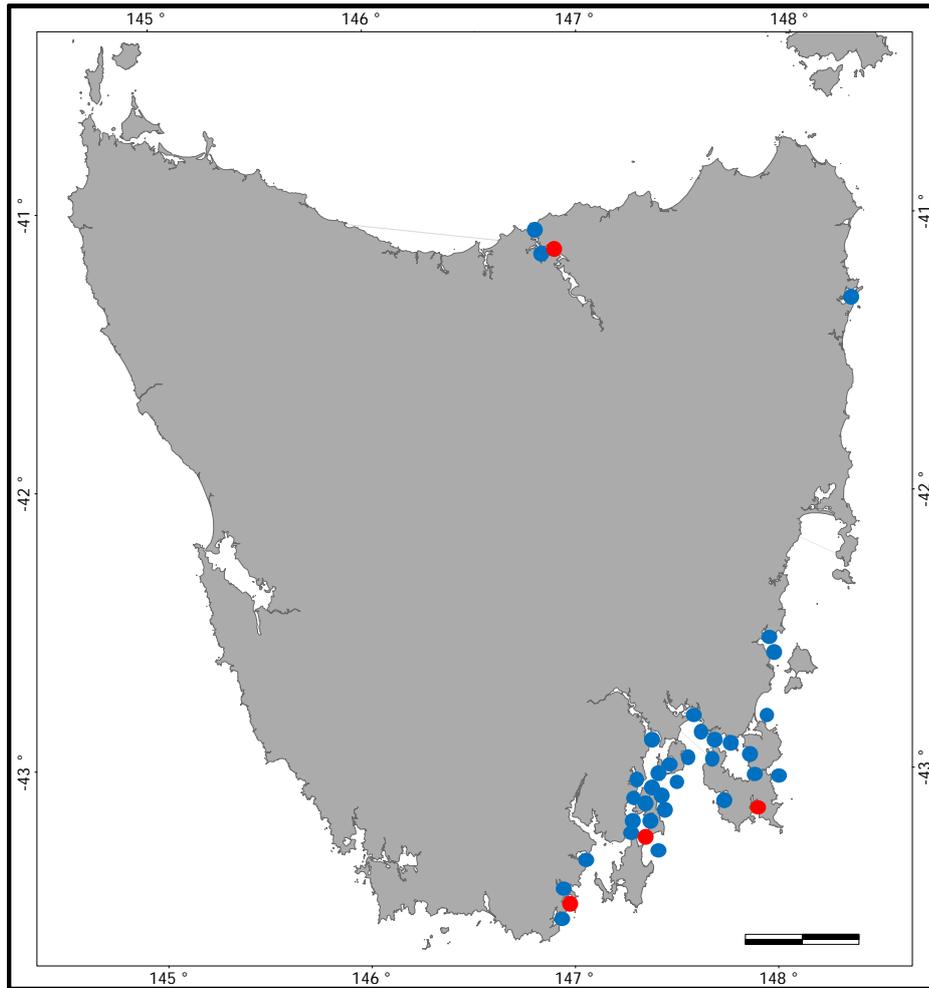


Fig. 6. Map of Tasmania indicating locations of interest for Sand Flathead muscle melanisation. Red dots indicate sites of specific interest (refer text).

Locations with no melanisation reports

A total of 309 reports across 102 locations from 162 recreational fishers, suggested locations where they had observed no evidence of Sand Flathead muscle melanisation. Of these locations, 48 had more reports suggesting no muscle melanisation, than reports suggesting the presence of muscle melanisation (Fig. 7). Locations with multiple reports include: Coles Bay (8 reports), Orford (6 reports), Bicheno (5 reports), St Helens (7 reports), Stanley (6 reports), and Pirates Bay (7 reports). Furthermore, the North Coast region and the sub-region of the Central-East Coast, Great Oyster Bay, also had more total reports suggesting no muscle melanisation. There were an additional 10 reports where the location was unclear or insufficient information was provided, these reports were not included in the analysis.

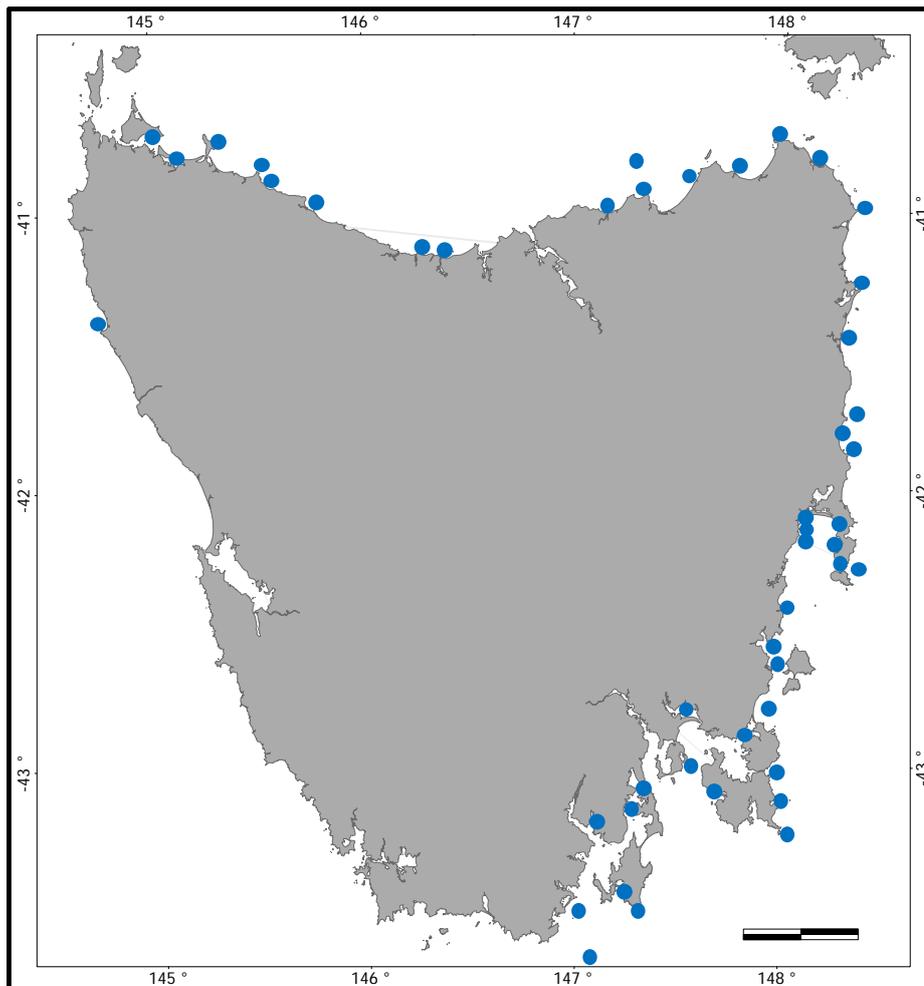


Fig. 7. Map of Tasmania indicating locations with more reports suggesting no muscle melanisation than those suggesting muscle melanisation.

Patterns of melanisation

The observations of most recreational fishers regarding potential relationships between fish size and muscle melanisation in Sand Flathead was divided between No Obvious Pattern (35.2%), and Mostly Medium Sized Fish (33.7%) (Fig. 8). Respondents suggested eleven potential factors that could be related to the presence of muscle melanisation in Sand Flathead. Out of these proposed factors, sediment type (5 reports), seasonal variation (3 reports), and Water depth (3 reports), had the most mentions.

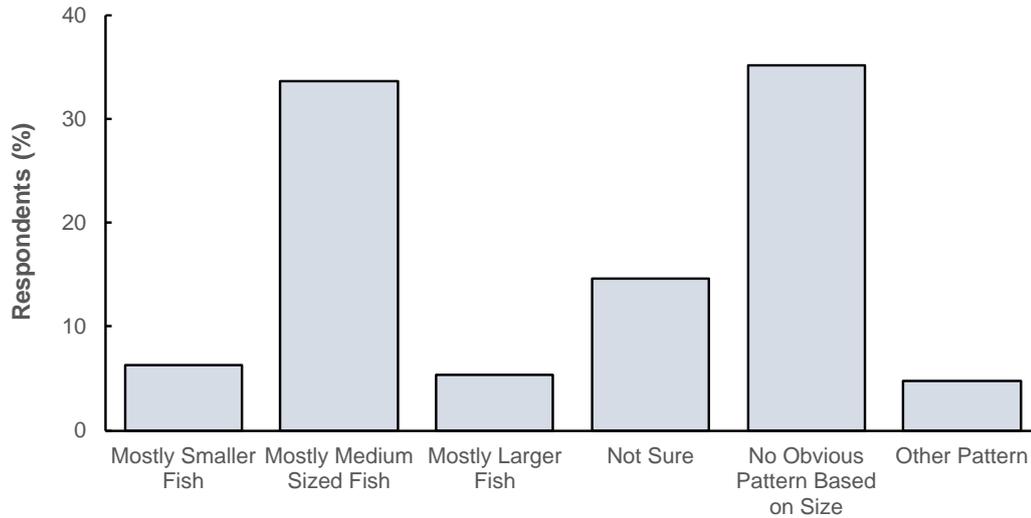


Fig. 8. Fisher observations on influence of fish size and the presence of muscle melanisation in Sand Flathead. “Mostly Smaller Fish” <32 cm, “Mostly Medium Sized Fish” 32 – 36 cm, “Mostly Larger Fish” > 36 cm.

History of melanisation

Most respondents (42.4%) had been aware of the muscle melanisation in Sand Flathead for over 10 years (Fig. 9). These data were compared to the recreational fishing experience, suggesting that most recreational fishers with between 1 – 20 years of experience, have been aware of the phenomenon for between 1 – 5 years. (Table 1). However, most recreational fishers with > 20 years of experience, had been aware of the phenomenon for more than 10 years. Based on when respondents first encountered muscle melanisation in Sand Flathead, would appear to indicate that fish in at least nine of 16 regions were displaying melanisation by 1990.

The earliest reported observation of muscle melanisation was in the D’Entrecasteaux Channel in 1958 while in Frederick Henry Bay another respondent reported the phenomenon in Sand Flathead from Pitt Water as early as 1968.

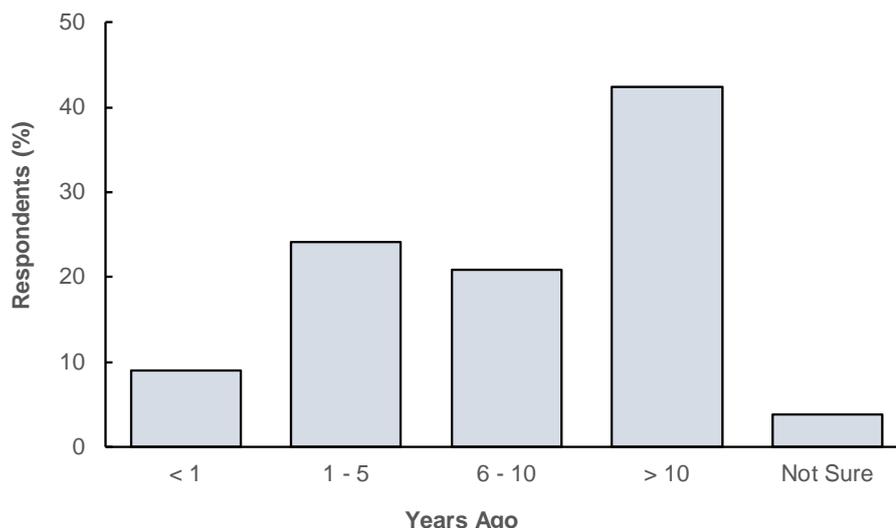


Fig. 9. Period (years) since respondents became first aware of muscle melanisation in Sand Flathead.

Table 1. Percentage of respondents at different levels of experience, compared to when they first became aware of muscle melanisation in Sand Flathead.

Shaded cells indicate results of interest.

Years since first aware	Years fishing experience						Responses (no.)
	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	>50	
Within last year	22.2	20.0	9.5	5.0	5.2	8.9	35
Within last 5 years	50.0	35.6	31.0	19.8	15.5	15.6	93
Within last 10 years	16.7	22.2	11.9	28.7	24.7	13.3	82
Over 10 years ago	0.0	17.8	40.5	43.6	52.6	62.2	165
Not sure	11.1	4.4	7.1	3.0	2.1	0.0	15
Responses (no.)	18	45	84	101	97	45	390

Response to Sand Flathead affected with melanisation

The most common practices partaken by recreational fishers following the discovery of fish affected muscle melanisation were to consume as normal (33.8%), discard only badly affected fillets (25.8%) or remove areas of affected muscle (Fig. 10). Discarding affected fillets regardless of the extent of muscle melanisation was also a relatively common practice (24.5%), although some respondents noted that they would still retain fillets but would not use them for human consumption.

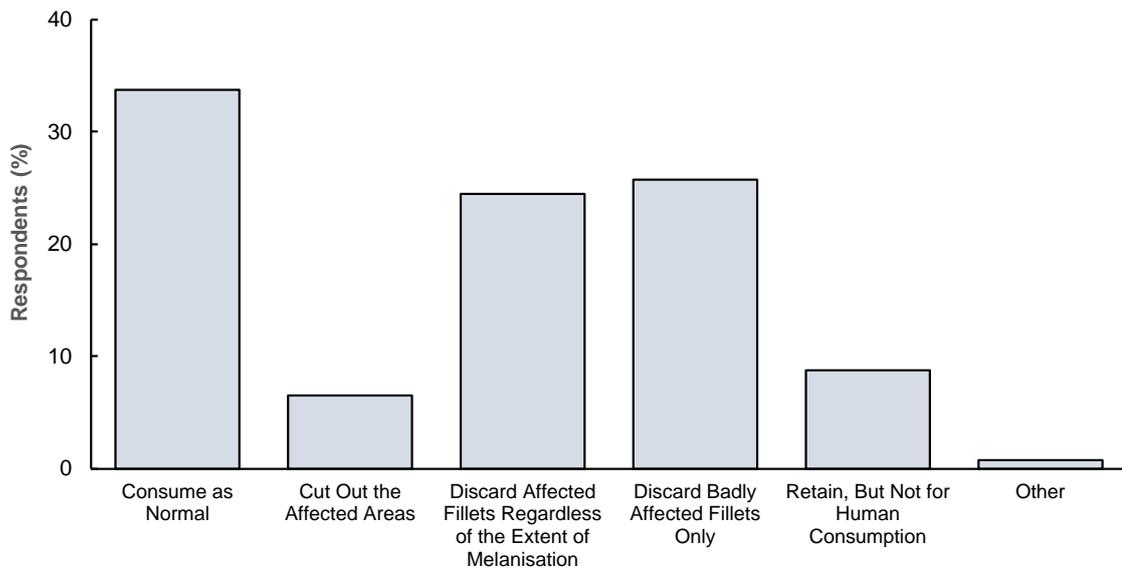


Fig. 10. Fisher responses to the presence of melanised fillets in Sand Flathead

Perceptions about melanisation in Sand Flathead

Most recreational fishers perceived all posed issues as potentially related to muscle melanisation in Sand Flathead (Table 2). Muscle melanisation as an indicator of ecosystem and environmental health was perceived as a potential issue by the greatest majority of respondents (79%) and had 33% also convey the issue as extremely important, suggesting the issue as the most crucial to the recreational fishing community. However, most recreational fishers also perceived muscle melanisation as an indicator of fish health as a very important issue (25%), and muscle melanisation as a potential issue for human health if consumed as extremely important (31%). This suggests that the respondents are concerned about the presence of the phenomenon in Tasmanian waters, perceiving issues potentially related to Sand Flathead muscle melanisation as significant to the future of the recreational fishing community.

Table 2. Fisher perceptions to potential issues related to Sand Flathead muscle melanisation.

Could Muscle Melanisation be...	Yes	No	Significance of the Issue				
			Not Important	Slightly Important	Moderately Important	Very Important	Extremely Important
an Indicator of Fish Health?	52.5	47.5	16.7	19.0	22.6	24.6	17.1
an Indicator of Ecosystem and Environmental Health?	79.2	20.8	7.1	10.2	19.2	30.2	33.3
a Potential Issue for Human Health if Consumed?	61.3	38.7	10.8	14.1	17.3	26.5	31.3

DISCUSSION

Key locations where melanisation in Sand Flathead was identified by recreational fishers were primarily in the Tamar River in the north and throughout the inshore waters of south-eastern Tasmania. Many of the key areas identified represent shallow estuarine environments. The recreational fishing community suggested that water depth and sediment types are potential factors affecting Sand Flathead muscle melanisation (Appendix 3).

Estuaries within Tasmania are reported to vary in environmental conditions, ranging from areas heavily affected by pollutants to those in a nearly pristine state (Edgar *et al.*, 2000). These results, coupled with the species' sedentary and demersal nature (Bani *et al.*, 2009), emphasises the importance of the current research into heavy metal analysis (C.K. Ooi, pers. comm.). However, the survey results indicate that Sand Flathead muscle melanisation occurs in areas irrespective of pollution or water contamination. Therefore, it is possible there are other explanations for the cause of Sand Flathead muscle melanisation.

A previous study conducted by Ware (2015), expressed the widespread nature of Sand Flathead muscle melanisation, with affected individuals occurring in the north and south of Tasmania. The findings of this survey complement that study. Reports of Sand Flathead muscle melanisation from the recreational fishers highlight the widespread nature and the extent to which the phenomenon is present in Tasmania waters.

A comparison of all the reported locations irrespective of the presence of Sand Flathead muscle melanisation shows respondents fished in the north, east and south of Tasmania. This wide coverage of locations legitimises the identification of the key regions of interest. These regions had many reports of Sand Flathead muscle melanisation and align with the most recent survey of recreational fishing in Tasmania (Lyle *et al.*, 2014). In 2012/13 the south and south-east coasts accounted for 55% of the recreational fishing effort in Tasmania and 80% of Sand Flathead catch occurred from the south to east coasts of Tasmania (Lyle *et al.*, 2014). Furthermore, the D'Entrecasteaux Channel had the most reports of muscle melanisation, with recreational fishers portraying an extreme proportion of Sand Flathead muscle melanisation and an increased incidence over the last 5 years. This region is one of the most heavily fished areas in Tasmania, where the most commonly landed species is Sand Flathead (Lyle *et al.*, 2014).

The recreational fishing community suggested potential patterns in the occurrence of melanisation, with fish size, sediment type, season and water depth as factors (Appendix 3). Although the respondents might be restricted in their observations (e.g. size limits on catch), the survey suggested that the cause of Sand Flathead muscle melanisation may differ to examples from the northern hemisphere. These established causes included: excess levels of copper (Cooper *et al.*, 2011), parasitic infection (Esteeves *et al.*, 2009), response to vaccination (Larsen *et al.*, 2014; Bjorgen *et al.*, 2015), and increased immune response to bacterial or viral infection (Bjorgen *et al.*, 2015; Krasnov *et al.*, 2016).

The survey had many respondents and a high completion rate. Although this is partially explained by the targeted and self-selected nature of the respondents, it also highlighted both the effectiveness of the survey design and the importance of the issue to recreational fishers. The recreational fishing community, especially those with many years of experience, perceived muscle melanisation in Sand Flathead as an established phenomenon within

Tasmanian waters. The fishers suggested that in many regions Sand Flathead were present with muscle melanisation prior to 1990, with the earliest recollection occurring in the D'Entrecasteaux Channel in 1958. In previous research into Sand Flathead muscle melanisation, this condition was considered recent with an increase in observations and reports from the recreational fishing community (Ware, 2015; Ooi, 2016). The results of this questionnaire question this notion.

In the recreational fisheries of Tasmania, Sand Flathead is an iconic and targeted species (Frijlink and Lyle, 2013; Lyle *et al.*, 2014). This focus on the species continues through to on-going research regarding the presence of muscle melanisation. Although the common practice for most respondents was to consume affected fillets as normal, most respondents also perceived all proposed issues related to muscle melanisation as either very or extremely important. This is further supported by the additional comments where respondents expressed concern, intrigue and interest in current research into the phenomenon, with an overall willingness to participate in future research (Appendix 3).

Future Research

This study provided strong basis for further research, which could involve targeted sampling of Sand Flathead from the key locations identified in the survey, to confirm the presence and prevalence of Sand Flathead muscle melanisation. This could result in the discovery of site specificity within different regions and the identification of common histories and characteristics across areas with higher prevalence. These potentially include: sediment types, water depth, pollution, environmental conditions and proximity of aquaculture and other marine activities.

Respondents of the questionnaire expressed the need for clear descriptions and examples of the phenomenon, to increase their accuracy of reports. Furthermore, regular updates on the progression and findings of the current research would ensure improved access to samples and information from the recreational fishers. In response, the development and implementation of a website is underway, both as a response to these concerns and to assist in all future studies into melanisation in Sand Flathead (<https://blackfilletproject.com.au/>).

CONCLUSION

This study has successfully explored the experiences and knowledge of the recreational fishing community. The results determined key regions where Sand Flathead muscle melanisation has been observed and explored perceptions, the history and patterns relating to Sand Flathead muscle melanisation in Tasmanian waters. This survey has successfully connected the recreational fishing community of Tasmania to the current scientific research into the phenomenon and formed the basis and groundwork for further studies. Although the cause and origin of Sand Flathead muscle melanisation remains elusive at this stage, a variety of avenues for future research have resulted from the survey, including; continued collaboration with the recreational fishers through the implementation of a Sand Flathead muscle melanisation website, and further investigation into the common histories and environmental conditions in locations where melanisation is prevalent.

ACKNOWLEDGEMENTS

This survey formed a component of Clayton Stocker's Honours research and is part of a broader initiative to better understand the causes and implications of melanisation in Sand Flathead.

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Appendix 1: Survey Invitation



Have you noticed black areas on the flesh of your fish catch? – if so IMAS is interested in hearing from you.



Melanisation of Sand Flathead Survey

Each year there are many reports from the recreational fishing community regarding Sand Flathead fillets that have areas of blackened flesh, a phenomenon known as melanisation. Whilst many reports are from the Derwent and Tamar estuaries, reports also extend to more pristine waters. The geographical extent of the issue, its causes and the risk to the fish are unclear. Furthermore, it is unknown whether other species are also affected by this phenomenon.

Where muscle melanisation has been reported in fish species from the Northern Hemisphere it has been caused either by the presence of parasites or heavy metal (copper) residues in the muscle of the affected fish. Preliminary results from Tasmania suggest that neither parasites nor copper are involved in melanisation of flathead.

We are inviting recreational fishers to share their observations of melanisation in Tasmanian fishes. By tapping into the practical knowledge of the recreational fishing community, we hope to gain a greater understanding of the patterns, locations and prevalence of this phenomenon. In doing so we plan to draw conclusions on characteristics and factors of individual fish and locations that are contributing to the presence of melanisation.

If you would like to find out more please follow the link below:

<https://www.surveymonkey.com/r/melanisation>

Dr Jeremy Lyle (Senior Research Scientist, IMAS)

Appendix 2: Survey Questionnaire

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Information for Participants		

Thank you for considering taking part in this survey. Please note, respondents should be 18 years or older and recreational fishers in Tasmania.

Each year there are many reports and concerns raised by the recreational fishing community regarding areas of blackened flesh in Sand Flathead fillets, a phenomenon known as melanisation. Whilst many reports are from the Derwent and Tamar estuaries, reports also extend to more pristine waters. The geographical extent of the issue, its causes, the risk to the fish and human health are unclear. Furthermore, whether other species are also affected by this phenomenon is unknown.

Where muscle melanisation has been reported in the Northern Hemisphere it has been caused either by the presence of parasites or heavy metal (copper) residues in the muscle of the affected fish. Preliminary results from Tasmania suggest that neither parasites nor copper are involved in melanisation of Sand Flathead.

The purpose of this survey is to gain a greater understanding of the characteristics, and the factors contributing to the presence of melanised muscle and the locations where the phenomenon is present. In addressing these questions, we hope to have a better scientific understanding of the implications of melanisation in Sand Flathead for the benefit of the general fishing community.

This survey is a component of a larger project examining various aspects of melanisation in Sand Flathead - the research team consists of Dr Jeremy Lyle, Prof Gretta Pecl, Dr Trevor Lewis and Prof Barbara Nowak (IMAS). This survey will be used as partial fulfilment of an Honours degree for Clayton Stocker. The focus of the Honours study is the relationship between melanisation and capture location, size, sex and condition of the fish.

Participation in this survey is voluntary and expected to take 10 - 15 minutes to complete. The practical knowledge of the recreational fishing community in extending our understanding of the patterns, location and prevalence of this phenomenon is invaluable.

This study has been approved by the Tasmanian Social Sciences Human Research Ethics Committee (HREC). If you have any concerns or complaints about the conduct of this study, please contact the Executive Officer of the HREC (Tasmania) Network on +61 3 6226 6254 or email human.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants. Please quote the following ethics reference number (H0017513).

Submitting this survey confirms your consent for the information you have provided to be used for this research. Please be assured, any personal identifying information will be treated in the strictest confidence and will be removed from the databases at the completion of the survey.

Thank you

Dr Jeremy Lyle



Survey of Melanisation in Sand Flathead Fillets

PART A: INFORMATION ABOUT YOU

Firstly, we have some questions about you and your fishing experience.

1. How many years have you been actively involved in recreational fishing?
2. During the past 12 months, how many days did you spend **saltwater fishing** in Tasmania, whether you caught anything or not?
3. During the past 12 months, how many days did you spend **freshwater fishing** in Tasmania, whether you caught anything or not?
4. During the last 12 months, which of the following types of fishing have you done in Tasmania? (Please tick as many as are relevant to you)
 - Shore-based line fishing
 - Inshore boat-based line fishing
 - Offshore bottom line fishing
 - Game fishing
 - Gillnet fishing
 - Other net fishing
 - Lobster pot/ring
 - Dive fishing
 - Flounder spear
 - Trout fishing
 - Other (please specify)
5. Your Age (Please note respondents should be 18 years or older)
 - 18 – 20
 - 20 – 29
 - 30 – 39
 - 40 – 49
 - 50 – 59
 - 60 – 69
 - 70 plus
6. Your gender?
 - Male
 - Female
 - Other
7. Your postcode?

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Survey of Melanisation in Sand Flathead Fillets

PART B: YOUR OBSERVATIONS OF MELANISATION IN FISH FILLETS

In this section, we want you to think about all of the fishing you have done in Tasmania and any observations you have about discolouration of fillets of freshly caught fish.

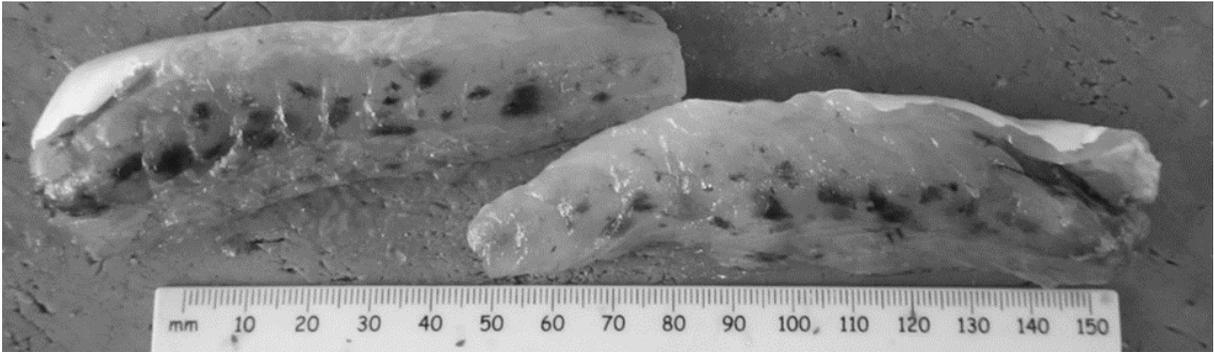


Figure 1 - Example of moderate melanisation in flathead fillets. (From Ware, 2015)

8. Have you ever observed areas of blackened muscle in the fillets of any fish you have caught in Tasmania (do not include areas of bruising due to capture) (e.g. Figure 1)?
- Yes – PROCEED TO NEXT QUESTION
 - No – PLEASE PROCEED TO THE END OF THIS PAGE AND CLICK “NEXT”
9. In which fish species have you observed this?
- Sand Flathead
 - Other species (please specify)



Survey of Melanisation in Sand Flathead Fillets

PART C: YOUR OBSERVATIONS OF MELANISATION IN SAND FLATHEAD

In this section, we want you to think about the fishing you have done for Sand Flathead in Tasmania.

10. Please list the fishing locations (up to five) in which you have **most commonly** observed muscle melanisation in your catches (be as specific as possible where you can. For example, NW Bay rather simply D'Entrecasteaux Channel)

Location 1

11. Location 2

12. Location 3

13. Location 4

14. Location 5

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PART D: YOUR OBSERVATIONS OF MELANISATION IN SAND FLATHEAD CONT		

In this section, we want you to think about your specific observations regarding melanisation in Sand Flathead.

15. In those locations you have observed melanisation in Sand Flathead, on average what proportion of your catch numbers are affected, and in those fish that are affected what is the typical extent of the melanisation.

	Proportion of Fish	Extent of Melanisation
{{Q10}}	<input style="width: 100%; height: 25px;" type="text"/>	<input style="width: 100%; height: 25px;" type="text"/>
{{Q11}}	<input style="width: 100%; height: 25px;" type="text"/>	<input style="width: 100%; height: 25px;" type="text"/>
{{Q12}}	<input style="width: 100%; height: 25px;" type="text"/>	<input style="width: 100%; height: 25px;" type="text"/>
{{Q13}}	<input style="width: 100%; height: 25px;" type="text"/>	<input style="width: 100%; height: 25px;" type="text"/>
{{Q14}}	<input style="width: 100%; height: 25px;" type="text"/>	<input style="width: 100%; height: 25px;" type="text"/>

16. Have you noticed any patterns between melanisation and the size of the fish?

- Mostly smaller fish (approximately less than 32 cm)
- Mostly medium sized fish (approximately between 32 cm and 36 cm)
- Mostly larger fish (approximately above 36 cm)
- No obvious pattern based on size
- Not sure
- Other (pattern is not to do with fish size, please specify below)



Survey of Melanisation in Sand Flathead Fillets

PART E: YOUR EXPERIENCE WITH MELANISATION IN SAND FLATHEAD

In this section, we want you to think about your general observations regarding melanisation in Sand Flathead.

17. Do you recall when you first became aware of melanisation in Sand Flathead?

- Within last year
- Within last 5 years
- Within last 10 years
- Not sure

If possible note the specific area and year.

18. Thinking of the fishing areas you have observed melanisation, have you noticed any obvious changes in the incidence of melanisation during the last five or so years (or time you have been fishing, if less than 5 years)?

Incidence of melanisation

{{Q10}}

{{Q11}}

{{Q12}}

{{Q13}}

{{Q14}}

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PART F: AFTER AFFECTED FISH ARE		

In this section, we want you to think about what you normally do with fish affected by melanisation.

19. If you catch an affected fish, what do you **usually** do with fillets?

- Consume as normal
- Cut out the affected areas
- Discard badly affected fillets only
- Discard affected fillets regardless of the extent of melanisation
- Retain but not for human consumption
- Other (please specify)

 UNIVERSITY of TASMANIA	 IMAS INSTITUTE FOR MARINE & ANTARCTIC STUDIES	Survey of Melanisation in Sand Flathead Fillets
PART G: FINAL QUESTIONS		

20. Are there any other locations that you regularly fish for Sand Flathead where you have not observed evidence of melanisation in the fillets? Please list below.

21. Overall, do you consider that the occurrence of melanisation in Sand Flathead could represent...

	Yes/No	Significance
A general indicator of fish stress or health	<input style="width: 100%; height: 28px;" type="text"/>	<input style="width: 100%; height: 28px;" type="text"/>
An indicator of ecosystem and environmental health	<input style="width: 100%; height: 28px;" type="text"/>	<input style="width: 100%; height: 28px;" type="text"/>
A potential issue for human health if consumed	<input style="width: 100%; height: 28px;" type="text"/>	<input style="width: 100%; height: 28px;" type="text"/>

Other (please specify issue and significance)

22. Please add any further comments or observations about melanisation in Sand Flathead that you would like to share.

23. Would you be willing to be connected again about any further studies or results that are obtained regarding melanisation in Sand Flathead?

- Yes
 No

24. What are your contact details?

Name

Email Address

By clicking "Done" you are confirming your consent for the information you have provided to be used in this research. Once submitted it is not possible to withdraw the data.

If you have provided an email address above we will send a brief summary of this research when finalised to that address, otherwise, results will be promoted on the IMAS web and Facebook pages.

Thank you for your Participation

Appendix 3: General Comments of Respondents

To summarise the additional comments, the recreational fishing community perceive the phenomenon to be a recurring problem, that has been present for the entire time they have been fishing. Although agreeing muscle melanisation is observed most times they fish, respondents are divided in their perceptions of the overall change in incidence of muscle melanisation. Respondents varied in their description of the muscle melanisation in Sand Flathead. These include: “streaked”, “black dots”, “thin bands”, “thick black patches”, “black lines”, “blackened veins”, and “bruising”. Further observations regarding muscle melanisation were mentioned, including: seasonal and yearly variation, less muscle melanisation in open waters and clear sandy habitat, and no difference in behaviour or external characteristics of those melanised individuals. Many potential explanations for the presence of muscle melanisation were further suggested, including:

- Diet (Squid, Octopus, and Calamari)
- Sea lice, parasites and disease from other species
- Deoxygenated substrate, water temperature and river/creek outfall
- Heavy metals including: copper (Cu), cadmium (Cd), mercury (Hg) and zinc (Zn)

The recreational fishers emphasised their concern in the additional comments, regarding the potential adverse effects of the multiple sources of pollution entering the recreational fishing areas. These sources include: oyster and fish (salmonid) aquaculture, Zinc Works, thermal power station, fishmeal plant, anti-fouling paint, fertilisers, marine fuels, raw sewage, agriculture runoff, and the treated pine applied to pylons and jetties.

Some respondents reported receiving different explanations for the occurrence of muscle melanisation depending on the source. For example, CSIRO reportedly informed fishers that they initially thought it was caused by the weeds they were eating. In addition, informal conversations between fisheries scientists and recreational fishers have described the muscle melanisation as “freckles” on the fillets. Despite different explanations, the general consensus of recreational fishers is that melanised individuals are safe to consume. Respondents elaborated on their experiences with consuming melanised individuals. Overall the fillets were described as: “softer”, “not as rigid”, “floury”, “different in texture”, and in some cases “cooked them and the flesh went white”. Furthermore, there have been differing opinions regarding the taste of melanised fillets, and no observed side effects after consumption. Despite the perception that melanised fillets are safe to consume; some recreational fishers have since avoided fishing in areas known to have muscle melanisation.

Generally, the additional comments suggested that the recreational fishing community is intrigued by the research into the phenomenon. Many recreational fishers are interested in results relating to the cause of muscle melanisation and the potential human health risks. Overall, the muscle melanisation in Sand Flathead is a “regular conversation topic”, with many recreational fishers wanting to be more involved in finding answers.

Appendix 4: Respondent Profiling

Out of the recreational fishers who completed the questionnaire, 95% were male. The prominent age category for males was 40 – 49 years old (24%), closely followed by those 50 – 59 years old (23%). The dominant age category for female respondents was 50 – 59 years old (32%) (Fig. A1). The proportion of respondents living in the south of Tasmania (76%) outweighed the north (23%), with a focal point surrounding the Derwent River (Fig. A2). Furthermore, five respondents located outside of Tasmania completed the questionnaire. There were 70% of respondents with between 21 and 50 years of recreational fishing experience, with the average being 36.7 ± 0.7 years (Fig. A3). The most prominent respondent demographic was 40 – 49 year old males, from the south of Tasmania, with between 31 – 40 years of recreational fishing experience.

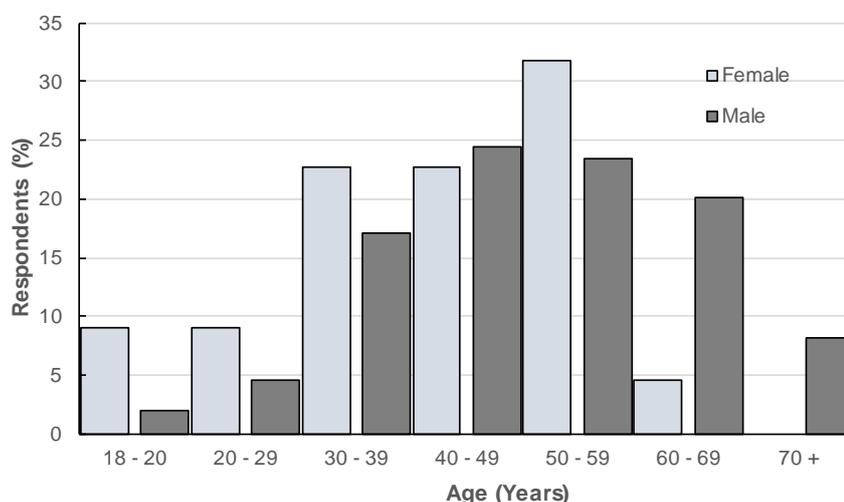


Fig. A1. Distribution of male and female respondents by age categories. Separate calculations of proportions for male and female respondents.

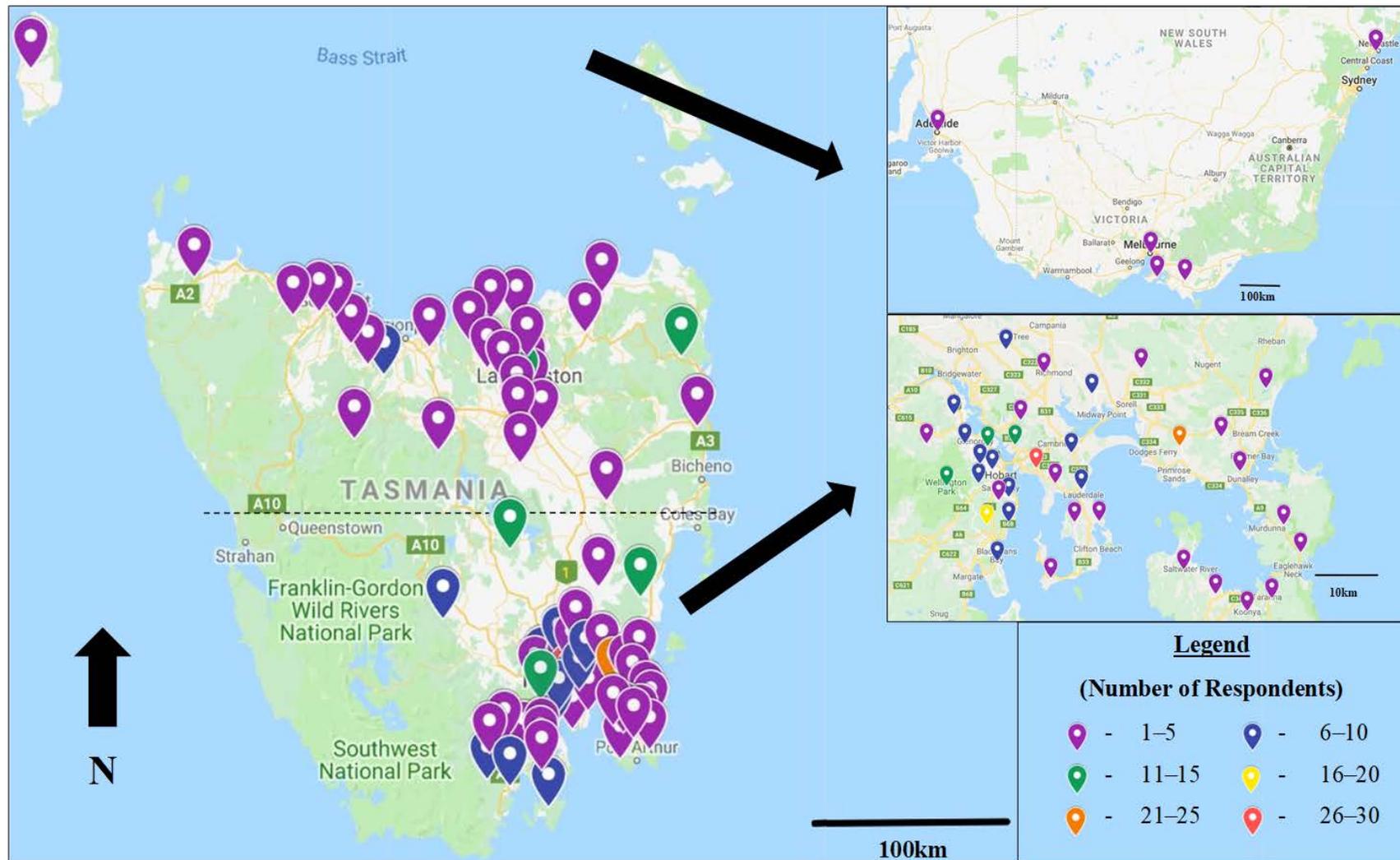


Fig. A2. Postcodes of recreational fishers who completed the questionnaire. Dotted line represents division between north and south Tasmania.

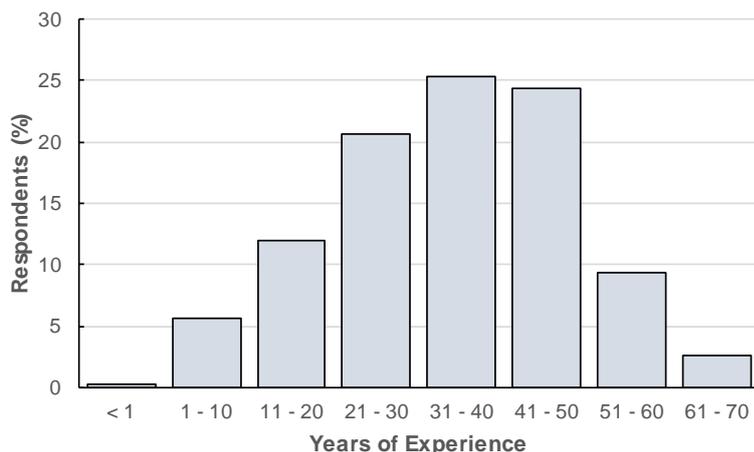


Fig. A3. Fishing experience (years) for survey respondents

In the previous 12 months, 98% of respondents fished in saltwater environments, with only 35% fishing in freshwater. A high proportion of respondents reported fishing in saltwater environments between 11 and 20 days (26.5%), with the average being 34.6 ± 1.7 . Fishing in freshwater environments was found to be less frequent (5.4 ± 0.7 days) (Table A1). Overall, 65% of respondents reported over 20 days saltwater fishing within the last 12 months, suggesting a high representation of avid fishers. The most common fishing techniques implemented by respondents included: Inshore Boat-Based Line (88%), Offshore Bottom Line (65%), Shore-Based Line (55%) and Lobster Pot/Ring (54%) (Table A2).

Table A1. Percentage of respondents and the days spent recreationally fishing in saltwater and freshwater environments within Tasmania, in the last 12 months.

Shaded cells indicate results of interest.

Days	Saltwater	Freshwater
0	1.6	64.8
1 - 10	14.4	21.5
11 - 20	26.5	7.8
21 - 30	23.0	2.4
31 - 40	10.7	0.5
41 - 50	9.8	1.4
51 - 60	4.7	0.2
61 - 70	2.6	0.2
71 - 80	1.4	0.2
81 - 90	0.2	0.0
91 - 100	2.1	0.5
101 +	3.0	0.5
Total	100.0	100.0

Table A2. Fishing techniques implemented by respondents within the previous 12 months.

Shaded cells indicate results of interest.

Fishing Techniques	Respondents (%)
Inshore Boat-Based Line	87.7
Offshore Bottom Line	65.0
Shore-Based Line	54.9
Lobster Pot/Ring	53.7
Gamefishing	41.2
Dive	34.3
Gillnet	29.2
Trout	28.7
Flounder Spear	26.4
Other Net	6.3
Other	1.7

Appendix 5: Overview of the key Regions of Interest

Tamar River

In the Tamar River region there was a total of 64 reports of muscle melanisation in Sand Flathead across 20 locations from 40 recreational fishers. Out of these reports, 96.9% identified the proportion of Sand Flathead experiencing muscle melanisation. These reports were evenly distributed across three proportions, including: < 5% (27.4%), 6-10% (29.0%), and 11-20% (27.4%). Therefore, a proportion of muscle melanisation in Sand Flathead between < 5% and 20% was proposed. There were 53.1% of the reports that identified the average extent of muscle melanisation in Sand Flathead. Most recreational fishers (50.0%) suggested that there is generally a moderate level of muscle melanisation in Sand Flathead. A total of 93.8% of reports identified the change in occurrence of muscle melanisation over the past 5 years. Of these reports, 51.7% suggested that the incidence of muscle melanisation has remained largely unchanged (Table A3).

There were three key locations identified in the Tamar River region. These locations included: Beauty Point (6), Bell Bay (8), and Low Head (5), which had many reports of muscle melanisation in Sand Flathead. A location of specific interest was Bell Bay, where reports from recreational fishers suggested > 50% proportion of Sand Flathead with muscle melanisation (57.1%), and an increased incidence of muscle melanisation over the past 5 years (42.9%).

Central-East Coast

In the Central-East Coast region there was a total of 130 reports of muscle melanisation in Sand Flathead across 23 locations from 86 recreational fishers. Within this region three sub-regions were identified, including: Marion Bay, Great Oyster Bay and Mercury Passage/Maria Island. Marion Bay had 36 reports of muscle melanisation in Sand Flathead from 36 recreational fishers. Great Oyster Bay had 21 reports of muscle melanisation in Sand Flathead across 9 locations from 20 recreational fishers. Lastly, Mercury Passage/Maria Island had 73 reports of muscle melanisation in Sand Flathead across 14 locations from 53 recreational fishers.

Out of the total number of reports from each sub-region, 94.4% of reports from Marion Bay, 95.2% from Great Oyster Bay, and 93.1% from Mercury Passage/Maria Island identified the proportion of Sand Flathead experiencing muscle melanisation. In Marion Bay (82.4%), Great Oyster Bay (85.0%), and Mercury Passage/Maria Island (54.4%), most recreational fishers suggested that the proportion of Sand Flathead with muscle melanisation is < 5% (Table A3).

From the total number of reports from each sub-region, 55.6% of reports from Marion Bay, 61.9% from Great Oyster Bay, and 53.4% from Mercury Passage/Maria Island identified the average extent of muscle melanisation in Sand Flathead. In Marion Bay, 45.0% of recreational fishers suggested that there is generally a moderate level of muscle melanisation in Sand Flathead. In Great Oyster Bay (69.2%), and Mercury Passage/Maria Island (46.2%), most recreational fishers suggested that there is generally a minor level of muscle melanisation in Sand Flathead (Table A3).

A total of 83.3% of reports from Marion Bay, 100% from Great Oyster Bay, and 94.5% from Mercury Passage/Maria Island identified the change in occurrence of muscle melanisation over the past 5 years. In Marion Bay (56.7%), Great Oyster Bay (57.1%), and Mercury Passage/Maria Island (40.6%), most recreational fishers stated they were not sure. Of the remaining reports, most suggested the incidence of muscle melanisation has remained largely unchanged in Marion Bay (23.3%) and Great Oyster Bay (23.8%). In Mercury Passage/Maria Island, there were equal reports suggesting largely unchanged (21.7%) and increased incidence of muscle melanisation (21.7%) (Table A3).

There were three key locations identified in the Central-East Coast region. Although none of these were of specific interest, Marion Bay (36), Spring Bay (10), and Triabunna (10) had many reports of muscle melanisation in Sand Flathead.

Norfolk Bay

In the Norfolk Bay region there was a total of 64 reports of muscle melanisation in Sand Flathead across 15 locations from 58 recreational fishers. Out of these reports, 95.3% identified the proportion of Sand Flathead experiencing muscle melanisation. Many recreational fishers suggested that the proportion is < 5% (50.8%). There were 60.9% of the reports that identified the average extent of muscle melanisation in Sand Flathead. Most recreational fishers (43.6%) suggested that there is generally a moderate level of muscle melanisation in Sand Flathead. A total of 89.1% of reports identified the change in occurrence of muscle melanisation over the past 5 years. Of these reports, 56.1% suggested that the incidence of muscle melanisation has remained largely unchanged (Table A3).

There were two key locations identified in the Norfolk Bay region. Although none of the locations were of specific interest, Connelys Bay (5) and Murdunna (5) had many reports of muscle melanisation in Sand Flathead.

Frederick Henry Bay

In the Frederick Henry Bay region there was a total of 108 reports of muscle melanisation in Sand Flathead across 14 locations from 83 recreational fishers. Out of these reports, 96.3% identified the proportion of Sand Flathead experiencing muscle melanisation. Many recreational fishers suggested that the proportion is < 5% (58.7%). There were 53.7% of the reports that identified the average extent of muscle melanisation in Sand Flathead. Most recreational fishers (55.2%) suggested that there is generally a moderate level of muscle melanisation in Sand Flathead. A total of 86.1% of reports identified the change in occurrence of muscle melanisation over the past 5 years. Of these reports, 55.9% suggested that the incidence of muscle melanisation has remained largely unchanged (Table A3).

There were five key locations identified in the Frederick Henry Bay region. Although none of the locations were of specific interest, Cremorne (7), Dodges Ferry (12), Pitt Water (6), Primrose Sands (9), and Sloping Main (10) had many reports of muscle melanisation in Sand Flathead.

Tasman Peninsula

In the Tasman Peninsula region there was a total of 57 reports of muscle melanisation in Sand Flathead across 13 locations from 45 recreational fishers. Within this region, two sub-regions were identified, including Eaglehawk Neck and Port Arthur. Eaglehawk Neck had 19

reports of muscle melanisation in Sand Flathead, across two locations from 19 recreational fishers. Secondly, Port Arthur had 38 reports of muscle melanisation in Sand Flathead, across 11 locations from 30 recreational fishers.

Out of the total number of reports from each sub-region, 84.2% of reports from Eaglehawk Neck and 100.0% from Port Arthur identified the proportion of Sand Flathead experiencing muscle melanisation. In Eaglehawk Neck (62.5%) and Port Arthur (34.2%), most recreational fishers suggested that the proportion of Sand Flathead with muscle melanisation is < 5% (Table A3).

From the total number of reports from each sub-region, 31.6% of reports from Eaglehawk Neck and 57.9% from Port Arthur identified the average extent of muscle melanisation in Sand Flathead. In Eaglehawk Neck (50.0%), most recreational fishers suggested that there is generally a minor level of muscle melanisation in Sand Flathead. In Port Arthur, 45.5% of recreational fishers suggested that there is generally a moderate level of muscle melanisation in Sand Flathead (Table A3).

A total of 84.2% of reports from Eaglehawk Neck and 86.8% from Port Arthur identified the change in occurrence of muscle melanisation over the past 5 years. In Eaglehawk Neck, most recreational fishers (50.0%) suggested the incidence of muscle melanisation has remained largely unchanged. In Port Arthur, 45.5% of reports suggested an increased incidence of muscle melanisation over the last five years (Table A3).

There were four key locations identified in the Tasman Peninsula region. These locations included: Carnarvon Bay (7), Eaglehawk Bay (5), Pirates Bay (6), and Nubeena (5), which had many reports of muscle melanisation in Sand Flathead. A location of specific interest was Carnarvon bay, where reports from recreational fishers (57.1%) suggested an increased incidence of muscle melanisation over the past five years.

Derwent River

In the Derwent River region there was a total of 83 reports of muscle melanisation in Sand Flathead across 20 locations from 64 recreational fishers. Out of these reports, 94.0% identified the proportion of Sand Flathead experiencing muscle melanisation. An equal number of recreational fishers suggested that the proportion is < 5% (28.2%) and 6-10% (28.2%). There were 51.8% of the reports that identified the average extent of muscle melanisation in Sand Flathead. Most recreational fishers (48.8%) suggested that there is generally a moderate level of muscle melanisation in Sand Flathead. A total of 90.4% of reports identified the change in occurrence of muscle melanisation over the past 5 years. Of these reports, 42.7% suggested that the incidence of muscle melanisation has remained largely unchanged (Table A3).

There were three key locations identified in the Derwent River region. Although none of the locations were of specific interest, Ralphs Bay (14), Sandy Bay (6), and South Arm (9) had many reports of muscle melanisation in Sand Flathead.

D'Entrecasteaux Channel

In the D'Entrecasteaux Channel region there was a total of 182 reports of muscle melanisation in Sand Flathead across 37 locations from 108 recreational fishers. Out of these reports, 92.9% identified the proportion of Sand Flathead experiencing muscle

melanisation. An equal number of recreational fishers suggested that the proportion is 6-10% (26.6%) and 11-20% (26.6%) (Table A3). There were 52.7% of the reports that identified the average extent of muscle melanisation in Sand Flathead. Most recreational fishers (45.8%) suggested that there is generally a moderate level of muscle melanisation in Sand Flathead (Table 8). A total of 87.9% of reports identified the change in occurrence of muscle melanisation over the past five years. Of these reports, 40.6% suggested that the incidence of muscle melanisation has remained largely unchanged (Table A3).

There were eight key locations identified in the D'Entrecasteaux Channel region. These included: Barnes Bay (10), Dennes Point (9), Gordon (8), Great Bay (7), Middleton (9), North West Bay (28), Simpsons Bay (12), and Woodbridge (7), which had many reports of muscle melanisation in Sand Flathead. A location of specific interest was Simpsons Bay, where recreational fishers (40.0%) suggested an increased incidence of muscle melanisation over the past 5 years.

Storm Bay

In the Storm Bay region there was a total of 72 reports of muscle melanisation in Sand Flathead across seven locations from 57 recreational fishers. Out of these reports, 98.6% identified the proportion of Sand Flathead experiencing muscle melanisation. Many recreational fishers suggested that the proportion is < 5% (62.0%). There were 61.1% of the reports that identified the average extent of muscle melanisation in Sand Flathead. The recreational fishers of the area suggested that there is between a minor (36.4%) and moderate (38.6%) level of muscle melanisation in Sand Flathead. A total of 94.4% of reports identified the change in occurrence of muscle melanisation over the past five years. Of these reports, 48.5% suggested that the incidence of muscle melanisation has remained largely unchanged (Table A3).

There were four key locations identified in the Storm Bay region. Although none of the locations were of specific interest, Adventure Bay (6), Betsey Island (5), Bull Bay (14), and Trumpeter Bay (10) had many reports of muscle melanisation in Sand Flathead.

Table A3. Percentage of reports indicating the proportion of affected Sand Flathead, extent of muscle melanisation and incidence of muscle melanisation within the last 5 years, by region.

Shaded cells indicate results of interest.

Region	Sub-Region	Respondents	Locational reports	Proportion of Sand Flathead with Muscle Melanisation (%)					Extent of Muscle Melanisation				Incidence of Muscle Melanisation Within the Last 5 Years			
		No.	No.	< 5	6-10	11-20	21-50	> 50	Minor	Moderate	Extensive	Variable	Decreased	Increased	Unchanged	Not Sure
North-West Coast		16	28	76.0	12.0	4.0	8.0	0.0	46.2	23.1	0.0	30.8	4.6	4.6	68.2	22.7
Tamar River		40	64	27.4	29.0	27.4	6.5	9.7	23.5	50.0	5.9	20.6	5.0	11.7	51.7	31.7
North Coast		15	19	79.0	21.1	0.0	0.0	0.0	62.5	37.5	0.0	0.0	23.5	11.8	52.9	11.8
Flinders Island		4	5	80.0	20.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
North-East Coast		26	29	40.7	37.0	7.4	3.7	11.1	16.7	58.3	8.3	16.7	7.4	11.1	44.4	37.0
Central-East Coast	Great Oyster Bay	20	21	85.0	10.0	5.0	0.0	0.0	69.2	7.7	15.4	7.7	14.3	4.8	23.8	57.1
	Marion Bay	36	36	82.4	11.8	2.9	0.0	2.9	35.0	45.0	10.0	10.0	3.3	16.7	23.3	56.7
	Mercury Passage/ Maria Island	53	73	54.4	23.5	8.8	7.4	5.9	46.2	35.9	5.1	12.8	15.9	21.7	21.7	40.6
Dunalley		21	23	56.5	17.4	21.7	0.0	4.4	85.7	0.0	14.3	0.0	0.0	10.0	50.0	40.0
Norfolk Bay		58	64	50.8	26.2	14.8	3.3	4.9	30.8	43.6	7.7	18.0	3.5	19.3	56.1	21.1
Frederick Henry Bay		83	108	58.7	25.0	12.5	1.0	2.9	24.1	55.2	15.5	5.2	1.1	20.4	55.9	22.6
Tasman Peninsula	Eaglehawk Neck	19	19	62.5	18.8	0.0	18.8	0.0	50.0	16.7	16.7	16.7	0.0	12.5	50.0	37.5
	Port Arthur	30	38	34.2	29.0	10.5	13.2	13.2	31.8	45.5	13.6	9.1	0.0	45.5	24.2	30.3
Derwent River		64	83	28.2	28.2	16.7	15.4	11.5	25.6	48.8	20.9	4.7	5.3	14.7	42.7	37.3
D'Entrecasteaux Channel		108	182	19.5	26.6	26.6	11.8	15.4	24.0	45.8	13.5	16.7	4.4	30.0	40.6	25.0
Huon River		17	22	18.2	50.0	18.2	4.6	9.1	28.6	35.7	28.6	7.1	0.0	50.0	25.0	25.0
Port Esperance		21	23	21.7	21.7	17.4	21.7	17.4	15.4	46.2	0.0	38.5	0.0	26.1	56.5	17.4
Southport		37	48	37.0	21.7	6.5	15.2	19.6	38.1	33.3	9.5	19.1	2.4	4.8	73.8	19.1
Storm Bay		57	72	26.8	62.0	4.2	4.2	2.8	36.4	38.6	15.9	9.1	0.0	19.1	48.5	32.4