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Canadian Technical Report of Fisheries and Aquatic Sciences

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Numbers 1-456 in this series were issued as Technical Reports of the Fisheries Research Board of Canada. Numbers 457-714 were issued as Department of the Environment, Fisheries and Marine Service, Research and Development Directorate Technical Reports. Numbers 715-924 were issued as Department of Fisheries and Environment, Fisheries and Marine Service Technical Reports. The current series name was changed with report number 925.

Rapport technique canadien des sciences halieutiques et aquatiques

Les rapports techniques contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles, mais qui ne sont pas normalement appropriés pour la publication dans un journal scientifique. Les rapports techniques sont destinés essentiellement à un public international et ils sont distribués à cet échelon. II n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques de Pêches et Océans Canada, c'est-à-dire les sciences halieutiques et aquatiques.

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Les numéros 1 à 456 de cette série ont été publiés à titre de Rapports techniques de l'Office des recherches sur les pêcheries du Canada. Les numéros 457 à 714 sont parus à titre de Rapports techniques de la Direction générale de la recherche et du développement, Service des pêches et de la mer, ministère de l'Environnement. Les numéros 715 à 924 ont été publiés à titre de Rapports techniques du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 925.

Canadian Technical Report of
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2021

ESTIMATION OF FORK LENGTH USING CRANIAL MEASUREMENTS OF SABLEFISH (*ANOPLOPOMA FIMBRIA*) IN BRITISH COLUMBIA.

by

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ABSTRACT

Kathryn x. Temple, K.R. Holt and Lacko, L.C. 2021. Estimation of fork length using cranial measurements of sablefish (*Anoplopoma fimbria*) in British Columbia.. Can. Tech. Rep. Fish. Aquat. Sci. nnn: vi + 17 p.

Routine biological sampling of whole round sablefish from commercial fishing operations in British Columbia have occurred since the early 1990's. Historically, specimens have been obtained through a voluntary catch sampling program and tagged sablefish recovery program. In order to improve the quantity and size range of samples received, we investigated the potential for obtaining biological information using heads, rather than the entire fish. In 2016, 438 sablefish (240-1080 mm) were sampled at sea and six different fish head measurements were assessed to see if they could predict fork length. Genetic samples (137) were collected to develop methods for DNA-based sex identification. A pilot study was conducted in 2017 with head-only samples and sex determination provided by a commercial vessel, followed by scientific sampling on shore. Regression analysis results show that the interorbital distance measurement was a good predictor of sablefish fork length, while samplers ranked it the most efficient and easily repeatable. Initial genetic samples (130/137) were successfully PCR amplified from genomic DNA and results indicate 92% accuracy in sex detection. Subsequently, the 2018 sampling collection program was modified so that returns of whole round sablefish were replaced by head-only samples with knife cuts on the operculum to indicate sex.

RÉSUMÉ

Kathryn x. Temple, K.R. Holt and Lacko, L.C. 2021. Estimation of fork length using cranial measurements of sablefish (*Anoplopoma fimbria*) in British Columbia.. Can. Tech. Rep. Fish. Aquat. Sci. nnn: vi + 17 p.

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1 Introduction

Biological samples of British Columbia (BC) sablefish (*Anoplopoma fimbria*) have been collected from a voluntary catch sampling program since 1995 (Haist and Wyeth 2001) and processed by the Department of Fisheries and Oceans (DFO) port samplers and contracted service providers. In addition, whole tagged fish recovered in commercial fisheries (trap, trawl, hook and line) have been received at the point of landing via the dockside monitoring program (DMP) and sampled by Archipelago Marine Research (AMR) since the early 1990's. These data provide a fishery dependent source of age and size composition data for the two-sex structured operating model of the coastal Management Strategy Evaluation (MSE) (Cox et al. 2019).

In recent years, a sablefish head only catch sampling and tagging program was developed in order to improve the number of returns, maintain the quality of the biological data and increase the range of fish sizes. Instead of returning the whole fish, commercial crew j-cut the fish as per commercial practice, view the gonads to determine sex, mark the sex with knife cuts on the operculum and store the head (and/or floy tag) for later sampling by the department and AMR.

Previous research has accurately estimated fish lengths from i) head measurements (Serafy et al. 1996; Park et al. 2019), ii) head and mandible lengths (Isermann and Vandergoot 2005) and iii) relative eye size (Richardson et al. 2015). In our research, six unique sablefish head dimensions including fork length (FL), eye diameter (ED), interorbital distance (ID), snout length (SL), post orbital to preoperculum distance (PP) and post orbital head length (PH) were regressed against fork length (FL). In addition, a task performance ranking system was developed to reveal the most accurate and efficient cranial measurement.

In 2016, standard biological data including operculum clips (DNA) were obtained on several research surveys from 216 female and 222 male sablefish, followed by cranial measurements at the Pacific Biological Station (PBS). Methods for DNA-based sex identification were developed by the PBS Molecular Genetics lab. In 2017, a pilot study was conducted on a commercial vessel. Head-only samples with sex markings were collected at sea, followed by scientific sampling on shore. DNA analysis measured the commercial fisher sex accuracy.

In this technical report we describe the results of 1) the relationship between head measurements and fork length; 2) the feasibility of the head measurements; 3) the methods of DNA sex detection; and 4) the fisher-determined sex accuracy via genetic methods. Successful application of this research has resulted in program revisions in the catch sampling programs and shore-side sampling of sablefish in 2018.

2 Methods

2.1 2016

2.1.1 Sample collection

Sablefish were selected for sampling during the 2016 biennial DFO Groundfish Synoptic Bottom Trawl surveys, following a trip-wide length stratified selection protocol. A total of 431 fish were sampled on the West Coast Vancouver Island survey (212 fish) (Williams et al. 2018) and the West Coast Haida Gwaii survey (219 fish) (Nottingham et al. 2018). In addition, seven small sablefish were collected during the 2016 salmon survey (Figure 1).

For each selected fish, fork length, round weight, fish sex and maturity (determined by internal examination of the gonads) were recorded at sea. The heads were removed, tagged and frozen. On shore, cranial dimensions were measured using Mitutoyo Absolute® 500-762-20 coolant proof digimatic calipers. Ageing structures (sagittal otoliths) were also collected from each head. Operculum clips (DNA) were collected from the first 137 fish measured (79 male and 58 female), and were stored in vials containing 95% ethanol.

2.1.2 Estimation of Fork Length using Cranial Measurements

A number of cranial dimensions were considered as possible candidates for estimating fork length: upper jaw length (UJ), eye diameter (ED), interorbital distance (ID), snout length (SL), post orbital to preoperculum distance (PP), and post orbital head length (PH) (Table 1; Appendix B). Each cranial dimension was ranked by samplers on a five point rating scale in terms of ease of use and repeatability with electronic calipers. The ease of use metric focused on three key attributes of the measurement learnability (task understanding), efficiency (task-completion time) and degree of difficulty (task performance ease). The repeatability metric focused on ranking each measurement under repeated caliper placement, taking into consideration the soft and hard head tissues.

2.1.3 Genetic test development for gender determination

DNA multiplex polymerase chain reactions (PCRs) were conducted using fluorescently labelled forward primers. X-insert and Y-insert specific primers developed by Rondeau et al. (2013) were used, but the X-insert forward and Y-nested reverse were redesigned to produce slightly smaller PCR products (Table 2). Sex specific alleles were size fractionated in an ABI 3730 capillary DNA analyzer and were scored with ABI GeneMapper using an internal lane sizing standard.

2.2 Pilot study sample collection 2017

In 2017, a pilot study was conducted with the commercial sector returning sablefish head only samples. A total of 360 heads were collected from J-cut sablefish on a limited-entry fishery trip to the SGaan Kinghlas - Bowie (SK-B) seamount. Each operculum was marked by commercial fishers with either one knife cut (male) or two knife cuts (female) (Appendix B). Scientific sampling occurred on shore, with the first 99 heads of the pilot study measured by three technicians for ID, SL, UJ and PP. Fin clips were forwarded to the molecular genetics lab for sex determination.

3 Results and Discussion

3.1 Sample collection

A total of 306 specimens comprising 111 males, 97 females and 98 indeterminate were used for the study. The smallest length of captured fish was 3.30 cm and highest was 14.00 cm in TL (Table 3).

A total of 438 specimens comprising 222 males and 216 females were used for the study. The smallest fork length of the collected specimens was 240 mm and highest was 1080 mm.

collected for six head measurements (UJ,ED,IO,SL, PP, PH), fork length, round weight, otoliths and DNA. Post orbital head length (Posterior inner edge of orbit to dorsal insertion of opercle) was also measured, but this was abandoned after 130 measurements, to save time, and because it was not possible to measure this on a number of the heads for a variety of reasons (opercula had been cut off from some heads, it was awkward to take longer measurements using the electronic calipers, and the end points of the measurement were difficult to define.

3.2 Estimation of Fork Length using Cranial Measurements

The mean values of the predictor and response variables (Table 2).

Given the ease of measurement, we suggest that Interorbital distance be used to predict sablefish fork lengths and weights (Table 3).

We found evidence of relationships between upper jaw length and fork length (p = 9.358×10^{-278}) ; eye diameter and fork length (p = 5.34×10^{-203}); interorbital distance and fork length (p = 5.539×10^{-272}); upper snout length and fork length (p = 4.593×10^{-292}); postorbital to preoperculum length and fork length (p = 2.024×10^{-247}); and postorbital head length and fork length (p = 0).

The estimated slope is 7.695 (SE 0.088) units of fork length per unit of upper jaw length; the estimated slope is 21.994 (SE 0.389) units of fork length per unit of eye diameter; the estimated slope is 11.622 (SE 0.138) units of fork length per unit of interorbital distance; the estimated slope is 11.182 (SE 0.118 units of fork length per unit of snout length; the estimated slope is 14.373 (SE 0.191) units of fork length per unit of postorbital to preoperculum length; and the estimated slope is 6.83 (SE 0.185) units of fork length per unit of postorbital head length.

3.3 Pilot Collection of Sablefish Heads as a Biological Sample

Heads were received by DFO in good condition (intact and not deformed), segregated by set, for measuring and otolith extraction. Operculum cuts worked well to indicate sex

3.4 Repeatability of measurements between technicians

4 Discussion

Routine biological sampling procedures have been modified so that commercial fisheries are now only returning heads, rather than entire fish.

5 Tables

Table 1. List of head dimensions, measurement descriptions and specification of caliper jaw placement.

Head dimension	Head description	Caliper jaw position
UJ	Tip of snout to the posterior edge of the maxilla.	Outside caliper jaw measurement from forward point and centre of snout to back of maxilla.
ED	Anterior-posterior diameter of eye socket.	Inside caliper jaw measurement firmly stretched against eye socket at vertical midpoint of eye.
IO	Narrowest distance between eye sockets, measured on dorsal surface.	Outside caliper jaw measurement of the horizontal midpoint of eyes on dorsal surface.
SL	Tip of snout to anterior inner edge of eye socket.	Outside caliper jaw measurement from forward point and centre of snout to horizontal midpoint of anterior edge of eye socket.
PP	Posterior inner edge of orbit to visual insertion point of preopercle.	Outside caliper jaw measurement from back of eye socket to preopercle bone insertion point. Preopercle must be lifted to expose preopercle bone underneath.
PH	Posterior inner edge of orbit to dorsal insertion of opercle.	Outside caliper jaw measurement from back of eye socket to bone underneath gill cover notch at dorsal insertion of the opercle. The operculum must be held taut.

Table 2. Primers used in the development of a genetic test for determining sablefish sex.

Locus	Sequence	Fragment.Size
X-insert-DFO_F1	6FAM-CACCGCTCATGTACACTTTG	321
X-insert-2R	TGCTGCACTGTACCATCAAA	
Y-nested-1F	NED-GTCAGAAGGCAGTGGTGTAGT	234
Y-nested-MGL_2R	CGCTTGCAGATACTACTGAATG	

on each head dimension manual calipers for >15cm distances other metrics indicate if calipers were limited after >15 cm, bilateral measurements were possible and if the measurement involved bone.

Table 3. Summary of sablefish biological data collected. Tally of fork lengths (FL), round weight (RW), upper jaw length (UJ), eye diameter (ED), interorbital distance (IO), snout length (SL), post orbital to preoperculum distance (PP), post orbital head length (PH), females (F), males (M), sagittal otoliths (O) and operculum clips (DNA) listed by survey.

Survey	FL	RW	UJ	ED	IO	SL	PP	PH	F	M	Otoliths	DNA	Total
2016 WCHG	219	219	219	219	218	219	207	52	111	108	219	59	219
2016 WCVI	212	212	211	212	212	211	212	78	105	107	212	78	212
Salmon	7	0	7	7	7	7	7	0	0	7	0	0	7

Table 4. Table of sample size, mean and standard deviation for predictor and response variables for each head dimension.

Predictor variable	n	mean	sd	Response variable	mean	sd
Upper jaw length	437	57.95	15.22	Fork length	573.27	120.44
Eye diameter	438	25.9	5.13	Fork length	573.3	120.3
InterOrbital distance	437	40.37	10.06	Fork length	573.36	120.43
Snout length	437	44.81	10.52	Fork length	573.27	120.44
Post orbital to preoperculum length	426	31.5	8.02	Fork length	571.34	119.54
Post orbital head length	130	60.85	18.87	Fork length	566.46	134.8

Table 5. Ease of use and repeat ability considerations for each measurement.number, ease of use and repeatability five point ranking where 5-Great; 4- Good; 3-Moderate; 2-Questionable; 1-Terrible.

	5 Point			Measurement		
Head Dimension	Ease of use	Repeatable	Caliper limitation	Bilateral	Bone	Considerations
UJ	3	4	x	x	x	End of the maxilla difficult to define. Caliper jaw position must be in center of snout.
ED	3	2		x		Caliper outside jaw position on soft tissue in eye socket may result in measurement differences.
IO	5	5			x	Tissue is compressed to obtain bone measurement. Easy to determine caliper jaw position.
SL	4	5		x	x	Caliper jaw position must be in center of snout.
PP	4	5		x	x	Caliper position on pre-operculum may result in measurement differences.
PH	3	2	x	x		Operculum damage from handling was observed on several fish.

Table 6. Ease of use and repeat ability considerations for each measurement.number, ease of use and repeatability five point ranking where 5-Great; 4- Good; 3-Moderate; 2-Questionable; 1-Terrible.

Head dimension	**slope**	**SE**
Upper jaw length	7.6946	0.088
Eye diameter	21.994	0.389
InterOrbital distance	11.622	0.138
Snout length	11.182	0.118
Post orbital to preoperculum length	14.373	0.191
Post orbital head length	6.8299	0.185

6 Figures

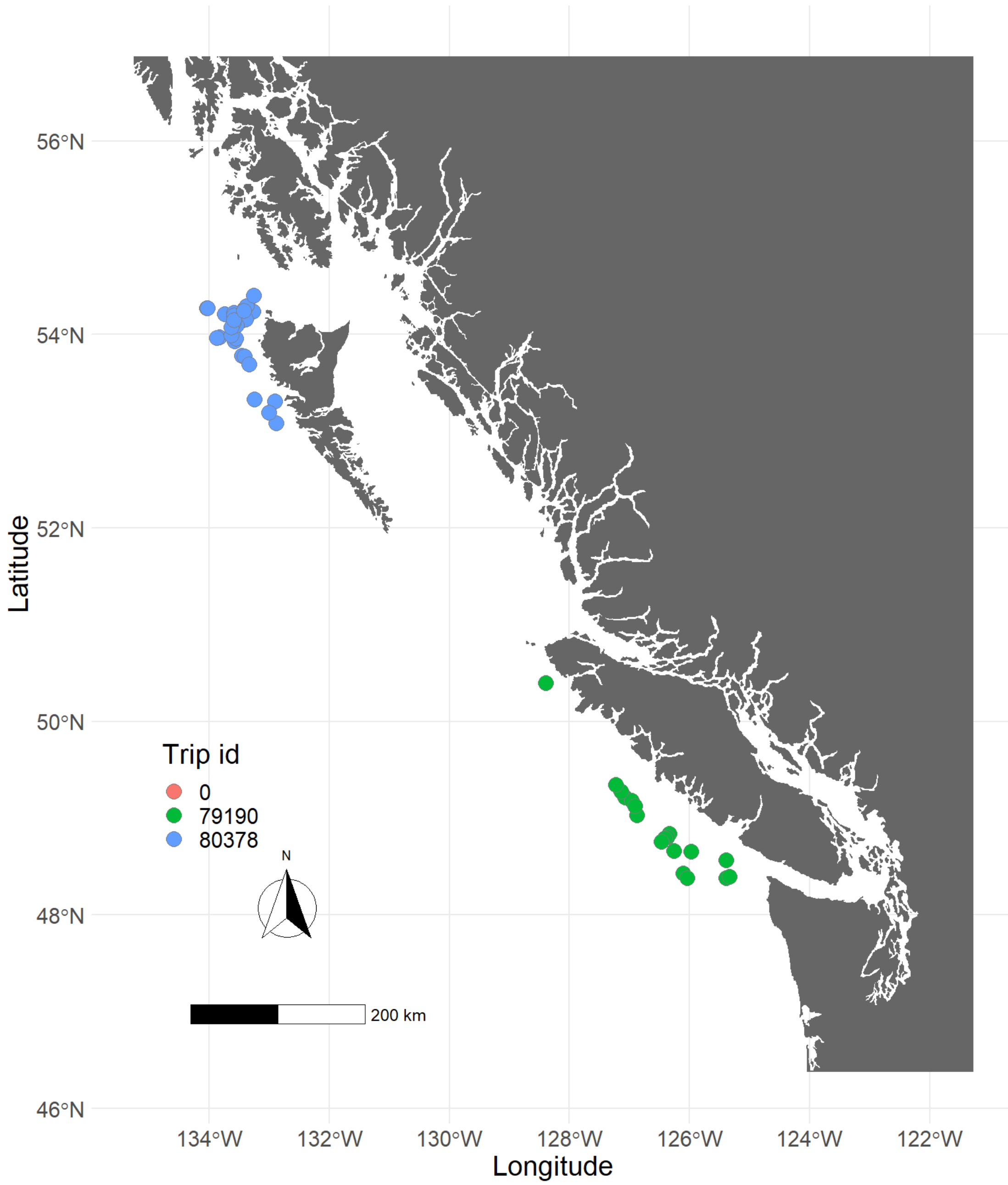


Figure 1. Sample locations in 2016 from the WCVI survey (GFBIO trip id 79190), WCHG survey (GFBIO trip id 80378) and salmon survey (?).

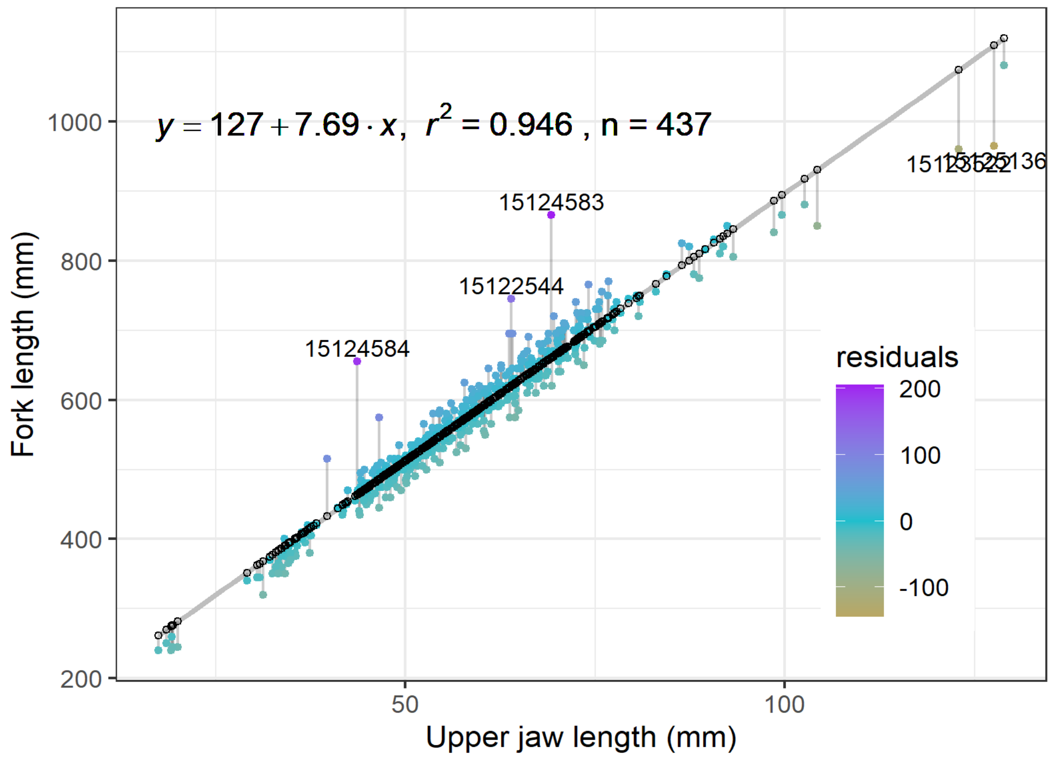


Figure 2. Scatterplot upper jaw vs fork length, measurements in millimeters.

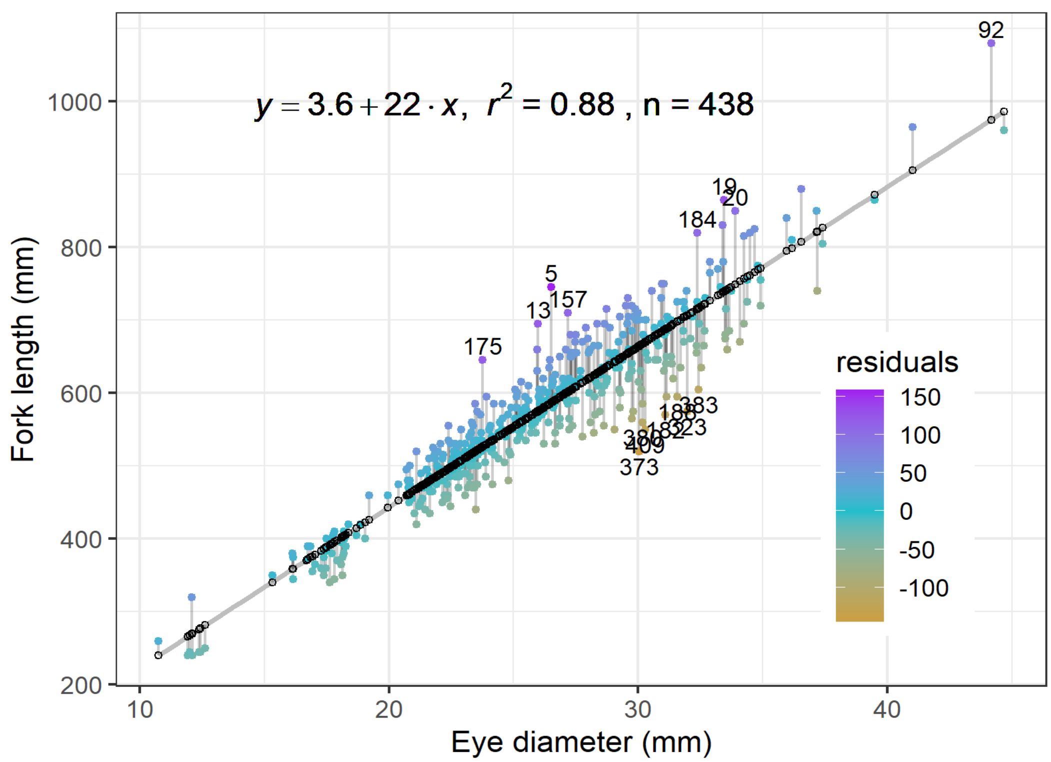


Figure 3. Scatterplot eye diameter vs fork length, measurements in millimeters.

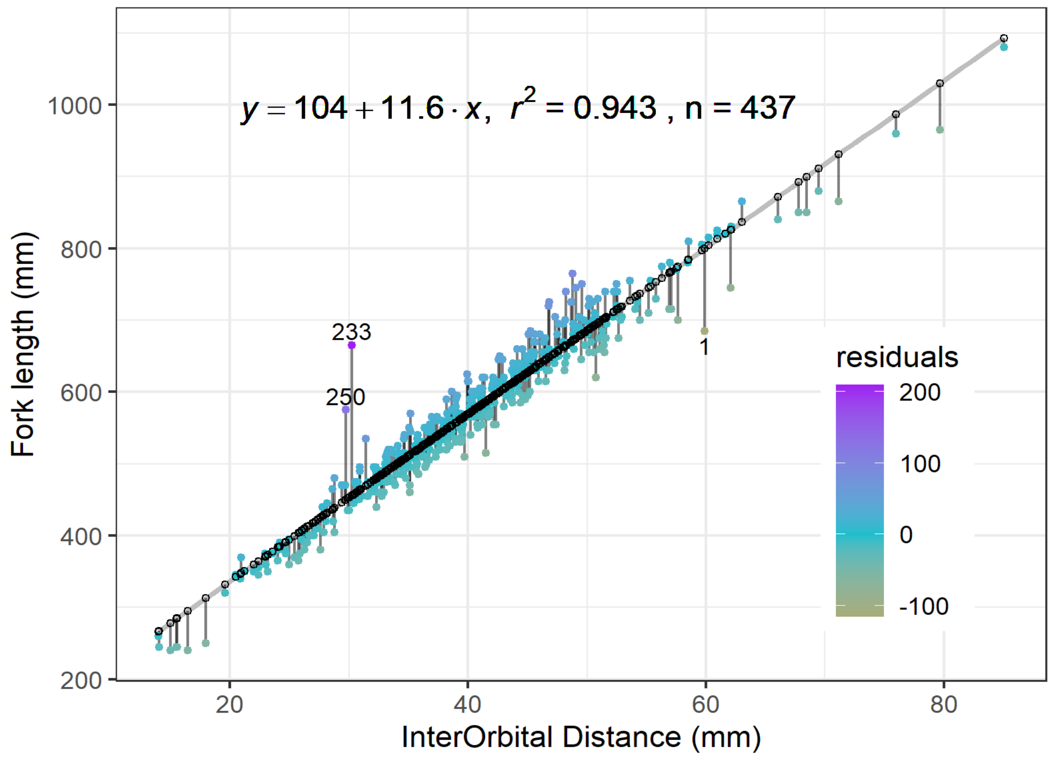


Figure 4. Scatterplot interorbital vs fork length.

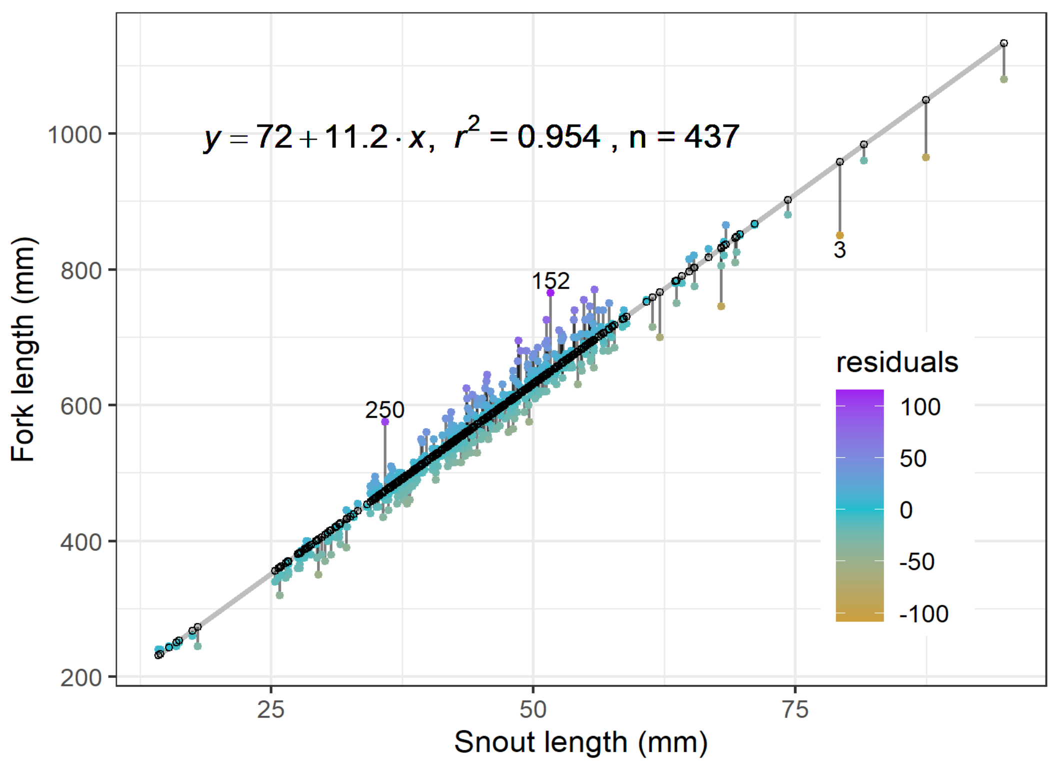


Figure 5. Scatterplot snout length vs fork length.

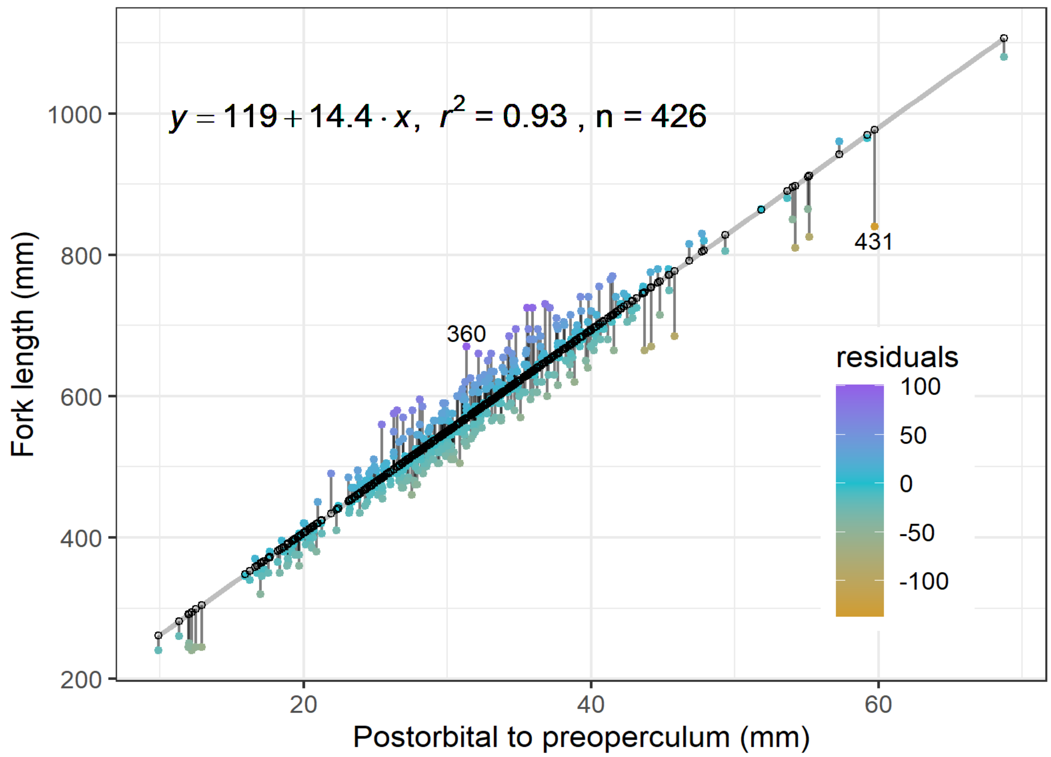


Figure 6. Scatterplot post orbital to preoperculum length vs fork length.

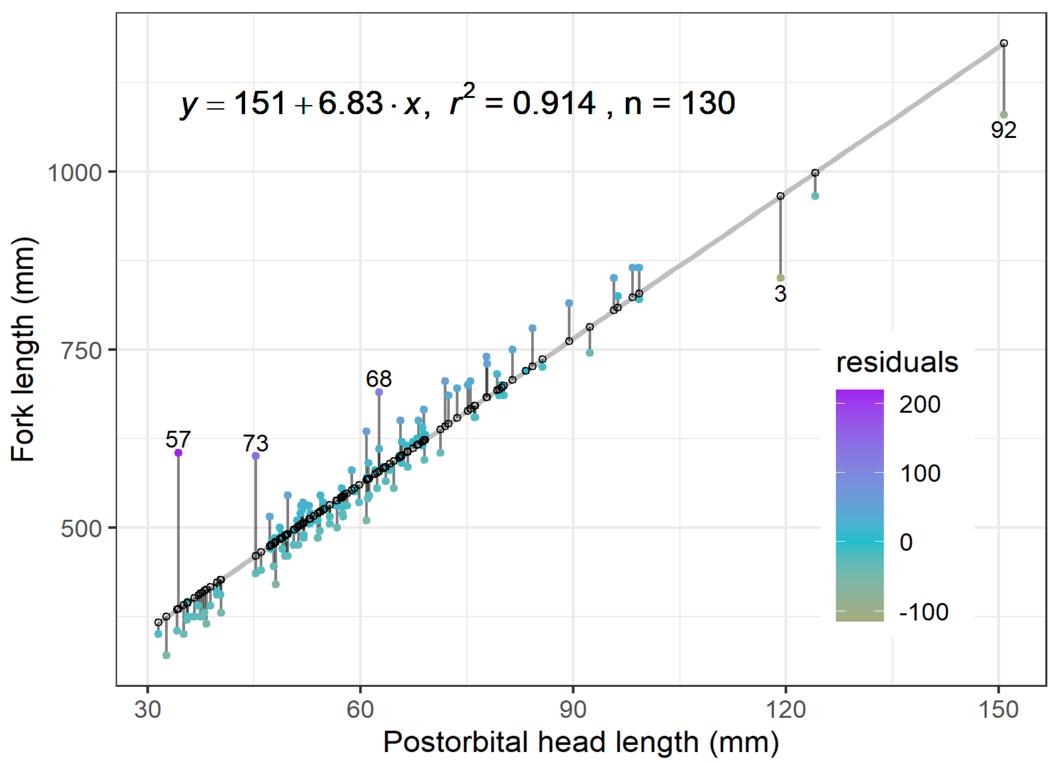


Figure 7. Scatterplot of post orbital length vs fork length.

7 Discussion

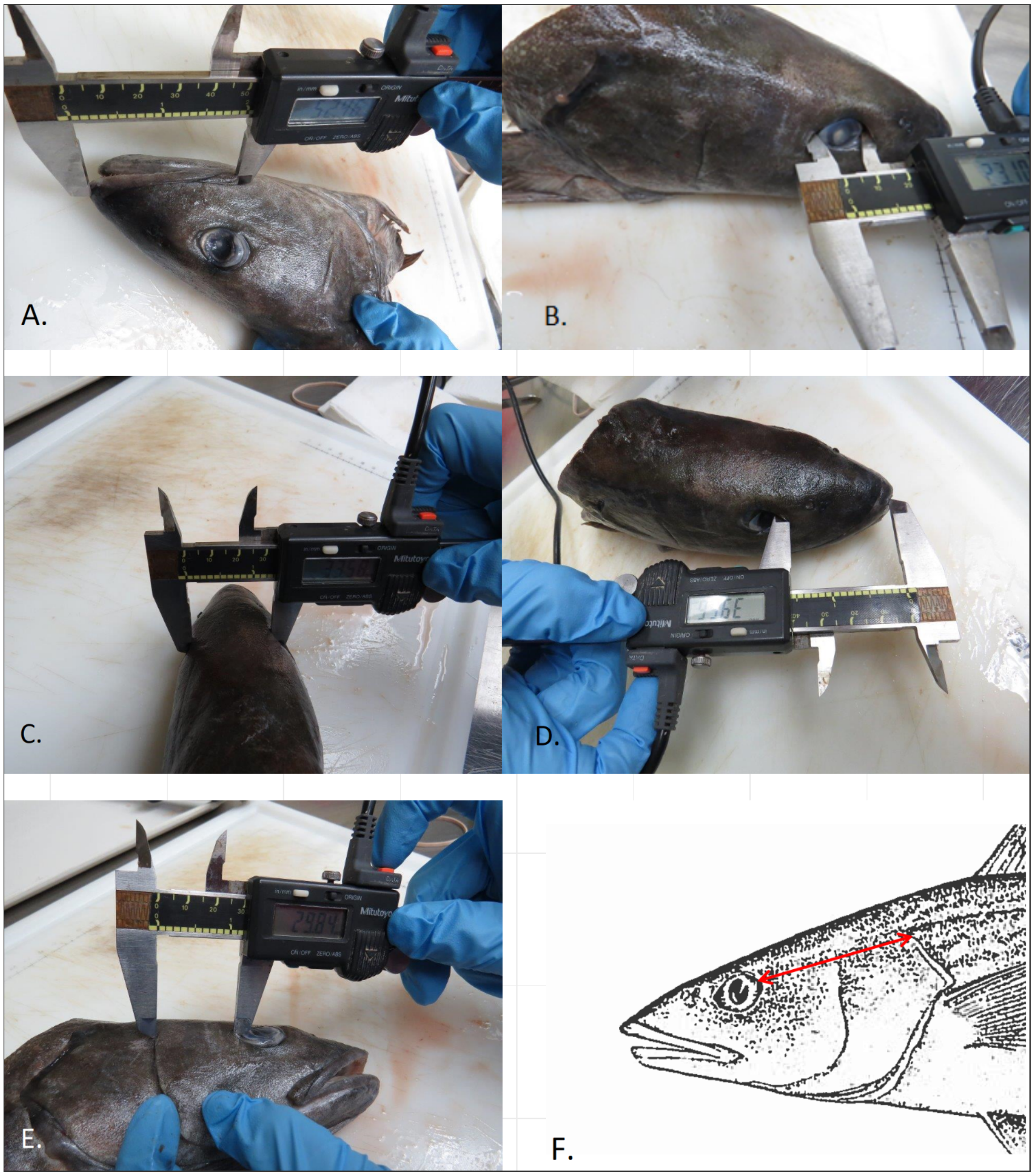
Interorbial head length (IO) proved to be a good predictor of fork length for sablefish.

8 Acknowledgments

We thank . . .

APPENDIX A IMAGES OF THE SIX CRANIAL DIMENSION MEASUREMENTS.

A. Upper jaw measurement (UJ); B. Eye diameter measurement (ED); C. Interorbital distance (ID); D. Snout length (SL); E. Post orbital to preoperculum length measurement (PP); F. Post orbital head length (PH).



APPENDIX B SEX DETERMINATION BY OPERCULUM MARKING

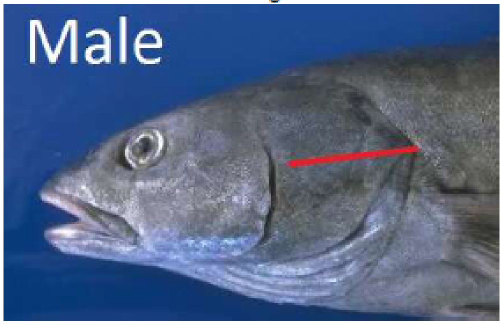
Operculum knife cuts for sablefish males (A) and females (B).

SABLEFISH – Sexing and Marking

MALES

Look for lobes that have an 'edge' to them. Due to the 'edge', they will not 'roll' easily in your fingers. The lobes are fused together at the end closest to the head.

Mark with **one** cut on the gill cover

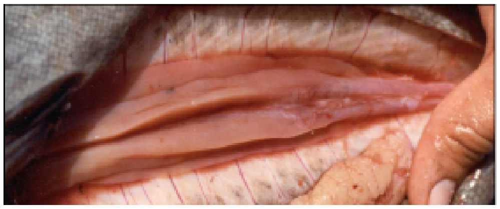


Sample photos for *color* and *shape reference*:

Juvenile: translucent-white

Developing: creamy-white

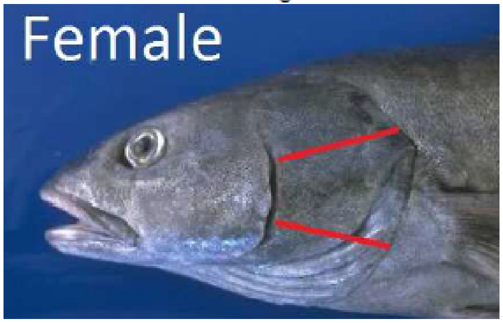
Post Spawning: brown or tan



FEMALES

Look for tubes that are oval in cross section and will 'roll' in your fingers.

Mark with **two** cuts on the gill cover



Sample photos for *color* and *shape reference*:

Juvenile: translucent pinky purple

Developing: creamy white, filled with eggs

Post Spawning: reddish- purple- brown, whitish sheen to the exterior surface

NOTE: If sex can NOT be determined, leave the fish head **unmarked.**

Juveniles can be tough to sex. If you are unsure do not mark the head

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