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Taihoro Nukurangi

Estimation of the target strength of orange roughy by-catch species

Gavin Macaulay, Alan Hart, and Paul Grimes

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Final Research Report

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Authors	Gavin Macaulay, Alan Hart, and Paul Grimes
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7. Executive Summary

Target strength to length relationships for 10 orange roughy by-catch species are presented. The relationships were derived from casts of swimbladders from basketwork eels, four-rayed rattails, robust cardinalfish, johnson's cod, javelin fish, ribaldo, and white rattail. The latest results from other MFish funded research into the target strength of hake, and smooth and black oreos are reported, but not discussed, here.

The results from the swimbladder casts appear to be reasonable estimates, but without estimates from other, complementary techniques (such as *in-situ* measurements) they must be taken as preliminary estimates only.

8. Objectives

To estimate the target strength of associated bycatch species, especially the species taken as bycatch on the flat areas away from the main spawning plume in the spawning box on the Chatham Rise.

9. Methods

9.1 Introduction

Estimates of abundance are required for the stock assessment of any species. Deepwater acoustic methods for orange roughy were trialed successfully in winter 1995 and further developed in winter 1996 and 1997. Acoustic surveys to estimate the abundance of orange roughy were completed in the spawning box and northeast hills areas of the Chatham Rise part of ORH 3B in winter 1998, for the northwest hills of the Chatham Rise in winter 1999 and in the spawning box, north-eastern and eastern hills in winter 2000.

The results of the acoustic surveys conducted in 1998 and 1999 suggest that more than 50% of the orange roughy biomass may be found on flat bottom outside the main spawning plumes (1998 spawning box survey) or away from the main hills (1999 northwest hills survey). One of the main uncertainties in the estimates of orange roughy biomass on these flat bottom areas is the target strength of associated bycatch species. The target strength of most of these species is unknown or poorly known, and this report details initial estimates for several of the by-catch species.

A sensitivity analysis of the data collected during the 1999 acoustic survey of orange roughy on the northwest hills was carried out. The factors contributing to higher importance were a high abundance and a high assumed backscatter/weight ratio. The results have been placed into three classifications (high, moderate and low importance) and are presented in Table 1. Given the large number of species in the table, we concentrated on the species in the high and moderate classifications. This selection is consistent with a similar analysis presented in Kloser et al. (2000) for an acoustic survey conducted in 1998 on the spawning box of the Chatham Rise, but also included ribaldo, which are not common on the northeast hills. Consequently, ribaldo has been included in the moderate classification. Two of the species in the moderate classification and five in the low classification do not have gas-filled swimbladders (Baxters lantern dogfish, bigscaled brown slickhead, smooth skin dogfish, plunkets shark, shovelnose spiny dogfish, longnose velvet dogfish and leafscale gulper shark), and no swimbladder casts have been collected from them.

Swimbladders were collected and analysed from some of the species in the low classification – these included robust cardinalfish and white rattail. Also, several species are, or have been, the subject of other MFish projects and were not further investigated in this project, except to report the latest results here. These include black and smooth oreo (project OEO2000/01A) and hake (project HAK9801).

9.2 Swimbladder cast collection

The swimbladder casts analysed in this report were collected during a *Tangaroa* voyage from 5 July to 23 July 2000 on the Chatham Rise.

For each species, the swimbladder inflation volumes required for neutral buoyancy were estimated by weighing the fish in air and water. Fish covering the entire size range were weighed. The difference between these two weights represents the lift required for neutral buoyancy.

The casts were made from freshly caught fish by injecting the swimbladder with a measured volume of an epoxy resin mixture to the level estimated for neutral buoyancy. This was done with the swimbladder still inside the fish. Until the mixture was set the body of the fish was positioned with the ventral surface uppermost. Epiglass HT9000 resin and hardener with the additives HT440 epispheres, HT330 microballoons, and HT110 extender glue were used. By varying the amount of additive, the physical properties of the unset mixture were altered to suit swimbladder size, strength of the swimbladder wall, and whether the swimbladder was burst (in cases where insufficient intact swimbladders were available). For severely damaged swimbladders cases a light dough-like mixture was used and this was pre-shaped to match the best injected examples then pressed into position within the swimbladder though a rupture point, or into the cavity that the swimbladder occupied.

The inclination of the swimbladder relative to the fish was measured during the casting process and when scanned was orientated so that the (now absent) fish was level.

9.3 Target strength estimation from swimbladder casts

A selection of the casts collected were digitised using a 3D scanner and associated software (Polhemus 2000) to produce a set of connected triangles in 3D space that represents the surface of the swimbladder. The target strength (TS) at 38 kHz was calculated for each cast, at a range of dorsal tilt angles using the Kirchhoff ray approximation (Foote 1985). The TS values were then convolved with an assumed fish dorsal tilt angle distribution to produce tilt-averaged target strength values (<TS>) for each fish. Very little is known about the *in situ* tilt angle distribution of the various species analysed, so a normal distribution with a mean of 0° and a standard deviation of 15° were assumed (McClatchie et al. 1996).

Several swimbladders were scanned multiple times to determine the repeatability of the scanner. The resulting target strengths were within 0.05 dB of each other.

To test the sensitivity of the estimated target strengths to under or over inflation of the swimbladder casts, the target strength was calculated for each swimbladder at 85, 90, 95, 105, 110 and 115% of the original size. This was a deliberately simple approximation to what happens when too little or too much resin is injected into a swimbladder. A more accurate, but considerably more difficult technique would be to take into account the constraints on the swimbladder such as the relatively rigid backbone and the less rigid organs surrounding the swimbladder when simulating the injection of too little or too much resin. This level of realism was not attempted (but is being carried out for hoki as part of MFish project HOK2000/03). For each species, the difference between the under or over inflated swimbladder <TS> and the original swimbladder <TS> was calculated for each swimbladder inflation level. The mean difference and standard variation was calculated from the results for each species.

To simulate different fish sizes, each swimbladder was scaled using a relationship obtained from measurements of the swimbladder and fish size of many fish. Tilt-averaged target strength was then calculated for each of these scaled swimbladders, resulting in a set of target strength/fish length points for each cast.

The target strength estimates from the swimbladder models only include the acoustical scattering from the swimbladder itself. They do not include any contribution from other parts of the fish, such as the flesh and bones. However, for fish containing gas filled swimbladders, 90–95% of the reflected acoustic energy comes from the swimbladder (Foote 1980), and neglecting the contribution from the flesh and bone does not markedly affect the result. Consequently, fish without gas filled swimbladders tend to have low target strengths.

10. Results

Ninety-four swimbladders from seven species (see Table 2) were scanned and used to estimate target strength. Fish length and swimbladder cavity measurements were made from over 100 fish, and swimbladder/fish length relationships derived for all seven species (see Table 3). In all cases, these data were modelled using a linear regression and were used to scale the swimbladders in the subsequent analysis.

The un-scaled swimbladder <TS> estimates are given in Figure 1. The scaled swimbladder <TS> results and the fitted target strength/fish length relationships are presented in Figure 2. The data fall within the range of points for gas filled swimbladder fish given in Figure 3 of McClatchie et al. (1996), indicating that the results are not atypical. The target strength/fish length regressions for all of the orange roughy by-catch species for which there are data are given in Figure 3. The slope and intercept of these regressions are given in Table 4. The estimates for black and smooth oreo are from Coombs et al. (2000) and those for hake are from Macaulay (2000).

The simulation of under or over inflation of the swimbladder casts indicated that an inflation level of 85% changed the <TS> by, at most, 2 dB, reducing to about 0.3 dB at 95 and 105%. The changes were relatively constant over all of the species. This result indicates that moderate levels of under or over inflation can have a not insignificant effect on <TS>.

11. Conclusions

Target strength/fish length relationships have been derived from casts of swimbladders from basketwork eels, four-rayed rattails, robust cardinalfish, johnson's cod, javelin fish, ribaldo, and white rattail.

The swimbladder estimates presented in this report are the first to be produced for these species, and as such should be treated as initial estimates. Greater confidence in these results would be achieved by collecting *in situ* target strength data from these species in their natural environment. Work currently contracted to NIWA under project OEO2000/01A and OEO2000/01B, and due for reporting by 31 May 2002, may provide *in-situ* estimates for some of these species.

12. Publications

None.

13. Data Storage

Data collected from trawling is stored in the Ministry of Fisheries Trawl survey database.

14. References

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Polhemus (2000). User Manual for the FastSCAN hand held laser scanner, Polhemus Inc. 47 p.

Table 1: Importance of species target strength knowledge to estimates of acoustic biomass surveys of orange roughy on flat bottom

High	Moderate	Low
Basketwork eel	Smooth oreo	Black oreo
Four-rayed rattail	Baxters lantern dogfish	Smooth skin dogfish
	Bigscaled brown slickhead	Back cardinalfish
	Johnson's cod	Plunkets shark
	Ribaldo	Shovelnose spiny dogfish
		Hoki
		Longnose velvet dogfish
		Robust cardinalfish
		Javelin fish
		White rattail
		Hake
		Serrulate rattail
		Ridge scaled rattail
		Leafscale gulper shark

Table 2: Number of swimbladder casts analysed per species

Species code	No. of casts
BEE	8
CSU	14
EPR	4
HJO	20
JAV	10
RIB	30
WHX	8
Total	94

Table 3: Swimbladder to fish length relationships from *(swimbladder length) = slope * (fish length) + intercept*, with lengths in cm

Species code	Intercept	Slope
BEE	7.0	0.57
CSU	0.13	0.11
EPR	0.26	0.28
HJO	0.93	0.39
JAV	0.70	0.12
RIB	0.81	0.31
WHX	1.5	0.18

Table 4: Target strength/fish length relationships for orange roughy by-catch species (<TS> = *slope* * log10(*fish length*) + *intercept*, where <TS> has units of dB re 1 µPa at 1 m and fish length has units of cm.). Results derived from swimbladder modelling, as detailed in this report, are indicated by *

Species code	Name	Intercept (dB)	Slope (dB)
BOE	black oreo (*Allocyttus niger*)	–65.4	17.6
BEE*	basketwork eel (*Diastobranchus capensis*)	–76.7	23.3
CSU*	four-rayed rattail (*Coryphaenoides subserrulatus*)	–92.5	31.8
EPR*	robust cardinalfish (*Epigonus robustus*)	–78.8	30.7
HAK	hake (*Merluccius australis*)	–83.5	27.1
HJO*	johnson's cod (*Halargyreus johnsonii*)	–74.0	24.7
JAV*	javelin fish (*Lepidorhynchus denticulatus*)	–73.5	20.0
RIB*	ribaldo (*Mora moro*)	–66.7	21.7
SSO	smooth oreo (*Pseudocyttus maculates*)	–66.4	16.3
WHX*	white rattail (*Trachyrincus aphyodes*)	–62.1	18.1

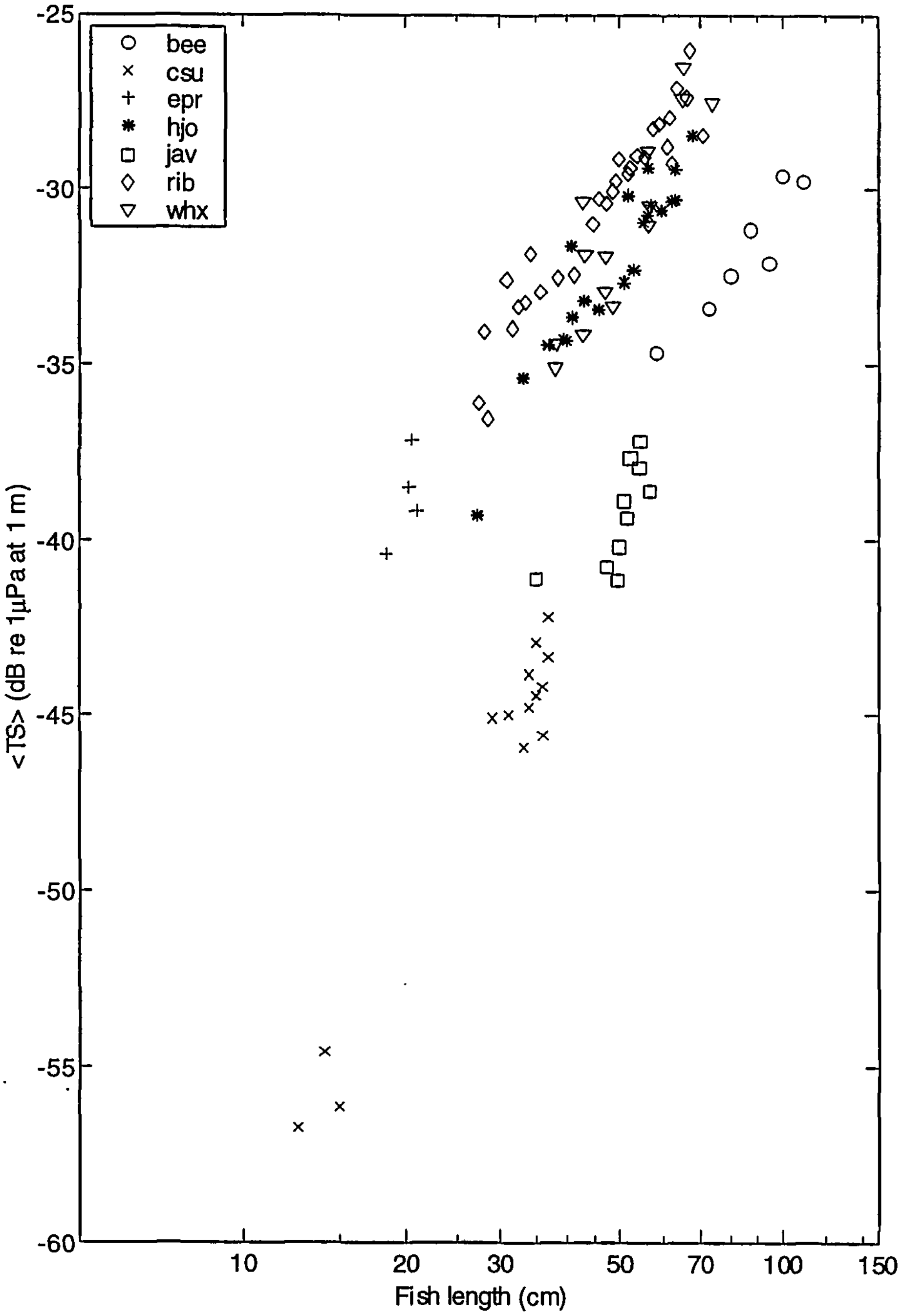

Figure 1: Individual <TS> estimates from swimbladder casts.

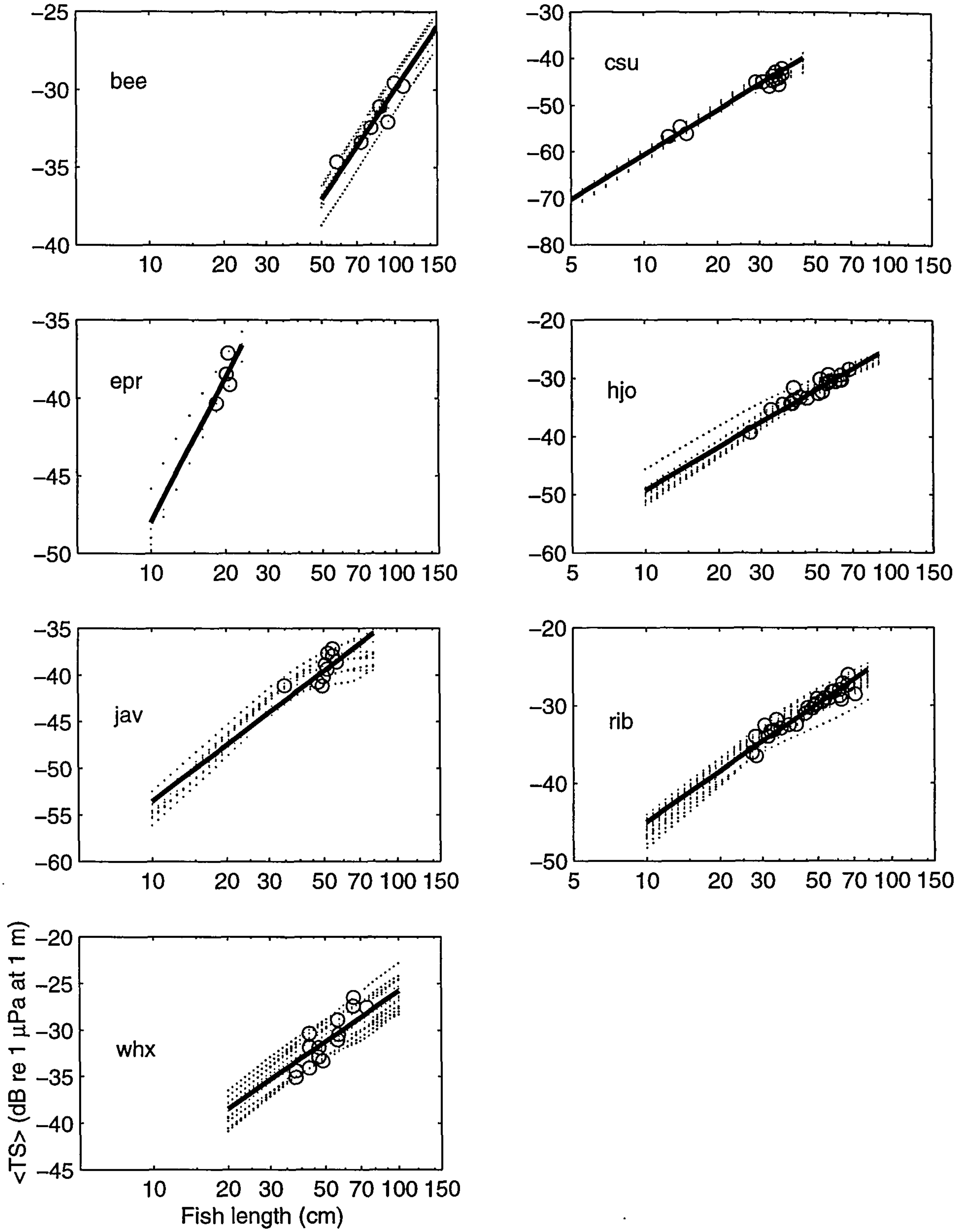

Figure 2: Scaled <TS> estimates from swimbladder modelling for various by-catch species. The open circles are <TS> estimates from the actual swimbladder casts while the small dots are <TS> estimates obtained by scaling each swimbladder cast to simulate fish of a range of lengths. The solid lines are linear regressions to all of the small dots in each graph.

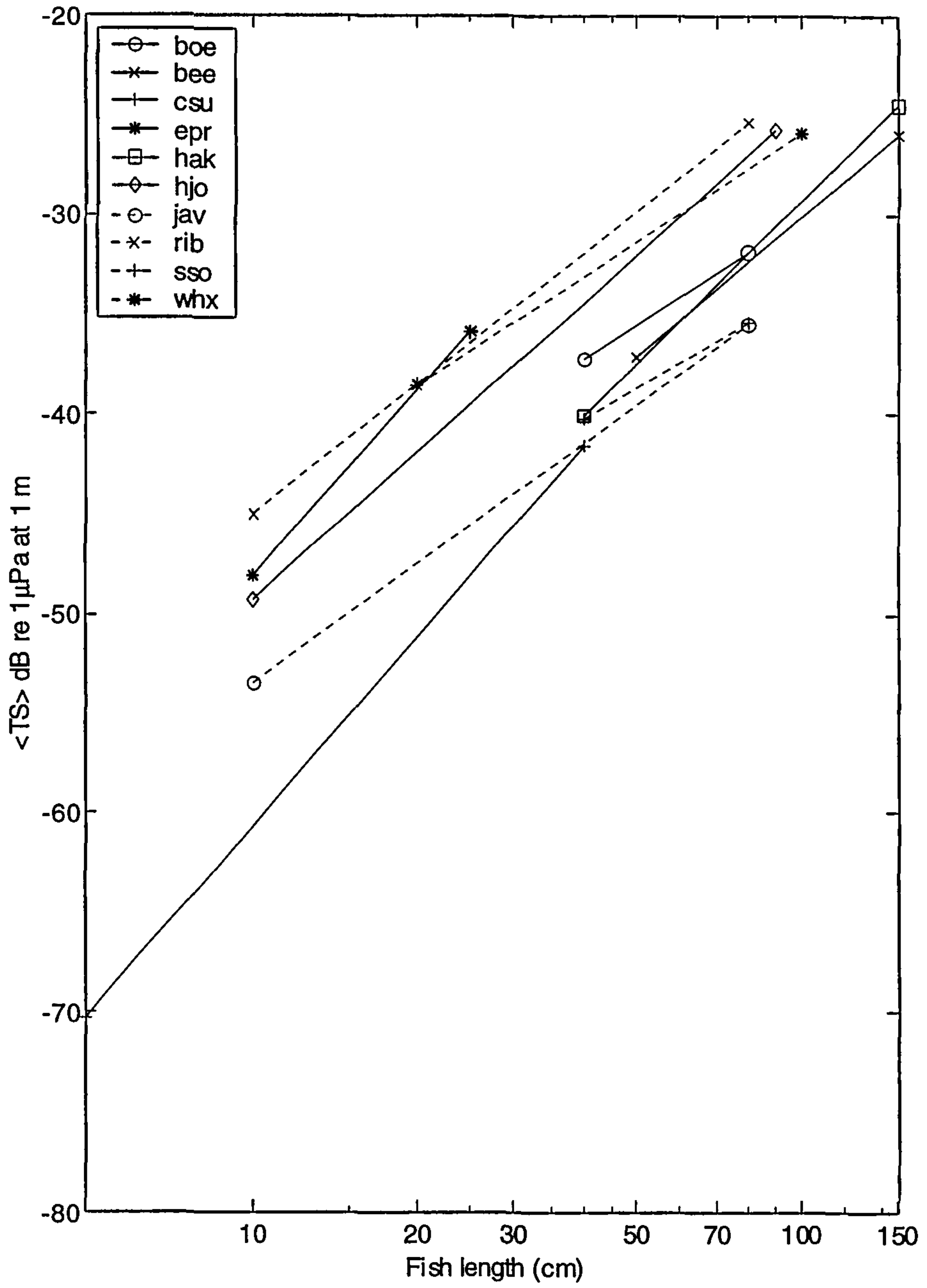

Figure 3: Summary of all orange roughy by-catch species target strength/length relationships.