Short Notes

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REVISED ESTIMATES OF SEABED AREAS WITHIN THE 500 M ISOBATH OF THE SOUTH ORKNEY ISLANDS (SUBAREA 48.2) AND CONSEQUENCES FOR STANDING STOCK BIOMASS ESTIMATES OF NINE SPECIES OF FINFISH

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Abstract

A revised bathymetric map of the South Orkney Islands (Subarea 48.2) was generated using several integrated bathymetric databases and newly available acoustic seafloor data. The region extends between 60.2°–62.2°S latitude and 42.5°–47.5°W longitude. From the integrated datasets, areas of seabed within the 500 m isobath (i.e. 0–500 m) were computed for 50 m depth intervals. Areas were calculated based on interpolated surface area of seabed incorporating seafloor slope. These results were compared to the previously reported estimates of Everson (1987) for the 50–150, 150–250 and 250–500 m depth intervals. The updated estimates are about 1 424 (20%) n miles larger in area within the 50–500 m isobaths than Everson's estimates, though changes in area are specific to the depth interval. There is a corresponding change in estimated biomass within strata when these areas are incorporated into swept area trawl survey models, though not for total estimated biomass. Of the nine species examined, the point estimate of total biomass increased from 5 to 30% for eight species and decreased by 20% for one.

Résumé

Une carte bathymétrique révisée des îles Orcades du Sud (sous-zone 48.2) est créée en utilisant plusieurs bases de données bathymétriques intégrées et des données acoustiques sur le fond marin disponibles depuis peu. La région est comprise entre 60.2°–62.2°S de latitude et 42.5°–47.5°W de longitude. À partir des jeux de données intégrés, les surfaces de fond marin à l'intérieur de l'isobathe 500 m (c.-à-d. de 0 à 500 m) sont calculées par intervalles de 50 m de profondeur. Les calculs de la surface reposent sur la surface interpolée de fond marin, pente comprise. Ces résultats sont comparés aux anciennes estimations d'Everson (1987) pour les intervalles de profondeur de 50–150, 150–250 et 250–500 m. Les nouvelles estimations dépassent d'environ 1 424 (20%) milles naut. celles d'Everson entre les isobathes de 50 et de 500 m bien que les changements de surface soient spécifiques à l'intervalle de profondeur. Un changement correspondant de biomasse estimée est apparent dans les strates lorsque ces régions sont incorporées dans les modèles de campagnes d'évaluation par chalutages de l'aire balayée, mais non pour la biomasse totale estimée. Sur les neuf espèces examinées, l'estimation ponctuelle de la biomasse totale a augmenté de 5 à 30% pour huit espèces et diminué de 20% pour la neuvième.

Резюме

Была составлена новая батиметрическая карта Южных Оркнейских о-вов (Подрайон 48.2) на основе нескольких интегрированных баз батиметрических данных и новых акустических данных по морскому дну. Данный регион лежит между 60.2°-62.2°ю.ш. и 42.5°-47.5°з.д. Площади морского дна в пределах 500-метровой изобаты (т.е. 0-500 м) рассчитывались по интегрированным базам данных для 50-метровых горизонтов. Расчеты основывались на интерполированной площади морского дна, учитывающей уклон дна. Было проведено сравнение результатов с результатами Эверсона (1987) для горизонтов 50-150, 150-250 и 250-500 м. В пределах изобат 50-500 м обновленные оценки почти на 1 424 кв. морских мили (20%) больше сделанных Эверсоном оценок, хотя изменения площади зависят от конкретного горизонта. Отмечено соответствующее изменение оценочной биомассы по отдельным горизонтам, когда эти площади включаются в модели протраленных площадей, однако это не касается общей оценочной биомассы. Из 9 рассмотренных видов оценка общей биомассы возросла на 5-30% для 8 видов и сократилось на 20% для одного.

Resumen

Un mapa batimétrico modificado de las islas Orcadas del Sur (Subárea 48.2) fue generado a partir de datos batimétricos integrados de varias bases de datos y nuevas estimaciones acústicas del lecho marino. La región se sitúa entre los 60.2° y 62.2°S de latitud y 42.5° y 47.5°W de longitud. Las bases de datos integrados se utilizaron para calcular las áreas de lecho marino en intervalos de 50 m de profundidad dentro de la isóbata de 500 m (esto es, 0–500 m). El cálculo se hizo en base a interpolaciones del área superficial de lecho marino que incorporaban la pendiente del fondo del mar. Estos resultados fueron comparados con las estimaciones de Everson (1987) notificadas anteriormente para los intervalos de 50–150, 150–250 y 250–500 m de profundidad. El area de lecho marino estimada actualmente entre las isóbatas de 50–500 m es un 20% mayor (alrededor de 1 424 millas náuticas) que la estimación de Everson, si bien los cambios del área se relacionan específicamente con el intervalo de profundidad. En consecuencia, la estimación de la biomasa para cada estrato cambia cuando se utilizan estas estimaciones actualizadas del área como área de barrido en los modelos de las prospecciones de arrastre, pero la estimación de la biomasa total no cambia. La estimación puntual de la biomasa total aumentó entre 5 a 30% para ocho de las nueve especies de peces examinadas, y disminuyó en 20% para una especie.

Keywords: seabed areas, bathymetry, South Orkney Islands, biomass estimates, CCAMLR

INTRODUCTION

Information on area of seabed within particular depth strata is important when calculating biomass estimates from bottom trawl surveys using 'swept-area' models. In most cases, these types of models compute overall biomass B as

$$B = \sum_{j=1}^{k} \bar{d}_j * A_j , \qquad (1)$$

where the biomass is a product of the mean density $\bar{d}_j$ of a given strata j and the area A_j of that strata (de la Mare, 1994). Similarly, variance $\hat{\sigma}_B^2$ of abundance estimates are a product of the strata area squared, where

$$\hat{\sigma}_B^2 = \sum_{j=1}^{k} \hat{\sigma}_j^2 * A_j^2 . \qquad (2)$$

Hence, errors or bias in computation of seabed areas directly affect estimates and confidence limits of standing stock biomass.

Estimates of seabed areas within the 500 m isobath (i.e. 0–500 m) of the South Orkney Islands (Subarea 48.2) were presented by Everson (1987). These estimates were based on constructing isobaths by hand based on Admiralty charts, and subdividing areas into smaller rectangular subareas. These subdivisions were then converted to planar square areas by measuring the distances between isobaths and converting to square kilometres or nautical miles.

In this paper, revised areas of seabed around the South Orkney Islands are computed using methods similar to those presented in Jones et al. (1999). These estimates are based on several integrated bathymetric databases, including extensive acoustic measurements from the US Antarctic Marine Living Resources (AMLR) Program bottom trawl survey of the South Orkney Islands in 1999. These databases were then used to compute bathymetric surface areas of seabed at 50 m intervals within the 500 m isobath of the South Orkney Islands. This region extends between 60.2°–62.2°S latitude and 42.5°–47.5°W longitude.

MATERIAL AND METHODS

Geographic information from several databases of regularly and irregularly spaced measured and estimated depths was merged to produce one large dataset of depth soundings. Data used specifically for bathymetry consisted of the measured and estimated soundings from shipboard depth soundings, magnetic, gravitational and seismic measurements, as well as continuously collected acoustic measurements from the 1999 US AMLR bottom trawl survey (Table 1). Because no information was available on accuracy of soundings other than data collected during the US AMLR survey in 1999, there was no weighting by data series, and any replicated data points were averaged. Data used to more accurately georeference coastlines were extracted from US Defense Mapping Agency (DMA) World Vector Shoreline (Wessel and Smith, 1996) and DMA hydrographic charts.

Table 1: Sources of measured and estimated depth soundings used to estimate areas of seabed within the 500 m isobath of the South Orkney Islands.

Source	Number of Surveys	Number of Observations
US AMLR	1	65 585
Germany	3	14 884
United Kingdom	14	2 898
Lamont-Doherty Earth Observatory	3	2 658
Smith and Sandwell, 1987	na	1 349
US National Science Foundation	1	1 121
Rice University	1	490
Scripps Institute of Oceanography	1	487
Spain	2	436
US Defense Mapping Agency (DMA)	na	416
Texas A&M University	1	397
World Vector Shoreline Database	na	236
Brazil	1	132
Argentina	2	35
Total		91 124

Table 2: Summary of polygon coverage, average slope (degrees) and computed seabed area by stratum for the South Orkney Islands, between 60.2°–62.2°S latitude and 42.5°–47.5°W longitude.

Stratum (m)	Polygons (Number)	Average Slope (degrees)	Area (n miles^2)
Land masses	na	na	195.38
0–50	3 663	2.28	161.71
50–100	5 642	1.59	278.54
100–150	7 202	1.66	345.70
150–200	11 074	1.41	559.90
200–250	18 119	1.10	963.60
250–300	32 351	0.85	1 809.60
300–350	23 773	1.18	1 267.40
350–400	24 041	1.09	1 307.32
400–450	19 627	1.43	1 041.08
450–500	19 887	1.62	1 046.43

The handling of the raw data follows that of Jones et al. (1999). Briefly, raw data of the combined information base were gridded to a 350 x 450 matrix of latitude, longitude and depth using surface mapping software (a total of 157 500 data points). These data were reprojected from geographic (latitude/longitude) coordinates to a universal transverse mercator projection (UTM zone 23). Surface areas were computed by first converting the data matrix using GIS software to a triangular irregular network (TIN) data coverage. Using the TIN, standard contour lines were then calculated and used as masks for extracting component depth strata. Seabed areas for 10 strata were computed from 0 to 500 m at 50 m intervals. Area within each depth stratum was estimated by transforming the TIN into polygon coverage (surface area, slope and aspect for each polygon), and summing the areas of polygons within for each of the 10 strata. Table 2 summarises the number of polygons and average slopes for each of the 10 depth strata.

The effect of the revised seabed areas on swept-area biomass models (equation 1 and 2) was examined for nine species of finfish: *Notothenia coriiceps*, *Chaenocephalus aceratus*, *Champsocephalus gunnari*, *Lepidonotothen larseni*, *Gobionotothen gibberifrons*, *Pseudochaenichthys georgianus*, *Notothenia rossii*, *Chionodraco rastrospinosus* and *Lepidonotothen squamifrons*. Estimates of standing stock biomass, along with standard error and 95% confidence limits were computed using the Delta-lognormal maximum likelihood estimator (Pennington, 1983; de la Mare, 1994) with the seabed area estimates of Everson (1987) and those presented in this paper.

RESULTS

A bathymetric map around the South Orkney Islands generated from this analysis (Figure 1) demonstrates the very narrow shelf area to the north and broad plain to the south. In most regions of the South Orkney Islands, the shelf breaks

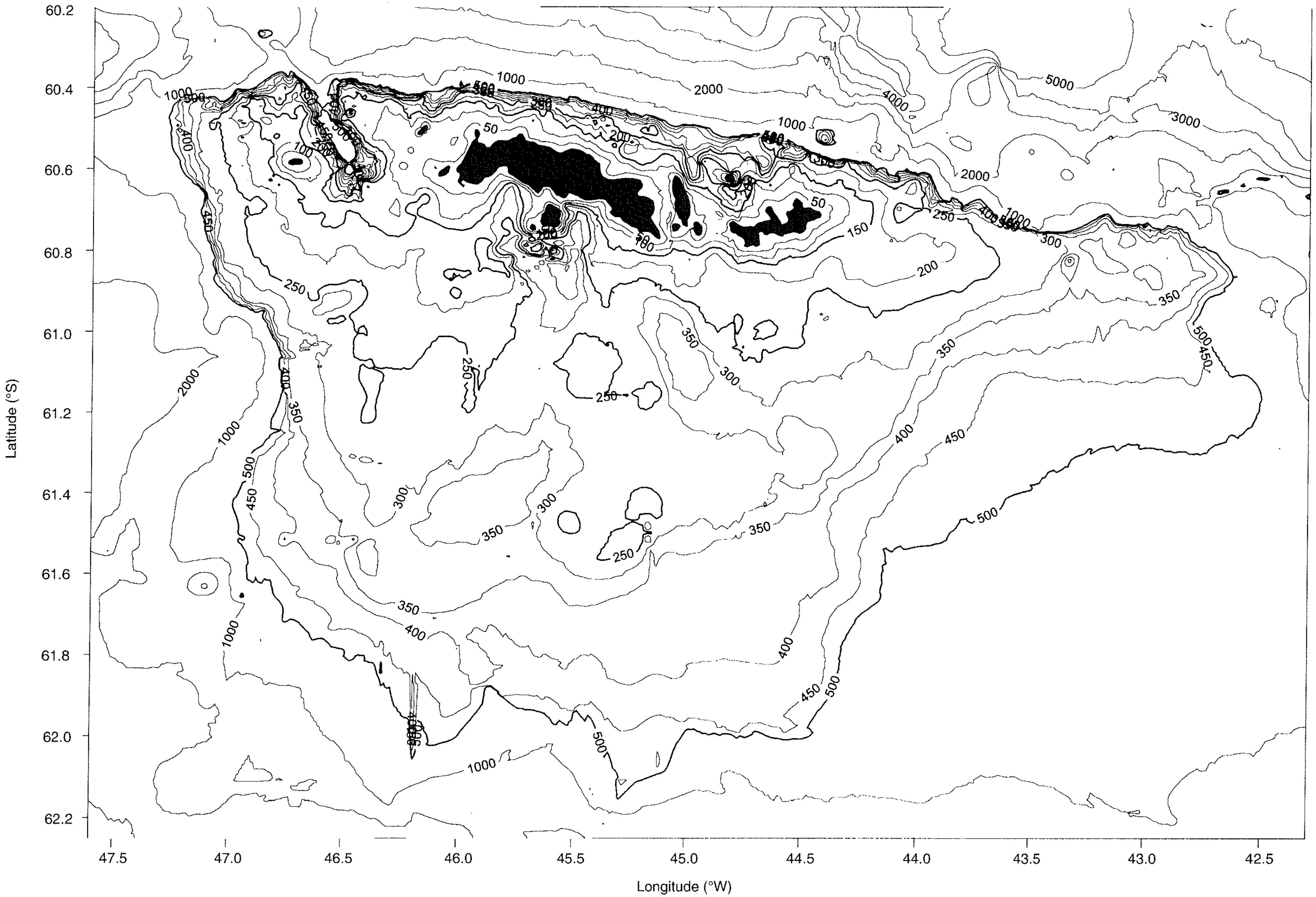

Figure 1: Bathymetric map of the South Orkney Islands. Heavier lines demarcate the 150, 250 and 500 m isobath.

Table 3: Comparison of seabed areas for three depth strata (n miles^2) for the South Orkney Islands.

Stratum (m)	Everson, 1987	This Study	Difference	
50–150	992.45	624.24	-368.21	(-37%)
150–250	1 240.56	1 523.50	282.94	(+23%)
250–500	4 962.24	6 471.82	1 509.58	(+30%)
50–500	7 195.25	8 619.55	1 424.30	(+20%)

sharply below the 500 m isobath. This is particularly sharp in the northern sectors and less so in the southeast sectors. Within the 500 m isobath, the average slope of the seafloor, computed using mean polygon angles, is greatest in the shallowest and deepest strata, and gentlest in the 250–400 m range (Table 2). Computed areas of seafloor are greatest in the 250–300 m strata, where the plain is most extensive.

The estimates of seabed areas were compared to those of Everson (1987) for three levels of depth strata: 50–150, 150–250 and 250–500 m. Although the overall appearance of bathymetric features around the South Orkney Islands was likely to be very similar, there were substantial differences in the estimate of seabed area (Table 3). The greatest difference between the two studies by strata was for the 50–150 m stratum, where the area estimated by the current study was 37% less than that estimated by Everson (1987). However, there was a 20% overall higher estimate of seabed area in this study due to a more extensive computed seabed area within the 150–500 m range (Table 3).

DISCUSSION AND CONCLUSION

Changes in stratum size will have a direct affect on estimates of biomass when incorporated into swept-area models such as those used for bottom trawl surveys. The change in biomass estimates and standard errors or confidence limits within a given stratum will be directly proportional to the change in stratum size, as computed in equations 1 and 2 (i.e. a 10% increase in stratum size results in a 10% increase in levels of biomass, standard error and confidence limits). However, when estimates of total biomass and associated confidence limits for the stock (or combined strata) are desired, the differences are not proportional to the change in overall seabed area. These differences will be a function of species-specific distribution and patchiness throughout the strata of the survey area. For example, estimated biomass and variability will be higher within a sampling stratum for species with higher densities and more uneven spatial distributions within that stratum. Since the estimates of total biomass and variability of stock size incorporate combined strata, the resulting estimates will not be proportional to changes in seabed area.

As an illustration, percentage changes in biomass estimates from data obtained during the US AMLR survey of the South Orkney Islands in 1999 (Jones et al., 2000) were examined for nine species of Antarctic finfish: *N. coriiceps*, *C. aceratus*, *C. gunnari*, *L. larseni*, *G. gibberifrons*, *P. georgianus*, *N. rossii*, *C. rastrospinosus* and *L. squamifrons*. Computed estimates of biomass, standard error and confidence limits within the 50–150, 150–250 and 250–500 m were strongly influenced by changes in seabed area of strata (-37%, 23% and 30% respectively; Table 3). However, due to differences in spatial distribution among the strata, the changes for total biomass were species specific (Figure 2), and likely to be influenced by survey design. These changes in biomass estimates ranged from -21% for *N. coriiceps* to +30% for *L. squamifrons*. The magnitude of change in biomass by species in Figure 2 is a function of the change in seabed area (Table 3) and preferred depth range of each particular species. Given the significant increases in estimated seafloor at greater depths, it follows that species with the greatest positive percentage change in biomass estimates are those that prefer deeper strata.

The changes in standard errors and confidence limits around point estimates are less straightforward. In certain species, such as *P. georgianus*, *C. rastrospinosus* and *L. squamifrons*, the percentage changes corresponded to the point estimates. However, in the case of other species such as *G. gibberifrons* and *L. larseni*, the confidence limits about the point estimate were reduced by over 30% while the point estimate increased by about 10%. Because confidence limits about biomass estimates are driven by uneven spatial distributions (i.e. spawning or prespawning aggregations), strata with the highest variability, coupled with the greatest change in seabed area, will drive the overall estimates of uncertainty.

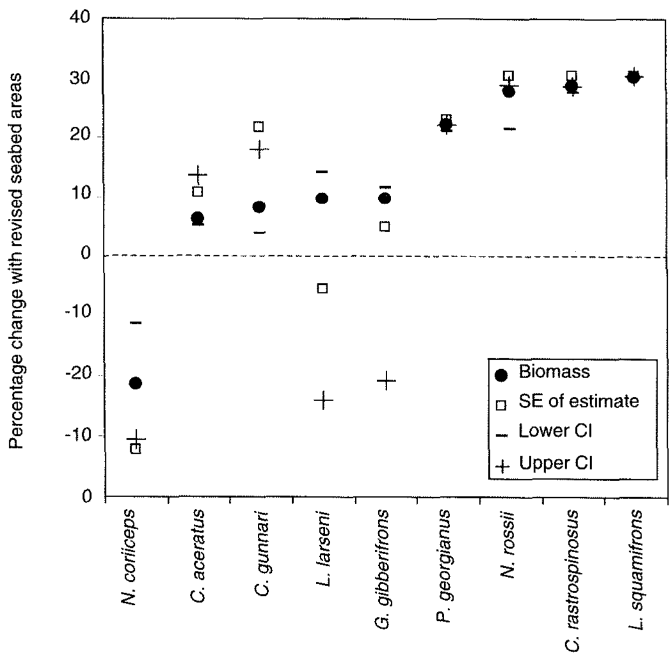

Figure 2: Percentage change in computed biomass, standard error and confidence limits for nine species of fish based on revised estimates of seabed area.

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