Archive of Fishery
and Marine Research

Zygochlamys patagonica beds on the Argentinian shelf. Part I: Energy flow through the scallop bed community*)

Claudia Bremec[1, 2]; Thomas Brey[3]; Mario Lasta[2]; Juan Valero[4]; Luis Lucifora[5]

[1] *Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)*
[2] *Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP), Mar del Plata, Argentina*
[3] *Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany*
[4] *School of Fisheries, University of Washington, Seattle, USA*
[5] *Departamento de Biología, Universidad Nacional, Mar del Plata, Argentina*

Abstract

The scallop bank, "Reclutas", on the Argentinian shelf was sampled on two occasions, first, some months after initial settlement of the scallop *Zygochlamys patagonica* (1995) and again, 4 years later (1998). *Z. patagonica* already dominated the epibenthic community (33 species) in 1995, contributing 26 % to community biomass (2.85 g $C{\cdot}m^{-2}$) and 40 % to community production (0.75 g $C{\cdot}m^{-2}{\cdot}y^{-1}$; 95 % confidence interval: 0.63 to 0.89 g). In 1998, both community biomass (4.64 g $C{\cdot}m^{-2}$) and production (1.33 g $C{\cdot}m^{-2}{\cdot}y^{-1}$; 95 % confidence interval: 1.12 to 1.57 g) were higher, and the proportion of *Z. patagonica* rose to > 60 % for both.

Zusammenfassung

Zygochlamys-patagonica-Bänke auf dem argentinischen Schelf. Teil I: Energiefluss in der Pilgermuschelbank-Gemeinschaft

Die Pilgermuschelbank „Reclutas" auf dem argentinischen Schelf wurde zweimal beprobt, zuerst einige Monate nach dem Festsetzen der Pilgermuschel *Zygochlamys patagonica* (1995) und dann noch einmal 4 Jahre später (1998). *Z. patagonica* dominierte schon 1995 das Epibenthos (33 Arten): ihr Anteil betrug 26 % an der Biomasse der Benthosgemeinschaft (2,85 g $C{\cdot}m^{-2}$) und 40 % an der Produktion (0.75 g $C{\cdot}m^{-2}{\cdot}y^{-1}$; 95 % Vertrauensinterval: 0.63 bis 0.89 g). 1998 waren Biomasse und Produktion auf 4,64 g $C{\cdot}m^{-2}$ bzw. 1,33 g $C{\cdot}m^{-2}{\cdot}y^{-1}$ (95 % Vertrauensinterval: 1.12 bis 1.57 g) gestiegen. Der Anteil von *Z. patagonica* betrug an jedem über 60 %.

Resumen

Bancos de vieiras *Zygochlamys patagonica* en la plataforma argentina. Parte I: Flujo de energía en la comunidad del banco de vieiras.

El banco de vieiras "Reclutas" de la plataforma argentina fue muestreado dos veces, algunos meses (1995) y cuatro años (1998) después del asentamiento inicial de *Zygochlamys patagonica*. La vieira patagónica dominó la comunidad epibentónica (33 especies) desde 1995, contribuyendo

*) INIDEP Publication N°: 1159

26 % a la biomasa comunitaria (2,85 g C·m^{-2}) y 40 % a la producción comunitaria (0,75 g C·m^{-2}·y^{-1}; intervalo de confianza 95 %: 0,63 a 0,89g). En 1998, la biomasa comunitaria (4,64 g C·m^{-2}) así como la producción (1,33 g C·m^{-2}·y^{-1}; intervalo de confianza 95 %: 1,12 a 1,57g) fueron mayores, y la contribución de *Z. patagonica* se elevó a >60 % tanto en biomasa como en producción.

Introduction

In 1995, large scallop beds (*Zygochlamys patagonica* King and Broderip, 1832) were discovered on the Argentinian shelf between 39 and 43° S, situated along the 100m depth isobath close to the continental slope (Lasta and Bremec 1998). Part of those beds, which was identified as recruitment areas, was protected from the fishery which subsequently developed. However, the 1060 km^2 area investigated in this study was exploited to some extent over the following years (areas swept: 1996: 0.5 %; 1997: 6.4 %, 1998: 0.2 % of total scallop bed area). Primary production over the shelf and slope area ranges between 0.1 and 2.7g C·m^{-2}d^{-2} and amounts to about 350 g C·m^{-2} annually (Carreto *et al.* 1995, Negri 1993). In 1994, there were high levels of scallop recruitment to the bed, "Reclutas" (Lasta and Bremec 1998).

This publication deals with production and productivity of the epibenthic community in general. We analyse whether and how the partitioning of energy flow among the various epibenthic taxa changed with the development of the scallop population between 1995 and 1998. The population dynamics of *Zygochlamys patagonica* will be dealt with in the second part of this study.

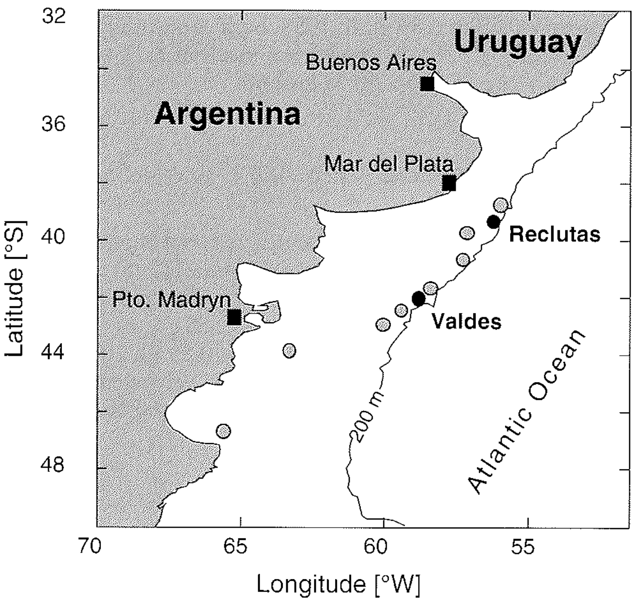

Figure 1: Position of major banks of *Zygochlamys patagonica* (dots) on the Argentinian shelf. The bank "Reclutas" is the subject of this study. Gear efficiency was studied on the bank "Valdes".

Methods

The scallop bed, "Reclutas", was sampled in 1995 and again in 1998. All samples were taken in the region 39°04' to 39°29' S and 55°44' to 56°04' W, at a water depth of 90 to 130 m (Figure 1). Between March 23rd and October 29th 1995, 11 samples were collected using a bottom otter trawl as deployed by the commercial fishery (12.6 m mouth opening, 10 cm mesh size at the cod end). On average, one haul took 7 min, covered 9665 m^2 and yielded 840 kg wet mass of epibenthic fauna. Between August 30th and September 1st, 1998, 10 samples were col-

Table 1: Biomass and abundance of all species sampled in 1995 and in 1998 on the *Zygochlamys patagonica* bank "Reclutas".

Species	Taxon	g C·m^{-2} 1995	N · m^{-2} 1995	g C·m^{-2} 1998	N·m^{-2} 1998
Zygochlamys patagonica	Pectinacea	0.740	4.664	2.864	5.700
Tedania sp.	Porifera	0.366	0.100	0.179	0.758
Actinostolla crassicornis	Cnidaria	0.424	0.517	0.088	0.043
Choriactis sp.	Cnidaria	0.000	0.000	0.032	0.022
Flabellum sp.	Cnidaria	0.114	0.217	0.002	0.003
Peachia sp.	Cnidaria	0.000	0.000	0.019	0.024
Hyatella solida	Bivalvia	< 0.001	0.023	0.001	0.052
Admete magallanica	Gastropoda	< 0.001	0.053	0.000	0.000
Argobuccinum magall.	Gastropoda	0.218	0.127	0.072	0.038
Calliostoma consimmilis	Gastropoda	< 0.001	0.037	0.000	0.000
Calyptraea pileolus	Gastropoda	< 0.001	0.033	0.001	0.022
Glyptheutria sp.	Gastropoda	< 0.001	0.013	0.000	0.000
Murex clenchi	Gastropoda	< 0.001	0.003	0.000	0.000
Odontocymbiola magall.	Gastropoda	0.211	0.033	0.153	0.038
Paraeutria sp.	Gastropoda	< 0.001	0.010	0.000	0.000
Photinula coerulescens	Gastropoda	< 0.001	0.020	0.000	0.000
Volvarina patagonica	Gastropoda	0.001	0.077	0.000	0.000
Lybidoclaea granaria	Crustacea	0.012	0.304	0.047	0.065
Pagurus comptus	Crustacea	0.098	0.067	0.264	0.258
Picnogonida	Crustacea	0.001	0.013	0.003	0.035
Asteroidea unident.	Asteroidea	0.000	0.000	0.003	0.008
Calyptraster vitreus	Asteroidea	0.004	0.007	0.029	0.038
Cosmasterias lurida	Asteroidea	0.075	0.173	0.124	0.127
Ctenodiscus australis	Asteroidea	0.031	0.197	0.043	0.144
Pterasteriidae	Asteroidea	0.000	0.000	0.014	0.019
Austrocidaris canaliculata	Echinoidea	0.037	0.137	0.053	0.157
Sterechinus agassizii	Echinoidea	0.048	0.153	0.196	0.445
Pseudocnus d. leoninus	Holothuroidea	0.001	0.030	0.000	0.008
Psolus patagonicus	Holothuroidea	0.004	0.120	0.003	0.046
Ophiacantha vivipara	Ophiuroidea	0.396	5.415	0.240	3.620
Ophiactis asperula	Ophiuroidea	0.044	2.008	0.030	0.933
Ophiuroglypha limanii	Ophiuroidea	0.016	1.535	0.177	1.635
Molgula sp.	Ascidiacea	0.000	0.000	0.005	0.092

lected using a rectangular dredge (2.5 m mouth opening, 25 mm mesh size in the top net, 35 mm in the bottom net). On average, one haul took 10 min, covered 2340 m^2 and yielded 98 kg wet mass of epibenthic fauna. Average gear efficiency in the scallop fishery was estimated experimentally to be about 30 % for the bottom otter trawl (Valdes scallop bed, Lasta and Iribarne 1997) and about 18 % for the dredge (*Chlamys tehuelcha* scallop beds, Iribarne *et al.* 1991).

A sub-sample of about 6 to 7 kg was taken with a bucket from each catch and frozen for further analysis. In the laboratory, animals were sorted and 33 species were identified (Table 1). Numbers and wet mass per group were determined. Epibiotic organisms living on the scallop shells were not considered in this study.

Species-area curves, i.e. number of species vs. number of pooled samples, were produced using a bootstrap approach (see *e. g.* Efron 1982; Efron and Gong 1983). The average number of species in one sample was calculated directly from the 11 (1995) or 10 (1998) samples, respectively. For larger pooled samples of size n(1995: $2 \leq n \leq 11$; 1998: $2 \leq n \leq 10$), the following procedure was used:

(i) n samples were randomly selected from all samples and pooled,
(ii) the number of species in this pooled sample was determined,
(iii) this procedure was repeated 100 times to obtain 100 estimates of the number of species,
(iv) the mean number of species and standard deviation were calculated from these 100 estimates.

To derive estimates of abundance and biomass per square meter, number and wet mass data were multiplied by:

(i) the factor "weight of catch/weight of sub-sample" and
(ii) a factor correcting for gear efficiency (see above).

Wet mass data were converted to g C_{org} and kJ, using conversion factors for major taxonomic groups published in Cummins and Wuycheck (1971), Dayton *et al.* (1974), Atkinson and Wacasey (1976), Steimle and Terranova (1985), Rumohr *et al.* (1987), Wacasey and Atkinson (1987), Walker *et al.* (1987), Brey *et al.* (1988), Dauvin and Joncourt (1989), Barthel (1995) and references therein.

The production-to-biomass (P/B) ratio of different species was estimated using the multiple linear model of Brey (1999). This model (version 00-02) calculates the P/B with 95 % confidence limits from mean body mass, water temperature, water depth and taxonomic, as well as, life style information. Production was derived by multiplying biomass with the P/B ratio, and community production by adding together the production of all species. 95 % confidence limits for community production were calculated accordingly.

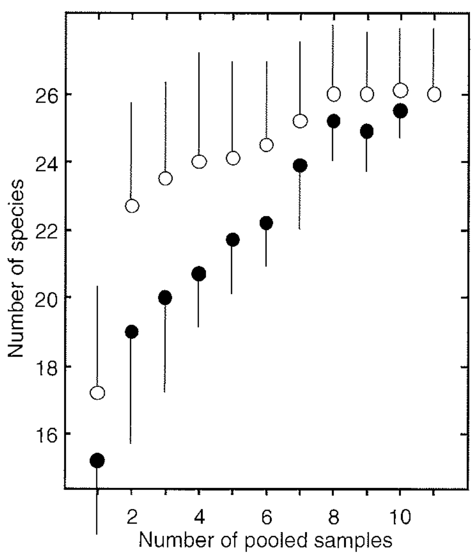

Figure 2: Species-area-curves obtained from samples collected in 1995 (circles) and in 1998 (dots). Vertical bars indicate standard deviation of mean.

Results

Altogether 33 species, including *Zygochlamys patagonica*, were sampled during 1995 and 1998 (Table 1). A total of 28 and 26 species was found in 1995 and 1998, respectively. 7 species disappeared from and 5 new species were added to the community between 1995 and 1998. Species-area curves show saturation beyond 8 samples, thus indicating that the majority of species present was sampled in both years (Figure 2). Community biomass was distinctly higher in 1998, at 4.64 g $C \cdot m^{-2}$ (S.D.: ± 0.46 g) than in 1995, at 2.85 g $C \cdot m^{-2}$ (S.D.: ±1.00 g). Annual community production increased from

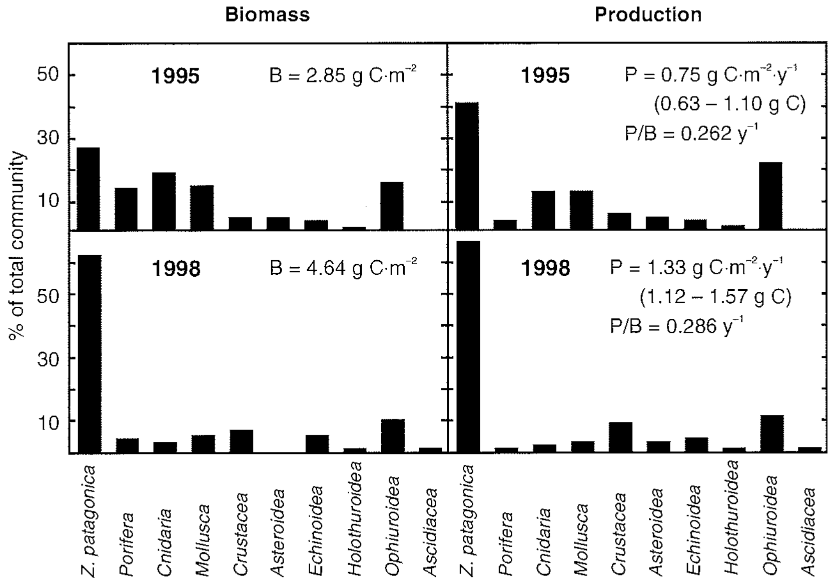

Figure 3: Proportion of biomass and annual production for the major epibenthic taxa on the scallop bank "Reclutas" in 1995 and 1998.

0.75 g $C{\cdot}m^{2}{\cdot}y^{-1}$ (95 % confidence range: 0.63 to 0.89 g) in 1995 to 1.33 g $C{\cdot}m^{-2}{\cdot}y^{-1}$ (95 % confidence range: 1.12 to 1.57 g) in 1998, whereas the P/B ratio increased slightly from 0.262 y^{-1} to 0.286 y^{-1}.

Zygochlamys patagonica showed the most distinct differences in biomass, B, and production, P, between 1995 and 1998. Both B and P values for *Z. patagonica* increased from 0.74 g $C{\cdot}m^{-2}$ and 0.30 g $C{\cdot}m^{-2}{\cdot}y^{-1}$ to 2.86 g $C{\cdot}m^{-2}$ and 0.89 g $C{\cdot}m^{-2}{\cdot}y^{-1}$, respectively. This means an increase in terms of the proportion of the epibenthic community B and P from 26 % and 40 %, in 1995, to 62 % and 67 % respectively, in 1998 (Figure 3). The B and P of the other major sessile taxa (Porifera and Cnidaria combined) decreased distinctly in absolute terms (from 0.90 g $C{\cdot}m^{-2}$ and 0.11 g $C{\cdot}m^{-2}{\cdot}y^{-1}$ to 0.32 g $C{\cdot}m^{-2}$ and 0.03 g $C{\cdot}m^{-2}{\cdot}y^{-1}$, respectively), as well as relatively (from 30 % and 14 % to 7 % and 2 % respectively, Figure 3).

Discussion

Sampling benthic communities with trawls always involves a potentially high, but mostly unknown, bias towards underestimation of abundance and biomass due to the low and variable sampling efficiency of the trawls and dredges, which may be as low as 5 % (Eleftheriou and Holme 1984). In this study, different gears were even used for each of the two surveys; a bottom otter trawl in 1995 and a rectangular dredge in 1998. In contrast to most studies using towed gear, however, the efficiency of both devices is known, at least for catching scallops. It was assumed that gear efficiency is similar for scallops and other epibenthos, especially since during trawling the meshes of the gear are quite rapidly covered with scallops, thus preventing soft bodied animals being squeezed out through the mesh. Our benthic biomass estimates fall within the range encountered at about 100 m water depth on subtropical and boreal shelves (Brey and Gerdes 1997).

As discussed by Brey (1999), multiple linear regression models based on empirical data are not suitable for estimating the P/B ratio of a single species because of the large potential error involved. These errors tend to cancel each other out when estimates for several populations are pooled to calculate community P and P/B (Brey 1990, 1999). The "Reclutas" community is dominated by one species, *Zygochlamys patagonica*, hence errors in estimating the P/B ratio of this species will significantly affect the accuracy of the community data. Detailed investigations currently being carried out on the population dynamics of *Z. patagonica* (Lasta, personal communication), indicate that our estimate of scallop P/B is about 30 % below values derived by direct methods, but this may partially be due to the much larger and more representative sample analysed.

The benthic community of the scallop bank "Reclutas", which is, in terms of species occurrence, rather consistent over the investigation period (Table1), seems to be representative of a wider geographic area, as indicated by Bremec and Lasta (1997). Examining undisturbed Patagonian scallop beds found along the shelf break front (39°to 43°S) and in areas situated in low salinity coastal regimes (44° to 47°S), they found *Zygochlamys patagonica* to be the dominant species (21 to 58 % of total biomass), accompanied by other suspension feeders (Porifera), predators (Cnidaria, Asteroidea, Gastropoda, Crustacea) and grazers-detritivores (Echinoidea, Ophiuroidea). In contrast, shallow water beds of the scallop *Aequipecten tehuelchus* situated in the north Patagonian gulf, San Matías, show distinct differences in community structure between different banks, which are related to sediment texture (Olivier *et al.* 1970; Ciocco 1988).

One year after initial settlement, *Zygochlamys patagonica* already dominated the benthic community of the scallop bank "Reclutas" both in terms of biomass (26 %) and production (40 %). This dominance increased substantially during the subsequent three years (Figure 3), when *Z. patagonica* contributed to about 2/3 of the total standing stock and energy flow. Compared to other benthic systems which are dominated by a single suspension feeding species, however, the proportion of *Z. patagonica* is not exceptionally high (Table 2). Data from *Placopecten magellanicus* grounds situated at a similar water

Table 2: Proportion of principal species in biomass and production of macrobenthic communities dominated by suspension feeders. B: Bivalvia; G: Gastropoda; O: Ophiuroidea; 1) 1995; 2) 1998

Community	Principal species	% of community biomass	% of community production	Reference
Sand flat (intertidal)	*Mesalia brevialis* (G)	32	38	Sprung 1994
Mussel bank (intertidal)	*Mytilus edulis* (B)	97	93	Asmus 1987
Soft bottom (14m)	*Pharus legumen* (B)	63	62	Warwick *et al.* 1978
Soft bottom (14m)	*Spisula elliptica* (B)	73	56	Warwick and George 1980
Hard bottom reef (37m)	*Ophiotrix fragilis* (O)	92	71	George and Warwick 1985
Scallop bank1) (100m)	*Zygochlamys patagonica* (B)	26	40	This study
Scallop bank2) (100m)	*Zygochlamys patagonica* (B)	62	67	This study

depth on Georges Bank (90 to 100 m, Thouzeau *et al.* 1991a, 1991b) and in the Gulf of Maine (60 to 80m, Langton and Robinson 1990), however, indicate that the abundance of *Z. patagonica* on the bank "Reclutas" (about 5 ind.·m^{-2}) is distinctly higher than the abundance of *P. magellanicus* (≤ 1 ind.·m^{-2})at these North Atlantic sites. Unfortunately, we cannot compare the relative proportion of the scallops contributing to community biomass owing to the different sampling devices used in these studies.

There was a conspicuous decrease in biomass and annual production between 1995 and 1998 (Table 1 and Figure 3), mainly observed in Porifera and Cnidaria. It remains unclear whether they have been out-competed by the growing scallops or whether trawling activity caused habitat modifications or direct mortality in these sessile taxa (compare Alverson *et al.* 1994; Hall 1996; Brand *et al.* 1997). The extent of fishing on the bank "Reclutas" during 1995 to 1998 was low, but experimental studies on the bank "Valdes" (Bremec and Lasta 1998, 1999), as well as similar studies on Georges Bank (Collie *et al.* 1997), showed sessile species to be exceptionally sensitive to fishing.

On the Patagonian shelf, about 5000 km^2 of *Zygochlamys patagonica* banks have been identified during recent years (Lasta and Bremec 1998). Our data indicate that these banks represent a valuable resource with the potential for supporting a long-term fishery. Potential damage to the benthic environment caused by trawling seems to be limited because of the minor role of the accompanying fauna in scallop bank energy flow. Long-term effects of incidental mortality, however, of releasing shells and non-target invertebrates back into the sea and of potential modifications of primary settlement substrates are not known.

References

Alverson, D.L.; Freeberg, M.H.; Pope, J.G.; Murawski, S.A., 1994: A global assessment of fisheries by-catch and discard. FAO Fish. Tech. Paper 339: 1–233.

Asmus, H., 1987: Secondary production of an intertidal mussel bed community related to its storage and turnover compartments. Mar. Ecol. Prog. Ser. 39: 251–266.

Atkinson, E.G.; Wacasey, J.W., 1976: Caloric values of zoobenthos and phytobenthos from the Canadian Arctic. Fish. Mar. Service Tech. Rep. 632: 1–23.

Barthel, D., 1995: Tissue composition of sponges from the Weddell Sea, Antarctica: not much meat on the bones. Mar. Ecol. Prog. Ser. 123: 149–153.

Brand, A.R.; Hill, A.S.; Veale, L.O.; Hawkins, S.J., 1997: The environmental impact of scallop dredging. XI Int. Pectinid Workshop, La Paz, México, p. 40–41.

Bremec, C.; Lasta, M., 1998: Experimental study on macrobenthic community structure of patagonian scallops (*Zygochlamys patagonica* King and Broderip 1832) beds affected by fishing disturbances. ICES Symposium on Marine Benthos Dynamics: Environmental and Fisheries Impacts, Crete, Greece, October 5 – 7, 1998, p. 42–43.

Bremec, C.; Lasta, M., 1999: Effects of fishing on faunistic composition in scallop beds in the Argentine Sea. XII International Pectinid Workshop, Bergen, Norway, May 5 11, 1999, p. 152–153.

Brey, T., 1990: Estimating productivity of macrobenthic invertebrates from biomass and mean individual weight. Meeresforschung 32: 329–343.

Brey, T., 1999: A collection of empirical relations for use in ecological modelling. NAGA The ICLARM Quarterly 22(3): 24–28.

Brey, T.; Gerdes, D., 1997: Is Antarctic benthic biomass really higher than elsewhere? Antarct. Sci. 9: 266–267.

Brey, T.; Rumohr, H.; Ankar, S., 1988: The energy content of macrobenthic invertebrates: General conversion factors from weight to energy. J. Exp. Mar. Biol. Ecol. 117: 271–278.

Carreto, J.I.; Lutz, V.A.; Carignan, M.O.; Cucchi Colleoni, A.D.; De Marco, S.G., 1995: Hydrography and chlorophyll *a* in a transect from the coast to the shelf-break in the Argentinian Sea. Cont. Shelf Res. 15: 315–336.

Ciocco, N., 1988: Observaciones sobre la ecología del molusco bivalvo *Chlamys tehuelchus* (d'Orb.) en el Golfo San José (Chubut, Argentina). I. Análisis biocenótico. Neotropica 34: 3–22.

Collie, J.S.; Galo, A.E.; Valentine, P.C., 1997: Effects of bottom fishing on the benthic megafauna of Georges Bank. Mar. Ecol. Prog. Ser. 155: 159–172.

Cummins, K.W.; Wuycheck, J.C., 1971: Caloric equivalents for investigations in ecological energetics. Int. Ass. Theor. Appl. Limn. Comm. 18: 1–158.

Dauvin, J.-C.; Joncourt, M., 1989: Energy values of marine benthic invertebrates from the Western English Channel. J. Mar. Biol. Ass. U.K. 69: 589–595.

Dayton, P. K.; Robillard, G.A.; Paine, R.T.; Dayton, L.B., 1974: Biological accommodation in the benthic community at McMurdo Sound, Antarctica. Ecol. Monogr. 44: 105–128.

Efron, B.; 1982: The jackknife, the bootstrap, and other resampling plans. SIAM, Monograph No. 38, CBMS-NSF, 92p.

Efron, B.; Gong, G.; 1983. A leisurely look at the bootstrap, the jack-knife, and cross-validation. Amer. Statist. 37: 36–48.

Eleftheriou, A.; Holme, N.A., 1984: Macrofauna techniques. In: Holme; N.A., McIntyre, A.D. (eds.): Methods for the study of marine benthos. Oxford: Blackwell, p. 140–216.

George, C.L.; Warwick, R.M., 1985: Annual macrofauna production in a hard-bottom reef community. J. Mar. Biol. Ass. U.K. 65: 713–735.

Hall, M., 1996: On by-catch. Rev. Fish Biol. Fisheries 6 (3): 319–352.

Iribarne, O.O.; Lasta, M.L.; Vacas, H.C.; Parma, A.M.; Pascual, M.S., 1997: Assessment of abundance, gear efficiency and disturbance in a scallop dredge fishery: results of a depletion experiment. In: Shumway, S.E.; Sandifer, P.A. (eds): Scallop biology and culture. The World Aquaculture Society, selected papers from the VIIth International Pectinid Workshop, p. 244–248.

Langton, R.W.; Robinson, W.E., 1990: Faunal associations on scallop grounds in the western Gulf of Maine. J. Exp. Mar. Biol. Ecol. 144: 157–171.

Lasta, M.L.; Bremec, C., 1998: *Zygochlamys patagonica* in the Argentine Sea: a new scallop fishery. J. Shellfish Res. 17: 103–111.

Lasta, M.L.; Iribarne, O.O., 1997: Southern Atlantic scallop (*Zygochlamys patagonica*) fishery: assessment of gear efficiency through a depletion experiment. J. Shellfish Res. 16: 59–62.

Negri, R.M., 1993: Fitoplancton y producción primaria en el área de la plataforma bonaerense próxima al talud continental. INIDEP Informe Tecnico 1: 7.

Olivier, S.; Christiansen, H.E.; Capitoli, R., 1970: Notas preliminares sobre la vieira tehuelche del Golfo San Matías (Prov. Río Negro). Doc. Inf., UNDP/FAO, Proy. Des. Pesq., 30 pp.

Rumohr, H.; Brey, T.; Ankar, S., 1987: A compilation of biometric conversion factors for benthic invertebrates of the Baltic Sea. Baltic Mar. Biol. Publ. 9: 1–56.

Sprung, M., 1994: Macrobenthic secondary production in the intertidal zone of the Ria Formosa - a lagoon in southern Portugal. Estuar. Coast. Shelf Sci. 38: 539–558.

Steimle, F.W.;. Terranova, R.T, 1985: Energetic equivalents of marine organisms from the continental shelf of the temperate Northwest Atlantic. J. Northwest Atl. Fish. Sci. 6: 117–124.

Thouzeau, G.; Robert, G.; Ugarte, R., 1991a: Faunal assemblages of benthic mega-invertebrates inhabiting sea scallop grounds from eastern Georges Bank, in relation to environmental factors. Mar. Ecol. Prog. Ser. 74: 61–82.

Thouzeau, G.; Robert, G.; Smith, S.J., 1991b: Spatial variability in distribution and growth of juvenile and adult sea scallops *Placopecten magellanicus* (Gmelin) on eastern Georges Bank (Northwest Atlantic). Mar. Ecol. Prog. Ser. 74: 205–218.

Wacasey, J.W.; Atkinson, E.G., 1987: Energy values of marine benthic invertebrates from the Canadian Arctic. Mar. Ecol. Prog. Ser. 39: 243–250.
Walker, M.; Tyler, P.A., Billett, D.S.M., 1987: Organic and calorific content of body tissues of deep-sea elapsoid holothurians in the northeast Atlantic Ocean. Mar. Biol. 96: 277–282.
Warwick, R.M.; George, C.L.; Davies, J.R., 1978: Annual macrofauna production in a Venus community. Estuarine Coast. Mar. Sci. 7: 215–241.
Warwick, R.M.; George, C.L., 1980: Annual macrofauna production in an *Abra* community. In: Collins, M.B.; Banner, F.T.; Tyler, P.A.; Wakefield, S.J.; James, E. (eds.): Industrialized embayments and their environmental problems. Oxford: Pergamon, p. 517–538.

Acknowledgements

This study is part of a joint Argentinian-German project (No. ARG 002/98 MAR) funded by Comisión de Ciencia y Técnica (Argentina) and the International Office of the Bundesministerium für Forschung und Technologie (BMFT) (Germany). We are indebted to Angel Marecos for work on board.

Authors' addresses: Dr. Claudia Bremec, Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), INIDEP. e-mail: cbremec@lisa.inidep.edu.ar; mlasta@ lisa.inidep.edu.ar; **Dr. Thomas Brey**, Alfred Wegener Institute for Polar and Marine Research, P.O.Box 120161, 27515 Bremerhaven, Germany, e-mail: tbrey@awi-bremerhaven.de; **Lic. Mario Lasta**, Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP), P.O.Box 175. Paseo V. Ocampo I, 7600 Mar del Plata, Argentina. e-mail: mlasta@ lisa.inidep.edu.ar; **Lic. Juan Valero**, School of Fisheries, University of Washington, P.O.Box 355020, Seattle, WA 98195, USA. e-mail: juan@u.washington.edu; **Lic. Luis Lucifora**, Departamento de Biología Universidad Nacional, Mar del Plata. P.O.Box 82. Funes 3250, 7600 Mar del Plata, Argentina. e-mail: lolucif@mdp.edu.ar

Communicated by W. Arntz, received: 1st December 1999, accepted: 2nd October 2000, print proof received from author(s): 9 November 2000.