Deep-sea demersal fish density estimates compared from simultaneous net catches and photography

Deep-sea
Demersal fish
Fish densities
Photographs
Benthos
Faune démersale
Densité de poissons
Photographies

R. A. RUSSELL [1a], J. SERAFY [b*]
[a] Institute of Oceanographic Sciences, Brook Road, Wormley, Godalming, Surrey GU8 5UB, UK.
[b] Marine Science Laboratories, Menai Bridge, Gwynedd, North Wales.
* *Present address:* Coastal Ecology Research Laboratory, Box 1106, University of Maryland, Eastern Shore Campus, Princess Anne, MD 21853, USA.

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ABSTRACT

The numbers of fish caught and photographed in the eastern North Atlantic (49-52°N and 10-15°W) were compared from 46 hauls, made between 1979 and 1983 using an epibenthic sledge with an ancillary camera. There were 1966 specimens captured and 258 photographed. Fish species of similar appearance were grouped to aid identification from photographs. The 20 species/groups common to both gears were represented by 83.6% of the specimens captured. Although there was good correlation between the numbers, catch density was about one third of that photographed, demonstrating how much such estimates may be at variance. Larger species showed a greater discrepancy, to suggest net avoidance. A bow-wave might sweep aside less active animals. The camera also demonstrated selectivity; small and camouflaged fish were unseen, even where catches suggested a high density.

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RÉSUMÉ

Densité de poissons d'espèces démersales profondes estimées à partir de captures et de photographies simultanées

Les nombres de poissons capturés et photographiés dans le nord-est de l'Atlantique (49-52°N, 10-15°W) ont été comparés sur 46 échantillonnages effectués entre 1979 et 1983 à l'aide d'un engin de pêche épibenthique équipé d'un appareil photographique. 1 966 spécimens ont été capturés et 258 ont été photographiés. Les espèces d'apparence voisine sont groupés pour faciliter leur identification sur les photographies. Les 20 espèces/groupes communs aux deux engins représentent 83,6 % des spécimens capturés. Malgré une bonne corrélation entre les nombres, il y a un facteur 3 entre la densité de capture et celle de l'observation photographique, ce qui montre la variabilité de ces estimations. Les espèces les plus grandes présentent un désaccord tel que l'usage du filet doit être évité. Une vague d'étrave peut écarter les animaux les moins actifs : les petits poissons camouflés sont invisibles, même aux endroits où la densité de capture est élevée.

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INTRODUCTION

Cameras have been used to study deep-sea life *in situ*, both alone and in combination with nets, bait, traps and submersibles (*e.g.* Cohen, Pawson, 1977; Rice *et al.*, 1979; 1982; Lampitt *et al.*, 1983). Photographs provide a variety of environmental and some behavioural information. They facilitate estimates of population density and give an indication of the response of mobile organisms to sampling gears (*e.g.* Marshall, Bourne, 1964; Serebrov, 1974; Grassle *et al.*, 1975; Ohta, 1983). They do not replace the need for captured specimens but rather provide valuable complementary evidence (*e.g.* Dyer *et al.*, 1982; Cohen, Haedrich, 1983).

Recently a survey of the benthic fauna of the Porcupine Seabight, in the eastern North Atlantic to the southwest of Ireland, has been made using an epibenthic sledge with an ancillary camera mounted on the frame. Serial photographs of the sea bed ahead of the gear were taken during sampling. This paper compares the numbers of fish captured by the net with those photographed in the volume of water ahead of it and notes behaviour in five instances where the same fish was photographed in consecutive frames.

MATERIALS AND METHODS

The Institute of Oceanographic Sciences' (I.O.S.) epibenthic sledge (Aldred *et al.*, 1976; Rice *et al.*, 1982, *see* their Fig. 1) consisted of a net supported by a steel frame mounted on broad skids. The frame gave a fixed mouth opening of 2.3 m wide by 0.6 m high, although sinking in soft sediment may sometimes have reduced this area. The frame carried an odometer to measure distance fished, a camera and an acoustic net monitor to relay *in situ* temperature, soundings and distance fished at two second intervals, to shipboard recording equipment. The lever mechanism that operated a mesh blind to keep the net closed in midwater switched on the camera when the sledge was on the seabed.

Two cameras were used during this survey. A commercial model 374 "Benthos" camera was fitted on eight occasions. This was mounted on the sledge frame so that the lens height was 0.86 m above the seabed at an angle of 30° from horizontal. The area photographed was 7.36 m^2, extending 3.9 m ahead of the net, together with a skewed pyramidal volume of water of 2.11 m^3 (Fig. 1). The camera used for the majority of hauls (38) was an I.O.S. shutterless camera (Collins, 1984) mounted to give a lens height of 0.80 m above the seabed and an angle of 30° from horizontal. The area photographed was 2.32 m^2, extending 2.6 m ahead of the net, and the water volume 0.62 m^3 (Fig. 1). All but one of the tows using the "Benthos" camera had a frame interval of three seconds. Some overlap between frames was to be expected at the usual towing speed of 1.5-2.0 knots, although this was rarely detectable. Alternate frames were used here, however, to eliminate any chance of the same volume of water being photographed twice. The camera on the remaining tow was set at six second intervals, allowing sufficient distance towed between the frames for each to be used. The I.O.S. camera had a frame interval of 15 seconds. Any frame where the net was obviously tipped up or down or the photograph obscured in any way was discounted.

The volume of each photographic sample was taken to be the pyramidal volume of each exposure times the number of useable frames per tow. The volume of water sampled by the net was calculated as the mouth area times the distance towed.

Since September 1981 a calculated distance run (CDR) was computed from gear depth, warp length and distance travelled by the ship. The odometer always recorded shorter distances than were travelled by the ship. One possible explanation could be the frequent loss of seabed contact by the net, although net monitor records of blind opening and closure do not indicate such interrupted fishing. Another more likely cause is the insufficient friction on the bearing surface of the odometer wheel by the bottom substrate (Rice *et al.*, 1982). It was necessary to ascertain the consistency of this slippage to enable all samples to be incorporated in this study, as among earlier samples distance was recorded only from the odometer. By regressing CDR values with those distances obtained from the odometer (ODR), for all hauls where both were available, a good positive correlation was obtained (r = 0.976) confirming

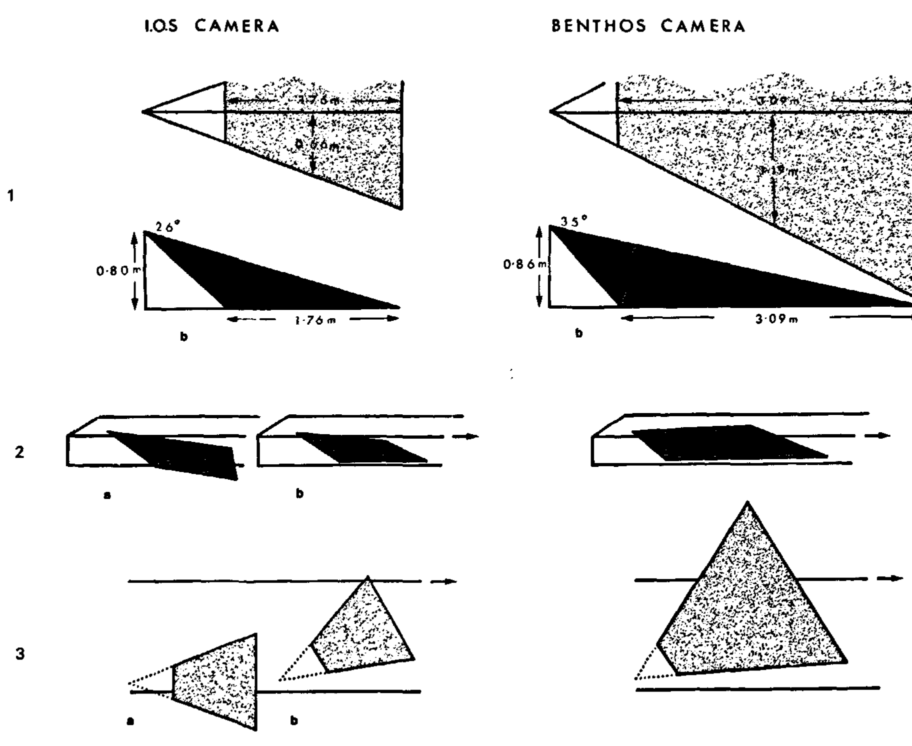


Figure 1
1: *a) Area of seabed and b) section of skewed pyramid of seawater photographed.*
2: *impression of the volume of seawater (shaded area) photographed a) before and b) after May* 1981. *The arrows indicate direction of tow.*
3: *Area of seabed photographed in relation to the width of the nets track: a) before, and b) after* 1981.

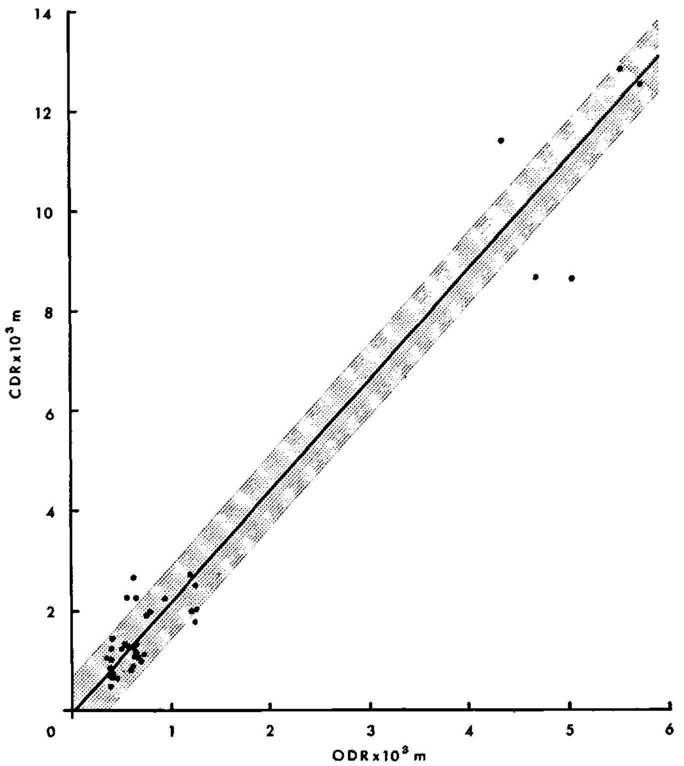


Figure 2

Comparison of distance travelled by the sledge, calculated from warp length, depth of net and distance travelled by the ship (CDR) with that measured by the integral odometer wheel (ODR) (shaded area = standard deviation of y about the line). The regression equation is ODR = 38.2 + 0.42 CDR (n = 37 : r = 0.96).

that the odometer gave a consistent reflection of distance fished (Fig. 2). Using the regression equation ODR = 38.2 + 0.452 CDR, a CDR could be estimated for samples taken before 1981 where no other data were recorded.

The cameras sampled a smaller volume of water than the net, the relationship between the two varying with the number of useable frames in a tow (I.O.S. camera 0.5-4.8 %, $\bar{x}$ 2.4 %; "Benthos" camera 4.1-26.5 %, $\bar{x}$ 15.4 % of the water filtered by the net).

For comparative purposes the numbers of fish photographed and caught were standardised to numbers per 1 000 m³ for each sample. The density of each species was calculated from the total volume of water sampled in their known depth ranges (*see* Tab.).

A total of 88 hauls were made with the I.O.S. epibenthic sledge in the Porcupine Seabight (49°-52°N: 10°-15°W; Fig. 3) between June 1979 and May 1983, during seven cruises on *RRS Challenger* and one on *RRS Discovery*. Data from only 46 of these hauls were used, the others being discounted due to: 1) total camera or odometer failure, where no CDR could be estimated; 2) less than 1 % of the volume filtered being photographed; or 3) net damage.

The mid-depths of the samples ranged from 158-4080 m soundings and the calculated distances run from 579-3 789 m. The numbers of useable photographs taken in each haul varied between 28 and 214 frames.

Table

Depth ranges of observations (capture and photographic) indicating the total number of samples and density/1 000 m³ of water sampled, 1.9 % of total fish caught (mainly damaged alepocephalids and macrourids) and 7.8 % of those photographed could not be identified.

** Known depth range: in some cases the known depth range of a species in this area has been extended by samples from Granton and semiballoon otter trawls.*

⁺ There were 40 species caught by the sledge that never appeared in photographs. All but one of these were represented by a total of one or two specimens, the exception being the Gaidropsaurus *sp.*

Species/Groups	No. sledge and camera samples from * known depth range	Depth range (mid-depths of samples) epibenthic sledge (m)	photographs (m)	No/1 000 m³ water sampled in * known depth range caught	photographed
Caught and Photographed					
Flatfish	5	158-497	497	3.53	1.94
Helicolenus dactylopterus	4	400-700	510	0.70	2.15
Phycis blennoides	8	400-857	857	0.49	1.32
Coelorinchus coelorinchus	14	497-700	1 326	0.11	0.93
Halargyreus johnsoni	19	497-940	857	0.34	1.10
Lepidion eques	21	497-1 327	700-1 327	0.80	3.18
(*Synaphobranchus kaupi; Ilyophis blachei*)	21	497-1 635	700-1 535	23.51	42.09
(*Coelorinchus occa; Trachyrincus* spp.)	19	497-1 635	497-1 380	2.12	6.96
Nezumia aequalis	19	700-1 178	700-1 500	1.37	3.30
(*Alepocephalus rostratus; A. bairdii*)	16	857-1 500	1 286-1 327	0.76	2.17
(*Notacanthus bonapartei; N. chemnitzi; Polyacanthanotus rissoanus*)	21	857-1 635	1 178-1 535	1.61	2.83
Coryphaenoides (*Coryphaenoides*) *rupestris*	16	857-1 635	857-1 635	1.32	9.11
Myxine ios	14	940	1 326	0.03	0.48
(*Chimaera monstrosa; Hydrolagus mirabilis*)	19	980-1 380	980-1 303	0.25	1.10
Coryphaenoides (*Coryphaenoides*) *guentheri*	28	1 115-2 780	1 303-2 800	2.31	3.09
Hoplostethus atlanticus	13	1 303-1 380	1 303-1 327	1.75	9.74
(*Coryphaenoides* (*Chalinura*) *profundicola; C.* (*C.*) *brevibarbis; C.* (*C.*) *leptolepis*)	25	1 997-4 080	3 950	0.28	0.71
Coryphaenoides (*Nematonurus*) *armatus*	23	2 665-4 080	2 748-4 050	0.29	2.29
Histiobranchus bathybius	25	2 735-2 905	2 775-4 050	0.17	1.42
Photographed only					
Bathypterois dubius	12	—	1 322	—	0.50
Galeus sp.	5	—	955	—	2.54
Caught only ⁺					
Gaidropsaurus sp.	8	400-980	—	7.87	—

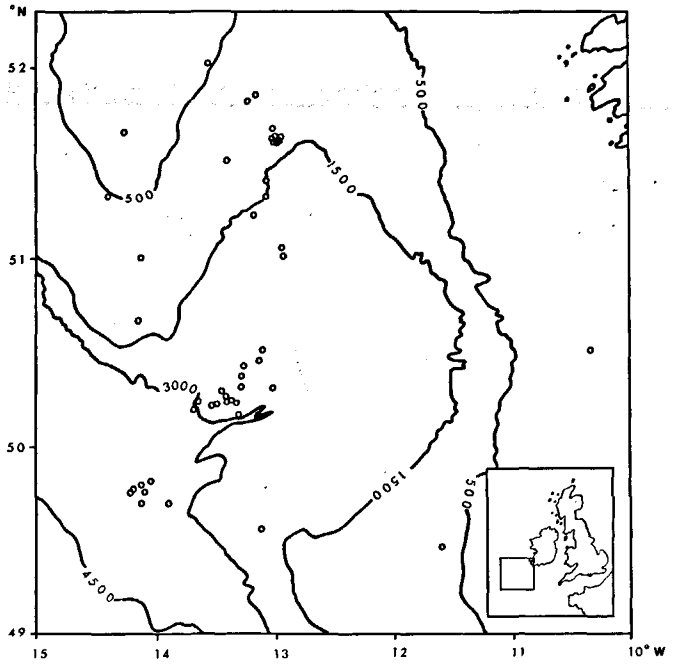


Figure 3
Chart of the Porcupine Seabight showing the positions of stations used.

Many species could easily be identified from photographs but in some cases, where very similar looking fish inhabit the same depth ranges, they were combined into groups, for example the synaphobranchid eels, *Synaphobranchus kaupi* and *Ilyophis blachei*.

RESULTS AND DISCUSSION

The sledge captured 1966 fish specimens representing 59 species. They comprised 51 easily recognisable species and species groups that could be identified from photographs to aid comparison between the two sampling methods. The photographs taken concurrently showed 258 specimens and 21 species/groups of which two, the shark *Galeus* sp. and the tripod fish *Bathypterois dubius*, were never captured. Nineteen species/groups were, therefore, common to both net and photographic samples and contained 83.6% of the specimens captured. The remaining species/groups were mainly represented by one or two specimens with the exception of a large number of juvenile *Gaidropsarus* sp. (*see* Tab.). In all samples there were species captured but not photographed, while there were also several instances when species were photographed but not caught.

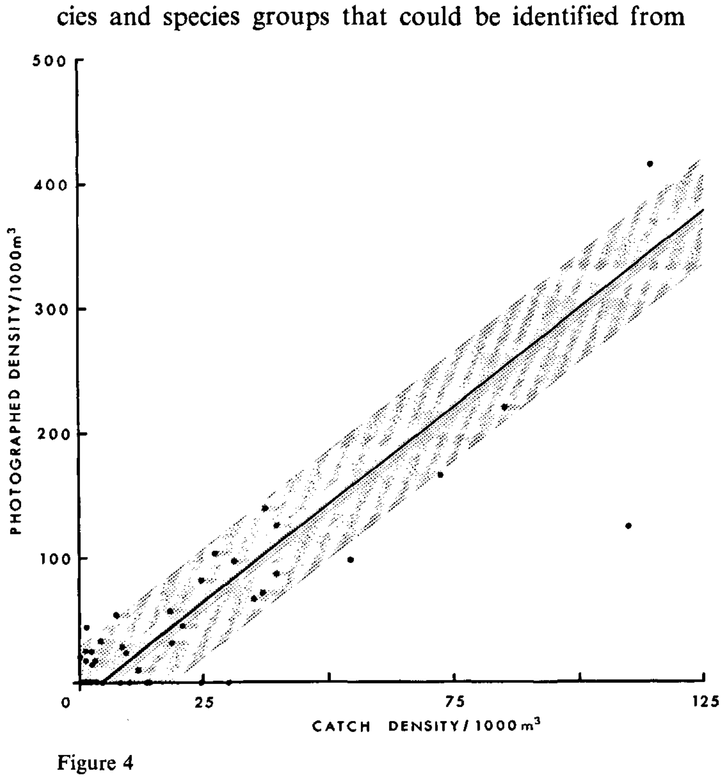


Figure 4
Comparison of total fish densities (shaded area = standard deviation of y about the line) estimated from photographs and sledge catches for each haul. The regression equation is photodensity = 5.43 + 0.316 catch density (n = 46: r = 0.86).

Whilst the estimated densities of fish photographed were almost always higher than those based on catches (Tab.), on average three times as many, there was a good positive correlation between them (Fig. 4). A general decrease in density with increased depth as shown by earlier reports (*e.g.* Merrett, Marshall, 1980; Wishner, 1980) is confirmed by these results.

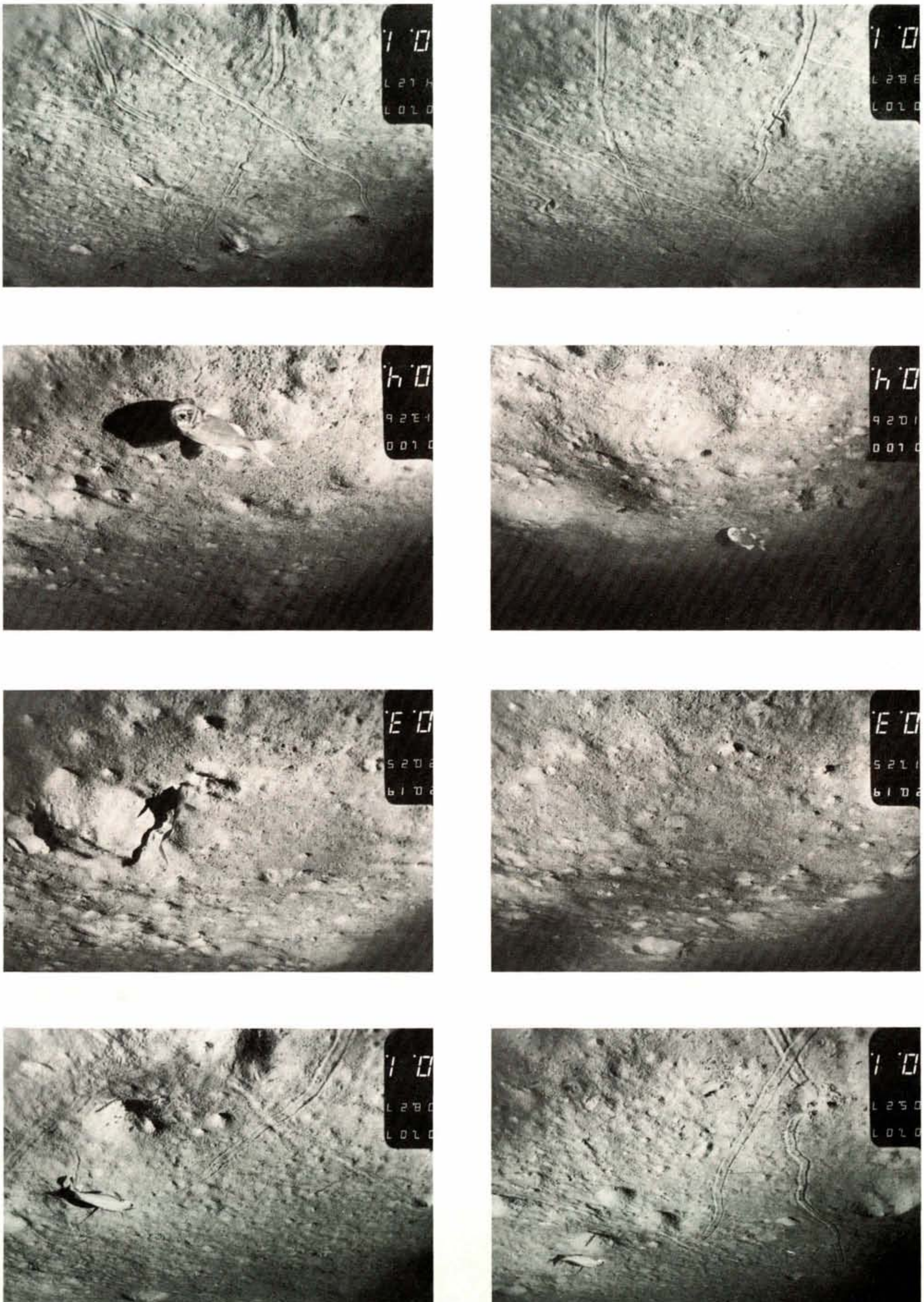
It has been suggested that deep-sea fishes may avoid smaller gear which may account for the discrepancy between catch and photo densities (*e.g.* Rice *et al.*, 1979; Merrett, Marshall, 1980; Stein, 1985). This set of samples show a tendency for the larger or more active fishes (*e.g. C.* (*C.*) *rupestris* or *Hoplostethus atlanticus*) to show a proportionally greater photodensity to catch density than smaller species (*e.g. C.* (*C.*) *guentheri* or the smaller synaphobranchiid eels) (*see* Tab.). On five occasions when the "Benthos" camera was set on three second intervals and consecutive frames overlapped a fish was photographed twice showing no reaction to the approaching gear (Plate).

It is also possible that the bow wave of the net sweeps aside some fish. Evidence for this is that the sledge only samples about half the density of sedentary animals photographed in its path (Aldred *et al.*, 1979; Rice *et al.*, 1982).

The selectivity of the camera is clearly demonstrated in two cases. First, although the catches of *Gaidropsarus* sp. made up a large proportion of the total catch (7.3%) and were very dense in one sample ($70.3/1\,000\ m^3$) all were juveniles and probably were never seen in photographs due to their countershading and small size (Rice *et al.*, 1982). Second, flat fish (mainly *Lepidorhombus whiffiagonus*) were fairly common in one haul although not photographed, possibly due to effective camouflage against the sediment. This suggestion is supported by the fact that in the one photograph in which a flat fish is recognisable, it was visible only on the one side which was raised off the bottom slightly.

The rather small volumes of water photographed resulted in most samples having five or fewer fish in them and, therefore, only the commonest species were represented (*see* Tab.).

Recently an I.O.S. epibenthic sledge carrying a camera, but no net, has been used for much longer tows giving a greater volume of water photographed, which has increased the diversity of species seen.



Plate

Consecutive frames with a three second time interval where a fish was photographed twice.
a) Lepidion eques;
b) C. (Coryphaenoides) rupestris;
c) Hoplostethus atlanticus;
d) Synaphobranchus kaupi.

The epibenthic sledge and camera have been shown in this and other work (Uzmann *et al.*, 1977; Rice *et al.*, 1982) to be selective samplers, the net tending to catch the smaller, less active animals more efficiently than the larger, faster species. The camera is also selective due to visibility. These results from simultaneously obtained photographic and catch data confirm the advantages of using both techniques, earlier suggested by Marshall and Bourne (1964). Such complementary sampling combines species richness data from the epibenthic sledge catches with improved estimates of fish density from photography.

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