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Pecten Scallop Survey In Southern Geographe Bay, September 1976

BY

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PECTEN SCALLOP SURVEY IN SOUTHERN GEOGRAPHE BAY, SEPTEMBER 1976

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ABSTRACT

Reports of Pecten scallops in Geographe Bay in late 1975 were followed up by a preliminary stock survey in February 1976 using 1.22 m dredges and by a more extensive survey in September 1976 using 1.22 m and 2.25 m scallop dredges and a 0.5 m^2 Baird grab. Two very limited concentrations of scallops were located adjacent to rough ground. The best dredge catch rates were equivalent to 44 kg per hour per standard haul and the maximum grab catch was equivalent to a density of six scallops per square metre. The extremely rough terrain resulted in considerable damage to the dredges which indicated that the area is not favourable to dredging with existing gear.

I INTRODUCTION

Live *Pecten* scallops were first located in southern Geographe Bay by a diver working off Eagle Bay in September 1975. In November 1975, a small sample of live *Pecten* scallops was provided for examination. Preliminary age determination suggested that the year classes 1+ and 2+ were equally represented in the sample. These reports were followed up in February 1976 by J.W. Penn of the Department of Fisheries and Wildlife using 1.22 m Baird-type try dredges. Three trawls for king prawns were also undertaken near Dunsborough on the only area which appeared to be suitable bottom, to assess the strength of the king prawn (*Penaeus latisulcatus*) population. Although negligible catches of king prawns were made, the high catch rates of scallops taken by the try dredges in several hauls appeared to indicate the existence of a useful population of *Pecten*. It was decided to test further the commercial potential of the *Pecten* scallop population by a full scale survey, using 1.22 m try dredges, a commercial sized 2.25 m scallop dredge, and a 0.5m^2 Baird grab. Commercial dredging for scallops was prohibited in the area from 4th May to 31st December 1976 to allow for an assessment of the stocks and any requirements for management.

II METHODS

The equipment and procedures used in the survey are described under separate headings below. Both surveys were undertaken with the Department's research vessel, "R.V. Flinders".

A. EQUIPMENT

Three types of equipment were used in the survey:-

(i) 1.22 m (4 ft) Baird style dredge, inter-tooth spacing 6-8 cm, steel meshes of basket measuring 4.5 x 7.0 cm.

(ii) 2.25 m (7 ft 4 ins) Baird style dredge, of commercial size, inter-tooth spacing 3-4 cms, steel basket meshes 4.5 x 7.0 cm. (plate 2).

In the February 1976 survey by J.W. Penn, the 1.22 m dredge was used with fine plastic mesh to retain small scallops but in the September survey unlined dredges were used:-

1. to sample commercial sized scallops more effectively;

2. to reduce clogging which may have caused the dredge to fill quickly and thus catch inefficiently for the remainder of the haul.

(iii) a 0.5 m^2 Baird grab, capable of accurately sampling larger organisms, such as scallops, within a half square metre (plate 3). The grab could be preset to penetrate to a known depth, with a maximum of about 22 cm (8 ins). A plastic mesh cover was used over the top of the jaws to prevent scallops escaping with the wash during hauling. This alternative method of sampling would sample all sizes of scallops present effectively, without the selection expected from the dredge teeth and basket meshes. The grab could also reveal areas unsuitable for dredges when used in advance of them.

B. SURVEY PROCEDURES

Dredge trials on mud in 10 fathoms in Cockburn Sound and on medium grained sand in 5 fathoms off Swanbourne Beach had previously established that the following hauling conditions would produce optimum catch rates:

1. Hauls should cover 0.3 sea miles to facilitate position fixing by radar which is precise to only 0.1 nautical miles.

2. For the 2.25 m dredge, best catch rates were at 2-2½ knots ground speed on sand and at 3+ knots on mud. The optimum towing speed for the 1.22 m dredge, although unknown, was presumed to be of the same order as for the larger dredge. Correction of engine r.p.m. could be made after hauls to allow for changing wind and swell.

3. Haul duration should be 5 minutes for the 1.22 m dredge, to prevent overfilling and 10 minutes for the 2.25 m dredge which has a much larger capacity.

4. Warp to depth ratios (warp calculated from top of tipper cradle) should be 6 : 1 or less for depths of 18 metres or more.

A diver was towed independently of the dredge to observe its behaviour in the first few hauls of the first day.

Records were kept of wind strength and direction, swell, r.p.m., haul distances, and depth from the continuous echo soundings, which also allowed adjustments to be made to warp : depth ratio. Details of catches, the numbers and sizes of *Pecten* scallops, the quantities of doughboy scallops *(Chlamys asperrimus)*, *Pecten* clappers and live scallops damaged by dredge capture, the presence of seagrasses and rocks in the "trash" to give an indication of foul hauls, were all recorded separately.

After each day's hauling, the accumulated catch of *Pecten* held in deck tanks was marked for liberation on the following day.

Grab samples were made along transects which traversed areas where reasonable catches of *Pecten* had been taken by dredge. Grab sampling of the whole area in a grid pattern was also planned but had to be abandoned after Station 7 due to rough weather and damage to the grab. The following information was recorded from grabs:-

1. Numbers of live *Pecten* and *Chlamys*.

2. *Pecten* sizes.

3. Other fauna in the grab sediment.

4. The presence of seagrasses *Posidonia australis* and *Heterozostera* sp.

5. Sediment type and grain size.

6. Rocks, to indicate foul ground in addition to those areas already known.

A collection of molluscs, fish, and echinoderms was made for the W.A. Museum, sponges for chemical residue extraction and molluscs for biochemical analysis.

III RESULTS

A. TOPOGRAPHY OF THE SURVEY AREA

Geographe Bay is the southern most major embayment on the west coast of Western Australia (Figure 1) situated near the ports of Busselton and Bunbury to the east and enclosed by Cape Naturaliste to the west. The meridians 33°30'S latitude and 115°20'E longitude cross approximately in the centre of the bay. The dredge and grab surveys were undertaken in the southern part of Geographe Bay, in the lee of Cape Naturaliste, where the major part of the *Pecten* scallop population was thought to be located. Depths of between 17-35 metres, were tested for scallops in this area, just north of Dunsborough.

The benthic topography is dominated by: (i) a steep shelf which flattens out to the east; and (ii) a considerable area of rough rocky bottom (see Figure 2, black patches) which runs in a broken band SE/NW along the shelf. Adjacent depth soundings (made 150 metres apart) which revealed sudden changes in depth, were used as the basis for outlining these areas of rough rocky bottom. The changes were thought to represent either depressions in the shelter of rocky ground or pinnacles of reef. Isolated seagrass meadows, recorded down to depths of 32 metres were replaced in deeper water by a zone of sponge and live coral.

The Department's diver reported the presence of distinctive furrows which meandered in an approximately perpendicular direction from the shore. In the two hauls which he observed off Pt Picquet, the furrows were 0.1 metres deep.

Distinctive sediments (Table 3, footnotes) were found in the area. Of these, a grey to orange-coloured coarse to gravelly quartz sand (sediment types 5 and 6) was frequently found with live *Pecten* and *Chlamys*, together with their shells and fragments, which were indicative also of former populations of scallops in this area. No live *Pecten* or *Chlamys* were associated with sediment types 2 or 4, probably due to their low frequency in the grab samples.

The major geological influence in the survey area has been the Dunsborough fault which runs from NW to SE crossing the coast at about Dunn Bay (not shown, but SE of limits of map, Figure 2). To the west of this is the Leeuwin Block which has been the major source of sediments and is mostly Pre-cambrian granitic gneiss. To the east of the fault, slippage has produced a basin, which is now largely filled by quartz sand sediments. Isolated outcrops of green, possibly Jurassic rock (pers. comm. B. Balme) exposed by weathering were also located to the east of the fault. In deeper water, a bio-strome substrate with isolated pockets of quartz sand is more common (pers. comm. J. Searle).

B. DETAILS OF HAULS AND CONDITIONS

Table 1 shows details of sea and wind conditions, vessel orientation, speed, position, distance travelled, haul duration, warp requirement, and the cause of fouling for individual hauls in this survey. The combination of sea, wind, warp, vessel r.p.m., and dredge size determined the effective speed in knots of the dredge under tow. The positions of dredge hauls are shown for the September 1976 survey in Figure 2 and for the February 1976 survey in Figure 3.

C. SCALLOP STOCKS AND THE INFLUENCE OF VARIOUS FACTORS ON CATCH RATE

Table 2 shows the actual catches of *Pecten* by the two sizes of dredge in the September 1976 survey and the catch rates standardized to a 5 minute haul of the 1.22 m dredge by multiplying the numbers of *Pecten* caught with the 2.25 m dredge by the following factor:

$$\frac{1.22}{2.25} \times \frac{5}{10} = 0.271$$

which is the product of the ratio of mouth widths and the ratio of haul durations for each size of dredge. This assumption of a direct relationship is the only practical one available in the absence of any information on relative dredge efficiencies. One reason for standardisation to a 1.22 m dredge was that all hauls in February and 70% of hauls undertaken in September used the 1.22 m dredge.

Catch rates in September ranged from 0-137 scallops per standard haul (Table 2 and Figure 5). Of the sixty-four hauls, sixteen (25% of total) were foul and no scallops were caught on another twenty-three hauls (36% of total). For the remaining twenty-five hauls, catch rates of 23, 28, 33, and 137 scallops per standard haul were recorded for the best four, but in the other twenty-one hauls (84% of productive hauls) catch rates of 1-20 scallops were made, the majority of which were in the range of 1-10 scallops. From Figure 5 it can be seen that the locations of the four best catch rates were at two separate sites. One group of three hauls was approximately 0.55 nautical miles NE of Pt Picquet and the other was approximately 1.5 nautical miles NE of Pt Picquet.

In the February 1976 survey (Figure 4) the distribution of catch rates was quite similar to the distribution in September. There were forty-nine hauls undertaken in February of which four were foul and fifteen (30% of total) caught no scallops. In the thirty productive hauls, the four best catch rates were 31, 35, 46, and 47 scallops per standard haul and in the remaining twenty-five (84% of productive hauls), 1-20 scallops were caught, most of which contained only 1-10 scallops.

To examine the influence of effective (ground) speed of the dredge on subsequent catch rate, catch rate data (excluding hauls fouled in any way) were grouped into five speed ranges, viz. 1.7 - 2.1 knots, 2.2 - 2.6 knots, 2.7 - 3.1 knots, 3.2 - 3.6 knots, and 4.2 - 4.6 knots. The mean effective speed and mean catch rate of *Pecten* calculated for each group indicated an inverse relationship between catch rate and speed. The catch rate dropped from a maximum of 4.1 scallops per 0.1 nautical mile of standard haul at a mean speed of 1.8 knots to 0.4 scallops at a mean speed of 3.5 knots. The last speed grouping had only one haul in it, so an average could not be calculated. These data suggest that speeds of about 2 knots caught scallops more effectively than higher speeds, on this coarse gravelly sand bottom.

The effect of depth on catch rate was examined in a similar manner. Values for mean depth, mean catch rate and mean speed were calculated for the depth ranges 16-19 metre, 20-23 metre, 24-27 metre, 28-31 metre, 32-35 metre. Speed was considered together with depth because, had it differed significantly in each depth range, it could well have been the primary influence on catch rate instead of depth.

However, it can be seen from the table below that speed did not differ substantially in four of the five categories. The best catch rates were taken in depths from 24-27 metres.

DEPTH CATEGORY (METRES)	MEAN DEPTH (METRES)	MEAN CATCH RATE	MEAN SPEED (KNOTS)	NO. HAULS
16-19	17.5	0	3.8	2
20-23	22.0	3.3	2.8	4
24-27	24.8	4.5	2.4	6
28-31	30.5	0.9	2.8	22
32-35	32.0	2.2	3.0	2

The main difference between the two surveys was that in February the best catch rates of scallops were in the deeper water off Pt Picquet (1.0-1.5 nautical miles NE of the Point) rather than inshore where best catch rates were made in the September survey. The majority of foul hauls was caused by tooth damage through collision with rocks, stones and rocks filling the dredges and resulting in poor performance, or seagrasses jamming between the teeth and preventing their effective raking. (Table 1.)

D. SIZE OF DREDGED SCALLOPS

The size of scallops caught over the survey area in September showed little variation between hauls with mean height per haul ranging generally from 63-73 mm (Table 2). The selectivity of the gear is thought to be responsible for the negatively skewed size distribution of *Pecten*, (Figure 8 (b)). In the February survey (Figure 8 (a)), scallops in the size range 20-45 mm were retained by the fine mesh plastic screens lining the dredge and the mean size of scallops caught was 66 mm. The mean size of all dredge-caught *Pecten* in the September survey was 69 mm and the modal class was 71-75 mm compared with the February mode of 65-70 mm. The proportion of scallops larger than 70 mm had risen from 37% in February (Figure 8 (a)) to 54% in September (Figure 8 (b)). Although difference in the overall size composition is probably due to selection, selectivity at the modal size is unlikely to be important and it seems probable that at least some of the change in modal position represents growth, of the same order as previously observed in Cockburn Sound. The dotted lines drawn at 70 mm on Figures 8 (a) to 8 (c) represent an arbitrary division into size (> 70 mm) and undersize scallops (< 70 mm) as 70 mm would be the smallest size for efficient processing.

E. TAGGING

Most of the scallops caught by dredge and all those caught by grab were tagged. Of the total of 514 scallops tagged, 423 bore individually numbered tags. The remainder were marked only with a patch of grey epoxy resin. Scallops were released at six separate sites (Figure 6, marked A-F). They were held overnight in open circuit deck tanks before release to minimize tagging mortality. Only one scallop died in the deck tanks. The sizes of individually numbered scallops were recorded and each was notched with a triangular file as a check on its growth in the event of subsequent recapture. A reward of $1.00 is offered for each tagged scallop returned.

F. GRAB SURVEY

The grab survey was to be undertaken in two parts:-

1. A series of transects across areas of best catch rates located by dredge (373 grabs).

2. A grid pattern of stations covering the complete survey area mainly to indicate the areas likely to contain *Pecten* scallops on the basis of sediment type disclosed by grabbing.

Only twenty grab hauls of the grid of stations could be completed due to limitations of time and damage to gear.

From Table 3, it can be seen that the mean density of *Pecten* along transects varied from 0.1 scallops per square metre (Transect 13), to 1.6 scallops per square metre (Transect 14). As a maximum separation of these two adjacent transects is 0.7 nautical miles, whilst the minimum distance apart is 0.1 nautical miles, the patchy nature of the scallop distribution can be readily appreciated. Excluding foul grabs, the mean overall density of *Pecten* taken by the 379 effective grabs was 0.31 scallops per square metre. A maximum density equivalent to six scallops per square metre was obtained on three separate occasions. The mean observed density of scallops sampled by grab (at 0.31 scallops/m^2) is of the same low order of density as that reported by Mason and Colman (1955) in Scottish beds, by Caddy (1970) for areas of lowest density in the productive Georges Bank area in the Bay of Fundy, Canada, and by Baird and Gibson (1956) for the low density beds in Isle of Man waters.

In Figure 5, which shows *Pecten* caught both in successful grabs and by dredge, it can be seen that the best catches taken by grab (see Legend) also closely correspond to the location of the three best dredge hauls in September, 0.5 nautical miles E to NE of Pt Picquet. Another bed of scallops appears to be located 1.0-1.5 nautical miles NE of Pt Picquet judging from the consistent series of grabs which caught two scallops per square metre there. This offshore patch, which was not well verified during the September survey did however yield reasonably significant catch rates in February of 22, 36, 46, and 47 scallops per 5 minute haul.

Two further sites which might prove promising, (marked A, B on Figure 5) yielded scallops at a density of two per square metre in successful grabs. Area A is rough rocky ground unsuitable for dredging. Insufficient is known about area B for comment.

Factors Influencing Grab Catches

In Table 4, catches of *Pecten* taken by individual grab shots are given for transects and stations, together with the associated catches of *Chlamys* scallops, alive and dead, other molluscs, seagrass, and the sediment type in each grab.

Catches of live *Pecten* were usually taken either associated with or in close proximity to live *Chlamys* (Table 4). Live *Pecten* were not commonly associated with seagrass, due probably to the difficulty of burying in sediment containing extensive root mats (Table 4).

For the six sediment types listed as footnotes to Tables 3 and 5, eighty-seven grabs contained type 1 sediment , two grabs type 2, four grabs type 3, seven grabs type 4, 105 grabs type 5, and 175 grabs type 6. A test of significance could be undertaken only for sediment types 1, 5, and 6 as there were too few results for the other sediment types. The chi square test showed that the observed frequencies of *Pecten* on these three sediments were significantly different from the expected frequencies ($p < .01$). Figure 7, shows that type 5 sediment was the most productive of *Pecten*; 50% of the total grab catch of *Pecten* was caught in this sediment which was present in only 27% of grabs. In addition 21% of grabs on type 5 sediment contained *Pecten*. Type 6 sediment was the next most productive. Of the total grabs, 45% contained type 6 sediment and these caught 38% of all grab-caught *Pecten* with 10% of grabs on this sediment yielding *Pecten*. Sediment types 5 and 6 together accounted for 84% of total *Chlamys* caught. The relative incidences of seagrass in each sediment type were type 1 (30%), type 2 (100%, both grabs), types 3 and 4 no grabs with seagrass, type 5 (4%), and type 6 (23%).

The size composition of grab-caught scallops (Figure 8(c)) is interesting for two reasons. Firstly, it demonstrates the bimodality of the *Pecten* stock in Geographe Bay in September, indicating the presence of a strong recruit class first detected in February, and now with a mode at 56-60 mm, which was effectively masked by the selection of large sized scallops during dredging in September and secondly, because it demonstrates that providing the capture of smaller sized scallops was not biased by use of the grab, less than one third of the population of scallops would have been at a size suitable for processing, if taken by methods other than dredging (e.g. skindiving).

The mean densities of *Chlamys* scallops observed from the same grab sampling varied from 0.1 - 6.4 scallops per square metre between transects (Table 3) and the actual numbers caught in individual grabs ranged from 0-33 *Chlamys* per grab ($\simeq$ 0-66 *Chlamys* per m^2). The overall mean of 0.82 *Chlamys* per square metre is unlikely to be of commercial density. This figure is based on a total of 196 square metres sampled by grab.

IV DISCUSSION

A. DREDGE EFFICIENCY

Previous workers have found that both the traditional scallop dredges and the newer Baird sledge dredge operate with a generally low but also largely variable efficiency from 2% to 49% (Baird 1955, 1957, 1959; Baird and Gibson 1956; Mason and Colman 1955; Sanders 1967; Rolfe 1969, and Mason, Chapman and Kinnear 1976). There are a number of reasons for both the low efficiency and its variability.

For traditional dredges and drags, the low efficiency is caused by their behaviour under tow. The traditional European dredge travels in a series of long shallow leaps over the bottom (Baird and Gibson 1956), thus "missing" most of the ground in the haul path. The Canadian drag, by contrast, remains in contact with the bottom but due to its lack of teeth, moves along bulldozing a mound of sediment in front, most of which is dumped to each side of the track at regular intervals and very little of which enters the drag mouth (Caddy 1968).

The Baird-type dredges used in February and September have been built with a depressor plate which helps maintain better contact with the substrate. J.W. Penn, who undertook the February survey, concluded (pers. comm.) that the fine plastic mesh screen used on the 1.22 m dredge to sample small sizes of scallops may have resulted in "porpoising" behaviour by the dredge. Baird dredges, which were thought to range in efficiency from 5% - 20% (Baird 1957) have been shown to have an efficiency on *Pecten maximus* ranging from 33% by the Delury method to 24% by a mark-recapture method (Rolfe 1969). However, on the rough ground characterizing much of the survey area in Geographe Bay, it would be expected that Baird dredges may have a much lower efficiency than 33%. A dredge riding over undulations of 0.1 metre (as reported by diver) would either skim the crests and miss scallops recessed at the bottom of undulations or else bulldoze through the ridges, thus burying scallops in the depressions. Escape reactions caused by the approach of the dredge may further reduce the efficiency of capture of scallops by dredge. Scallops held in deck tanks showed considerable swimming activity.

Size selection would also be expected during capture of scallops by dredge (Mason, *et al* 1976). By appropriate size and separation of teeth, the required size of scallops can be selected, leaving smaller scallops to pass between the teeth or through the basket meshes of the dredge (Baird and Gibson 1956). The absence of the mode at 56-60 mm in a sample taken exclusively by unlined dredge (Figure 8 (b)), but its presence in Figure 8 (c) (scallops taken by grab only) is cited as evidence of selection against this size by the dredges used in September.

B. AVAILABLE STOCKS OF *PECTEN*

Despite the likelihood of the dredge's inefficiency on the undulating substrate of the survey area in southern Geographe Bay, the available stock of scallops there appears to be low both in terms of the very limited area where the best catch rates were taken and also from the mean density revealed by grab at 0.3 scallops per square metre.

If it can be assumed that a 2.25 m commercial dredge fishing for 10 minutes would catch approximately four times as well as a 1.22 m dredge fishing for 5 minutes, the average of fifty-five scallops per standard haul for the four best September hauls, would be 220 scallops per 10 minute commercial haul. Assuming four hauls in an hour to allow for turnaround, this would be equivalent to 44 kg per hour. Using similar calculations to convert the catches per standard haul in September to equivalent hourly catch rates with a commercial 2.25 m dredge, the thirty-seven hauls remaining after elimination of foul and unsatisfactory hauls, and excluding the four best hauls, ranged from 0 kg per hour to 26.4 kg per hour with a mean of 7.4 kg per hour and with only one haul greater than 30 kg per hour. To support normal economic dredging, minimum catch rates would need to be considerably more than 44 kg per hour.

When compared with Cockburn Sound, the catch rates achieved in Geographe Bay were similar to those in the declining phase of the Cockburn Sound *Pecten* fishery, where the average hourly catch rate dropped from 60 kg per hour by two vessels in late 1971 to 25 kg by one vessel in early 1974 after which the fishery ceased.

By contrast, the previous peak of that fishery, between August and November 1970, yielded catch rates of 220-400 kg per hour (up to 10 bags per 10 minute haul) over an area calculated to be 3.5 square sea miles which supported thirty vessels. By comparison, a much smaller area, estimated to be little more than half a square sea mile, provided the best catch rates in September and February in Geographe Bay.

However, it may prove more practical in the rough bottom conditions to use a 1.22 m dredge in which case the average of fifty-five scallops per standard haul for the four best September hauls would convert to 22 kg per hour, based on eight 5 minute hauls per hour allowing for turnaround.

C. POSSIBILITIES FOR COMMERCIAL EXPLOITATION

If a suitable method can be found for harvesting the small stock in Geographe Bay, the profitability of the fishery would probably be close to break-even point, even if overheads were kept low. An important economic factor would be whether scallops were to be processed with roes on or off. A sample of fifty scallops from Geographe Bay, taken in late February showed that most had recently spawned so that meat recovery at that time would be almost entirely provided by the muscle. Thus it appears that the Geographe Bay *Pecten* stock is reproductively in phase with *Pecten* in Cockburn Sound which also

spawns from mid to late summer. Following spawning in Cockburn Sound, the roes start to refill and have regained sufficient weight and colour to warrant being retained during processing. This is also probably the case with *Pecten* in Geographe Bay. Full sexual maturity would be reached in mid summer, just before spawning, but the weight and volume of roe would be acceptable to the processor any time from winter to before spawning. In the September sample from Geographe Bay, scallops processed with roes on gave a recovery of 13%, but without roes the recovery (muscle only) averaged 10%. The roes examined were in developing condition, not completely filled. If processing of *Pecten* from Geographe Bay was delayed until after summer to increase the proportion of size scallops available, the gain in yield by the stock as a whole might be offset by both the lower recovery of the meats, most of which would have roes in a spent or small condition and the losses from natural mortality in the intervening period. At this stage, only a small fraction of the stock has reached maximum size and age.

The amount and severity of damage to all three of the Department's dredges indicates that dredges of current design are unlikely to prove a practical means for exploitation of the stock. In addition to the rough possibly rocky terrain represented as black patches in Figure 2, dredge damage was and could be done at a further fourteen sites (Figure 2, asterisks) discovered during the survey. Diving is seen as the only other practical method by which scallops can be taken at the present time. The conditions for diving would be favourable since 20 ft - 30 ft of visibility was reported by Mr L. Joll during observation of the 2.25 m dredge in action. There was also a sufficient light level to permit live scallops to be distinguished from dead ones.

Consideration might be given to the possible utilization of *Chlamys* meats, which could be taken by diving or together with *Pecten* in dredges. If taken by dredge, it would be necessary to line dredges with a suitable plastic mesh which would compromise between elimination of gravel sized trash and retention of the small *Chlamys* scallops, most of which were less than 40 mm(1.6 ins) in height.

D. RECOMMENDATION FOR FUTURE STUDY

1. If commercial exploitation is not undertaken in the near future, the Geographe Bay stock should be re-visited about once every three years to monitor the density of the stock. Scallop stocks in other areas of the world are renowned for their ability to undergo large scale changes from a low maintenance density to levels which would be considered highly economic.

2. Enquiries have been made about a new type of dredge with spring loaded teeth which has been developed in Scotland. Although it has a lower efficiency (16%) than the Baird dredge, its successful operation, free from damage by rocks and other hard objects, would mean a considerable saving in time and expense. Such a dredge would be ideal for survey conditions.

V ACKNOWLEDGEMENTS

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TABLE 1 - DETAILS OF DREDGE HAULS AND DREDGING CONDITIONS DURING THE SURVEY IN GEOGRAPHE BAY, SEPTEMBER 1976.

HAUL NO.	FOUL HAUL	WIND STRENGTH	DIRECTION	VESSEL ORIENTATION	COURSE	SWELL HEIGHT	DIRECTION	VESSEL R.P.M.	EFFECTIVE SPEED	HAUL DURATION	WARP	DEPTH Fm	START HAUL		END HAUL		DISTANCE
													1ST FIX	2ND FIX	1ST FIX	2ND FIX	
													G.R.	C.R.	G.R.	C.R.	
		16th September 1976															
1		10	N.E.	Cross W.	310°	None		600	3.1	10	85	12½	0.60	1.17	0.59	1.43	.51
2		8	N.E.	Cross W.	325°	None		550	1.8	10	85	13	0.77	1.57	0.83	1.70	.30
3	R	10	N.E.	Cross W.	100°	None		550	3.0	10	85	13	1.19	2.04	1.19	1.89	.50
4		2	N.E.	Cross W.	308°	None		550	1.8	10	75	16	0.53	1.41	0.70	1.61	.30
5		2	N.E.	Cross W.	135°	None		600	1.9	10	75	12	0.70	1.55	0.45	1.26	.31
6		2	E.	Head W.	115°	None		600	2.7	10	75	12	0.58	1.35	0.78	1.12	.45
7	D	3	E.	Head W.	115°	None		600	2.8	10	75	12	0.88	1.05	1.27	1.05	.47
		17th September 1976															
8		15	N.N.W.	Head W.	340°	None		550	2.4	5	100	16	1.58	2.03	1.65	2.15	.20
9	C	18	N.N.W.	Tail W.	180°	None		450	2.9	5	100	16	2.58	1.52	2.63	1.38	.24
10		17	N.N.W.	Head W.	340°	None		550	1.7	5	100	15	2.70	1.32	2.62	1.39	.14
													R.PT	G.R.	R.PT	G.R.	
11		18	N.N.W.	Tail W.	170°	None		400	2.2	5	100	15½	2.46	1.23	2.56	1.13	.20
12		18	N.N.W.	Head W.	335°	None		600	3.2	5	100	14	2.63	1.10	2.50	1.17	.27
13	U	20	N.N.W.	Head W.	335°	None		600	2.4	5	100	15	2.36	1.29	2.24	1.44	.20
14		20	N.N.W.	Head W.	335°	None		600	2.4	5	100	17	2.35	1.79	2.31	1.93	.20
		18th September 1976															
15	C	20	S.W.	Tail W.	000°	.9-1.2	N.W.	400	5.4	5	100	15	2.60	1.78	2.69	1.99	.45
16	C	18	S.W.	Head W.	180°	.9-1.2	N.W.	600	3.8	5	100	15	2.51	1.95	2.53	1.71	.32
17		18	S.W.	Tail W.	000°	.9-1.2	N.W.	550	1.3	10	100	14	2.59	1.38	2.70	1.55	.22
18		18	S.W.	Head W.	190°	.9-1.2	N.W.	650	2.7	10	75	16	2.33	1.81	2.30	1.45	.45
19	S	15	S.W.	Tail W.	035°	.9-1.2	N.W.	600	1.7	10	75	14½	2.73	1.43	2.91	1.72	.29
20	L	17	S.W.	Head W.	270°	.9-1.2	N.W.	650	2.0	10	75	14	2.33	1.29	2.02	1.20	.34
21	R	15	S.W.	Tail W.	090°	.9-1.2	N.W.	600	2.3	10	75	15	1.70	1.18	2.06	1.32	.38
22	R	15	S.W.	Tail W.	090°	.9-1.2	N.W.	600	2.5	10	75	15½	2.03	1.93	2.45	2.12	.41
23	R	15	S.W.	Cross W.	125°	.9-1.2	N.W.	600	1.9	10	75	15	0.93	1.53	1.21	1.37	.31
24		12	S.W.	Cross W.	305°	.9-1.2	N.W.	650	2.2	10	75	13	1.17	1.17	0.89	1.50	.37
25		12	S.W.	Cross W.	145°	.9-1.2	N.W.	600	2.3	10	75	13	0.80	1.50	1.20	1.12	.39
26		12	S.W.	Tail W.	075°	.9-1.2	N.W.	600	1.7	10	75	15	2.46	1.51	2.82	1.82	.28
27		12	S.W.	Tail W.	070°	.9-1.2	N.W.	400	3.2	5	95	15½	3.02	2.14	3.26	2.32	.27
28		12	S.W.	Cross W.	315°	.9-1.2	N.W.	500	2.6	5	95	15½	3.41	2.61	3.37	2.65	.22
		19th September 1976															
29		5	S.E.	Cross W.	040°	.6-.9	N.W.	500	3.0	5	95	17½	2.88	2.34	3.03	2.55	.25
30		5	S.E.	Head W.	110°	.6-.9	N.W.	500	3.0	5	95	17½	3.58	2.92	3.76	3.04	.25
31		5	S.E.	Head W.	130°	.6-.9	N.W.	500	3.0	5	95	16½	3.88	3.06	4.04	3.11	.25
32		5	S.E.	Head W.	130°	.6-.9	N.W.	500	3.1	5	95	16	4.19	3.20	4.49	3.33	.26
33		7	S.	Tail W.	050°	.6-.9	N.W.	500	3.0	5	95	16½	4.54	3.43	4.79	3.70	.25
34		5	S.	Head W.	130°	.6-.9	N.W.	500	3.6	5	95	15½	5.02	3.07	5.30	4.01	.30
35		5	S.	Tail W.	000°	.6-.9	N.W.	500	3.1	5	95	16½	5.40	4.23	5.52	4.45	.26
36		2	S.	Cross W.	080°	.6-.9	N.W.	500	3.6	5	95	17	5.88	4.83	6.16	5.08	.30
37		3	N.	Head W.	050°	.6-.9	N.W.	500	3.6	5	95	17	6.35	5.31	6.62	5.60	.30
38		4	N.E.	Head W.	050°	.6-.9	N.W.	500	3.6	5	95	16½	6.75	5.83	7.09	6.09	.30
39		4	N.	Head W.	050°	.6-.9	N.W.	500	3.6	5	95	17	7.27	6.36	7.60	6.61	.30
40		4	N.E.	Tail W.	205°	.6-.9	N.W.	500	3.6	5	95	16½	7.53	6.42	7.40	6.30	.30
41		15	S.	Head W.	220°	.6-.9	N.W.	550	3.4	5	95	16½	7.23	6.06	7.06	5.83	.28
42		15	S.	Head W.	185°	.6-.9	N.W.	550	3.2	5	95	16	6.97	5.69	7.00	5.64	.27
43		10	S.	Head W.	190°	.6-.9	N.W.	550	3.6	5	95	15	7.12	5.73	7.12	5.63	.30
44		10	S.	Head W.	240°	.6-.9	N.W.	500	2.4	5	95	15	6.94	5.46	6.75	5.21	.20
45		10	S.	Head W.	190°	.6-.9	N.W.	550	3.6	5	95	14½	6.79	5.25	6.87	5.21	.30
46	R	12	S.	Cross W.	265°	.6-.9	N.W.	550	3.6	5	95	13	6.63	5.02	6.41	4.77	.25

TABLE 1 (CONTD.)

HAUL NO.	FOUL HAUL	WIND STRENGTH	DIRECTION	VESSEL ORIENTATION	COURSE	SWELL HEIGHT	DIRECTION	VESSEL R.P.M.	EFFECTIVE SPEED	HAUL DURATION	WARP	DEPTH FM	START HAUL		END HAUL		DISTANCE
													1ST FIX	2ND FIX	1ST FIX	2ND FIX	
		20th September 1976											R.PT	G.R.	R.PT	G.R.	
47		10	S.E.	Tail W.	280°	None		500	2.4	5	75	13	1.96	0.71	1.77	0.71	.20
48		8	S.E.	Tail W.	310°	None		500	3.5	5	75	11½	1.09	1.07	0.88	1.31	.29
49		10	E.	Head W.	124°	None		500	3.4	5	75	10	2.81	0.86	3.08	1.13	.28
50		10	E.	Head W.	124°	None		500	4.2	5	75	9	3.59	1.66	3.96	1.97	.35
51		5	E.	Tail W.	270°	.5-.6	N.W.	500	3.1	5	100	16½	2.51	2.34	2.28	2.28	.26
52		5	E.	Tail W.	270°	.5-.6	N.W.	500	3.6	5	100	16½	1.88	2.20	1.59	2.23	.30
53		7	E.	Head W.	090°	.5-.6	N.W.	500	3.1	5	100	16	1.99	2.44	2.19	2.49	.26
54	NF	5	E.S.E.	Head W.	090°	.5-.6	N.W.	500	3.7	5	100	16½	2.51	2.57	2.82	2.71	.31
55	NF	4	E.S.E.	Head W.	090°	.5-.6	N.W.	500	3.6	5	100	17	3.20	2.88	3.47	2.99	.30
56		0			090°	.5-.6	N.W.	500	2.8	5	100	17	3.84	3.41	4.04	3.53	.23
57		0			090°	.5-.6	N.W.	500	2.9	5	100	16	4.25	3.60	4.47	3.80	.24
58		0			270°	.5-.6	N.W.	500	2.4	5	100	16	3.94	3.29	3.76	3.16	.20
59		0			080°	.5-.6	N.W.	500	2.4	5	100	15½	4.24	3.41	4.44	3.60	.20
60		0			075°	.5-.6	N.W.	500	2.9	5	100	16	4.68	3.89	4.08	4.92	.24
61	R	0			075°	.5	N.W.	500	3.0	5	100	16	5.27	4.40	5.49	4.62	.25
		26th September 1976															
62		8	S.W.	Cross W.	310°	.5-.6	N.W.	600	1.7	10	75	13	2.00	0.64	1.69	0.78	.28
63		12	S.W.	Cross W.	130°	.5-.6	N.W.	650	2.8	10	75	14	1.66	0.79	2.11	0.37	.47
64	R	10	S.W.	Cross W.	320°	.5-.6	N.W.	650	2.8	10	75	14	2.12	0.83	1.77	1.06	.47

EXPLANATION OF SYMBOLS

1. Haul numbers are listed in chronological sequence.

2. Foul Hauls
   - D = Damaged dredge
   - C = Teeth clogged by seagrass
   - U = Dredge hauled upside down
   - S = Warp at skewed angle to course
   - L = Lost dredge, warp broke
   - R = Rocks filled dredge, damaged teeth
   - NF = Dredge not fishing properly

3. Wind Strength and Direction
   (a) Wind strengths are in knots (nautical miles/hour).
   (b) Wind direction is that from which wind is blowing.

4. Vessel Orientation
   Wind direction may be considered as headwind, tail wind or cross wind with respect to vessel's course.

5. Course
   Direction vessel steers in degrees magnetic.

6. Swell Height
   In metres, converted from original data in feet.

7. Swell
   Stated as bearing from which swell originates, height in metres.

8. Haul Duration in minutes.

9. Warp
   Warp is measured in fathoms. Reference point from which warp/depth ratio calculated is top of tipper cradle.

10. Depth of Haul
    Echo sounder records in fathoms.

11. Position Finding
    Distances for fixes are in nautical miles, distance travelled also in nautical miles.
    - G.R. = Gannet Rock
    - C.R. = Castle Rock
    - R.Pt = Rocky Point

12. Effective Speed
    (a) Measured in knots.
    (b) Represents ground speed of dredge.

TABLE 2 Details of hauls, number and mean height and catch rates of *Pecten* scallops and additional information on associated catch in September 1976 in Geographe Bay.

Haul No.	Speed (Knots)	Duration (Minutes)	Distance (Sea Miles)	Dredge Width	W/D Ratio	Depth (Metres)	No. *Pecten*	Catch Rate No. per std. haul[1]	Mean Shell Height[2] (mm)	Rocks or Coral[3]	*Chlamys asperrimus*[6]	Sea Grass[5]
1	3.1	10	.51	2.25m	7.1	23	50	(14)	70	**	-	*
2	1.8	10	.30	2.25	7.1	24	102	(28)	70	1	-	-
3 D			Foul	Haul								
4	1.8	10	.30	2.25	5.1	29	5	(1)	69	-	-	-
5	1.9	10	.31	2.25	6.1	22	42	(11)	64	-	-	-
6	2.7	10	.45	2.25	6.1	22	59	(16)	69	1	-	-
7 D			Foul	Haul								
8	2.4	5	.20	1.22	6.1	29	23	(23)	72	*	-	-
9 NF?	2.9	5	.24	1.22	6.1	29	4	NF?	59	**	-	***
10	1.7	5	.14	1.22	7.1	28	-	-	-	***	-	-
11	2.2	5	.20	1.22	7.1	28	3	(3)	70	**	*	-
12	3.2	5	.27	1.22	7.1	26	14	(14)	75	-	*	-
13 NF			Foul	Haul								
14	2.4	5	.20	1.22	6.1	31	4	(4)	72	-	-	-
15 NF?	5.4	5	.45	1.22	7.1	28	5	NF?	73	-	-	***
16 NF?	3.8	5	.32	1.22	7.1	28	6	NF?	71	-	-	***
17	1.3	10	.22	2.25	7.1	26	11	(3)	67	***	-	*
18	2.7	10	.45	2.25	5.1	29	36	(10)	63	*	-	*
19 NF?	1.7	10	.29	2.25	5.1	27	9	NF?	68	*	-	*
20 D			Foul	Haul								

Haul No.	Speed (Knots)	Duration (Minutes)	Distance (Sea Miles)	Dredge Width	W/D Ratio	Depth (Metres)	No. *Pecten*	Catch Rate No. per std. haul[1]	Mean Shell Height[2] (mm)	Rocks or Coral[3]	*Chlamys asperrimus*[6]	Sea Grass[5]
TABLE 2 (Contd).												
21 D	2.3	10	.38	2.25m	5.1	28	7	D	71	***	-	-
22 D	2.5	10	.41	2.25	5.1	28	10	D	64	***	-	-
23 D	1.9	10	.31	2.25	5.1	28	12	D	66	***	-	-
24	2.2	10	.37	2.25	6.1	24	12	(3)	69	*	-	-
25	2.3	10	.39	2.25	6.1	24	58	(16)	72	-	-	-
26	1.7	10	.28	2.25	5.1	28	12	(3)	74	*	-	-
27	3.2	5	.27	1.22	6.1	28	-	-	-	-	-	-
28	2.6	5	.22	1.22	6.1	28	2	(2)	-	-	-	-
29	3.0	5	.25	1.22	5.1	32	11	(11)	72	1	-	-
30	3.0	5	.25	1.22	5.1	32	-	-	-	*	-	-
31	3.0	5	.25	1.22	6.1	30	1	(1)	-	*	-	-
32	3.1	5	.26	1.22	6.1	29	-	-	-	*	-	-
33	3.0	5	.25	1.22	6.1	30	1	(1)	-	*	-	-
34	3.6	5	.30	1.22	6.1	28	-	-	-	*	-	-
35	3.1	5	.26	1.22	6.1	30	2	(2)	-	**	-	-
36	3.6	5	.30	1.22	6.1	31	-	-	-	*	-	-
37	3.6	5	.30	1.22	6.1	31	-	-	-	-	-	-
38	3.6	5	.30	1.22	6.1	30	1	(1)	-	-	-	-
39	3.6	5	.30	1.22	6.1	31	-	-	-	*	-	-
40	3.6	5	.30	1.22	6.1	30	-	-	-	**	-	-
41	3.4	5	.28	1.22	6.1	30	-	-	-	*	-	-
42	3.2	5	.27	1.22	6.1	29	-	-	-	**	-	-
43	3.6	5	.30	1.22	6.1	28	-	-	-	**C	-	-
44	2.4	5	.20	1.22	6.1	28	-	-	-	*C	-	-
45	3.6	5	.30	1.22	7.1	27	-	-	-	*C	-	-
46 D	Foul Haul											
47	2.4	5	.20	1.22	6.1	24	137	(137)	69	-	-	-
48	3.5	5	.29	1.22	7.1	21	10	(10)	71	-	-	**

TABLE 2 (Contd)

Haul No.	Speed (Knots)	Duration (Minutes)	Distance (Sea Miles)	Dredge Width	W/D Ratio	Depth (Metres)	No. *Pecten*	Catch rate No. per std. haul[1]	Mean Shell Height[2] (mm)	Rocks or Coral[3]	*Chlamys asperrimus*[6]	Sea Grass[5]
49	3.4	5	.28	1.22m	8.1	18	-	-	-	*C	-	-
50	4.2	5	.35	1.22	8.1	17	-	-	-	*C	-	-
51	3.1	5	.26	1.22	6.1	30	-	-	-	*	-	*
52	3.6	5	.30	1.22	6.1	30	2	(2)	-	***	-	-
53	3.1	5	.26	1.22	6.1	29	-	-	-	C	-	-
54 NF	3.7	5	.31	1.22	6.1	30	1	NF	-	-	-	-
55 NF	3.6	5	.30	1.22	6.1	31	-	NF	-	*	-	**
56	2.8	5	.23	1.22	6.1	31	-	-	-	C	-	-
57	2.9	5	.24	1.22	6.1	29	-	-	-	***	-	-
58	2.4	5	.20	1.22	6.1	29	-	-	-	*	-	-
59	2.4	5	.20	1.22	7.1	28	-	-	-	*	-	-
60	2.9	5	.24	1.22	6.1	29	-	-	-	*	-	-
61 D	Foul Haul											
62	1.7	10	.28	2.25	6.1	24	68	(18)	70	*	*	*
63	2.8	10	.47	2.25	5.1	26	123	(33)	67	-	*	*
64 D	Foul Haul									****		

FOOTNOTES 1. Numbers of *Pecten* caught by the large dredge (2.25m) have been standardized to an equivalent catch by the 1.22m dredge for a 5 minute haul. The figures are shown in brackets.

2. Mean Height of Shell refers to standard measurement from umbo to dorsal edge. The number of scallops used to calculate the mean height was sometimes less than the number caught as damaged scallops were discarded.

3. Quantities of rocks
   * = few (< 5) rocks
   ** = many rocks
   *** = large quantity rocks
   **** = completely filled dredge with rocks.

TABLE 2 (contd.)

3.	Coral	C =	coral, records of quantity not kept.
4.	Other Symbols:	D =	Damage done to dredge or toothed bars.
		NF =	Dredge not fishing. NF? Suspected foul haul.
5.	Sea Grass		Usually *Posidonia australis*, some *Heterozostera* present however.
		* =	trace of sea grass
		** =	medium quantity
		*** =	teeth clogged by sea grass
6.	*Chlamys asperrimus* (Lamarck)	-	Present in most hauls. Large quantities (> 50 individuals) are signified by a single star thus *.

TABLE 3 Frequency of *Pecten*, density of *Pecten* + *Chlamys* per square metre and types of sediment encountered by grab sampling along Transects 1 - 27 and at Stations 1 - 7.

Transect No.	No. Grabs	Fouls	*Pecten*/m^2	Frequency of Grabs with Scallops				Frequency of Sediment^2 Types						*Chlamys*/m^2
				None	1	2	3	1	2	3	4	5	6	
1	15	-	0.53	11	3	1	-	4	-	-	1	6	4	1.2
2	15	-	0.40	12	3	-	-	5	-	-	1	5	4	4.8
3	15	-	0.67	10	3	1	1	1	-	-	1	9	4	2.1
4	7	-	-	7	-	-	-	5	-	-	-	2	-	6.3
5	10	-	-	10	-	-	-	-	1	-	-	-	9	0.4
6	10	1	0.20	8	1	-	-	6	-	-	1	-	2	-
7	10	-	0.20	9	1	-	-	10	-	-	-	-	-	-
8	10	-	-	10	-	-	-	7	-	-	-	-	3	-
9	10	-	0.20	9	1	-	-	1	-	-	-	6	3	1.6
10	9	-	0.22	8	1	-	-	5	-	-	-	3	1	-
11	10	-	0.20	9	1	-	-	-	-	-	-	8	2	6.4
12	12	-	-	12	-	-	-	1	-	2	-	8	1	-
13	20	1	0.10	18	1	-	-	8	-	-	3	5	3	0.2
14	11	-	1.6	7	2	-	2	2	-	-	-	6	3	5.3
15	9	1	-	8	-	-	-	1	-	-	-	2	5	-
16	8	-	-	8	-	-	-	7	-	-	-	-	1	0.1
17	15	1	0.86	10	2	2	-	7	-	-	-	3	4	1.3
18	19	-	0.74	13	5	1	-	-	-	-	-	5	14	0.9
19	10	1	0.67	6	3	-	-	4	1	-	-	1	3	9.1
20	10	1	0.22	8	1	-	-	3	-	-	-	2	4	-
21	21	-	0.19	20	-	1	-	-	-	-	-	8	13	3.2
22	31	-	0.19	28	3	-	-	2	-	1	-	8	20	3.0
23	30	1	-	29	-	-	-	3	-	-	-	4	22	-
24	10	-	-	10	-	-	-	-	-	-	-	-	10	0.6

TABLE 3 (Contd.)

Transect No.	No. Grabs	Fouls	*Pecten*/m^2	Frequency of Grabs with Scallops				Frequency of Sediment[2] Types						*Chlamys*/m^2
				None	1	2	3	1	2	3	4	5	6	
25	20	2	-	18	-	-	-	2	-	-	-	2	14	-
26	6	1	-	5	-	-	-	-	-	-	-	2	3	-
27	20	-	0.50	15	5	-	-	2	-	-	-	4	14	2.1
TOTALS	373	10	0.31[1]	318	36	6	3	86	2	3	7	99	166	1.74[1]

Station No.	No. Grabs	Fouls	*Pecten*/m^2	Frequency of Grabs with Scallops		Frequency of Sediment[2] Types				*Chlamys*/m^2
				None	1	1	3	5	6	
1	3	3	-	-	-	-	-	-	-	-
2	3	-	-	3	-	1	-	1	1	-
3	3	-	-	3	-	-	-	3	-	-
4	3	-	-	3	-	-	-	1	2	-
5	3	-	0.67	2	1	-	1	1	1	-
6	3	-	-	3	-	-	-	-	3	-
7	2	1	-	1	-	-	-	-	2	-
TOTAL	20	4	Mean N.A.	15	1	1	1	6	9	-

NOTES:

1. The mean density of *Pecten* and *Chlamys* for 363 random grabs.
2. The following sediment types were distinguished:

   TYPE 1 fine grain quartzose lime sand, with abundant angular shell fragments and other skeletal material. Colour grey, size of particles 0.15mm on average.

   TYPE 2 mainly fine sand (Type 1) and some gravelly coarse sand (Type 5). Abundance of black pigmented carbonate grains. Colour dark grey.

   TYPE 3 mainly fine quartzose lime sand (Type 1) together with a trace of coarse orange quartz sand (Type 4).

TYPE 4 mainly well sorted coarse orange quartz sand. Minor amount of limestone and fresh skeletal fragments. Colour orange, from iron stains in quartz grains and as a coating over skeletal fragments. Size of particles 0.5 - 1 mm.

TYPE 5 gravelly coarse-very coarse calcareous sand with abundant skeletal material, poorly sorted. Colour brown, size of particles 1 - 8 mm. *Chlamys* and *Pecten* shell fragments present.

TYPE 6 mainly coarse gravelly sand with some fine sand. Grey colour from black pigmented grains of skeletal material. *Chlamys* and *Pecten* shell fragments present.

TABLE 4 - DETAILS OF INDIVIDUAL GRAB SHOTS WITHIN EACH TRANSECT, SHOWING NUMBERS OF LIVE PECTEN AND CHLAMYS, PRESENCE OF DEAD CHLAMYS, OTHER MOLLUSCS, THE TYPES OF SEAGRASS TAKEN IN GRABS AND TYPE OF SEDIMENT IN EACH GRAB, IN SEPTEMBER 1976 IN SOUTHERN GEOGRAPHE BAY.

GRAB NO.	*PECTEN* LIVE	*CHLAMYS* SP. LIVE	*CHLAMYS* SP. DEAD	OTHER MOLLUSCS	SEAGRASSES IN GRAB	TRANSECT NO.	SEDIMENT TYPE
				21st September, 1976			
1						1	1
2	1		✓			1	5
3	1		✓			1	5
4			✓	1 *Amusium* (dead) 98 mm		1	5
5	1	1	✓			1	5
6			✓			1	5
7	2	7		1 *Circe weedingi*		1	6
8			✓			1	6
9			✓			1	6
10		1			*Heterozostera* sp.	1	1
11			✓			1	6
12			✓			1	5
13				1 *Notocallista* sp.		1	1
14						1	1
15						1	4
16						2	1
17	1		✓			2	5
18			✓	1 *Notocallista* sp.		2	5
19			✓			2	4
20			✓			2	5
21			✓	1 *Megacardita* sp.		2	5
22	1	7				2	5
23			✓			2	6
24		2				2	6
25		10				2	1
26	1	10		1 *Circe* sp.		2	6
27						2	1
28		7			*Heterozostera* sp.	2	1
29			✓		*Posidonia australis*	2	1
30			✓			2	6
31			✓			3	4
32			✓			3	5
33			✓			3	5
34	3		✓			3	5
35						3	1
36		5				3	5
37			✓			3	5
38	2		✓			3	6
39			✓			3	6
40	1		✓			3	6
41			✓			3	5
42			✓			3	5
43	1	6	✓			3	5
44	1	5			*Posidonia australis*	3	6
45			✓			3	5
46			✓			4	5
47			✓		*Posidonia australis*	4	1
48			✓			4	1
49			✓			4	1
50			✓	1 *Gomphina undulosa*		4	1
51		22				4	5
52						4	1
				22nd September, 1976			
53			✓			5	6
54			✓			5	6
55			✓			5	6
56			✓			5	6
57		2				5	6
58			✓			5	6
59					*Posidonia australis*	5	2
60			✓			5	6
61			✓			5	6
62			✓			5	6
63	1					6	6
64					Seagrass	6	1
65					Seagrass	6	1
66					Seagrass	6	1
67						6	4
68						6	1
69			✓			6	1
70			✓		Seagrass	6	1
71			✓			6	6
72F			✓	FOUL GRAB	*Posidonia australis* in jaws	6	-
73						7	1
74						7	1

GRAB NO.	*PECTEN* LIVE	*CHLAMYS* SP. LIVE	*CHLAMYS* SP. DEAD	OTHER MOLLUSCS	SEAGRASSES IN GRAB	TRANSECT NO.	SEDIMENT TYPE
75					*P. australis & Heterozostera* sp.	7	1
76	1					7	1
77						7	1
78						7	1
79			✓	*Gomphina undulosa*		7	1
80						7	1
81					*Posidonia australis*	7	1
82					*Heterozostera sp.*	7	1
83						8	1
84						8	1
85						8	1
86					*Posidonia australis*	8	1
87			✓			8	6
88			✓		*Posidonia australis*	8	6
89					*Posidonia australis*	8	1
90			✓		*Posidonia australis*	8	1
91						8	1
92			✓		*Posidonia australis*	8	6
93			✓		*Heterozostera sp.*	9	6
94			✓			9	6
95			✓		*Posidonia australis*	9	1
96			✓			9	6
97			✓			9	5
98			✓	1 *Amusium* (dead)		9	5
99			✓			9	5
100		8				9	5
101	1		✓			9	5
102			✓	*Circe weedingi*		9	5
103						10	1
104	1		✓	*Notocallista* sp.		10	1
105			✓			10	1
106			✓		*Posidonia australis*	10	1
107			✓			10	5
108			✓			10	5
109			✓			10	5
110						10	1
111			✓			10	6
112F		GRAB SHOT NOT DONE					
113			✓			11	5
114			✓			11	5
115		1				11	5
116			✓			11	5
117		20				11	5
118		11		1 *Megacardita* sp.		11	5
119	1		✓			11	5
120			✓			11	5
121			✓			11	6
122			✓			11	6
123			✓			12	5
124			✓			12	5
125			✓			12	3
126			✓			12	5
127			✓			12	5
128			✓			12	6
129			✓			12	3
130			✓	1 *Amusium* (dead) 101 mm		12	1
131			✓			12	5
132			✓			12	5
133			✓			12	5
134			✓			12	5
135						13	1
136					*Heterozostera* sp.	13	1
137						13	1
138						13	1
139					*Posidonia australis*	13	1
140			✓			13	1
141						13	1
142						13	1
143						13	4
144	1			1 *Megacardita* sp.		13	5
145			✓	1 *Megacardita* sp.		13	5
146			✓			13	6
147						13	4
148						13	4
149			✓			13	5
150			✓			13	6
151						13	5
152			✓	*Notocallista* sp.	Seagrass	13	5
153F		FOUL GRAB AS SPONGE ROCK AND *Posidonia australis* IN JAWS				13	-
154						13	6

GRAB NO.	*PECTEN* LIVE	*CHLAMYS* SP. LIVE	*CHLAMYS* SP. DEAD	OTHER MOLLUSCS	SEAGRASSES IN GRAB	TRANSECT NO.	SEDIMENT TYPE
				23rd September, 1976			
155	1	2	✓			14	5
156		2	✓		*Posidonia australis*	14	5
157	3	17	✓			14	5
158						14	6
159	3	8	✓	1 *Megacardita* sp.		14	5
160			✓			14	1
161	1		✓			14	5
162			✓			14	6
163						14	1
164			✓			14	6
165			✓			14	5
166F		FOUL GRAB, ROCKS AND ABUNDANT *Posidonia australis* IN JAWS				15	-
167			✓		*Posidonia australis*	15	6
168					*Posidonia australis*	15	1
169			✓		*Posidonia australis*	15	6
170			✓		*Posidonia australis*	15	6
171			✓		*Posidonia australis*	15	6
172			✓	1 *Megacardita*		15	6
173			✓	1 *Dosinia* sp.		15	5
174			✓			15	5
175						16	1
176				1 *Dosinia* sp.		16	1
177		1	✓			16	1
178					*P. australis & Heterozostera* sp.	16	1
179			✓		*Heterozostera* sp.	16	1
180			✓		*Posidonia australis*	16	1
181			✓		*Posidonia australis*	16	1
182			✓		*Posidonia australis*	16	6
183			✓			17	5
184			✓			17	5
185			✓			17	1
186			✓			17	1
187	1		✓			17	1
188			✓			17	6
189	2		✓			17	1
190	2		✓			17	6
191	1	8	✓			17	5
192		1	✓			17	1
193			✓			17	1
194			✓		*Posidonia australis*	17	6
195			✓	*Dosinia* sp.	*Posidonia australis*	17	6
196F		FOUL GRAB ROCK CAUGHT IN JAWS				17	-
197			✓		*Posidonia australis*	17	1
198			✓			18	6
199			✓			18	6
200			✓			18	5
201		3	✓			18	5
202	1		✓			18	6
203			✓			18	5
204			✓			18	6
205			✓			18	6
206			✓	1 *Circe weedingi*		18	6
207	2	4	✓	*Amusium* (Dead) 89 mm		18	6
208			✓	1 *Megacardita* sp.		18	6
209	1		✓			18	6
210			✓			18	6
211			✓			18	6
212			✓	1 *Notocallista* sp.	*Posidonia australis*	18	6
213	1		✓			18	5
214	1		✓	1 *Amusium* (dead)		18	5
215			✓			18	6
216	1	2	✓			18	6
217		2	✓		*Posidonia australis*	19	6
218			✓			19	1
219	1	4	✓			19	1
220	1		✓		*Posidonia australis*	19	5
221	1	4	✓	1 *Circe* sp.	*Posidonia australis*	19	6
222		33	✓			19	6
223			✓		*Posidonia australis*	19	2
224			✓			19	1
225F				FOUL GRAB, ROCK CAUGHT IN JAWS		19	6
226			✓			19	1
227			✓			20	1
228			✓			20	1
229			✓		*Posidonia australis*	20	6
230			✓		*Posidonia australis*	20	6
231	1		✓		*Posidonia australis*	20	5
232			✓			20	1
233			✓		*Posidonia australis*	20	6
234			✓		*Posidonia australis*	20	6

GRAB NO.	*PECTEN* LIVE	*CHLAMYS* SP. LIVE	*CHLAMYS* SP. DEAD	OTHER MOLLUSCS	SEAGRASSES IN GRAB	TRANSECT NO.	SEDIMENT TYPE
235F				FOUL GRAB, ROCK IN JAWS		20	-
236F				FOUL GRAB, ROCK IN JAWS		20	-
237			✓			21	5
238			✓	1 *Dosinia* sp.		21	5
239			✓			21	5
240	2		✓			21	5
241			✓		*Posidonia australis*	21	6
242			✓			21	5
243			✓		*Posidonia australis*	21	6
244			✓			21	5
245			✓		*Posidonia australis*	21	6
246			✓			21	5
247			✓	1 *Megacardita* sp.		21	5
248			✓		*Posidonia australis*	21	6
249			✓			21	6
250			✓		*Posidonia australis*	21	6
251			✓	Dead *Amusium*		21	6
252		4	✓			21	6
253		29	✓			21	6
254		1	✓			21	6
255			✓			21	6
256			✓			21	6
257			✓		*Posidonia australis*	21	6
				24th September, 1976			
258			✓			22	6
259		5	✓	Dead *Amusium*		22	6
260		9	✓			22	6
261			✓	Dead *Amusium*		22	6
262	1		✓			22	1
263			✓			22	6
264			✓			22	6
265			✓			22	1
266			✓			22	6
267	1		✓			22	6
268			✓			22	5
269			✓		*Posidonia australis*	22	6
270	1		✓			22	6
271			✓			22	5
272			✓			22	6
273		3	✓		*Posidonia australis*	22	6
274			✓			22	6
275			✓			22	6
276			✓			22	6
277		21	✓			22	3
278		3	✓	1 *Dosinia* sp.		22	6
279			✓			22	5
280			✓			22	5
281			✓			22	5
282		1	✓			22	5
283			✓			22	5
284			✓			22	6
285		3	✓	1 *Notocallista* sp.		22	5
286		2	✓			22	6
287			✓			22	6
288			✓	1 *Dosinia* sp.		22	6
289F			✓	FOUL GRAB, SPONGE AND ROCK IN JAWS		23	-
290			✓			23	6
291			✓			23	6
292			✓	1 *Megacardita* sp.	*Posidonia australis*	23	6
293			✓			23	6
294			✓		*Posidonia australis*	23	6
295			✓			23	6
296			✓			23	6
297			✓			23	6
298			✓			23	6
299			✓			23	6
300			✓			23	6
301			✓			23	6
302			✓			23	6
303			✓			23	6
304			✓			23	1
305			✓	1 *Notocallista* sp.		23	6
306			✓			23	6
307			✓			23	5
308			✓			23	6
309			✓			23	6
310			✓			23	5
311			✓			23	5
312			✓			23	6
313			✓				

GRAB NO.	*PECTEN* LIVE	*CHLAMYS* SP. LIVE	*CHLAMYS* SP. DEAD	OTHER MOLLUSCS	SEAGRASSES	TRANSECT NO.	SEDIMENT TYPE
314						23	5
315						23	1
316						23	1
317					*Posidonia australis*	23	6
318						23	6
319						24	6
320				1 cockle		24	6
321						24	6
322						24	6
323						24	6
324						24	6
325						24	6
326		3				24	6
327						24	6
328						24	6
329					*Posidonia australis*	25	6
330					*Posidonia australis*	25	6
331					*Posidonia australis*	25	6
332						25	5
333F				FOUL GRAB, ROCK IN JAWS		25	-
334						25	6
335						25	6
336					*Posidonia australis*	25	6
337					*Posidonia australis*	25	6
338						25	6
339					*Posidonia australis*	25	1
340						25	6
341						25	6
342					*Posidonia australis*	25	6
343					*Posidonia australis*	25	6
344					*Posidonia australis*	25	6
345						25	1
346					*Posidonia australis*	25	6
347F				FOUL GRAB, ROCK JAMMED IN JAWS		25	-
348						25	5
349						26	5
350F				FOUL GRAB, ROCK IN JAWS		26	-
351						26	6
352						26	5
353						26	6
354						26	6
355						27	6
356						27	1
357						27	6
358						27	6
359	1					27	6
360	1	5			*Posidonia australis*	27	6
361						27	6
362		8				27	6
363						27	1
364		3				27	5
365	1	4				27	5
366	1	1				27	6
367						27	6
368						27	6
369						27	5
370				1 *Dosinia* sp.		27	5
371						27	6
372	1					27	6
373					*Heterozostera* sp.	27	6
374						27	6
TOTALS	57	321			72 Seagrass records		

25th September, 1976

GRAB NO.	*PECTEN* LIVE	*CHLAMYS* SP. LIVE	*CHLAMYS* SP. DEAD	OTHER MOLLUSCS	SEAGRASSES IN GRAB	STATION NUMBER	SEDIMENT TYPE
1F				FOUL GRAB, NO SEDIMENT		1	-
2						1	5
3F				FOUL GRAB, ROCKS IN JAWS		1	-
4					*Posidonia australis*	2	1
5						2	5
6						2	6
7				*Amusium* (Dead) 107 mm		3	5
8						3	5
9						3	5
10						4	5

GRAB NO.	*PECTEN* LIVE	*CHLAMYS* SP. LIVE	*CHLAMYS* SP. DEAD	OTHER MOLLUSCS	SEAGRASSES IN GRAB	STATION NUMBER	SEDIMENT TYPE
11			✓			4	6
12			✓			4	6
13	1		✓			5	3
14			✓			5	6
15			✓	1 *Circe weedingi*		5	5
16			✓			6	6
17			✓			6	6
18			✓			6	6
19			✓		*Heterozostera* sp.	7	6
20F				FOUL, GRAB BADLY DAMAGED	UNABLE TO REPAIR	7	-
TOTALS	1				2 seagrass records		

NOTES:

1. Foul grabs are signified by F in grab number column.

2. Refer to Figure 6 for position of transects and stations.

3. A description of the sediment which also appears as a footnote to Table 3 is given below:-

TYPE 1 fine grain quartzose lime sand, with abundant angular shell fragments and other skeletal material. Colour grey, size of particles 0.15 mm on average.

TYPE 2 mainly fine sand (Type 1) and some gravelly coarse sand (Type 5). Abundance of black pigmented carbonate grains. Colour dark grey.

TYPE 3 mainly fine quartzose lime sand (Type 1) together with a trace of coarse orange quartz sand (Type 4).

TYPE 4 mainly well sorted coarse orange quartz sand. Minor amount of limestone and fresh skeletal fragments. Colour orange, from iron stains in quartz grains and as a coating over skeletal fragments. Size of particles 0.5 - 1mm.

TYPE 5 gravelly coarse-very coarse calcareous sand with abundant skeletal material, poorly sorted. Colour brown, size of particles 1-8mm. *Chlamys* and *Pecten* shell fragments present.

TYPE 6 mainly coarse gravelly sand with some fine sand. Grey colour from black pigmented grains of skeletal material. *Chlamys* and *Pecten* shell fragments present.

FIGURE 1. Geographe Bay, shown with depth contours, its relationship to the major coastal towns and its position on the Western Australian coast (inset). A gridwork of 10 mile square blocks used in statistical analysis by the Department of Fisheries and Wildlife is also shown. Crosses (×) represent submerged rocks ~ 2 metres below surface.

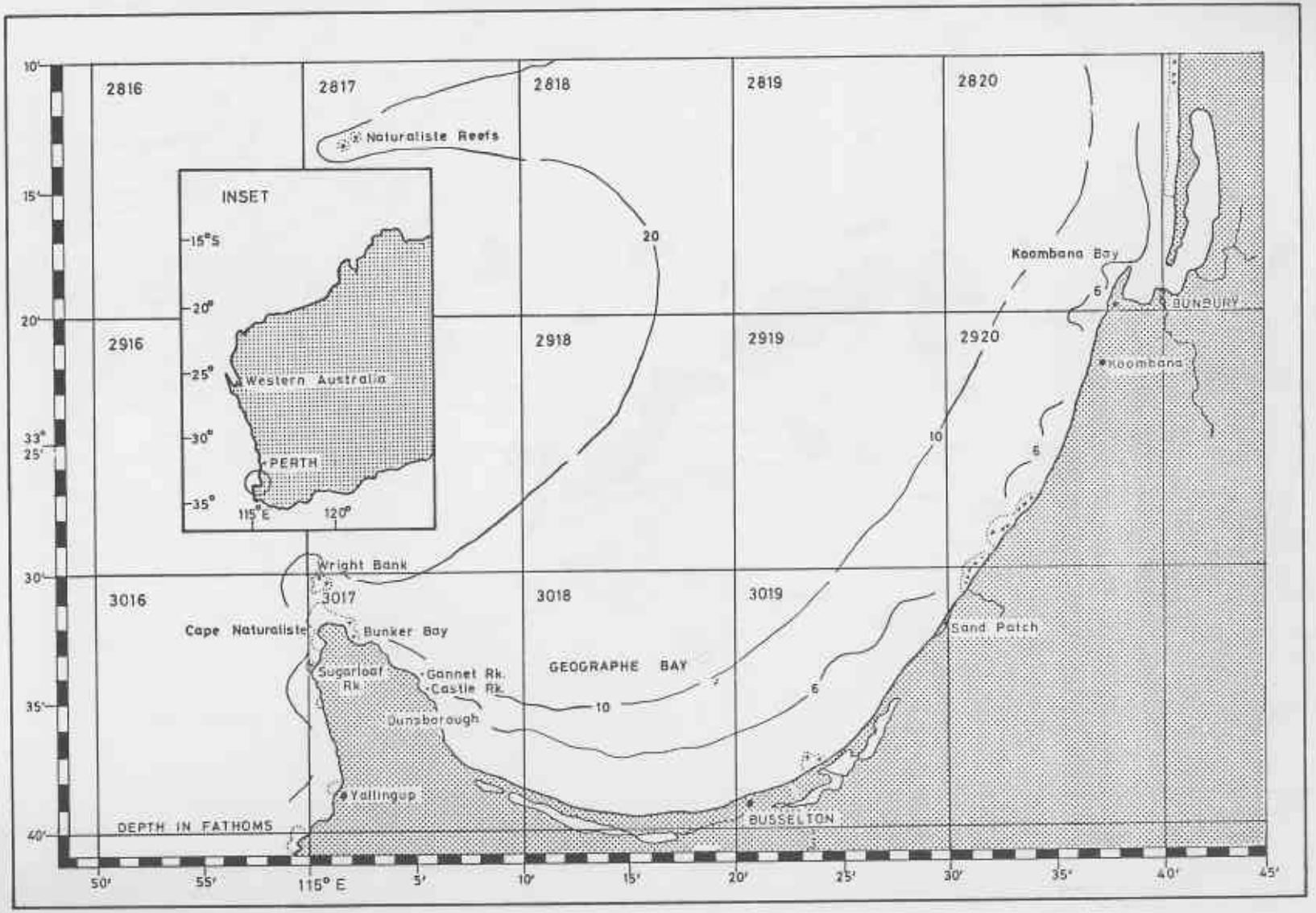


FIGURE 2 Location of dredge hauls during the survey period 16 - 26 September, 1976 in southern Geographe Bay. Arrowheads indicate direction of haul. Black patches indicate suspected areas of rough ground. 10, 20 & 30 metre depth contours are marked. * Asterisks show foul ground located by grab and dredge.

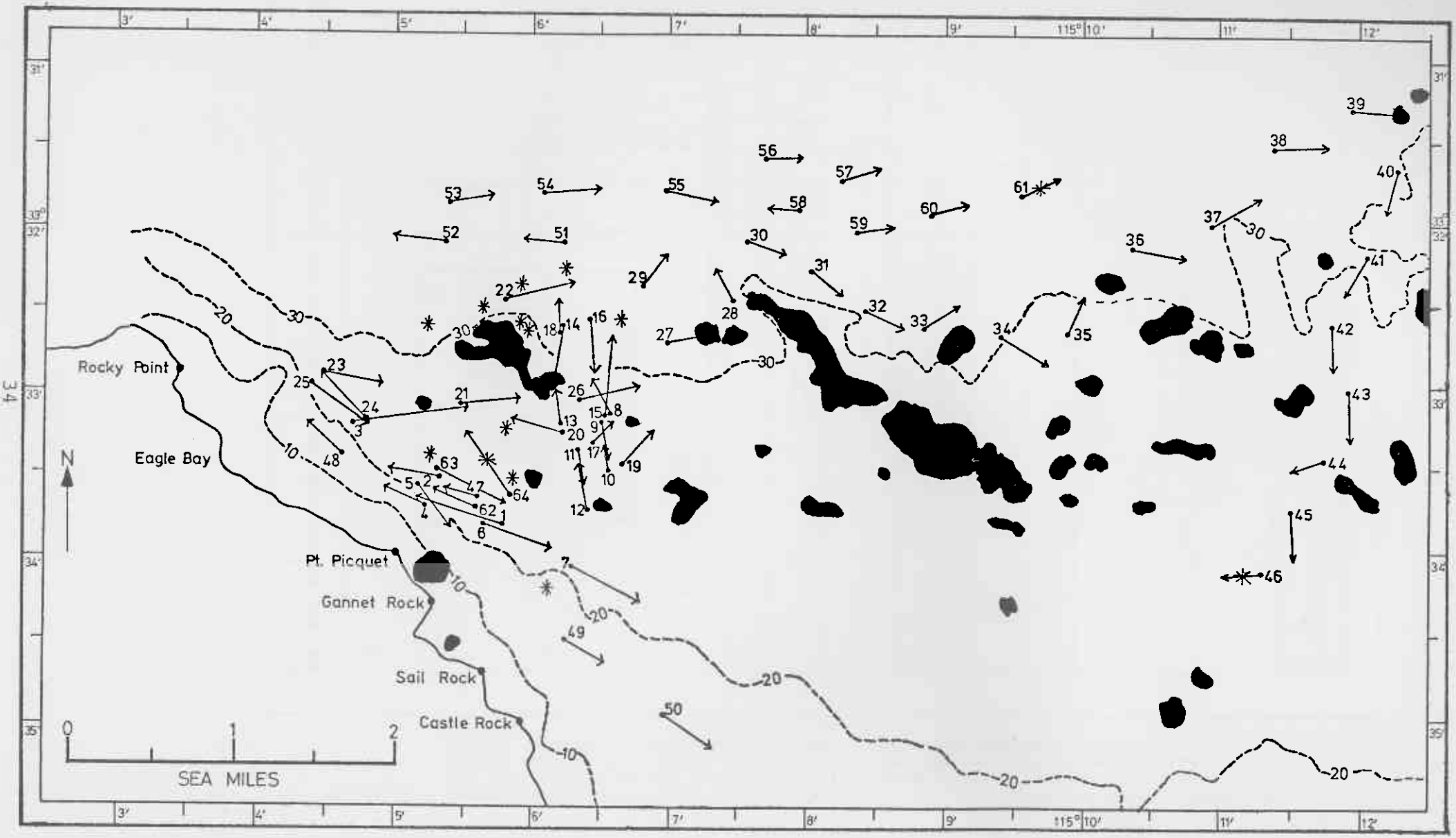


FIGURE 3 Location of dredge hauls during the survey period 25 - 28 February, 1976, in southern Geographe Bay.
Arrowheads indicate direction of haul.
10, 20 & 30 metre depth contours are marked.

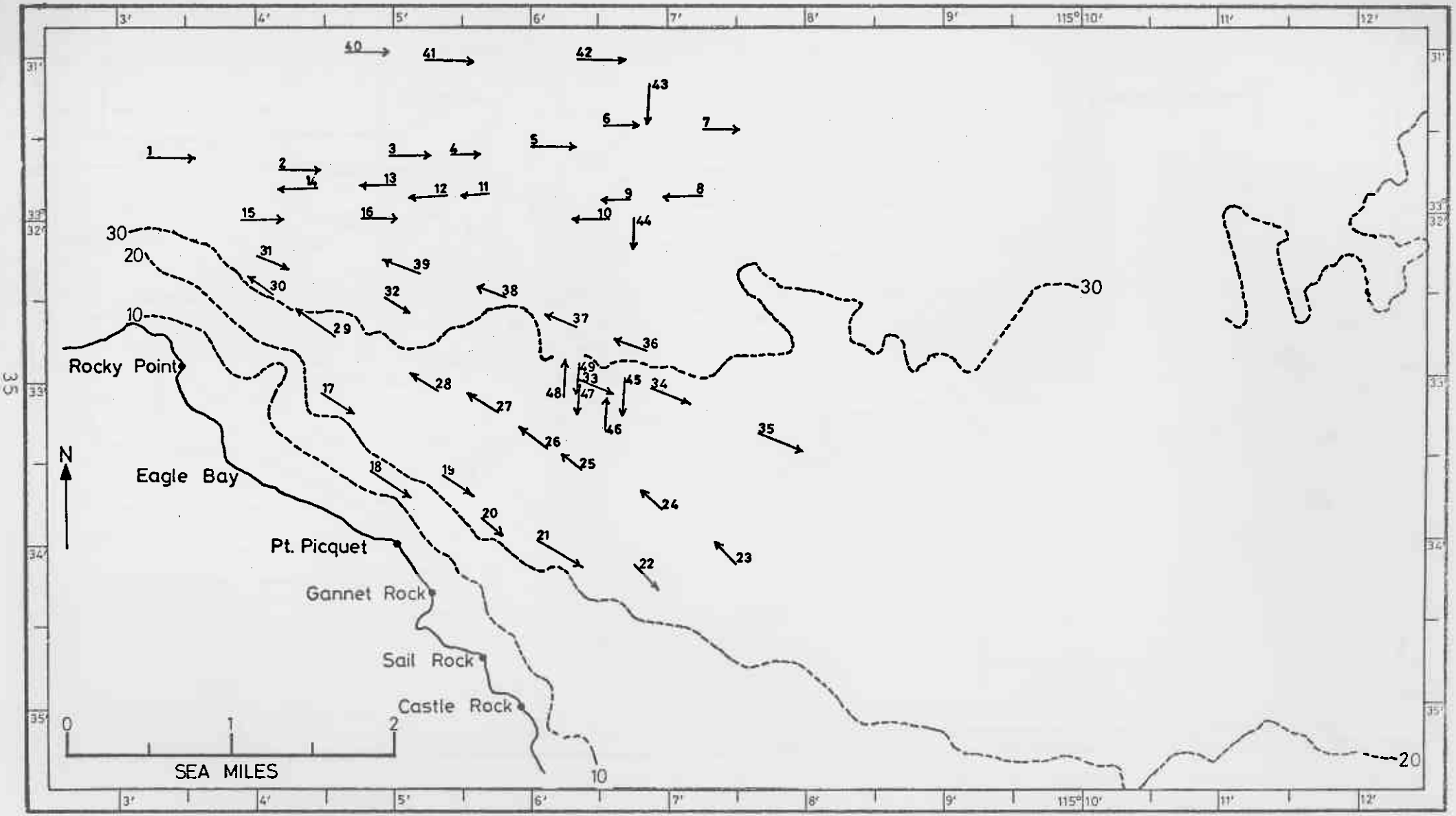


FIGURE 4 Catch rates of *Pecten* taken by 1.22 m dredge in the February 1976 Survey in Geographe Bay. The standard haul was of 5 minutes duration at 500 r.p.m. Depth contours are shown in metres.

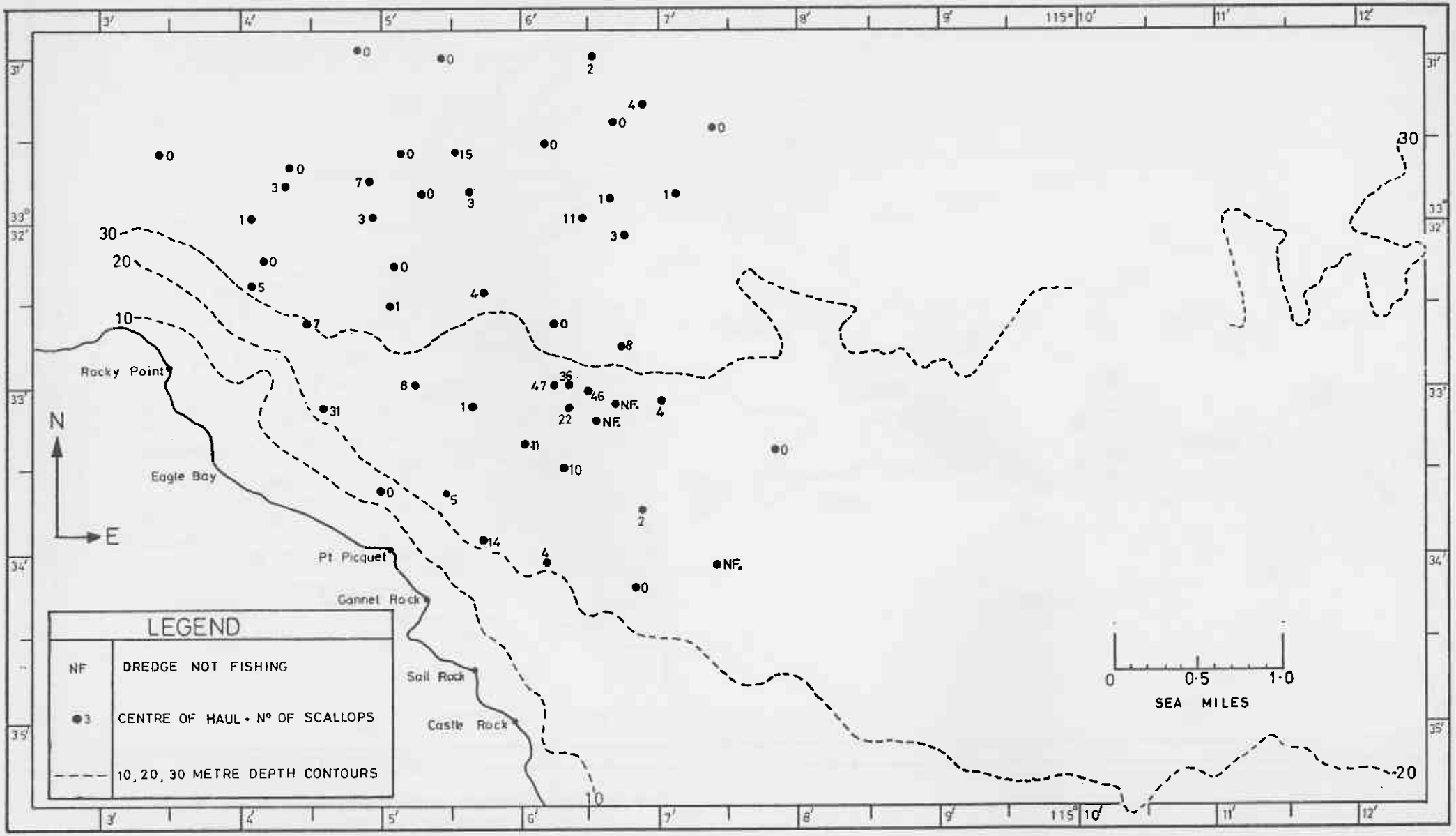


FIGURE 5 Catch rates of *Pecten* in the September 1976 survey, Geographe Bay, taken by dredge and grab. Dredge hauls by the two types of dredge have been made comparable by standardizing to a 5 min. haul with the 1.22m dredge. Areas marked A, B (outlined) discovered during grab sampling may represent concentrations of *Pecten*. Depth contours are shown in metres.

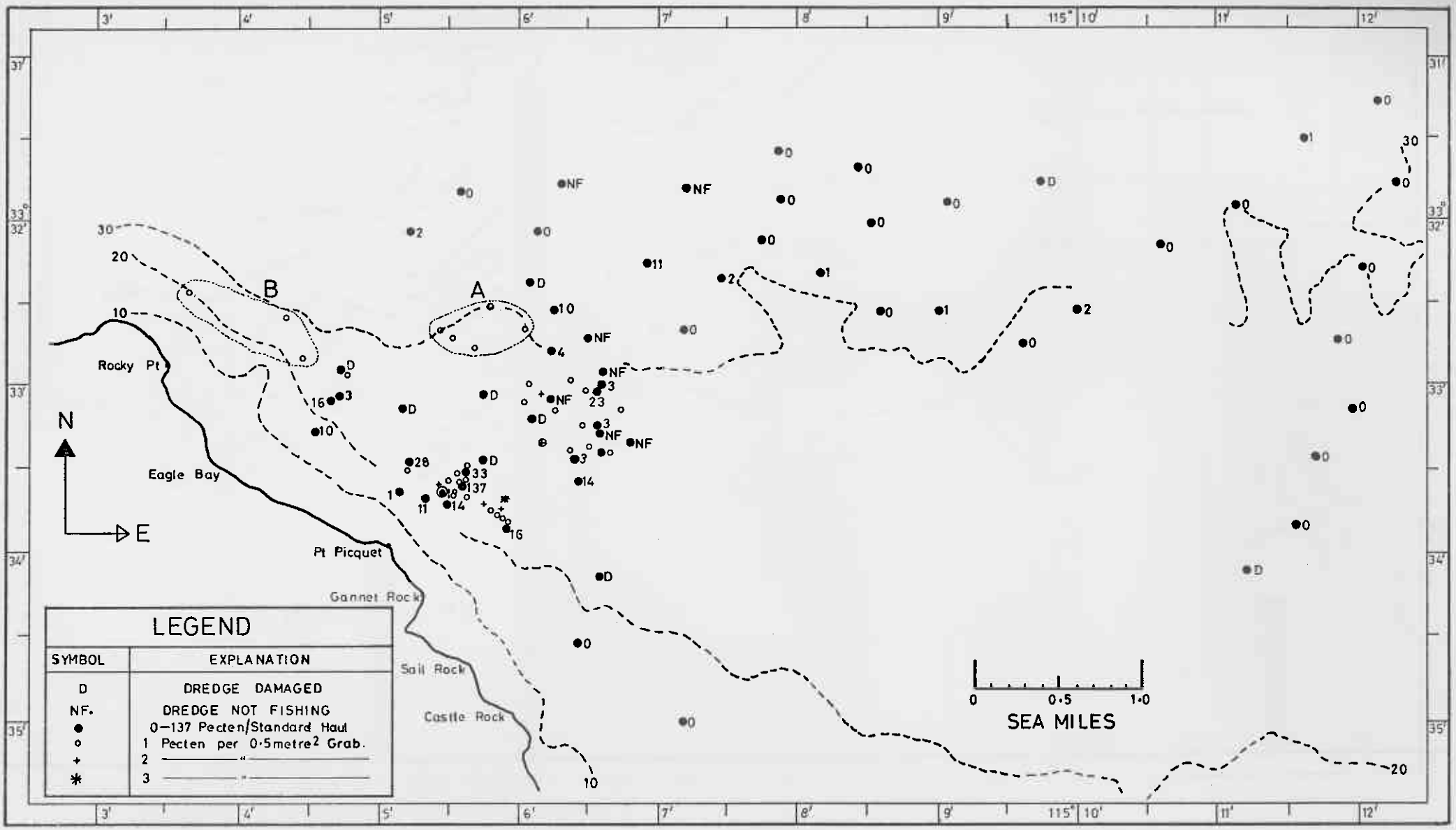


FIGURE 6 Location of all grab sampling transects and grab stations in the waters adjacent to Dunsborough, southern Geographe Bay, during the survey period 16 - 26 September, 1976. 10, 20 & 30 metre depth contours are marked. Release sites for tagged scallops are also shown as areas A-F.

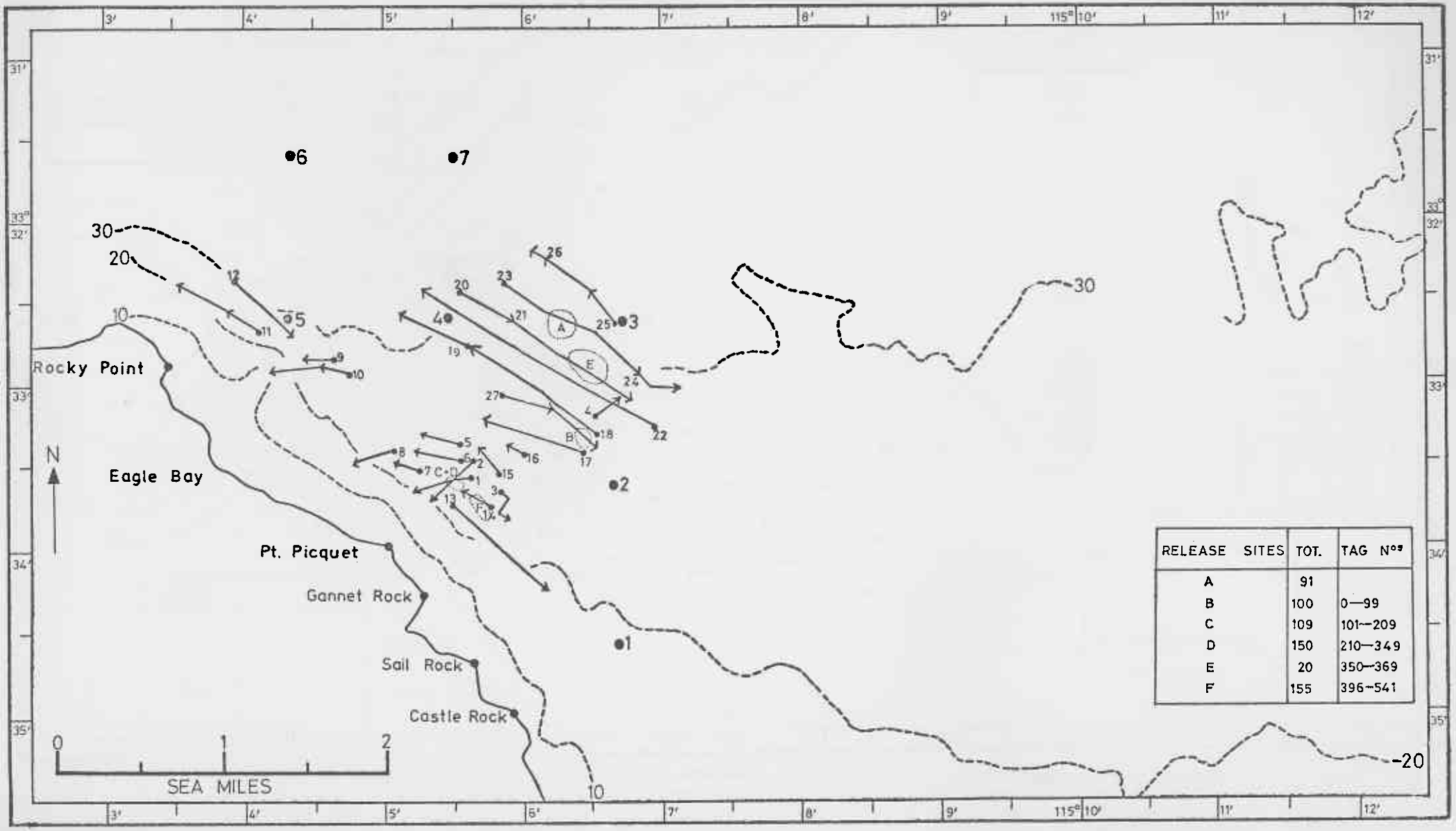


FIGURE 7. The percentage of the total grabs (C), total grab-caught *Pecten* (D) and *Chlamys* (E) associated with each sediment type is shown, together with the percentage of grabs on each sediment which caught *Pecten* (B), *Chlamys* (A) and seagrass (F).

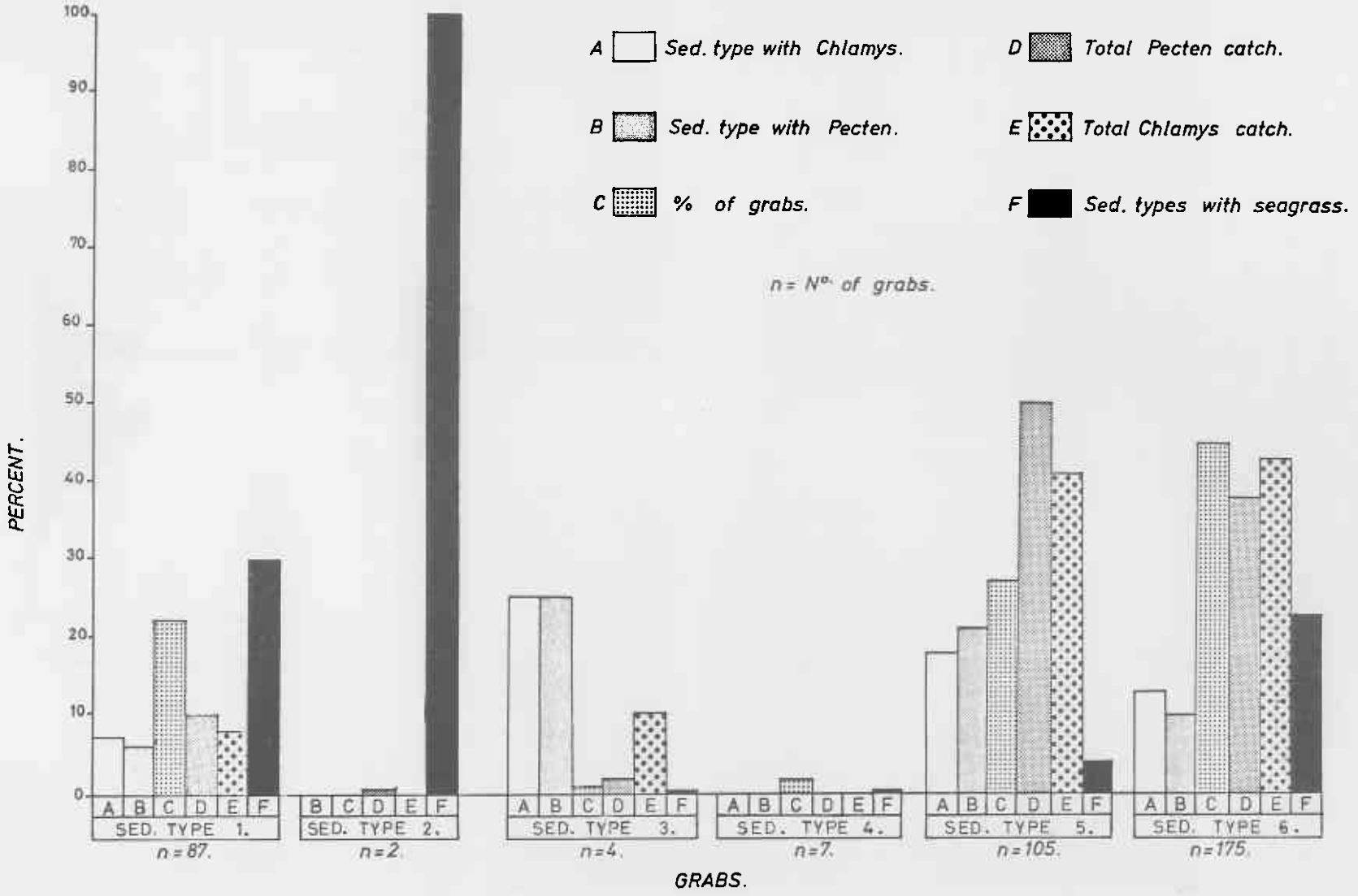
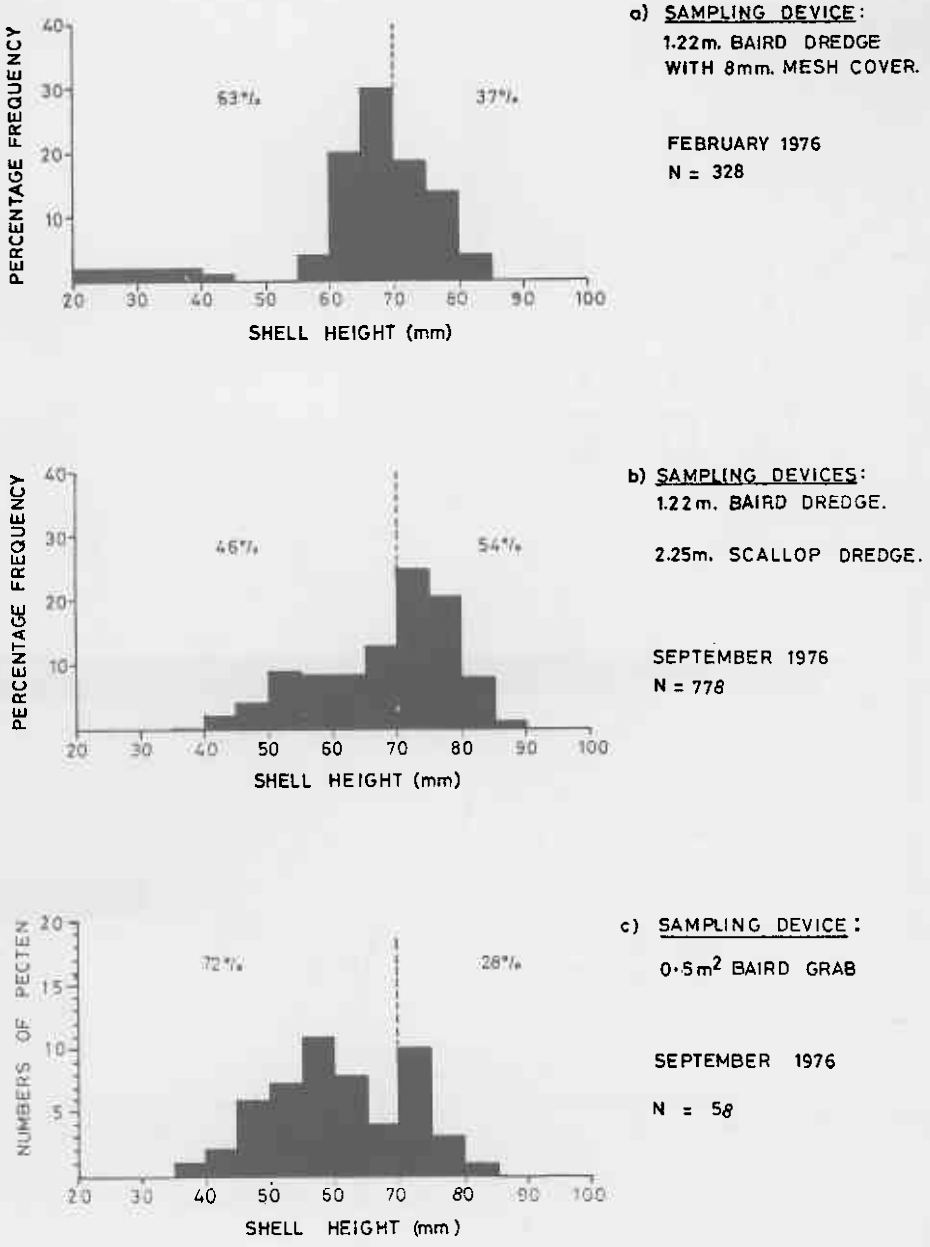


FIGURE 8 a,b,c. The size composition of *Pecten* scallops in Geographe Bay in :

(a) February 1976

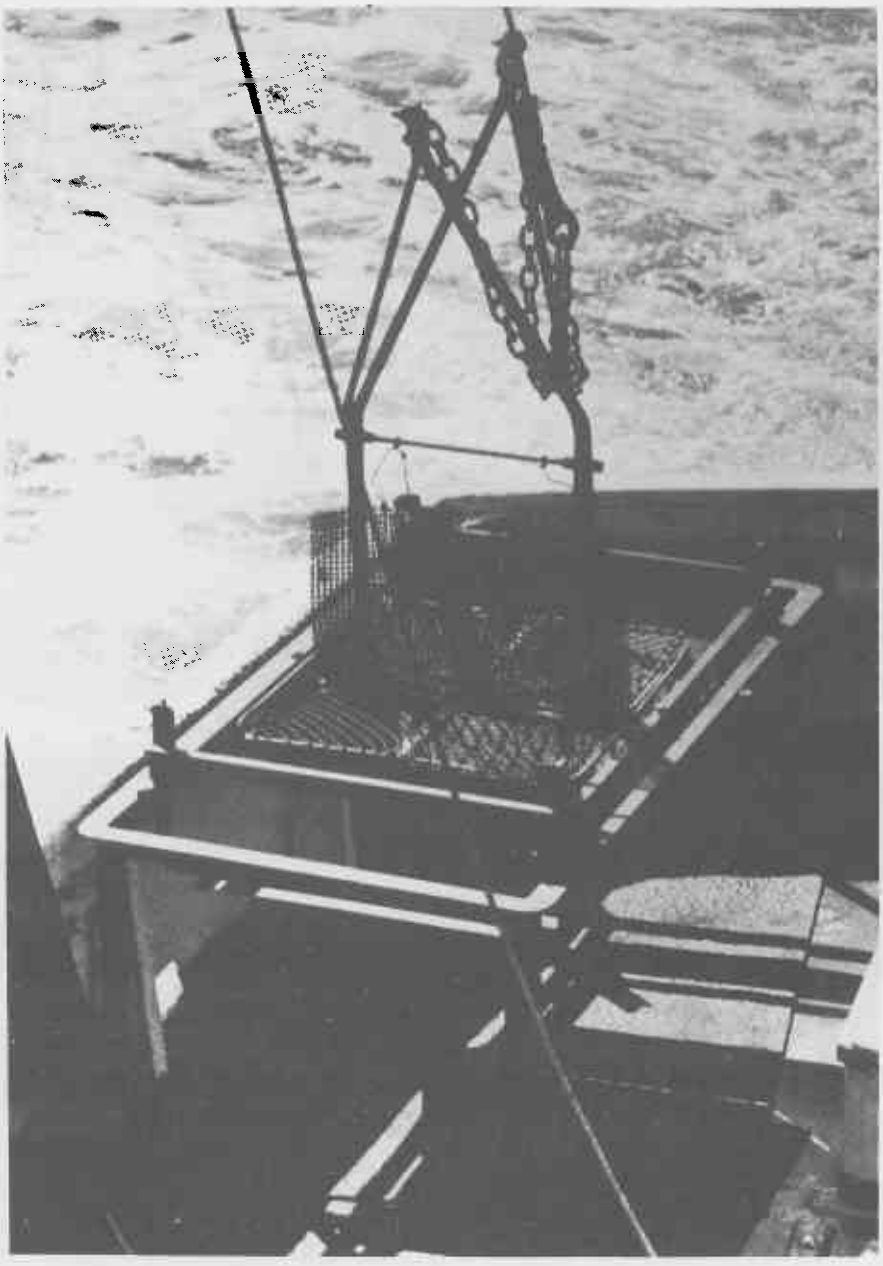
and (b), (c) September 1976.

The upper sample (a), was taken by 1.22m Baird dredges with 8mm plastic mesh lining. The lower sample (b), consists of the combined measurable catches of both the 1.22 m and 2.25 m dredges, each without fine plastic mesh lining. The histogram marked (c) is the total measurable catch of 393 grab shots with the 0.5 m^2 Baird grab.



PLATES

1. The Fisheries Research Vessel "Flinders" which undertook the *Pecten* scallop surveys in February and September 1976 in southern Geographe Bay.



2. The half square metre Baird Grab with covers to prevent escape of scallops during setting and hauling is shown (in the closed position) in its deck stand aboard "R.V. Flinders".

3. The commercial 2.25 m scallop dredge in its self-tipping cradle is shown together with rocks and debris caught on a foul haul in September 1976 in southern Geographe Bay.