THE D'ENTRECASTEAUX CHANNEL SCALLOP FISHERY: ITS PAST AND POSSIBLE FUTURE

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(with two tables and six text-figures)

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The history of the D'Entrecasteaux Channel scallop fishery is discussed and its past and present structure and management are examined, with a view to providing a basis for future management. It has opened or closed over the years as production has fluctuated, closure being forced again in 1986 by evidence of overfishing and the sudden appearance of the toxic dinoflagellate alga *Gymnodinium catenatum* Graham. Lack of a comprehensive management plan impedes dealing with difficult administrative and biological problems or unexpected developments such as increased amateur participation or the present preponderance of the doughboy scallop (*Chlamys asperrimus* Lamarck) over the commercial scallop (*Pecten fumata* Tate). This is a serious obstacle to successful conservation and utilisation of the resource. Recommendations concerning the future of the fishery are made, in particular that the the fishery should be amateur-only while scallop stocks remain low.
Key Words: scallop, fishery, D'Entrecasteaux Channel, Tasmania, resource management.

INTRODUCTION

The D'Entrecasteaux Channel scallop fishery is of considerable importance to Tasmanians: it was at one time the third largest scallop fishery in the world (Anon. 1962) and has sustained many professional and part-time (amateur) fishermen over much of the last 60 years. Historically, the fishery has been plagued by recurrent collapses in production, resulting in closures of scallop beds for up to 12 years at a time. This paper details the history of the fishery and examines those aspects pertinent to its future.

THE CHANNEL AND ITS SCALLOPS

D'Entrecasteaux Channel, between Bruny Island and mainland Tasmania, runs SSW for approximately 45 km (fig. 1). Olsen (1955) divided the Channel into three areas based on topography and bathymetry: a deep open southern entrance with an average depth of about 40 m, an extensive shallow mid-section with an average depth of about 14 m, and a narrow northern channel with an average depth of 20 m.

It is a complex area hydrologically, with tidal, riverine and estuarine influences. The Derwent estuary to the north and the Huon River in the south can both have a major influence (Fairbridge 1953) and there is an increasing salinity gradient, from south to north, after heavy rain (Langlois & Cooper 1978). Water temperature ranges from 7 to 20°C (Fairbridge 1953).

Substratum types are highly variable, ranging from fine silt to coarse sand and rock (Olsen 1955, Sea Fisheries Division 1974, 1976). The northern section (Areas 1–5, fig. 1) has mostly a muddy bottom with sand fringes in the shallower areas. The mid-section (Areas 6–9) has mud, shell and rock substrata, and fine sand down to 20 m depth in Area 9. The southern section (Areas 10–12) is also variable, Areas 10 and 11 having sandy bottoms and Area 12 having a muddy bottom at depth and sand, rock and weed in its shallower parts.

Three species of scallops are present in the Channel, the queen scallop, *Equichlamys bifrons* Lamarck, the doughboy scallop, *Chlamys asperrimus* Lamarck, and the commercial scallop, *Pecten fumata* Tate. A survey by Olsen (1955) found commercial scallops to be most abundant along the edge of the Channel in its northern and southern reaches, and at 8–16 m depth in its mid-section. Present on any substratum, from silt-sand through to coarse sand and shale, the commercial scallops were often in beds or strips, 1–30 m or more in both length and width, with their long axes parallel to a flow or tide, or along contours in sheltered bays. The queen scallop was found to

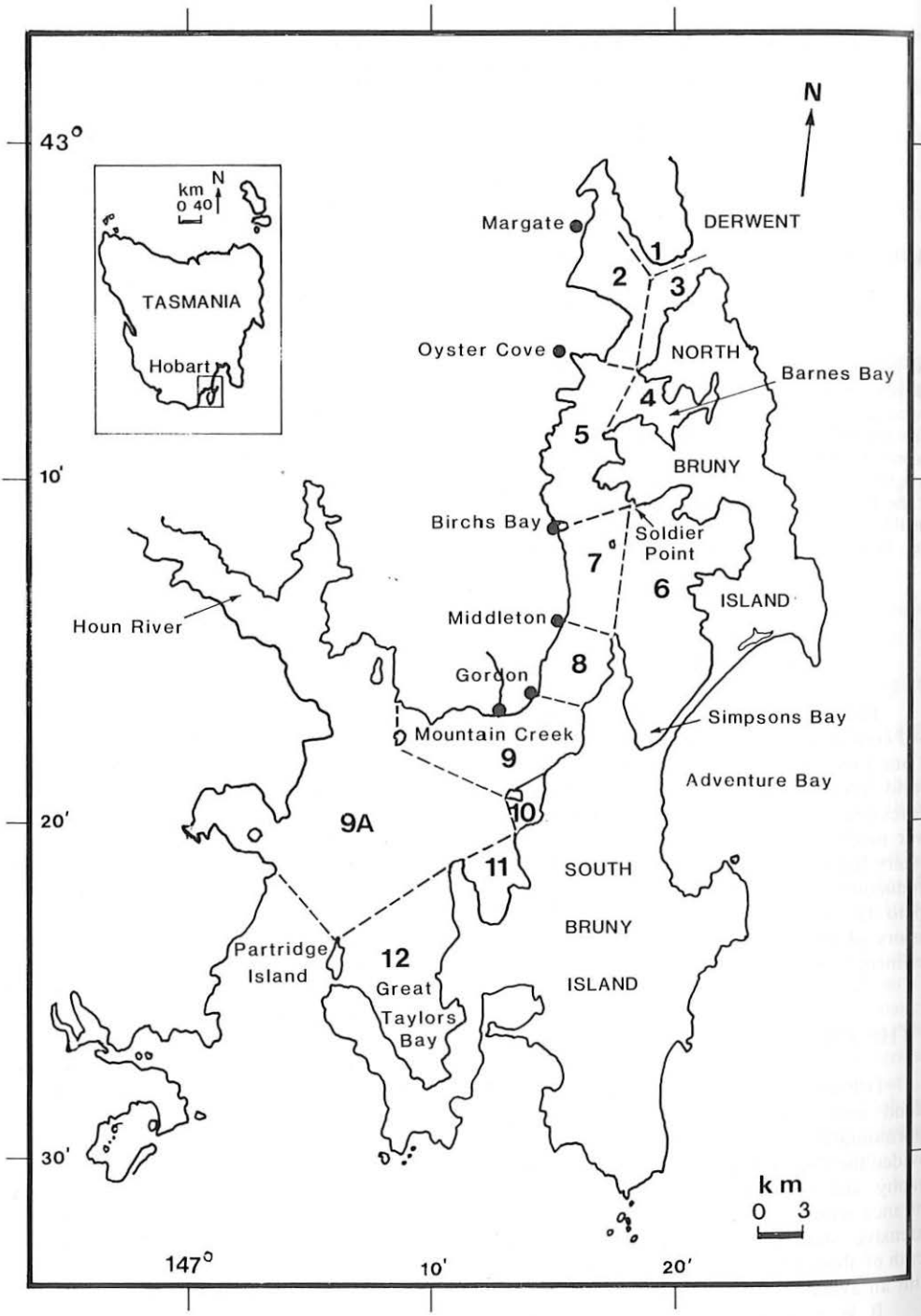

FIG. 1 — D'Entrecasteaux Channel showing designated scallop areas established in 1947 as part of an attempt to quantify catches and corresponding roughly with established scallop beds (Fairbridge 1953).

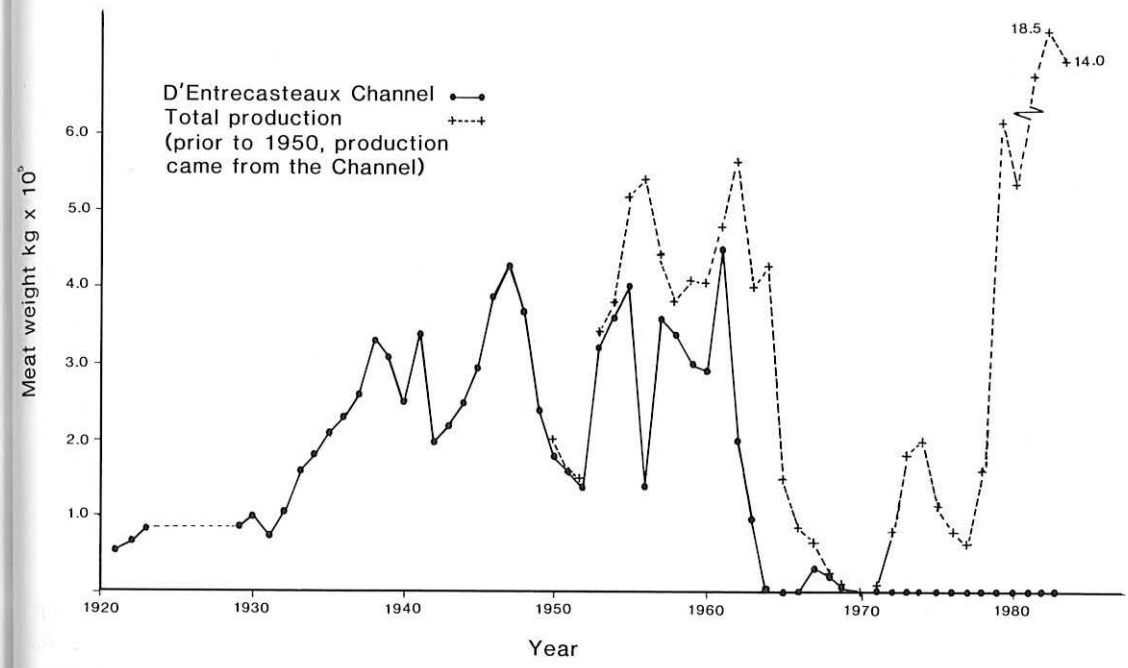

FIG. 2 — Tasmanian scallop production 1921–83. Data from Commissioners of Fisheries (1923), Fairbridge (1953), Anon. (1974) and TFDA (1982a, 1983).

occupy a shallower range throughout the Channel, from 2–14 m, often in association with rocky reefs and the seagrass *Zostera tasmanica* (Martens ex Aschers) den Hartog. The doughboy scallop had a similar depth range and horizontal distribution to the commercial scallop.

More recent surveys by the Tasmanian Department of Sea Fisheries (Harris 1981, 1982, 1983, Smith 1984, Zacharin 1985, 1986) have found that the commercial scallop is no longer abundant in the mid-section of the Channel, queen scallop numbers are also generally low, and the doughboy scallop is the most abundant species overall, particularly in Areas 5–8.

THE FISHERY TO 1982

As late as the 1880's scallops were not significant commercially in Tasmania, although the "commercial" scallop of today, *Pecten fumata*, was abundant in certain localities and was consumed locally (Seal *et al.* 1883). Significant numbers of scallops became available in the Hobart Market from 1905 (Anon. 1980). They were caught in the Derwent estuary in Rose Bay (Fairbridge 1953), Cornelian and Geilston Bays, near Lindisfarne and adjacent to the Domain (*The Mercury* 8 July 1910, p.6), and as far north as New Town Bay (E. Guiler, pers. comm.). However, depletion of the Derwent River beds soon forced fishermen downstream to Ralphs Bay (for doughboy scallops) and D'Entrecasteaux Channel (for commercial scallops) (Fairbridge 1953). The Ralphs Bay fishery was short-lived, closing in 1926, apparently due to restrictive legislation (Fairbridge 1953) and declining stock (Harrison 1965). Scallop fishing in D'Entrecasteaux Channel probably began around 1920 and continues to this day.

Figure 2 shows Tasmanian scallop production for the period 1921–83. Prior to 1950 the entire catch was from D'Entrecasteaux Channel. From the mid-1950's to the late 1960's a significant proportion of the catch was taken from beds off the east coast, and from the early 1970's the Bass Strait beds provided the harvest (see also Perrin & Hay 1987). Boat numbers and length of the scallop season for D'Entrecasteaux Channel for the period 1933–63 are shown in figure 3. Figure 4 shows an approximate measure of catch per unit effort over the same period (annual catch ÷ (number of boats x season length in months) = catch per boat-month). Figure 5 shows meat weight/1000 scallops and scallop prices.

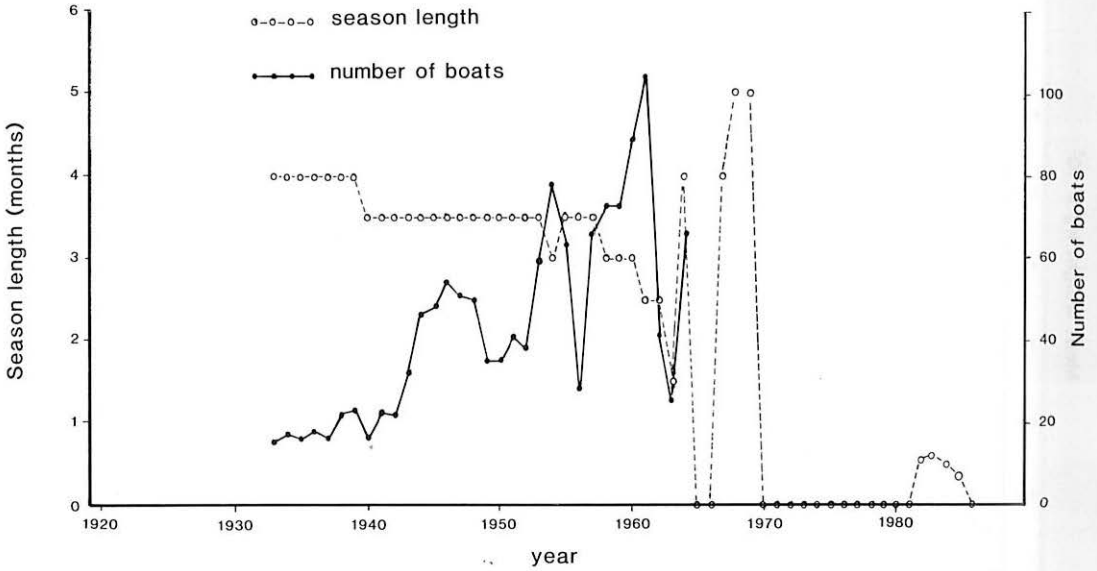

FIG. 3 — Boat numbers and scallop season length for D'Entrecasteaux Channel. Data from SFABT Subcommittee (1964) and an unpublished report of the Council for Scientific and Industrial Research, Fisheries Division (Anon. 1947).

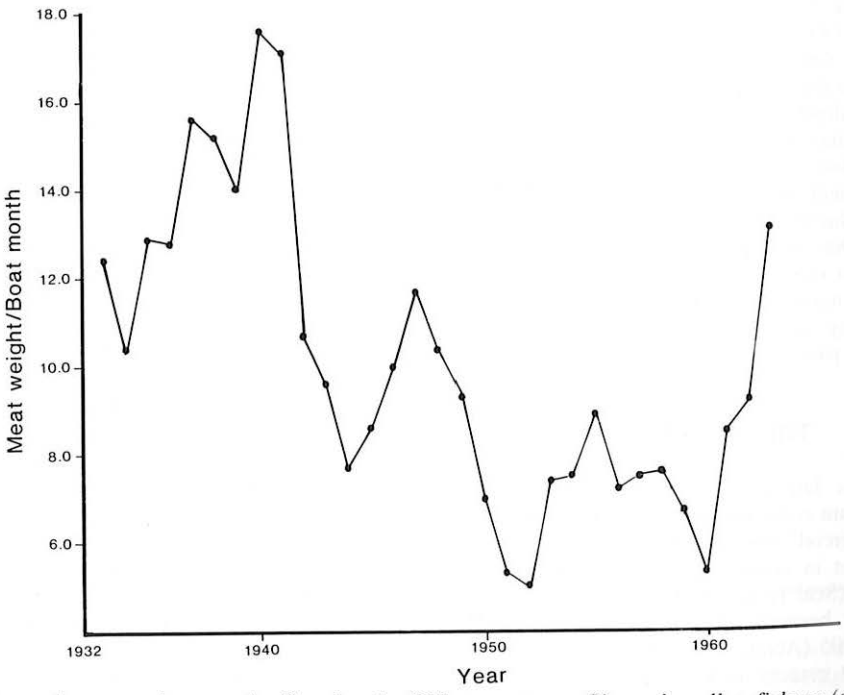

FIG. 4 — Approximate catch per unit effort for the D'Entrecasteaux Channel scallop fishery (see text).

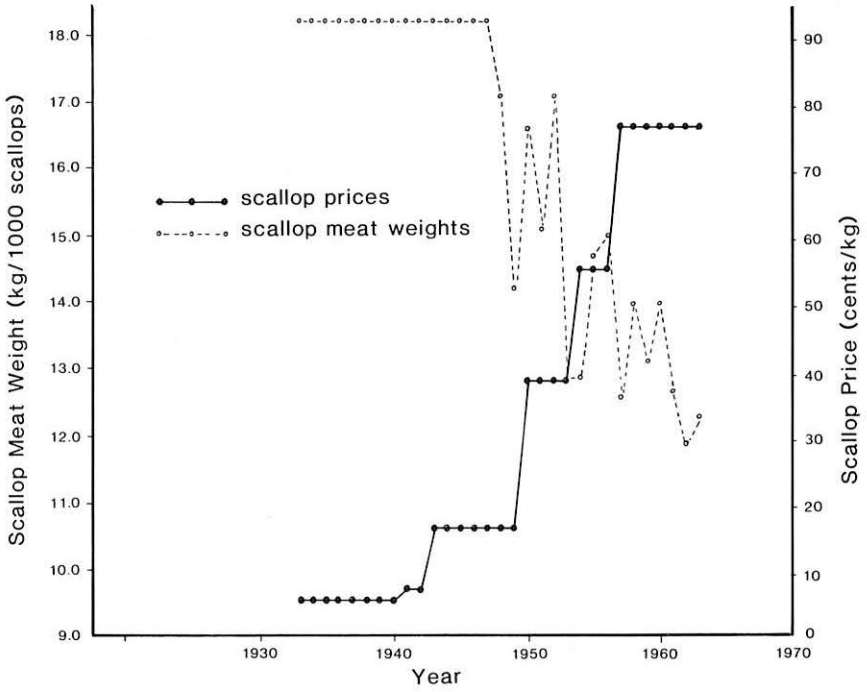

FIG. 5 — Scallop prices and scallop meat weights for D'Entrecasteaux Channel, 1933–63.

The fishery was carefully fostered from its early days. The beds were monitored for signs of overdredging (Sea Fisheries Board Tasmania (SFBT) 1933) and the northern parts of the Channel were closed for this reason in 1925–26 and 1930–31 (Select Committee of the Legislative Council (SCLC) 1960, SFBT 1930). The splitting of scallops at sea was also prohibited, due to the numbers of starfish attracted by the shells and adhering viscera (Anon. 1947).

The commercial scallop formed the bulk of the catch in the early 1920's (Fairbridge 1953) but during the late 1920's and 1930's the doughboy scallop became the most important constituent of the catch (SFBT 1933). This change in species catch was probably due to the commercial scallop becoming rare in the Channel at this time (Harrison 1965) possibly due to starfish predation (Anon. 1947). By 1938, however, 85% of scallops being caught were again commercial scallops (SFBT 1938, *The Mercury* 17 August 1940, p.4).

Total scallop production increased from 153 000 kg meat in 1933 to 327 000 kg in 1938 (fig. 2) but the number of boats fishing for scallops did not increase markedly, remaining at about 20 (fig. 3), and it is likely that the rise in catch per unit effort during this period (fig. 4) was due to the mechanisation of dredge-hauling.

In 1934 the legal minimum size for commercial scallops was increased from 3.5 inches (88 mm) at its widest diameter to 3.5 inches at its smallest diameter (Anon. 1947), while that for the doughboy scallop remained at its 1925 limit of 2.75 inches (69 mm) at its smallest diameter (Fairbridge 1953). In 1935 the width of scallop dredges was limited to four feet (1.3 m) to protect the scallops from being crushed by the weight of the net being dragged over the bottom (Anon. 1947). The meat weight per thousand scallops was stable around 40 lbs (18.2 kg) per 1000 scallops, an indication that there was no trend towards smaller scallops, as would be expected if recruitment overfishing was occurring (Sea Fisheries Advisory Board of Tasmania (SFABT) Subcommittee on the Scallop Fishery 1964).

From 1938–42 there were fluctuations in the catch and the catch per boat month, indicating that the fishery may have removed much of the accumulated stocks of scallops and that fishing was now relying on annual recruitment (Harrison 1965). It is also likely that the catch was adversely affected by enlistments in the Australian Imperial

Forces: in 1939 there were 27 boats with 74 men working 52 dredges but in 1940 there were 20 boats with 45 men working 42 dredges (*The Mercury* 31 May 1940, p.4).

Concern about the possible depletion of the scallop beds led to biological investigations on growth rates, migration, and the effect of fishing pressure (Tubb 1946). Tubb's work concentrated on scallop tagging experiments and he concluded that analysis of tag returns, together with the collection of fisheries catch data, could form the basis for an assessment of the effects of fishing on the scallop stocks.

From 1942 to 1947 scallop production increased, as did the number of boats. Harrison (1965) suggested the increase in production was due to four factors: an increase in the number of dredges carried by each boat, the change from doughboy to commercial scallops as the major species being caught, the development of the southern areas of the Channel for scallop fishing, and a good spawning of scallops in 1937–40.

From 1947–52 total scallop production fell. The number of boats also fell, from 51 in 1947 to 38 in 1952. Meat weights per 1000 scallops began to fall after 1947; it is likely that the accumulated stocks of legal-size commercial scallops were steadily reduced from 1942–46 and that after 1947 the size of the catch was more directly related to recruitment (SFABT Subcommittee 1964). A limit of two dredges per boat was enforced in 1949 (Department of Agriculture (D.A.) 1949).

The rapid decrease in production from 1947–52 resulted in speculation on the future of the Tasmanian scallop fishery, and fishermen were forced further afield into Norfolk Bay, Coles Bay, and other areas on the east coast. Concern about the future of the D'Entrecasteaux Channel beds led to a transplantation of 90 000 two- to three-year-old scallops from the east coast to Area 2 (fig. 1) (Harrison 1965, D.A. 1953).

A biological assessment of the Channel fishery was made by Olsen (1955) who found that "the successful spatfall and subsequent development of a strong year class is very sporadic and as yet, unpredictable". He found that there had been a heavy spatfall in about 1940 and another one in 1948, and it seemed the productive potential of the Channel's scallop stocks fluctuated around the success or otherwise of these spatfalls, if about six years was allowed for the scallops to enter the fishery (SFABT Subcommittee 1964).

The period 1952–55 saw a rapid increase in scallop catch, boat numbers, and catch per boat month (figs 2, 3, 4) but scallop meat weights began to decrease (fig. 5). The findings of Olsen (1955) suggested that the 1948 year class had entered the fishery and was providing the bulk of the catch. In 1956 the Channel fishery catch dropped sharply, and was only 27% of the total Tasmanian catch. The fall was due largely to a transfer of fishing effort to Norfolk Bay. However, the Norfolk Bay beds did not produce many scallops in 1957 and by 1959 the catches there had decreased to very low levels (Harrison 1965).

From 1956–61 scallop catches increased again in the Channel and in 1961 the peak catch of 454 000 kg meat was taken. Boat numbers steadily increased to a record 104 in 1961 but catch per boat month remained low. It seems that the high production level was achieved by increased fishing effort, and the low catch per boat month and decreasing meat returns per 1000 scallops suggest that the Channel scallop stock was being overfished. The season was shortened from 14 weeks in 1956 to 10 weeks in 1961.

One controversial alteration to fishing technique at this time was the introduction in 1958 of an English scallop dredge; the "Baird" or "Sputnik" dredge. The majority of Channel fishermen believed this new dredge destroyed more scallops than the established lip dredge (Langford 1959) but because the dredge was more efficient in deeper water and on hard substrates, many used it (*The Mercury* 12 June 1959, p.4). In 1958 the Licensed Fishermen's Association submitted a resolution to the Sea Fisheries Advisory Board asking that the dredge be banned from the Channel. This was accepted by the Board (SFABT 1959) but "Sputniks" were not banned from the Channel until the 1962 scallop season.

Concern over the scallop industry's future, prompted by the controversy surrounding the "Sputnik" dredge, resulted in the appointment in 1960, of a Select Committee of the Legislative Council to enquire into the scallop fishery of Tasmania. The Committee received submissions from 45 fishermen and took into account CSIRO research on scallop dredge efficiency before concluding that spiked dredges, such as the "Sputnik", caused considerably more damage to the scallops than did the lip dredge. The Committee recommended the banning of all spiked dredges from the Channel, subject only to further investigations by the CSIRO (SCLC 1961).

Harrison (1965) believed the controversy surrounding the "Sputnik" dredge helped to confuse the issue of why scallop stocks in the Channel were at such low levels and that factors such as the rising price of scallops (fig. 5) and the

shift in exploitation focus to new beds around the state also obscured the decrease in catch per unit effort, the usual indicator of overfishing.

The Channel scallop catch fell dramatically from 1961–64. This slump again forced some southern Tasmanian fishermen to look elsewhere for scallops, including Port Phillip Bay in Victoria, and also resulted in the appointment of a sub-committee by the Sea Fisheries Advisory Board to give advice on the opening date and duration of the 1964 scallop season and on the scallop fishing operation in general. The Committee reviewed the history of the Channel fishery, commented on the regulations in force, and recommended that the scallop season in the Channel be open for six months in 1964, from 15 May to 15 November (SFABT Subcommittee 1964). However, the fishery was opened for four months only, from May to August.

The arguments the Committee put forward for a six-month season are worth examining in the light of later events. The Committee stated that the basis of the two- to three-month season was that scallop flesh weight fluctuated during the year and the season was set to maximise yield per scallop. It argued, however, that the season brings little advantage by way of increased harvested meat, contending that weight loss due to year round harvesting would not exceed 27%. The Committee then listed the disadvantages of a short season, including the concentration of fishing effort resulting in inefficient use of equipment and labour, little regard for size regulations, and inefficiencies of splitting scallops. It concluded that the limited season made no contribution towards limiting catch or effort, and favoured a management policy which amongst other things placed no restriction on the time of fishing, with the provision that if fishing effort continued to the point where recruitment was endangered then the season should be closed (SFABT Subcommittee 1964).

Scallops are recorded as being taken from the Channel during only three months (May–July) in 1964 (DA 1965) and it seems they were rare and in poor condition (*The Mercury* 15 May 1964, p.2). The season was closed in 1965 and 1966. Scallop sampling undertaken every three months in 1965 revealed no signs of recovery of commercial scallop numbers, though doughboy scallops were plentiful in some places (Harrison 1966).

A survey in 1967, undertaken by officers of the Sea Fisheries Division, found that the commercial scallop numbers in the Channel were low but considerable recruitment of doughboy scallops had occurred due to spawning in 1962, 1963 and 1964 (Anon. 1967). The season was opened in 1967, from August to November, and eight boats took 35 000 kg of scallop meat.

In 1968 the Channel produced 24 000 kg of scallop meat and in 1969, just 6800 kg. The 1969 survey of the Channel showed that doughboy scallops were rare and the only juveniles present were those of the queen scallop (DA 1970).

Speculation on the causes of the major collapse (after 1961) included changes in the marine environment brought about by natural processes and industrialisation (Harrison 1975), changes in the hydrological condition of the area which precluded commercial scallop settlement (Anon. 1967), and pollution from insecticide sprays used in orchards (*The Mercury* 13 June 1969). It also seems likely that the extra long seasons of 1964, 1967, 1968 and 1969 (fig. 3), the disguised fall in catch per unit effort (Harrison 1965), and the introduction of the "Sputnik" dredge were contributing factors to this collapse.

For the next 12 years (1970–81) the Channel scallop fishery was closed in an attempt to rebuild scallop numbers. Annual surveys of the scallop beds continued. The 1970 survey revealed small concentrations of doughboy scallops, while queen and commercial scallops were scarce (DA 1971). This was the pattern for the next eight years, that is, an annual survey of the Channel beds and a report of few scallops. In 1979 and 1980 no surveys were done but in 1981 a survey revealed quantities of doughboy scallops in Great Bay and Simpsons Bay (fig. 1). At this stage fishermen pressed for a limited opening of the area and a more comprehensive survey was undertaken to evaluate this possibility. The second survey found that while there was a good settlement of doughboy scallops, commercial scallops numbers were still low. The recommendations were made that the Channel be closed in 1981 but that another survey be undertaken in 1982 with a view to opening the beds (Harris 1981). In 1982 a joint government/industry body, the Scallop Industry Liaison Committee, recommended a short open season be allowed in Area 6, and this is taken to be the commencement of the current fishery.

THE CURRENT FISHERY, FROM 1982

Since 1965, and probably earlier, the Department of Sea Fisheries (formerly the Sea Fisheries Division and then the Tasmanian Fisheries Development Authority (TFDA)) has conducted regular surveys of the Channel scallop

beds to assess the distribution, age, and size structure of the populations of doughboy, queen, and commercial scallops, and to determine the effects of the fishing of previous years on the scallop stock. The annual survey is carried out prior to any decision on the current year's scallop season. From 1970–78 few scallops were found and the beds remained closed.

In 1981 there was considerable pressure from fishermen to open Area 6 (fig. 1) due to the apparent presence of significant quantities of doughboy scallops in the area. A dredging survey was made using a 2.45 m mud dredge, and a similar survey has been conducted each year since. The results of these surveys are collated in table 1, and a summary of the Channel fishery statistics from 1982 to 1985 is given in table 2.

The 1981 survey was conducted between 12 and 14 May and showed that, while there were large numbers of doughboy scallops in Area 6, most were undersize; no season was allowed.

The 1982 survey was limited to Areas 6, 7 and 8, and once again showed the presence of large numbers of doughboy scallops, most of which had reached takable size. The Scallop Industry Liaison Committee recommended that there be a short open season with fishing limited to Area 6 (Harris 1982). Around 180 boats fished on the first day of the 17-day season (3–19 July). All three species of scallop could be taken, and there was no bag limit except for divers. Most amateur fishermen reported good catches, and some of the professional boats in the fishery were taking up to 30 bags in a seven-hour period (*The Mercury* 6 July 1982). There were complaints from some amateur divers that their bag limit of 200 scallops per day was too low, especially when there was no bag limit for other amateur or professional fishermen (TFDA 1982b). Fisheries inspectors reported a successful season from an enforcement viewpoint (TFDA 1983), but isolated incidents of scallop dumping were alleged, apparently due to excessive catches (*The Mercury* 5 August 1982).

The 1983 survey was conducted from 18 to 20 April and concentrated on Areas 6, 7 and 8. It showed virtually no change in the distribution of scallops but a slight increase in the abundance of doughboy scallops. Dredge tows undertaken in other parts of the Channel revealed no significant concentrations of scallops. The slight increase in

TABLE 1
Results of D'Entrecasteaux Channel scallop Surveys 1981–86*

Area**	1981			1982			1983			1984			1985			1986		
	D	C	Q	D	C	Q	D	C	Q	D	C	Q	D	C	Q	D	C	Q
1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2	–	–	–	–	–	–	2	0	0	–	–	–	49	0.33	0	91	1.7	0.7
3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	60	5.0	15
4	–	–	–	–	–	–	–	–	–	–	–	–	1.5	1.5	0	–	–	–
5	–	–	–	–	–	–	0	0	0	143	0.75	0	7.6	3.0	0	216	3.7	0.8
6	545	1	–	234	1	–	296	1		291	1.3	0.8	144	3.7	2.2	188	10.5	2.6
7	29	3	–	71	5	–	91	8		130	4.4	19.1	55	7.2	18.6	99.5	6.7	15.5
8	256	4	–	60	7	–	73	6		44	5.2	7.4	46	3.1	5.1	91	6.1	8.6
9	–	–	–	–	–	–	2.8	1.6	0	10	1.0	0	55.8	2.9	0.6	117	3.9	5.1
9A	–	–	–	–	–	–	0.3	0	0	–	–	–	–	–	–	–	–	–
10	–	–	–	–	–	–	–	–	0	96	0	7.0	124.6	0.5	7.2	59	2.0	5.0
11	–	–	–	–	–	–	10	0.7	0	115	0.6	3.5	227	1.6	7.4	45	7.3	7.9
12	–	–	–	–	–	–	0.2	0.8	0	4	0.2	3.6	0.33	3.3	0	1	10.8	0.1

* Numbers in table represent average catch per five-minute haul of a 2.4 m mud dredge with teeth. Dashes represent no survey being undertaken.
** Scallop areas (fig. 2).
D = doughboy; C = commercial; Q = queen.

doughboy scallop numbers from the 1982 to the 1983 survey resulted in a recommendation of a longer season of 4 to 6 weeks for the 1983 season, again restricted to Area 6 only (Harris 1983). Prior to the opening of the season, the Minister for Sea Fisheries announced tighter controls on fishing effort, such as the introduction of bag limits, which were designed to discourage the participation of large scallop fishing vessels (Media Release from Minister for Sea Fisheries, R. J. Beswick, 20 June 1983). Opening day (2 July) saw about 200 boats fishing in Area 6 (*The Mercury* 4 July 1983, p.3) for all three species of scallop (Anon. 1983). After some ten days, declining catch rates became obvious and forced a recommendation from the Minister for Sea Fisheries that the Channel should close early, on 20 July, on the grounds of excessive catches and the desire to leave some scallops for future breeding (Media Release from Minister for Sea Fisheries, I. M. Braid, 14 July 1983).

The 1984 survey was conducted from 9–11 April. Once again doughboy scallop numbers were greatest in Area 6, while commercial and queen scallops were most abundant in Areas 7 and 8. The number of doughboy scallops had not decreased in Area 6, even though there had been two fishing seasons in this area. The recommendations arising from this survey were that Area 6 be opened again, but Areas 7 and 8 should remain closed to protect the breeding stock of commercial and queen scallops (Smith 1984). A further reduction in bag limits was enforced, and a ban placed on the taking of commercial scallops. The 16-day season began on 7 July, and around 600 boats packed Simpsons Bay (Area 6), 500 of them with amateur licences (Anon. 1984).

The 1985 survey was conducted from 29 April–1 May and examined most areas of the Channel. Doughboy scallop numbers in Areas 6 and 7 had decreased markedly. The decrease in Area 6 was attributed to heavy fishing pressure during the 1984 season but no reason could be given for the decrease in Area 7 (Zacharin 1985). As the 1985 survey catch in Area 6 was less than 50% of the 1984 survey catch, and as there were many juvenile doughboy and commercial scallops present, it was recommended that Area 6 remain closed during 1985. Instead, Areas 8, 9, 10 and 11 were opened for a limited season from 6–15 July, with bag limits further reduced. Opening day again saw 600 boats or more in the Channel but total catch and catch rates were low, some boats returning without any catch (Anon. 1985a). This is surprising as the pre-season survey suggested high numbers of doughboy scallops in Area 11 in particular.

The 1986 survey was conducted from 28–30 April. It showed that Areas 5, 6 and 9 had the highest numbers of doughboy scallops, Area 7 had the highest numbers of queen scallops, and commercial scallops were increasing in abundance in a few areas of the Channel. The recommendations from this survey were that Areas 5 and 7 be opened for a nine-day season if the licensing arrangements for amateurs were changed from one licence per boat to one licence per person, and if commercial vessel numbers were severely restricted (Zacharin 1986). The Minister for Sea Fisheries approved arrangements to create a special

TABLE 2
D'Entrecasteaux Channel Scallop Fishery Statistics 1982–85

Year	Season	Area fished	Licences issued		Daily catch limits		Catch* (kg meat)	Catch per unit effort (kg meat/dredge hr)
			Amateur	Professional	Amateur	Professional		
1982	3–19 July	6	375	12	none**	none	2302	30.5
1983	2–20 July	6	667	70	1000	15000	32585	14.1
1984	7–22 July	6	751	104	400	8000	40451	7.7
1985	6–15 July	8	734	87	400	6000	663	2.4
1985	6–15 July	9					1360	2.6
1985	6–15 July	10					58	1.9
1985	6–15 July	11					64	1.3

* Catch and catch per unit effort are for professional fishermen only.
** In 1982, amateur divers were limited to 200 scallops per day.

licence for professional fishermen wishing to fish in the Channel, and in Storm and Norfolk bays. However, the 1986 Channel fishery did not eventuate, due to two factors: the sudden appearance of a planktonic toxic dinoflagellate in parts of the Channel, resulting in some scallops becoming contaminated to dangerous levels, and a desire on the part of management to rest the scallop beds (*The Mercury* 24 July 1986).

From the data in table 2, it is apparent that the Channel scallop beds are suffering from overexploitation. This is occurring despite the reductions in season length and bag limits introduced to control the rapid increase in fishing effort. The professional catch was relatively small in 1982, rapidly expanded in 1983 and 1984, but collapsed in 1985, and since 1982 the catch per unit effort for professional fishermen has fallen dramatically, making it economically non-viable for many to fish in the Channel (G. Innes, pers. comm.).

The modern fishery also has a very large amateur component: in 1985 some 730 amateur licences were issued, against 87 professional licences being endorsed for the Channel. Catch and catch per unit effort figures are not available for the amateur component of the fishery, but taking the 1985 professional/amateur licence numbers and catch limits, if all fishermen took their daily quota, then amateur fishermen would have caught about half as many scallops as the professionals.

MANAGEMENT

Management of the D'Entrecasteaux Channel scallop fishery is largely the responsibility of the Department of Sea Fisheries, with participation also by the Police Marine Division and the Marine Board of Hobart. The Department of Sea Fisheries conducts annual scallop surveys, issues licences to harvest the resource, liaises with fishermen and conducts a limited research program in the Channel. The Police Marine Division and the Marine Board of Hobart are responsible for enforcing the Sea Fisheries Regulations and the Port of Hobart Regulations respectively.

Other interested parties also have a management input, as is illustrated by the decision-making process for the opening of the Channel to scalloping (fig. 6). Following the scallop survey the Assistant Director (Management) calls a meeting or

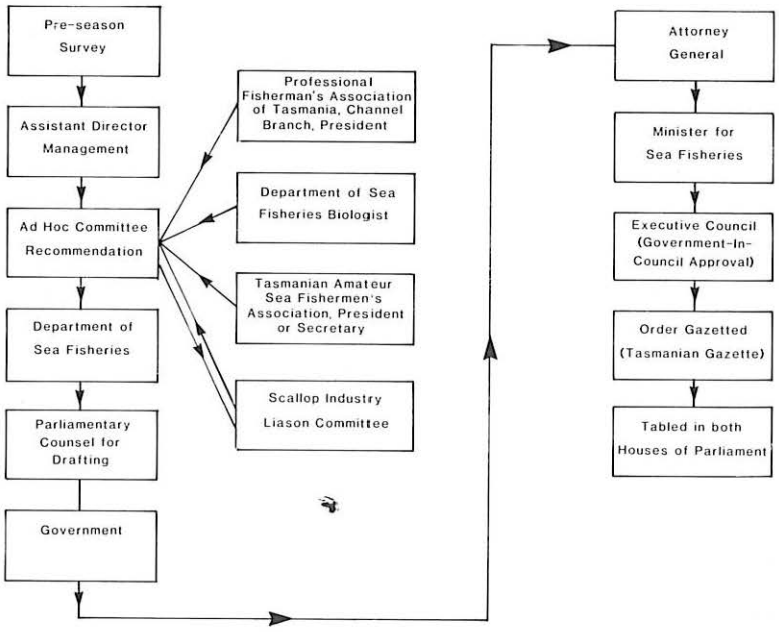

FIG. 6 — Decision-making process for the D'Entrecasteaux Channel scallop fishery.

contacts individually the President of the Channel Branch of the Professional Fishermen's Association of Tasmania (PFAT), the President or Secretary of the Tasmanian Amateur Sea Fishermen's Association (TASFA), and a biologist from the Department's research laboratories at Taroona. Recommendations on season length, bag limits, licence costs, areas of opening, and participation by amateur and professional fishermen are made at this meeting (J. Thomson, pers. comm.). The Scallop Industry Liaison Committee is informed of the meeting's recommendations and asked for comment. The recommendations are sent to the Director of Sea Fisheries: a Scallop Seasons Order is drafted and tabled in both houses of Parliament.

At present there is no formal written management policy for the D'Entrecasteaux Channel scallop fishery (J. Thomson, pers. comm.). However, the 1985 Channel survey report suggested that the prime management objectives of the Department of Sea Fisheries (DSF) concerning the scallop fishery in D'Entrecasteaux Channel were as follows (Zacharin 1985):

> "to build up the populations of commercial scallops throughout the Channel and the protection of juvenile scallops, and to ensure the continuation of a limited annual fishing season for doughboy and queen scallops."

Research in D'Entrecasteaux Channel by the Department of Sea Fisheries officers has concentrated on commercial scallop growth rates, re-seeding, and aquaculture potential. A number of scallops have been tagged and released to obtain growth rates and ring formation data for comparison with similar experiments elsewhere in Tasmania. A re-seeding trial has recently been carried out in one area of the Channel (results of the experiment are not yet available) and investigations have been made on spat settlement. An examination has also been made of the possibility of scallop aquaculture using a cage culture technique, but with little success due to poor growth rates and uneconomical methods of on-growing scallops (D. Cropp, pers. comm.).

Enforcement of the Sea Fisheries Regulations pertaining to scallops is undertaken by officers of the Police Marine Division. Under normal circumstances, the Marine Division maintains a "watching brief" on the D'Entrecasteaux Channel scallop fishery, that is, surveillance patrols made to the west coast of Tasmania or to southern Bruny Island also inspect D'Entrecasteaux Channel. About three weeks prior to the opening of the Channel, two boats make patrols of the Channel on a regular basis, and occasional night patrols are also made.

During the scallop season two or three boats are used to patrol the fishery. One boat (of 16 m with radar) is used as a mobile base and conducts night patrols (as daylight fishing only is permitted in the Channel), the others (faster runabouts) are used for inspectorial duties. Marine Division officers check on bag limits, gear, licences and evidence of shucking scallops, ensure that all fishing is within the prescribed scallop areas, and help to collate information on scallop catch rates.

According to the Divisional Inspector (Marine Division of the Police Department), amateur and professional fishermen transgress the regulations at about the same rate (R. Massie, pers. comm.). Taken overall, the Channel has been free of many enforcement problems, and amateur and professional fishermen have usually co-operated with police (TFDA 1983, 1984).

With regard to the operations of boats, professional and amateur fishermen come under the jurisdiction of both the Marine Board of Hobart and the Navigation and Survey Authority. The enabling Act is the *Marine Act* 1976 which, as amended, stipulates many practices with which fishermen must comply.

MANAGEMENT PROBLEMS

The situation faced by the managers of the D'Entrecasteaux Channel scallop fishery, management of a living marine resource with variable fecundity, high palatability and within easy reach of amateur and commercial fishermen, can hardly be considered easy and presents both biological and management problems.

Biological Problems

Variability of Recruitment

Annual recruitment to the fishery varies through variability in spatfall and consequent fluctuation in scallop production, as has been reported from scallop fisheries in Australia and throughout the world (e.g. Serchuk *et al.* 1979, Gwyther & Sause 1985). Olsen (1955) considered its importance for the scallop fishery of D'Entrecasteaux Channel, and found that the Channel fishery depended on occasional heavy spat settlement, which might sustain the fishery for up to nine years. He speculated that the successful settlement of spat was dependent on a delicate

balance of environmental variables; others have proposed specific biological and physical variables as controlling factors, including food availability (Franklin *et al.* 1980), water temperature (Dow 1962 *in* Serchuk & Rak 1983), and wind, current, and rainfall (Campbell 1984).

Attempts have been made to minimise the adverse effects of variable spatfall and recruitment. The management of many scallop fisheries relies heavily on pre-season spat collection programmes and/or dive surveys over scallop beds, such as in the Port Phillip Bay scallop fishery (Gwyther & Sause 1985) and the United Kingdom scallop fishery (Franklin et al. 1980). Pre-season dredge surveys over scallop beds, similar to those made in D'Entrecasteaux Channel, are also undertaken in the U.S.A. and Canada (Serchuk *et al.* 1979).

In Japan the routine production of scallop spat for re-seeding or aquaculture has resulted in a ten-fold increase in the total scallop catch, and in the U.S.A. and France it has increased production and helped stabilise the scallop industries (Miller *et al.*, *in* Campbell 1984). In Golden Bay (New Zealand) re-seeded areas are now increasing the availability of scallops for fishermen and consumers (Anon. 1986b).

In Tasmania spat forecasting has been tried but proved unsuccessful, while dredge surveys are used routinely prior to the opening of the D'Entrecasteaux Channel scallop season. Recent success with the production of hatchery-reared scallop spat (Anon. 1986a) suggests that improvements in total catch and an increasing degree of industry stability (via scallop aquaculture and re-seeding) may be feasible in the D'Entrecasteaux Channel scallop fishery in the near future.

Toxins

The second biological problem is the presence of toxic dinoflagellates. Dinoflagellates are planktonic unicellular algae and are part of the food chain for many marine organisms. Some dinoflagellate species produce potent neurological toxins, and these may be accumulated in filter-feeding organisms such as oysters, mussels and scallops, posing a threat to humans who eat these molluscs. Of the 1500 or so known dinoflagellates, only 20 are known to produce paralytic poisons (Hallegraeff & Sumner 1986) but problems with these toxic dinoflagellates are world-wide (Yentsch 1984).

In 1986 there was no Channel scallop season, partially due to the presence of high numbers (a "bloom") of the toxic dinoflagellate *Gymnodinium catenatum* Graham in various parts of the Channel, and high levels of toxins in oysters, mussels and scallops from these areas (Oshima *et al* 1987). This discovery resulted in the temporary closure of 14 aquaculture farms growing oysters and mussels in the Port Cygnet and lower Huon River area (Hallegraeff & Sumner 1986).

A monitoring programme was instigated to test for the dinoflagellates in the water column and toxins in the shellfish. Samples of scallops from the D'Entrecasteaux Channel were tested at the Institute of Medical and Veterinary Science in Adelaide and found to contain high toxin concentrations in the flesh and gonad, and low concentrations in the adductor muscle (DSF 1986).

The high populations of *Gymnodinium catenatum* may have been due to the heavy summer rains in 1986, which lowered salinities in inshore regions (which apparent favours some dinoflagellates), increased organic and inorganic runoff from agricultural land, and stabilised the water column due to freshwater inflows (*The Mercury* 26 July 1986, p.5, Hallegraeff & Sumner 1986).

The importance of this dinoflagellate bloom in 1986 to the viability of the D'Entrecasteaux Channel scallop fishery cannot be overstated. The major question facing scallop managers at this stage is, will these events prove to be an isolated incident or can these blooms be expected each year? It should be remembered that prior to a 1985–86 CSIRO plankton survey of Tasmanian waters (which included D'Entrecasteaux Channel), no work had been published on Channel phytoplankton. It is thus possible that *Gymnodinium catenatum* has been present each year with little apparent health risk. The answer to this question will not be known until a number of seasons have been monitored.

Changes in Species Abundance

A third biological consideration is that there have been a number of changes in the relative abundance of scallop species taken in the D'Entrecasteaux Channel. In the 1920's and in the period 1940–70 commercial scallops formed the bulk of the catch, but in the 1930's and since 1982 doughboy scallops have been more abundant.

The causes of the changes in species abundance are not known, but as far as the Channel is concerned, management policy needs to encompass all three species of scallop present, and research on scallop re-seeding should be expanded

to include the doughboy scallop, particularly if it is found that there has been some environmental change in the Channel which favours this species.

Pollution

Fourthly, pollution by human waste such as sewage, insecticide sprays and industrial pollution have been suggested as causes of the declining scallop populations in the Derwent River and D'Entrecasteaux Channel (*The Mercury* 8 July 1910, p.6, 13 June 1969, p.8, Harrison 1975). Scallop sensitivity to pollution is great and is demonstrated by the fact the U.S.A. Environmental Protection Agency now uses scallops as indicators of changing environmental conditions, such as eutrophication and siltation (Robert 1978). With only a few exceptions (e.g. Newell 1969) there is a lack of data on pollution levels in the Channel. However, it seems reasonable that the increasing urbanisation of the Channel environment might lead to increasing pollution levels, with consequent adverse affects on scallop stocks.

Administrative Problems

Over-exploitation

Excessive fishing effort is one of the major problems facing managers of the Channel scallop fishery. When a common resource is utilised there is a tendency for it to be depleted, as each individual exploiting it perceives profits and increases capital investment to maximise his/her share of the resource.

Because the Channel scallop fishery was open to all who wished to fish for scallops, there was a tendency to over-use it while profits could be perceived. This over-use has been exacerbated by the escalation of fishing effort by amateur fishermen.

The major problem arising from over-use of the resource is the effect on the spawning stock level. There is evidence to suggest that scallop stocks in the Channel fluctuate independently of the parental spawning stocks (SFABT Subcommittee 1964, Olsen 1955) but that there may exist a critical population level below which recovery of a decimated population may not occur (Harrison 1965). Whatever the case may be, it is desirable to know the size of an adult spawning stock that is sufficient to ensure adequate recruitment (McKenzie *et al.* 1978).

Dredging Damage

In D'Entrecasteaux Channel the use of dredges to harvest scallops causes significant damage to the scallops and to the sea bed itself. Damage to the scallops of the Channel by dredging was the major subject of a Tasmanian Senate Select Committee Inquiry in 1960 and 1961. The inquiry did not find conclusive evidence on the damage done by the different types of dredge in use, but it did take heed of fishermen's comments and personal observations of the Committee members and recommended the banning of spiked dredges in the Channel (SCLC 1960, 1961).

Overseas experience has shown that dredging can cause considerable physical damage to benthic fauna (Caddy 1973, Dupouy 1983) while in Port Phillip Bay, Victoria, dredging has been implicated in the increase in levels of heavy metals in the water over scallop beds (Fabris 1981). Disturbance of the bottom by dredging and consequent destruction of the prawn habitat has resulted in all dredges being banned in the Shark Bay fishery in Western Australia (Rogers *et al.* 1983). On the other hand, two studies have revealed that little damage is done by dredging (McShane 1981, Butcher *et al.* 1981). This is surprising, but it should be remembered that destruction of the sea bed is related to the sediment type, for example damage to open sandy sea beds, where species diversity is often low, may be minimal (Butcher *et al.* 1981).

Alternatives to scallop dredges include the Queensland-style beam trawl which has been trialed off Table Cape in northern Tasmania. The results indicated that the beam trawl caught fewer by-products such as sponges, bryozoa etc., more legal-size scallops, fewer undersize scallops, and fewer damaged scallops than the dredge (Wolfe 1986).

Scallop Seasons

Scallop seasons are invoked for three major reasons: to maximise the yield per scallop, to protect scallop stock from excessive fishing effort (Rogers *et al.* 1983), and to protect juvenile scallops.

The imposition of a scallop season has been criticised on the grounds that the seasonal limitation on effort does not effectively restrict fishing pressure (SFABT Subcommittee 1964, Mason 1983). However, in the Channel fishery, where scallop stocks are subjected to large fishing pressure, the length of the scallop season has been

one of the major management considerations for regulating fishing effort.

Aquaculture

Marine species currently being farmed in D'Entrecasteaux Channel include Atlantic salmon (*Salmo salar*), rainbow trout (*Salmo gairdnieri*), oysters (*Crassostrea gigas*), mussels (*Mytilus edulis planulatus*), and commercial scallops (*Pecten fumata*); there are now 26 aquaculture farms throughout the Channel and several more about to begin operations.

Two main problems are posed by aquaculture for fisheries managers, the restriction on traditional anchorages and activities for recreational fishermen, and the potential damage to marine ecosystems by waste food and faecal matter from fish farms.

The majority of objections to the establishment of marine farms in D'Entrecasteaux Channel which have been received by the Department of Sea Fisheries have been on grounds that safe anchorages and prime fishing locations are being taken over (J. Grant, pers. comm.). For example, the recent application for a salmon farm lease near Partridge Island resulted in at least 40 objections on the grounds that the farms would take away a protected anchorage and create a navigation hazard.

The development of Atlantic salmon and sea trout farms may involve a significant increase in the nutrient load for the Channel. In Scotland, where these types of farms have been established for over a decade, significant changes to the marine ecosystem have been recorded in the vicinity of the farms. These have included the sediments beneath the fish farms becoming anoxic, the macrofauna becoming impoverished, and the occurrence of marine organisms characteristic of highly enriched sediments (Gowen *et al.* 1985). While it is too early to predict the likely effects of fish farms on the Channel environment, the results here could be much the same. Therefore the Department of Sea Fisheries plans to monitor these by establishing an environmental monitoring section (M. Hortle, pers. comm.), an essential development if problems encountered in fish farms overseas are to be ameliorated here and existing conflicts between recreational fishermen and marine farm applicants successfully resolved.

THE FUTURE FISHERY: AMATEUR OR PROFESSIONAL?

The importance of amateur fishing to Australians is only now becoming apparent. The first national recreational fishing survey, in 1983–84, found that $2200 million was spent on recreational fishing in Australia in the 1983–84 financial year, making it at least as large as the professional fishery (Anon. 1986c). A 1983 Australian Bureau of Statistics (ABS) survey of non-commercial fishing activities (ABS 1984) showed that 49.9% of households surveyed owned fishing rods and reels, 23 713 boats were owned and used for fishing, and 107 000 Tasmanians who fish each year spend approximately $49 million per annum on recreational fishing. Compared with a total commercial catch for 1983–84 of $38 million (Schaap 1986) this shows the importance of amateur fishing to the Tasmanian economy. Scalloping in D'Entrecasteaux Channel has become an important amateur activity for many Tasmanian residents, and according to the president of the TASFA (D. Paton) it probably now rates as the biggest single recreational sea fishery in the country (Anon. 1983a). The major attractions of the Channel for amateur fishermen are that it is within easy reach of Hobart and is a relatively sheltered and safe waterway for small boat usage. While some take scallops for economic reasons, most fish for enjoyment and relaxation. This presents a number of difficulties for scallop managers, who must widen their aims to take account of social objectives such as quality of experience and non-consumptive activities such as underwater photography.

The channel is currently suffering from excessive fishing effort, and its declaration as an amateur-only fishery would be one way to decrease fishing pressure. Although the ratio of amateur to professional boats from the Channel is 7:1, the permissible catch ratio is 1:15 (in 1985): the professional fisherman can take 15 times as many scallops as his amateur counterpart, the professional component thus exerting twice the fishing pressure of the amateur component.

There are, however, arguments for the continuation of the fishery in its existing amateur/professional mode. Firstly, if the scallop stocks are capable of withstanding fishing pressure from both groups, it is difficult to rationalise an amateur-only status for the fishery. This approach is taken in Victoria by the Commercial Fisheries Branch of the Department of Agriculture and Rural Affairs: their

philosophy and policies of management require that the resource should be managed as harmoniously as possible where the resource can support both fisheries (Winstanley 1985). Secondly, the Channel fishery is an important winter living for some professional fishermen, providing a viable alternative to crayfishing for a short while. There are many professional boats with a long historical association with the Channel fishery, and scallop managers throughout the world have shown a tendency to regard historical associations as grounds for a right of access to the resource (e.g. Sturgess et *al.* 1982, Anon. 1985b). These historical association rights, while not enshrined in legal respectability, would make it politically difficult to introduce an amateur-only fishery.

The establishment of a professional-only scallop fishery in the Channel is difficult to justify. Firstly, the Channel stocks are in a depleted state, and many professional fishermen would find it non-viable to fish here. Secondly, the mobilisation of recreational fishermen into a coherent unit via the TASFA would militate against any moves to establish such a professional-only fishery Finally, from the viewpoint of society in general, the benefits of allowing numerous Tasmanian residents access to a safe and sheltered waterway far outweigh the benefits of allowing a select few to extract a living from a depleted fishery.

DISCUSSION AND CONCLUDING REMARKS

The historical catch data (fig. 2) and the recent decline in catch per unit effort (table 1) indicate that the D'Entrecasteaux Channel scallop stocks have been overfished and are in a depleted state. The specific reasons for the depletion of scallop stocks in the Channel are not proven, but the use of the "Sputnik" dredge, the disguised fall in catch per unit effort, increasing pollution levels, and the extra-long scallop seasons of 1964, 1967, 1968 and 1969 could all be included. Whatever the reasons may be, it is imperative that existing stocks be carefully nurtured and enhanced.

Overall Management

The primary management aim should be to ensure the long-term viability of scallop stocks in the Channel in sufficient numbers to support at least an amateur fishery. It is suggested that the D'Entrecasteaux Channel scallop fishery should be amateur-only while scallop stocks are low, the optimum sustainable yield being equated with the yield that guarantees amateur fishermen at least a short season, while protecting the scallop stocks. If stocks increase, a small-scale professional fishery could be allowed, and the small-boat owner who has a history of fishing in the Channel, who cannot safely fish elsewhere, and who relies on the Channel fishery for an important part of his livelihood should be given first option of fishing. If a professional fishery proved viable, a landings tax on scallops should be considered to assist in meeting management costs. Such a tax could be seen as reflecting the costs of the fishermen's actions to Tasmanian society in general.

Any proposed management plan will fail unless it is clearly understood and supported by fishery participants (at present there is reasonable harmony between the amateur and professional fishing components of the fishery and the Department of Sea Fisheries, indicating support for existing management practices). In particular, the close liaison between the Department of Sea Fisheries and the TASFA should be maintained, the participation of the TASFA in the management process should be enhanced by wider publication of the reasons behind management decisions, and the results of the pre-season survey should be widely communicated.

Regulations

The regulations concerning hours of fishing, scallop-size limits and the control of on-board shucking should remain. The present bag limits, which have provided scallop managers with a mechanism for maintaining close control over fishing effort, should also be maintained, and if fishing pressure is deemed excessive they should be tightened. The present ban on the taking of commercial scallops is sensible: it too should be maintained and could be extended to include doughboy scallops if they become scarce.

The licence fee, which needs to be commensurate with management costs (such as those for pre-season surveys, enforcement and research), could be increased. The present bag limit of 400 scallops per day results in approximately 6 kg of scallop meat (D. Fehre, pers. comm.), and at a conservative price of $8 per kg this represents considerable reward to amateur fishermen (assuming they are taking the bag limit each day). An increase in licence fees could contribute towards the administration and enforcement costs of the fishery, and possibly towards the cost of re-seeding depleted areas of the Channel. If licence

fees are increased, the reasons for this should be clearly communicated to participants.

If the Channel fishery should become an amateur-only fishery, the length of the season should be increased to avoid the congestion which accompanies the present short season. If the fishery remains an amateur/professional fishery then divers-only areas should be designated for the protection of the divers. The current system of opening and closing fishing areas seems reasonable, and provides a degree of protection to over-exploited and juvenile stocks. Consideration should be given to the permanent closure of one area, so that the effects of fishing on adjacent areas could be more easily assessed.

The lip dredge is conditionally recommended for continued use in the Channel fishery, pending further research on the damage done by the different types of scallop dredges.

The annual, pre-season survey should continue and be enhanced by diving surveys and, possibly, occasional underwater television monitoring of the scallop stocks; permanently closed areas should also be monitored for signs of alteration in the relative abundances of doughboy, commercial or queen scallops. The results of these surveys should be published and distributed as widely as practicable prior to the opening of the season, possibly in conjunction with the sale of a licence.

Enforcement and Fines

It seems likely that enforcement levels in the Channel could not be increased greatly owing to the shortages of resources but some reassessment of enforcement activities is required. In particular, an increase in surveillance levels by the Marine Board Inspectors should be considered.

Penalties for transgressions need to be increased so that poachers and cheats will be dissuaded from further breaching the law. Consideration should be given to having a Department of Sea Fisheries barrister present cases in court to bring about a greater realisation of the importance of protecting the fishery.

Research

Overall, research on scallops in the Channel should be upgraded. A spatfall monitoring programme implemented at selected sites would lead to a better understanding of the biology of the Channel scallops and the factors which influence spatfall, and might provide early estimates of recruitment, as well as of scallops for re-seeding purposes.

Re-seeding research should be increased, and the possibilities of generating income by the sale of rights to fish a re-seeded area should be examined. In Golden Bay the New Zealand Government, in conjunction with Japanese consultants, re-sowed an area of depleted scallop beds in 1984; harvesting of the area was expected to commence in November 1986 (Anon. 1986b). The establishment and harvesting of re-seeded areas thus seems possible, and may be appropriate for the D'Entrecasteaux Channel. Income for the scheme could be generated from the sale of rights to fish the re-seeded area.

Aquaculture of scallops in the Channel should be encouraged. There is already an experimental farm at Tinderbox (G. Squires, pers. comm.); such farms should be assisted, as they would contribute directly to the strength of the annual scallop recruitment and thereby enhance the Channel scallop stocks.

A full assessment is needed of the damage done by different scallop dredges, and the development of new fishing techniques should be encouraged. This encouragement could take the form of special permits to trial dredges in the Channel, or help for applicants in obtaining research and development grants from sources such as the Fishing Industry Research Committee. There is also a need for instruction for fishermen, showing the correct method of towing dredges, to offset the damage done by towing full or incorrectly set dredges. This also could be achieved by distributing a leaflet with the scallop licence.

Conclusion

The D'Entrecasteaux Channel scallop fishery is of great historical and social importance, and its present depleted state is deplorable. The survey report of 1985 contains three lines of management aims and objectives (Zacharin 1985) which are totally inadequate to prevent *ad hoc* decisions on fishing regulations, amateur/professional participation in the fishery, or research aims and objectives. If the scallops in the Channel are to provide food, recreation and possibly economic returns in the long term, a comprehensive management plan with clear goals and objectives is required.

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