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Foveaux Strait oyster (*Tiostrea chilensis*) assessment 1993

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1. EXECUTIVE SUMMARY

1. Mortality from *Bonamia* sp. reduced the Foveaux Strait oyster population from probably 1500 million in 1985 to 319 million by February 1992. In 1992 most of the fishery was closed and limited commercial fishing was permitted around the periphery. As the population was below 10% of the estimated virgin stock (a size at which recruitment is likely to fail), the fishery was fully closed in 1993 to allow the stock to rebuild.

2. A survey of the oyster population in October 1993 found that it was not significantly different in size from 1992. If *Bonamia* sp. is still causing mortality, it is at a low level and limited to the periphery of the oyster population.

3. Recruitment appears to have failed in the part of the oyster population that was first infected by *Bonamia* sp. and in which oyster density was very low by 1990. Recruitment in the east and around the southern perimeter of the population appears unaffected, but many of the recruits present had settled before *Bonamia* sp. reduced oysters there to very low densities.

4. Numbers of immediate pre-recruits were estimated to be 360 million in the 1993 survey. If growth and survival over the summer are high the oyster population could increase considerably by 1994. The CAY estimate of 27 000 sacks suggests that a yield of 8000 sacks (40% of the lower bound of the CAY estimate) is likely to be available from the fishery in 1993.

2. INTRODUCTION

In 1985 the oyster population was probably 1500 million (Doonan & Cranfield 1992). In 1986 *Bonamia* sp. caused localised high mortalities of oysters, which progressively spread through the population in the following years. The oyster population was reduced to 632 million by July 1990, and to 319 million by February 1992 (Doonan & Cranfield 1992).

In 1992 the population was below 10% of the virgin stock at which level recruitment was considered likely to fail (Allen 1979). Consequently the fishery was partially closed in 1992 and fully closed in 1993 to allow the population to rebuild. Exploratory commercial fishing was permitted around the periphery of oyster distribution in 1992 to substantiate stock size in this area; the maximum allocation of 18 400 sacks could not be caught and the mean catch rate was slightly over half that of 1991. An allocation of 4000 sacks under a special permit for the enhancement programme in 1992 could not be all caught either (fishing under the permit was spread uniformly over the entire oyster population by regulation).

Bonamia sp. was not monitored in 1993, so it is not clear what further mortality may have occurred. If mortality continued at levels similar to those of the past, the oyster population could have been reduced to a very low level by the spring of 1993; if mortality had diminished and recruitment was unaffected, the population could have remained static or even have increased.

In 1991 the Oyster Boat Owners Association was granted a special permit to enhance the oyster population using spat settled on oyster shell. Few oysters were caught for this purpose

in the 1991 breeding season. In 1992 the Bluff Oyster Enhancement Company was formed to develop this work and was granted a special permit to harvest 4000 sacks in the 1992 breeding season. The company landed 3141 sacks in 1992, and applied for 8000 in 1993 to extend operations. Because of uncertainty in the size of the stock by 1993, MAF Fisheries gave the company a permit to catch 4000 sacks and asked for an estimate of recruited and pre-recruit population size to assess the effect of harvesting a further 4000 sacks. In October 1993, the Bluff Oyster Enhancement Company contracted MAF Fisheries to survey the population.

2.1 Overview

In 1993, the size of the recruited population and numbers of immediate pre-recruits were estimated from a grid pattern dredge survey with a *c.v.* of 14%. The distribution of oysters, pre-recruits, and past mortality from *Bonamia* sp. were mapped. The management implications of the results are discussed.

2.2 The fishery

The fishery was described by Doonan & Cranfield (1992).

2.3 Literature review

Past work was reviewed by Cranfield *et al.* (1991) and Doonan & Cranfield (1992).

3. REVIEW OF THE FISHERY

3.1 Catch and catch rate

Catch is controlled by an annual catch limit allocated equally among the 23 vessels participating in the controlled fishery. Up to the outbreak of *Bonamia* sp. in 1986, individual vessel allocation was 5000 sacks. Annual catch limits have changed several times since then, and by 1991 were down to 2000 sacks. In 1992 and 1993 the fishery was closed to allow the stock to rebuild. The landings and catch rate of the exploratory fishing allowed around the periphery in 1992 are shown in Table 1 as are the landings and catch rate of the special permit fishing over all the oyster beds in 1992.

Table 1: Oyster catch, total allocated catch, individual vessel allocation, and the average catch rate 1986–92

	Catch (sacks)	Total allocated catch (sacks)	Individual vessel allocation (sacks)	Mean catch rate (sacks per hour)
1986	77 880	115 000	5 000	10.32
1987	61 544	64 400	2 800	10.90
1988	87 477	92 000	4 000	10.00
1989	85 029	92 000	4 000	10.70
1990	46 114	46 000	2 000	6.40
1991	54 000	46 000	2 000	5.80
1992*	5 822	18 400	800	3.24
1992†	3 141	4 000	–	4.96

* Exploratory commercial fishing in the periphery of oyster distribution.
† Commercial fishing spread uniformly over the whole oyster-bearing area under special permit.

3.2 Maori and recreational fishing

None known.

4. RESEARCH

4.1 Resource surveys

Resource surveys were conducted between 1960 and 1962, and in 1974, 1975, 1990 (Cranfield *et al.* 1991) and 1992 (Doonan & Cranfield 1992) and 1993 (Appendix 1).

4.2 Population size estimates

Estimates of population size are given in Table 2.

Table 2: Population size estimates in numbers of legal-sized oysters (≥ 58 mm length) in Foveaux Strait. Pre-1990 estimates are from Cranfield *et al.* (1991); 1990 and 1992 estimates are from Doonan & Cranfield (1992); 1993 from Appendix I

Year	Population (millions)	*c.v.* (%)
1960–62	1400	?
1974	1800	20
1975	1500	11
1990	689	13
1992	319	10
1993	370	14

4.3 *Bonamia* sp. studies

The life history of *Bonamia* sp. was discussed by Hine (1991a, 1991b), and its impact on the oyster population discussed by Doonan & Cranfield (1992). The distribution of infection was

not investigated during the 1993 survey because *Bonamia* sp. cannot be detected reliably in infected oysters during October (*see* Hine 1991a).

4.4 Yield estimates

4.4.1 Estimation of Maximum Constant Yield (MCY)

The yield through the late 1960s and early 1970s was considered sustainable, and the population in 1975 was thought to be in equilibrium with this rate of fishing. Hence the population estimate of 1975 (1500 million oysters) would be a reliable estimate of B_{av} before the outbreak of *Bonamia* sp (B_{av} is the average historic recruited biomass of a fully exploited fishery). The high mortalities from *Bonamia* sp. have caused the population to decline steadily from 1986 to 1992 which voids the use of B_{av} over this period to estimate MCY.

4.4.2 Estimation of Current Annual Yield (CAY)

CAY was estimated from the Baranov catch equation (Method 2 in Annala 1993) where the fishing mortality occurs over a short period at the beginning of the year.

$$CAY = (1-e^{-F_{ref}})B_{beg}$$

B_{beg} is the recruited biomass at the beginning of the fishing year; F_{ref} is the level of (instantaneous) fishing mortality that, if applied every year, would, within an acceptable level of risk, maximise the average catch from the fishery. B_{beg} was set equal to the population estimate of 370 million oysters from the 1993 dredge survey. The estimated exploitation rate in 1975 was 0.073 which was used as an estimate of F_{ref} (Doonan & Cranfield 1992). As it is an exploitation rate this is really an estimate of $(1-e^{-F_{ref}})$ so

CAY = 0.073 * 370 million oysters (95% CI, 266–474 million)
= 27 million oysters (95% CI, 19.4–34.6 x million)
= 27 000 sacks (95% CI, 19 400–34 600 sacks)

The level of risk to the stock by harvesting the population at the estimated CAY cannot be determined.

5. FACTORS MODIFYING YIELD ESTIMATES

Given the current state of the stock, the CAY estimate needs to be modified by the following factors when determining catch levels.

5.1 Continuing mortality from *Bonamia* sp.

The distribution of mortality over the winter of 1993 (Appendix 1) suggests that *Bonamia* sp. may have caused some mortality at the limits of oyster distribution. However, the total population has not changed significantly in size since 1992.

In theory, epizootics of very infectious organisms proceed in a series of damped waves. The first wave of infection reduces the host population to a low density at which the disease cannot spread, and infection drops to undetectable levels. As the host population rebuilds, infection breaks out and once more reduces the host density to a low level and again disappears, and so on until the host population reaches a new (and lower) equilibrium with the infection. Recovery of the oyster population could, therefore, be followed by a fresh outbreak of infection by *Bonamia* sp. The distribution of infection by *Bonamia* sp. should be monitored regularly to check this possibility.

5.2 Effect of low population size on recruitment

Doonan & Cranfield (1992) outlined the risk of recruitment failure at low population levels. The distribution of pre-recruits, particularly those likely to recruit to the population over the next summer, suggests that recruitment has failed in the far western and central western areas of Foveaux Strait (Appendix 1). If recruitment has failed in the southern and peripheral areas, the failure will not be apparent until pre-recruits can be sampled reliably in 4–5 years' time.

5.3 Concentration of fishing on only a few populations

Only a small fraction of the total stock is now in populations dense enough to support a commercially acceptable catch rate. Concentrated fishing in these areas alone might reduce their densities to levels that result in a local collapse of recruitment. To avoid this, any fishing needs to be spread uniformly, even within the area that still supports moderate densities of oysters.

6. MANAGEMENT IMPLICATIONS

Mortality from *Bonamia* sp. has apparently continued at low levels at the limits of the oyster distribution. Even in the absence of significant fishing mortality over the last 2 years, the oyster population did not increase in size between 1992 and 1993.

The population is below 10% of its virgin size, a level at which recruitment is likely to fail. Recruitment failure is indicated in the far western and central western areas where *Bonamia* sp. reduced oyster densities to very low levels some 4–5 years ago.

The population of immediate pre-recruits was estimated to be 360 million oysters in the 1993 survey. If growth and survival over the summer are high the oyster population could increase considerably in size by 1994. The population should be resurveyed in 1995 to reassess its status. The CAY estimate suggests that a yield of 8000 sacks (40% of the lower bounds of the 1993 estimate of CAY) is likely to be available from the fishery in 1993.

7. ACKNOWLEDGMENTS

We thank Paul Breen, Malcolm Clark, Paul Cresswell and especially John Annala who have critically reviewed this document and suggested constructive changes. The Bluff Oyster Enhancement Company funded the sampling and provided the vessels.

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APPENDIX 1

COMMERCIAL VESSEL GRID SURVEY OF FOVEAUX STRAIT OYSTERS IN 1993

Report to the Bluff Oyster Enhancement Company

1. SURVEY

1.1 Methods

The survey took 6 days between 18 and 27 October. The grid design and sampling procedures were kept as close as possible to those of the 1990 and 1992 surveys (*see* Doonan & Cranfield 1992). The number of stations and cost of the survey were reduced by sampling on a 1 n. mile grid over areas with the highest density of oysters in 1992, and a 2 n. mile grid over areas where density was uniformly low in 1992. The number of stations sampled was 177.

Two commercial oyster boats were provided by the Bluff Oyster Enhancement Company, *Golden Lea* (skipper Brian Hawke) and *Monica* (skipper Rex Ryan). Each vessel towed one

standard commercial dredge (3.35 m wide) in a straight line 0.2 n. mile (370 m) in a down-tide direction at each station. GPS was used to position the vessel for the start of the tow and to control the length of the tow. All oysters caught were sorted and counted in three categories; takeable oysters (≥ 58 mm in length), immediate pre-recruits (50–57 mm), and all remaining pre-recruits (10–49 mm). Clocks (articulated valves) of takeable size and pre-recruit size were counted as either clean or fouled (new clocks or old clocks).

1.2 Analyses

1.2.1 Contour plots

Data were contoured in the same way as in 1992 (*see* Doonan & Cranfield 1992).

1.2.2 Population Estimates

Population size and variance were estimated by treating the cells of the grid as strata with one station in each, following the methods described in the earlier surveys (*see* Doonan & Cranfield 1992). The efficiency of the two vessels was taken to be the same as catches by different vessels at common stations in the two previous surveys did not differ significantly (Doonan & Cranfield 1992).

The absolute population size was estimated assuming that the mean dredge efficiency was the same in 1993 as it was in 1990 (*see* Doonan & Cranfield 1992).

2. RESULTS

2.1 Distribution

The distribution of legal-sized oysters was similar to that found in 1992 (Figure 1). The apparent broad extension of distribution north of the Mutton Bird Islands in the central area of Foveaux Strait is carried by two stations in the 2 n. mile grid area and may not reflect the true distribution there as most dense patches of oysters found by Allen & Cranfield (1979) were less than 1 n. mile in their greatest dimension. The distribution of old clocks is almost exactly the same as in 1992 (Figure 2). The ligament of dead oysters takes 3 years to break down and hence these data indicate the area of high mortality over the last 3 years (*see* Doonan & Cranfield 1992) has not changed.

Mortality over the last winter (which may be the result of infection by *Bonamia* sp.) was found around the periphery of oyster distribution (Figure 3). The distribution of immediate pre-recruits (50–57 mm in length) is similar to the distribution of oysters in 1990 (compare Figures 4 & 1). Mortality from *Bonamia* sp. began in the far western and spread rapidly to the central western area of Foveaux Strait and the population has been very heavily reduced in this area; to 18% of the 1975 population of this area by 1990 and to 6% by 1992 (authors' data). There were very few 50–57 mm pre-recruits in this area in the 1993 survey. The distribution of the smaller pre-recruits, 10–49 mm in length, is similar to the distribution of legal-sized oysters in 1992 (compare Figures 4 & 1).

2.2 Population size

The takeable oyster population was estimated to be 370 million oysters (95% CI, 266–473 million). In 1992 the population in the same area was estimated to be 319 million (95% CI, 257–381 million). The oyster population in 1993 is not significantly different from that in 1992.

The population of immediate pre-recruits (50–57 mm in length) was estimated to be 360 million (95% CI, 259–461 million). As these are of a size that will be fully selected by the dredge (*see* Allen & Cranfield 1979) the estimate is likely to be accurate. The population of pre-recruits of 10–49 mm length, was estimated to be 538 million (95% CI, 431–734 million). Most pre-recruits of this size range which are not attached to oysters over 50 mm in length will be lost through the rings of the dredge bag, so this figure is likely to be an underestimate.

3. DISCUSSION

The number of takeable oysters is not significantly different from 1992. The distribution of new mortality suggests that *Bonamia* sp. may have caused some mortality in 1993 at the limits of oyster distribution. The similarity of the population estimates of 1992 and 1993 suggests this mortality has not been great. The distribution and intensity of infection by *Bonamia* sp. should be mapped when the disease is most easily diagnosed (in late February early March) to check that infection does not recur as oyster density builds up.

The low number of pre-recruits in the areas where population size had been most heavily reduced by *Bonamia* sp. suggests that recruitment will fail when populations are reduced to very low levels. The data indicate that recruitment is localised. This may be because most of the pre-recruits are attached to living oysters and this is the only surface on which they survive in good numbers. Hickman (MAF Fisheries, Greta Point, pers. comm.), recorded good settlement but poor survival of spat in Foveaux Strait on disarticulated shells of oysters and similar settlement but good survival on live oysters. If spat settle on other objects (or can metamorphose and survive culchless as they do in hatchery rearing techniques) localisation of recruitment could be largely the result of the limited dispersal of larvae before settlement (*see* Cranfield 1979, Cranfield & Michael 1989).

Unpublished data from 1979, 1980, and 1981, show oysters in a 50–57 mm length group grew an average of 5–7 mm each summer. These data suggest that, if survival is good, roughly half of the immediate pre-recruits will be added to the population in the summer of 1993–94. It remains to be seen whether *Bonamia* sp. will flare up again as these juveniles recruit to the population and oyster density increases.

4. ACKNOWLEDGMENTS

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communications. We thank Dave Fisher for his experienced help in planning and training staff and running the sampling work and Greg Meikle who was able to take part at such short notice.

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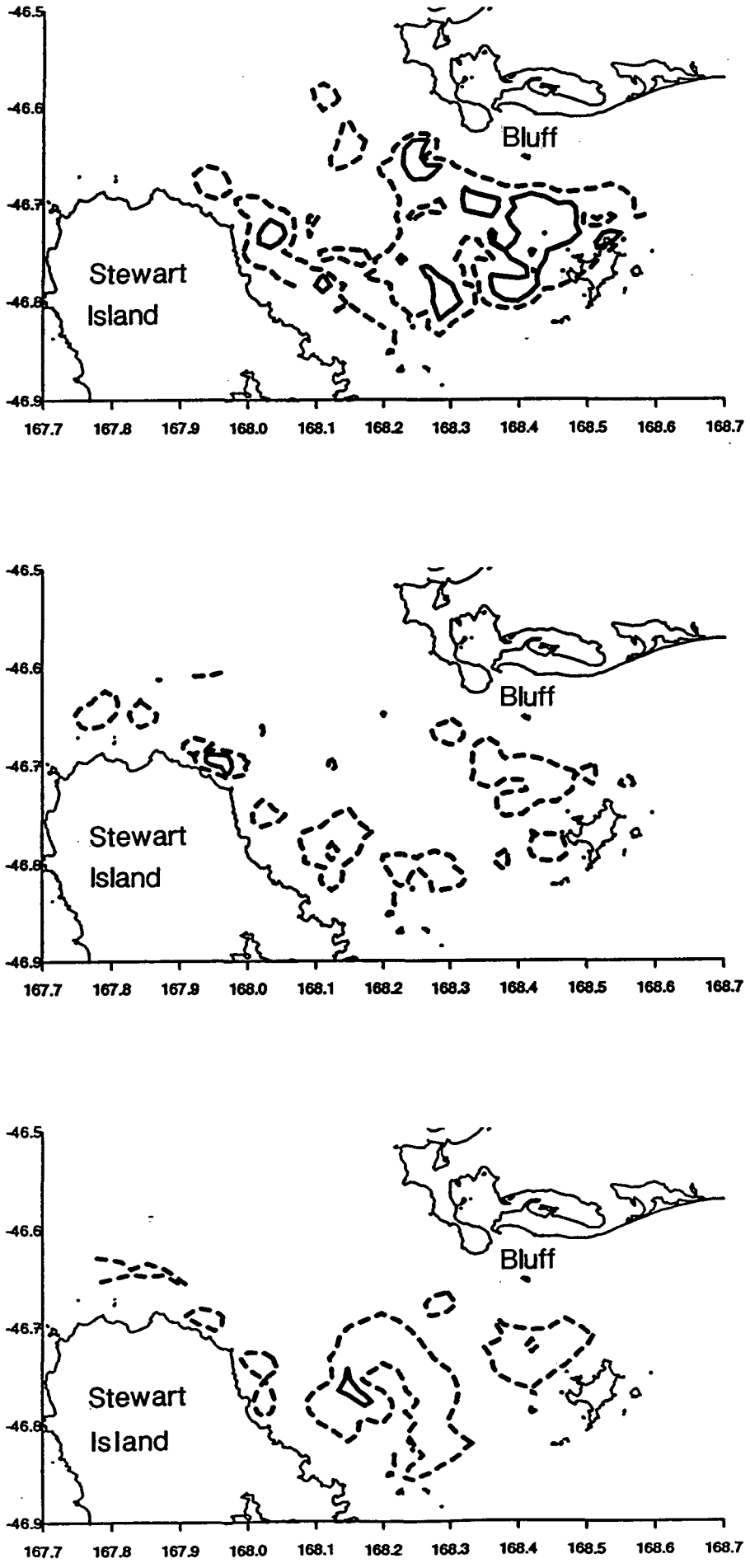

Figure 1: Catches of legal-sized oysters (≥ 58 mm in length) from the 1990 (top), 1992 (middle), and 1993 (bottom) surveys of Foveaux Strait, contoured at 101 (- -) and 400 (—) oysters per tow.

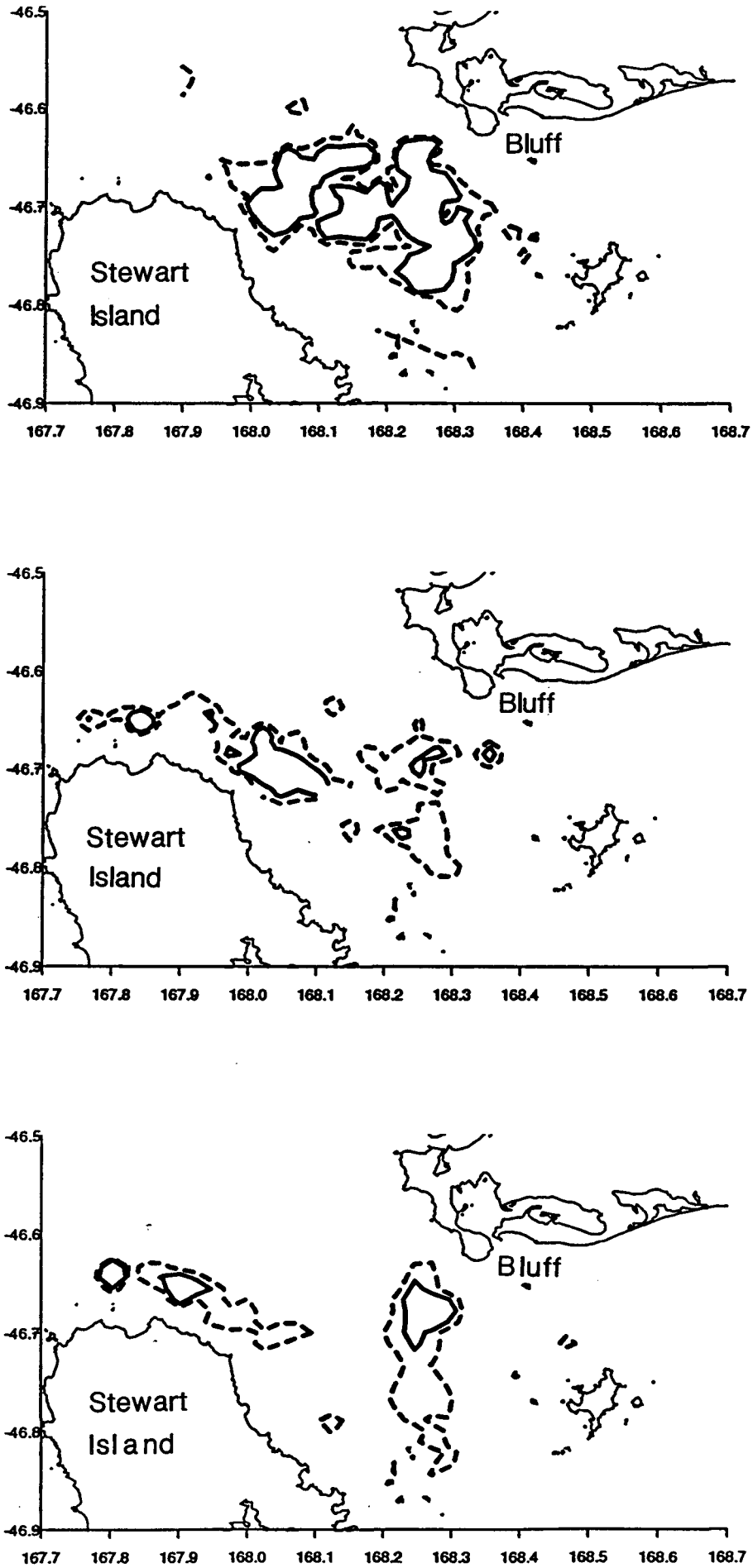

Figure 2: Catches of old clocks (articulated oyster shells that are fouled inside) from the 1990 (top), 1992 (middle), and 1993 (bottom) surveys of Foveaux Strait, contoured at 100 (- -) and 210 (—) per tow.

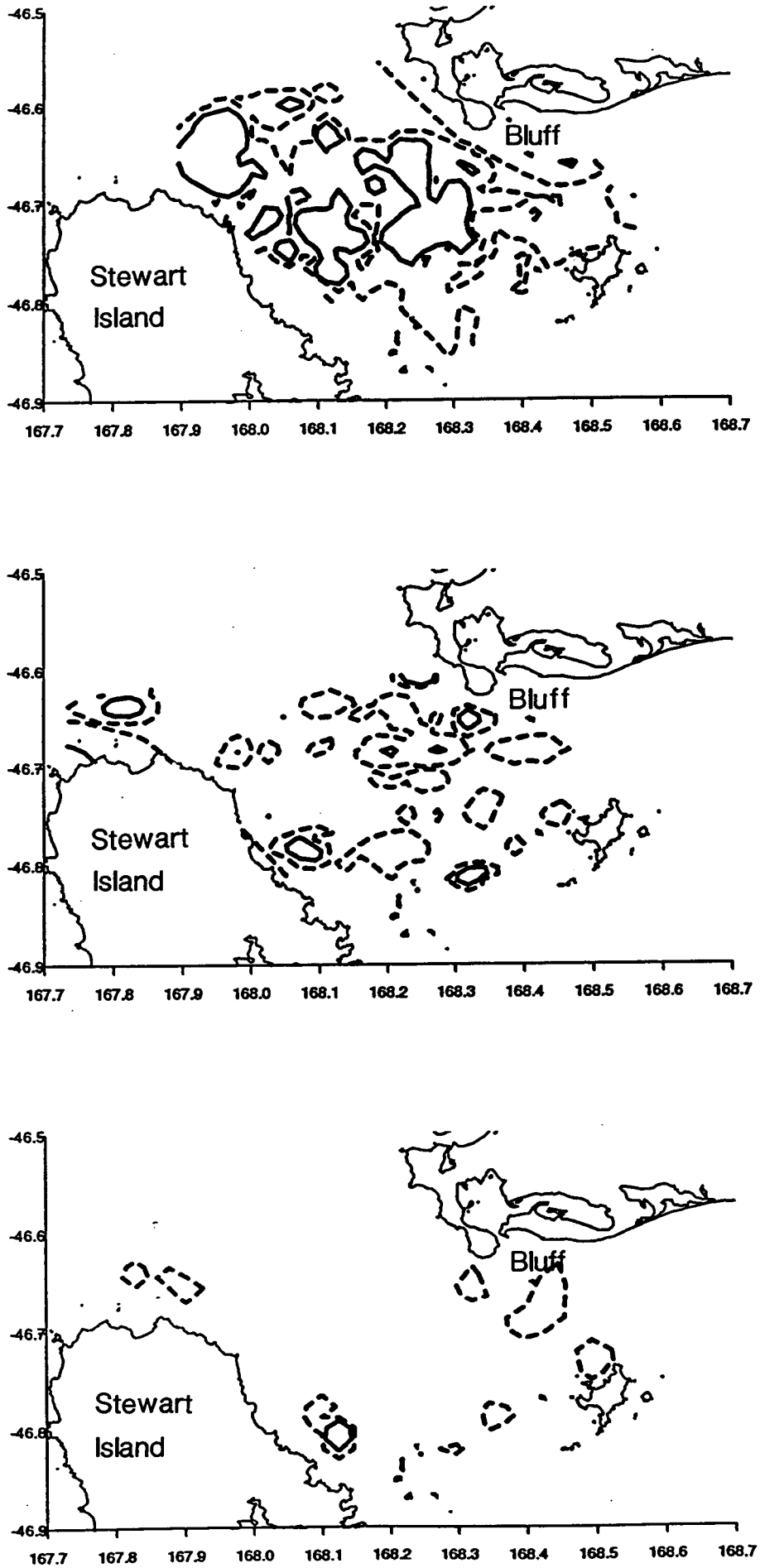

Figure 3: Recent mortality, defined by the ratio of new clocks (clocks with no internal fouling - oysters that had died in the previous winter period) to new clocks and live oysters; from the 1990 (top), 1992 (middle), and 1993 (bottom) surveys of Foveaux Strait. Contoured in levels of 1 % (- -) and 8 % (—).

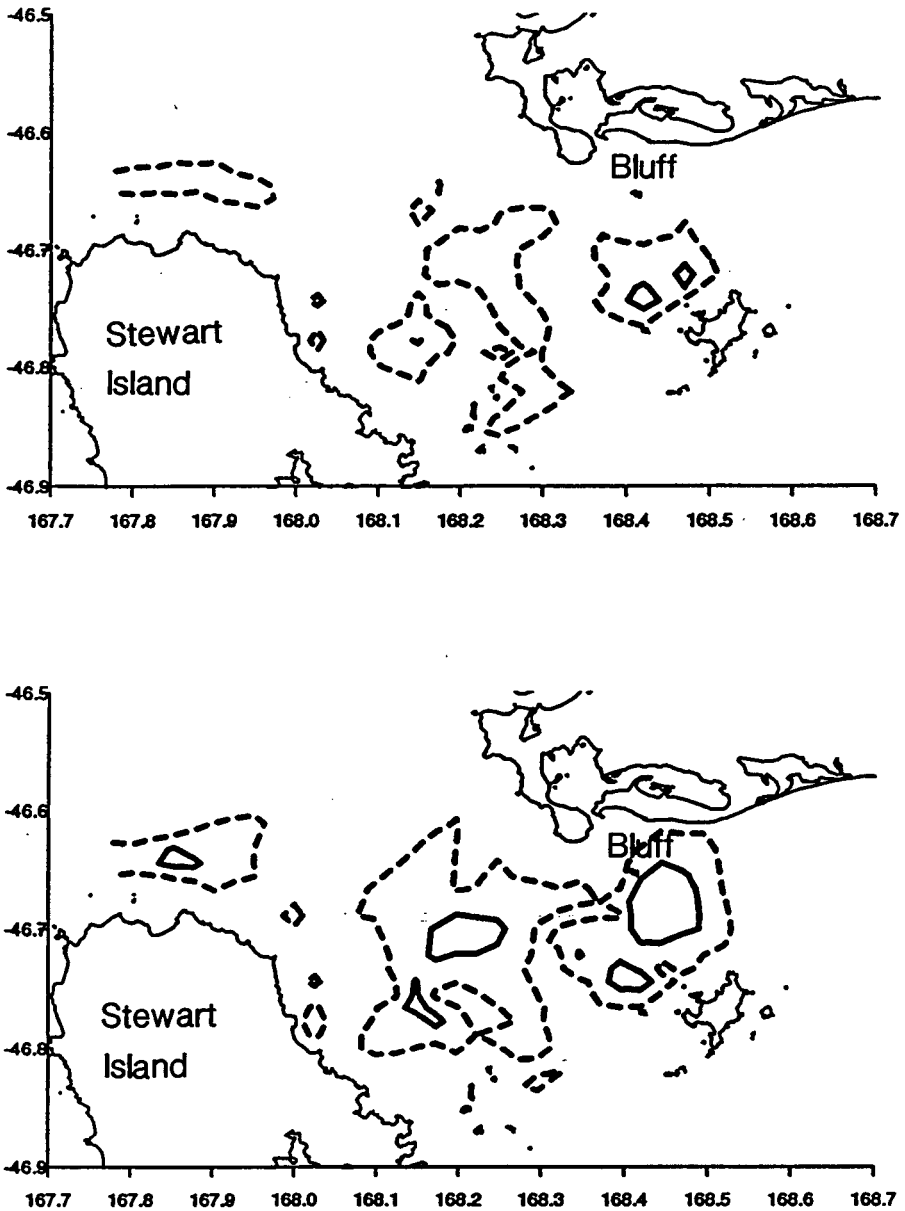

Figure 4: Catches of immediate pre-recruits (top), 50 - 57 mm in length and small pre-recruits (bottom), 10 - 49 mm in length, from the 1993 survey of Foveaux Strait, contoured at 100 (- -) and 400 (—) oysters per tow.