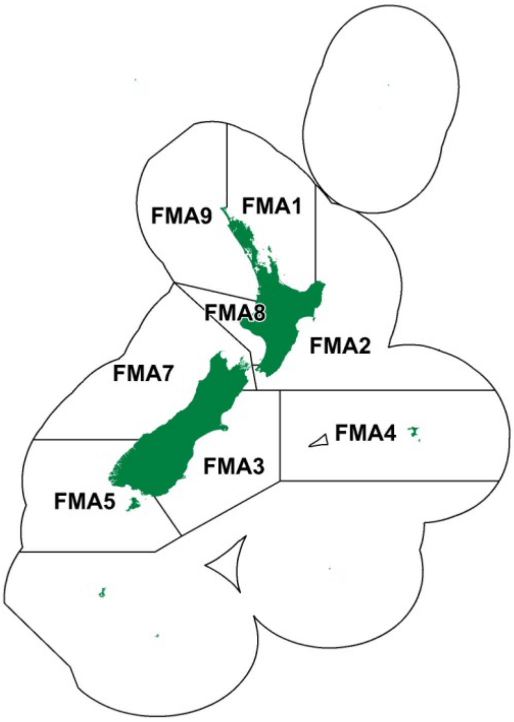
INTRODUCTION - SURF CLAMS

Surf clam is a generic term used here to cover the following seven species:

Deepwater tuatua	*Paphies donacina*	(PDO)
Fine (silky) dosinia	*Dosinia subrosea*	(DSU)
Frilled venus shell	*Bassina yatei*	(BYA)
Large trough shell	*Mactra murchisoni*	(MMI)
Ringed dosinia	*Dosinia anus*	(DAN)
Triangle shell	*Crassula aequilatera*	(SAE)
Trough shell	*Mactra discors*	(MDI)

The same FMAs apply to all these species and this introduction will cover issues common to all of these species. Each species has its own chapter.



1. INTRODUCTION

All surf clams were introduced into the Quota Management System on 1 April 2004. The fishing year is from 1 April to 31 March and commercial catches are measured in greenweight. Reported landings for the 2022-23 fishing year are considered preliminary. There is no minimum legal size (MLS) for surf clams. Commercial fishers may return surf clams to the waters from which they were taken if the return takes place as soon as practical and they are likely to survive, as provided for in the Fisheries (Landing and Discard Exceptions) Notice.

The development of hydraulic dredges, facilitated by the New Zealand Fishing Industry Board in 1985, enabled the potential for surf clam fisheries on exposed surf beaches to be investigated. Exploratory surveys between 1988 and 1992 found high densities of surf clams off beaches in Poverty Bay, the Kapiti and Manawatu coasts, Marlborough, Pegasus Bay, and Oreti Beach in Southland.

Before surf clams were introduced into the Quota Management System, commercial surf clam fisheries were managed using special permits (sections 63,64 (1) (c), and 66 of the Fisheries Act 1983). Four special permits for exploratory fishing were issued between 1986 and 1992. Permit holders had a sole right to fish a defined length of coastline and had an annual quota for each surf clam species. A moratorium was placed on the issue of new permits in 1993 to allow structured and informed development of surf clam fisheries. A special permit to fish for surf clams in Southland was granted in 2000. Commercial fishing trials began in FMA 8 in 1986, and FMAs 3 and 7 in 1987.

New Zealand operates a mandatory shellfish quality assurance programme for all bivalve shellfish grown and harvested in areas for human consumption. Shellfish caught outside this programme can only be sold for bait. This programme is based on international best practice and is managed by New Zealand Food Safety, in cooperation with the District Health Board Public Health Units and the shellfish industry[1]. This involves surveying the water catchment area for pollution, sampling water and shellfish microbiologically over at least 12 months, classifying and listing areas for harvest, regular monitoring of the water and shellfish, biotoxin testing, and closure after rainfall and when biotoxins are detected. Products are traceable by source and time of harvest in case of contamination.

2. BIOLOGY

Three families of surf clams dominate the biomass in different regions of New Zealand. At the northern locations, the venerids *D. anus* and *D. subrosea* make up the major proportion of the surf clam biomass, and *D. anus* is abundant at all other North Island locations. The mactrids and mesodesmatid become increasingly abundant south of Ohope (Bay of Plenty). The mesodesmatid *P. donacina* is most abundant around central New Zealand from Nuhaka on the east coast south to the Kapiti Coast, Cloudy Bay, and as far south as Pegasus Bay. The mactrids *M. murchisoni* and *M. discors* dominate in southern New Zealand (Blueskin Bay, Te Waewae, and Oreti), where they account for more than 80% of the total biomass (Cranfield et al. 1994, Cranfield & Michael 2001).

Each species grows to a larger size in the South Island than in the North Island (Cranfield & Michael 2002). Growth parameters are available for several surf clam species from two locations, Cloudy Bay (FMA 7) and the Kapiti Coast (FMA 8). Length frequencies of sequential population samples were analysed by Cranfield et al. (1993) using MULTIFAN to estimate the von Bertalanffy growth parameters (Table 1). MULTIFAN simultaneously analyses multiple sets of length frequency samples using a maximum likelihood method to estimate the proportion of clams in each age class and the von Bertalanffy growth parameters (see Fournier et al. 1990). Less confidence should be placed in the estimates from MULTIFAN for Cloudy Bay relative to the Kapiti Coast because length sample sizes were smaller from Cloudy Bay, and there was a lack of juvenile surf clams in samples.

Incremental growth of recaptured marked clams at Cloudy Bay was analysed using GROTAG to corroborate the MULTIFAN estimates (Cranfield et al. 1993). GROTAG uses a maximum-likelihood method to estimate growth rate (Francis 1988). The estimates and annual mean growth estimates at lengths α and β are shown in Table 2. Low numbers of marked clams were recaptured from the Kapiti Coast, indicative estimates are given in Cranfield & Michael (2001).

Table 1: Von Bertalanffy growth parameter estimates from Cranfield et al. (1993) for surf clams estimated using MULTIFAN (SE in parentheses). – Indicates where estimates were not generated.

Stock	Site	L_∞ (mm)	K
BYA 7	Cloudy Bay	–	–
BYA 8	Kapiti Coast	–	–
DAN 7	Cloudy Bay	0.10 (0.03)	77.5 (0.71)
DAN 8	Kapiti Coast	0.13 (0.02)	58.7 (0.28)
DSU 7	Cloudy Bay	–	–
DSU 8	Kapiti Coast	–	–
MDI 7	Cloudy Bay	0.41 (0.03)	68.0 (0.35)
MDI 8	Kapiti Coast	0.42 (0.02)	56.0 (0.95)
MMI 7	Cloudy Bay	0.57 (0.01)	88.0 (0.44)
MMI 8	Kapiti Coast	0.35 (0.01)	75.2 (0.30)
PDO 7	Cloudy Bay	0.33 (0.01)	94.1 (0.29)
PDO 8	Kapiti Coast	–	–
SAE 7	Cloudy Bay	1.01 (0.02)	60.3 (0.92)
SAE 8	Kapiti Coast	0.80 (0.03)	52.1(0.25)

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[1] For full details of this programme, refer to the Animal Products (Regulated Control Scheme-Bivalve Molluscan Shellfish) Regulations 2006 and the Animal Products (Specifications for Bivalve Molluscan Shellfish) Notice 2006 (both referred to as the BMSRCS) at: http://www.foodsafety.govt.nz/industry/sectors/seafood/bms/growers-harvesters.htm

Table 2: Mean annual growth estimates (mm/year) at lengths α and β (95% confidence intervals in parentheses for mean growth values) from Cloudy Bay (Cranfield et al. 1996). L^* is the transitional length, at which point the model allows an asymptotic reduction in growth rate and values of L_∞ are included for reference.

Species	α (mm)	g_α (mm year^{-1})	β (mm)	g_β (mm year^{-1})	L^* (mm)	L_∞ (mm)	Residual error (mm)
Paphies donacina	50.0	10.26 (9.7 – 10.8)	80.0	1.41 (1.1 – 1.7)	80.0	84.8	1.25
Crassula aequilatera	30.0	22.71 (22.2 – 23.0)	50.0	6.23 (6.0 – 6.4)	55.0	57.6	2.04
Mactra murchisoni	40.0	17.83 (17.4 – 18.2)	70.0	4.65 (4.3 – 4.9)	80.0	80.6	1.42
Mactra discors	35.0	11.01 (10.5 – 11.7)	55.0	2.69 (2.4 – 2.9)	62.0	61.5	0.63
Dosinia anus	20.0	12.5 (12.0 – 13.2)	55.0	1.99 (1.8 – 2.2)	63.0	61.6	0.44

The maximum ages for these species were estimated from the number of age classes indicated in MULTIFAN analyses, and from shell sections. Estimates of natural mortality come from age estimates (Table 3). Higher mortality is seen where the surf clams are subject to higher wave energies, e.g., *C. aequilatera* and *M. murchisoni* are distributed within the primary wave break and hence show higher mortality (Cranfield et al. 1993). The maximum age of Kapiti coast shells suggests higher mortality than Cloudy Bay, perhaps because the Kapiti Coast is more exposed and surf clams there have a higher chance of being eroded out of the seabed by storms (Cranfield et al. 1993). Surf clam populations are subject to catastrophic mortality from being dislodged from within the seabed and being washed ashore during storms, high nearshore seawater temperatures and low oxygen levels during calm summer periods, blooms of toxic algae, and long periods of reduced salinity from high freshwater outflow (Eggleston & Hickman 1972, Cranfield & Michael 2001).

Table 3: Estimates of the instantaneous natural mortality rate, M. A = minimum number of year classes indicated by MULTIFAN; B = maximum age indicated by shell sections; M1 = mortality range estimated from using two equations: $lnM = 1.23\text{-}0.832\ln(t_{max})$ and $1nM = 1.44\text{-}0.9821n(t_{max})$, (Hoenig 1983); M2 mortality estimated from $M = \ln100/(t_{max})$; t_{max} is the estimate of maximum age.

	A	B	M1	M2
Cloudy Bay				
Mactra murchisoni	8	11	0.40–0.46	0.42
Mactra discors	7	14	0.32–0.38	0.33
Crassula aequilatera	5	7	0.63–0.68	0.66
Paphies donacina	10	17	0.26–0.32	0.27
Dosinia anus	16	22	0.20–0.26	0.21
Kapiti Coast				
Mactra murchisoni	8	11*	0.40–0.46	0.42
Mactra discors	8	16*	0.28–0.34	0.29
Crassula aequilatera	3	5*	0.87–0.89	0.92
Paphies donacina†				
Dosinia anus	19	26*	0.17–0.23	0.18

*Shell sections not yet examined. Ages are inferred from Cloudy Bay data.
†Growth data could not be analysed.

3. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

This section was first introduced to the May 2011 Plenary after review by the Aquatic Environment Working Group and is updated as relevant research is undertaken and published. It was last updated in 2021. This summary is from the perspective of the surf clam fisheries; a more detailed summary from an issue-by-issue perspective is available in the Aquatic Environment and Biodiversity Annual Review 2021 (Fisheries New Zealand 2021), online at https://www.mpi.govt.nz/dmsdocument/51472-Aquatic-Environment-and-Biodiversity-Annual-Review-AEBAR-2021-A-summary-of-environmental-interactions-between-the-seafood-sector-and-the-aquatic-environment.

3.1 Ecosystem role

Worldwide, the ecosystem roles of subtidal communities on expose surf beaches are difficult to study. The physical environments of surf beaches are defined by their sand, wave, and tidal regimes. Surf beaches range from narrow and steep (reflective) beaches with no surf zone and coarse sediments (e.g., Cloudy Bay, FMA 7) to wide and flat (dissipative) beaches with extensive surf zones, finer sand and larger waves and tides (e.g., Pegasus Bay, (FMA 3), after Defo et al. 2009). The surf zone systems of

New Zealand dissipative beaches are similar to those describe in California (Morin et al. 1985) and South Africa (McLachlan et al. 1984). There is distinct zonation of subtidal, beach communities driven by an environmental gradient: the nearshore swash zone characterized by almost continual sweeping and shifting sands churned up by strong, fluctuating wave surge at one extreme, to a relatively benign environment with reduced surge, and finer sediments with almost no sand movement at the other extreme (Morin et al. 1985). As common on most exposed surf beaches, suspension feeding bivalves dominate the nearshore biomass. Beyond the primary wave break where the bottom becomes more stable and finer, there is a rapid rise in species diversity, but in New Zealand, generally a decreased in overall biomass.

Only three published papers examine aspects of the role of surf clams in the ecosystem in New Zealand. Juvenile surf clams, mainly *Paphies spp*., are important prey for the paddle crab *Ovalipes catharus* in central New Zealand (Wear & Haddon 1987). Predation of *Dosinia* spp. by rock lobsters has been documented from the reef/soft sediment interface zones (Langlois et al. 2005, Langlois et al. 2006), notably surf clams are usually harvested from exposed beaches, not reef/soft sediment interface zones.

Surf clams are filter-feeders; recent research suggests that most of their food is obtained from microalgae from the top 2 cm of the sediment and the bottom 2–3 cm of the water column (Sasaki et al. 2004). The effects of predation are difficult to study on exposed sandy beaches and it is believed internationally that there are no keystone species in this environment and predation is not important in structuring the community (McLachlan & Brown 2006).

3.2 Fishery captures (fish and invertebrates)

The only bycatch caught in large quantities associated with surf clam dredging in New Zealand is *Fellaster zelandiae* — the sand dollar or sea biscuit (Haddon et al. 1996, Triantafillos 2008a, Triantafillos 2008b, White et al. 2012). Other species caught in association with surf clams include paddle crabs (*Ovalipes catharus*), a number of bivalves including the lance shell (*Resania lanceolata*), otter clams (*Zenatia acinaces*), battle axe (*Myadora striata*), olive tellinid (*Hiatula nitidia*), the wedge shell (*Peronaea gairmadi*), and the gastropods the olive shell (*Baryspira australis*) and ostrich foot shell (*Struthiolaria papulosa*). Fish are rarely caught but include juvenile common soles (*Peltorhamphus novaezeelandiae*) and stargazers (*Kathetostoma* spp.) (NIWA, unpublished data).

3.3 Fishery captures (seabirds and mammals)

Not relevant to surf clam fisheries.

3.4 Benthic impacts

Surf clams mainly inhabit the surf zone, a high-energy environment characterised by high sand mobility (Michael et al. 1990). Divers observed that the survey dredge (used for surf clam surveys) formed a well-defined track in the substrate, but within 24 hours (probably much less time) the track could not be distinguished, indicating that physical recovery of the substrate was rapid (Michael et al. 1990). A different dredge is used for commercial fishing, and the impacts of this dredge have not been tested. Shallow water environments such as the surf zone or those subjected to frequent natural disturbance tend to recover faster from the effects of mobile fishing gears compared with those in deeper water (Kaiser et al. 1996, Collie et al. 2000, Hiddink et al. 2006, Kaiser et al. 2006).

Incidental effects of hydraulic dredging on the target species within New Zealand fisheries have not been studied. Any effects will be species, size, dredge, and location specific. For the Italian surf clam (*Chamelea gallina*), laboratory experiments found that 50% of the surf cams had reburied after 4 hours (95% CI 3.6–4.4) and 90% after 8 hours (95% CI 7.7–8.2) (Bargione et al 2021). There are no data on reburial times of New Zealand surf clams encountering hydraulic dredges. Given the time it takes for *Chamelea gallina* to rebury, and New Zealand surf conditions, surf clams may be washed ashore. In the same research Bargione et al (2021) found survival of disturbed clams in both laboratory experiments and caged sea trials was high. A laboratory study by Cranfield and Michael (1995) found that surf clams (PDO, SAE, and MMI) float on liquified sand, and based on laboratory observations suggest that some surf clams that encounter hydraulic dredges may suffer some damage or stress. The survival of New Zealand surf clams encountering hydraulic dredges and the return of surf clams to sea is currently unknown.

Surf clam species show zonation by sediment type and mobility which is generally, although not always, correlated with depth and wave exposure. Species with good burrowing ability are generally found in shallow, mobile sediment zones (for example, *Paphies donacina*), and those species less able to burrow (for example, *Dosinia subrosea* and *Bassina yatei*) are generally found in softer, more stable sediments. The present high-value species (*Crassula aequilatera, Mactra murchisoni, Paphies donacina* and *Mactra discors*) generally occur in transition zones from highly mobile sediments to mostly stable sediment. Mobile fishing gear effects will be primarily determined by the characteristics of the beach and target species. Little fishing presently takes place in the most vulnerable areas characterised by stable, soft fine sediment communities because of the lower densities of surf clams and the presently lower value of species there.

An Italian study showed that widespread intensive hydraulic dredging can adversely modify habitat at depths of 4–6 m within the surf zone environment, although recovery in this study occurred within six months (Morello et al. 2006). Scottish (Tuck et al. 2000; Hauton et al. 2003a, 2003b) and American (Mercaldo-Allen et al. 2017) studies detected benthic community and physical impacts, but survival of discarded bycatch was generally high. The applicability of these studies' finding to New Zealand is unknown, given the relatively sheltered nature of some of the habitats examined compared to surf beaches. In New Zealand, the effects of hydraulic dredging are likely to vary with site specific environmental conditions and depending on whether beaches have reflective or dissipative beach profiles.

3.5 Other considerations

None.

3.6 Key information gaps

The distribution of hydraulic dredging in New Zealand is localised at fishery scale, and generally not widespread geographically. The impacts of hydraulic dredging at the intensities fished are unknown. Key information gaps include population connectivity and stock structure, and spatial and temporal variability in key population parameters, e.g., recruitment patterns varied on Wellington west coast beaches with juveniles of *Mactra discors* and *M. murchisoni* dominating in alternate years (Conroy et al. 1996).

A key information gap is the survival of surf calms encountered by the hydraulic dredge and that pass under or through the dredge on the seabed, and of those landed onboard and returned to sea.

4. FOR FURTHER INFORMATION

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