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1.0 INTRODUCTION

This report establishes a baseline of biological information for the intertidal and shallow subtidal habitats of the northern entrance to Queen Charlotte Sound. The Department of Conservation (Nelson/Marlborough) commissioned this work in order that any impacts related to wakes from shipping could be detected and measured. In addition, this information will act as a baseline for the purposes for monitoring aspects of the state of the environment of Queen Charlotte Sound if continued or regularly repeated into the future.

The primary aim of this monitoring study was to quantitatively document the patterns of community composition and abundance from a variety of sites in the northern entrance of Queen Charlotte Sound. Davidson (1996, 1997) investigated intertidal and shallow subtidal species and communities in relation to wakes generated by conventional and fast ferries. The same methodology was adopted in the present study in order that data collected from the northern entrance could be incorporated into this wider baseline data set. A variety of sites from Davidson (1996, 1997) were resurveyed in addition to a number of supplementary sites which were established as part of the present study. All data during the present study were collected quarterly between January and December 1997.

2.0 STUDY AREA

The study area is defined as the area of Queen Charlotte Sound between Dieffenbach Point to Long Island (Map 1). This area was specifically chosen as this area represent the relatively sheltered waters of Queen Charlotte Sound currently free of regular large ferry service passages and therefore free of the waves generated by these vessels.

Within the study area and most often along the bay sides the intertidal and shallow subtidal habitats are dominated by relatively uniform cobble, pebble and small boulder substrata. At headlands and promontories are bedrock and reef habitats. Intertidal shores are generally relatively narrow (10 m to 20 m), gently sloping in gradient, with the shallow subtidal often representing an extension of the intertidal habitats.

3.0 METHODOLOGY

Fieldwork was undertaken between January and December 1997 (Table 1). Methodology followed those used during Davidson (1996, 1997).

The study was divided into three parts:

- a) cast animal study;
- b) intertidal animal study; and
- c) shallow subtidal animal study.

All study sites were located on either southern or northern aspect shores located in the northern entrance to Queen Charlotte Sound. Sites were widespread in an effort to represent a large range of situations and in an effort to establish potential impact or control sites depending on their likely-hood of being exposed to shipping wakes (i.e. based on their proximity to the recognised shipping lane)(Maps 1, 2 and 3). In each of these potential treatment groups, sample sites were also selected from shores with similar aspect, topography, substratum, physical size and wave exposure.

Table 1 Summary of sample occasions and time series values used in all figures. The present study sample dates range between 13/8/97 and 10/12/97, while the remaining data are from Davidson (1996, 1997).

Date	1995	1995	1995	1995	1995	1995	1995	1995	1996	1996	1996	1997	1997	1997	1997
Cast study															
Date	27/7	17/8	19/9	10/10	30/10	20/11	7/12	29/12	11/1	27/2	21/11	23/1	6/5	13/8	10/12
Time series (days)	1	22	55	76	96	117	134	156	169	216	481	547	681	748	866
Intertidal study															
Date	7/3	27/7		5/10	30/10	20/11	7/12		10/1	27/2	21/11	23/1	6/5	13/8	10/12
Time series (days)	1	142		213	233	253	270		304	351	619	682	816	883	1001
Subtidal study (Paua/kina)															
Date	25/2	3/8	19/9		30/10	20/11	8/12		11/1	27/2	21/11	23/1	6/5	13/8	10/12
Time series (days)	1	158	204		245	266	284		317	365	633	696	830	897	1015
Subtidal study (Cats-eye)															
Date						20/11	8/12		11/1	28/2	21/11	23/1	6/5	13/8	10/12
Time series (days)						1	18		33	81	349	412	546	613	731

3.1 CAST ANIMAL STUDY

Animals cast onto the drift line were investigated from seven sites in Queen Charlotte Sound (Map 1). Four of these sites were adopted from Davidson (1996, 1997).

At each site, permanent (4 m x 4 m) quadrats were installed along the upper boundary or drift line at each site. Each quadrat corner was either marked using a 600 mm steel peg driven into the substratum or marked using white paint. White spray paint was also used to mark the upper terrestrial shore adjacent to quadrats to ensure they could be relocated if pegs were washed away. Quadrats were spaced no closer than 10 m distance apart and were usually spaced > 30 m apart.

On each sample occasion, a search for recently dead or dying animals was conducted within each quadrat. Only recently dead or dying animals on the sediment surface or within surface drift material

(e.g. branches, seaweed) were counted. “*Recently dead or dying animals*” were defined as those having flesh or particular body parts present which would normally degrade or disappear with time spent on the shore (e.g. kina spines still present on test suggesting they had recently washed ashore). All animals recorded from quadrats were removed so they were not counted in subsequent visits. Animals living in their natural habitats within quadrats were not included in counts. Data from the cast animal study are presented in Appendix 1.

3.2 INTERTIDAL ANIMAL STUDY

A total of six sites were sampled in Queen Charlotte Sound (Map 2). Three of these sites were adopted from Davidson (1996, 1997) for continued study. All sample sites were located on shores dominated by cobble and small boulder substrata. At each site, at mid-tide (approximately 1 m above spring low water) and at low tide (approximately 0.5 m above spring low water), large immobile rocks were marked using dazzle paint and a steel peg was driven into the substrata in order that the same tidal height could be resampled on each occasion. Within these sample zones, small boulders (250 mm to 350 mm length) were randomly selected and individually placed on a white tray and all animals living on each rock were counted. All animals living in the area directly under each rock were also counted. The data recorded from “on rocks” and “under rocks” were combined for the purposes of the present study. Rocks selected for study were from the size category shown to regularly move in areas subjected to ferry wakes (Davidson 1995b, Grange *et al.*, 1995).

These data were categorised into:

- a) number of all invertebrate species;
- b) number of individual molluscs; and
- c) number of mobile mollusc species.

Raw data from mid and low tidal levels are presented in Appendix 2.

3.3 SHALLOW SUBTIDAL STUDY

Seven subtidal sites were investigated during the present study. Three of these sites were adopted from Davidson (1996, 1997) for continued study.

At each site, the subtidal shore between 0.8 m to 1.2 m depth below mean low water were sampled using SCUBA. The subtidal sample zone was marked using 600 mm steel stake driven into the substratum. On each sample occasion, between five and six random 10 m x 1 m quadrats were sampled by flipping over a 1 m² quadrat parallel to the shore. Within each quadrat, the number of urchins (*Evechinus chloroticus*) and black foot paua (*Haliotis iris*) were recorded. Cats-eye snails (*Turbo smaragdus*) were counted from approximately ten 1 m² quadrats randomly assigned from within the 10 x 1 m urchin quadrats. Shallow subtidal paua and kina data are presented in Appendix 3, while cats-eye snail data are presented in Appendix 4.

4.0 RESULTS

4.1 CAST ANIMAL STUDY

4.1.1 Description of Cast Animal Study Sites

All cast animal sites excluding Spencer Bay and Blumine (south), were exposed to the predominant northerly, north-east and/or north-west weather (see weather graph in Davidson 1996). Fetch distances were greatest at Patten Passage and Double Bay with relatively rough sea conditions being observed at all northerly aspect shores during the study. Substrata were combinations of cobbles, pebbles and granules (Table 2).

Table 2 Description of cast animal study sites located in the northern entrance of Queen Charlotte Sound.

Site no.	Site name	Dominant substrata	Aspect
1c	Long Island	Granule/pebble/cobble	North-west
2c	Blumine (north)	Cobble/Pebble/granule	North-west
3c	Spencer Bay	Cobble/pebble/granule	South-east
4c	Double Bay	Granule/pebble/cobble	North
5c	Snake Point (north)	Granule/pebble/cobble	North-west
6c	Blumine (south)	Cobble/pebble/granule	South
7c	Clark Point	Cobble/pebble	North, north-west

4.1.2 Number of Cast Animal Species

Species recorded as cast ashore over the duration of the Davidson (1996,1997) study and during the present study are displayed in Table 3. Results collected during the present study suggest that for the four sites where data existed, no change to the range of invertebrate species cast ashore were recorded. Similarly, for the sites only sampled during the present study, no obvious difference in the range of species washed ashore were apparent (Table 3).

The number of cast species recorded from northern entrance quadrats by Davidson (1996, 1997) and during the present study have been plotted against time elapsed since the start of the studies in Figures 1 and 2. Davidson (1996) reported fewer than three animal species from control sites for each sample occasion throughout his study (Figure 1). Results from the present study are relatively consistent with data collected by Davidson (1996, 1997) with the number of species peaking at Double Bay (4 species) in December 1997.

Results from the present investigation suggest that the pooled number of species washed ashore in the northern entrance to Queen Charlotte Sound showed a relatively consistent trend over the 866 day monitoring programme.

Table 3 Species recorded from cast animal quadrats by Davidson (1996, 1997) and during the present study in the northern entrance to Queen Charlotte Sound using four original sites and three new sites. Number of species have been combined from all quadrats and all sites in each column.

	Davidson (1996)	Davidson 1997	Present study
Date range	July 1995-Feb 1996	Nov 1996-Jan 1997	Jan -Dec 1997
Species			
Intertidal species			
<i>Chiton pelliserpentis</i>		*	
<i>Mytilus edulis</i>		*	*
<i>Paphies australis</i>	*		
Subtidal species			
<i>Evechinus chloroticus</i>	*	*	*
<i>Modiolarca impacta</i>	*	*	*
<i>Sardinops neopilchardus</i>	*		
<i>Lepas</i> sp.			*
<i>Parika scaber</i>	*		
<i>Pseudechinus albocinctus</i>	*		*
Number of sample occasions	12	2	4
Total number of species	6	4	5

4.1.3 Density of Cast Animals

Cast animal density recorded by Davidson (1996, 1997) and during the present study are plotted against time in Figures 3 and 4. Raw animal density data for the present study are presented in Appendix 1.

Davidson (1996, 1997) reported that mean cast animal densities recorded at sites varied from site to site. For example, no animals were recorded at Long Island while between 1 to 5 individual kina (*E. chloroticus*) per sample were collected from Clark Point. The author stated that comparison of these pooled data showed no significant difference. Densities of animals recorded during the present study were consistently low and were comparable with those recorded in the northern entrance by Davidson (1996, 1997)(Figure 3). Pooled data suggested that the density of animals recorded throughout the study were relatively stable.

4.2 INTERTIDAL ANIMAL STUDY

4.2.1 Description of Intertidal Animal Study Sites

All intertidal sites were characterised by substrata dominated by combinations of cobbles, small boulders, pebbles and granules (Table 4).

Table 4 Description of intertidal animal study sites located in the northern entrance to Queen Charlotte Sound.

Site no.	Site name	Dominant substrata	Aspect
----------	-----------	--------------------	--------

1I	Long Island	Small boulder/cobble	North-west, west
2I	Blumine Island (north)	Cobble/pebble	North, north-west
3I	Spencer Bay	Cobble/pebble/small boulder	South, South-east
4I	Snake Point (north)	Cobble/pebble/small boulder	North, North-west
6I	Patten Passage (South)	Cobble/small boulder	North, north-east
6I	Blumine Island (south)	Cobble/pebble/small boulder	South

4.2.2 Species Recorded from Mid and Low Intertidal Study Sites

The range of species recorded from pooled mid and low intertidal rock samples collected from the duration of the present study are presented in Table 5.

A combined total of 25 species were recorded from mid-tide, while 32 species were recorded from low tide sites by Davidson (1996, 1997) and during the present study. The small gastropod (*Littorina unifasciata*) and the purple crab (*Hemigrapsis edwardsii*) were the only species recorded from mid tide samples and not from low tide samples, while nine species were unique to low tide samples, including green-lip mussel, rock-fish, butterfly chiton, solitary ascidian and cats-eye snail (Table 5).

4.2.3 Intertidal Samples

Mean Number of Intertidal Species

The mean number of species living on and under rocks at sites remained relatively constant throughout the duration of all studies (Figures 5 and 7). Comparison of pooled data from mid and low tide stations showed little fluctuation throughout the 1001 day study period (Figures 6 and 8). No clear or consistent pattern separating individual sites were apparent suggesting that rocks supported a similar number of species at all sites.

Mean Number of Individual Molluscs

The mean number of individual molluscs living on and under rock samples at both tidal heights remained relatively constant throughout all studies (Figures 10 and 11). At low tide stations, however, the mean number of species living on and under rock samples was lowest in the early summer of 1995/96 and summer and into winter of 1996/97 (Figures 11 and 12).

Results suggest that rocks in the northern entrance to Queen Charlotte Sound support comparable numbers of mollusc individuals at low and mid tidal heights. Long Island was the only site that consistently supported greater numbers of mollusc individuals (Figures 9 and 11).

Table 5 Species recorded from intertidal sites at mid and low tidal levels in the northern entrance to Queen Charlotte Sound.

Mid tide species	Mid-tide	Low tide
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Species		
<i>Littorina unifasciata</i> (purple wrinkle)	*	
<i>Diloma nigerrima</i> (smooth topshell)	*	*
<i>Risellopsis varia</i> (ridged topshell)	*	*
<i>Melagraphia aethiops</i> (topshell)	*	*
<i>Haustrum haustorium</i> (dark rock shell)	*	*
<i>Lepsiella scobina</i> (oyster borer)	*	*
<i>Turbo smaragdus</i> (Cats-eye)		*
<i>Cominella maculata</i> (whelk)	*	*
<i>Cominella virigata</i> (whelk)		*
<i>Cellana stellifera</i> (large limpet)	*	*
<i>Notoacmea helmsi</i> (tiny limpet)	*	*
<i>Onchidella nigricans</i> (slug)	*	*
<i>Atalacmea fragilis</i> (fragile limpet)	*	*
<i>Chiton pelliserpentis</i> (snakeskin)	*	*
<i>Amaurochiton glaucus</i> (green chiton)	*	*
<i>Acanthochiton zelandica</i> (tufted chiton)		*
<i>Cryptoconchus porosus</i> (butterfly chiton)		*
<i>Mytilus edulis</i> (blue mussel)	*	*
<i>Aulacomya ater maoriana</i> (ribbed m.)	*	*
<i>Modiolarca impacta</i> (nestling mussel)	*	*
<i>Perna canaliculus</i> (green lipped mussel)		*
<i>Chamaesipho brunnea</i> (barnacle)	*	*
<i>Epopella plicata</i> (large barnacle)	*	*
<i>Actinia tenebrosa</i> (red anemone)	*	*
Anemone sp.	*	*
<i>Petrolisthes elongatus</i> (false crab)	*	*
<i>Hemigrapsus edwardsii</i> (purple crab)	*	
<i>Heterozius rotundifrons</i> (play dead crab)	*	*
Amphipods (hoppers)	*	*
Solitary ascidian		*
<i>Eulalia microphyla</i> (worm)		*
<i>Patiriella regularis</i> (cushion star)	*	*
Flatworm		*
Rock fish		*
Total number of species	25	32

Mean Number of Mobile Mollusc Species

Mean number of mobile mollusc species living on and under rock samples also remained relatively constant. No periods of prolonged increase or decrease were apparent (Figures 13 and 15). Pooled data for both tidal levels suggests the number of mobile mollusc species remain relatively consistent throughout the 1001 day study.

4.3 SHALLOW SUBTIDAL STUDY

4.3.1 Description of Subtidal Animal Study Sites

Densities of kina (*Evechinus chloroticus*), black-foot paua (*Haliotis iris*) and cats-eye snails (*Turbo smaragdus*) were collected from seven sites located throughout the northern entrance to Queen Charlotte Sound (Map 3). All sites apart from Blumine (south) and Spencer Bay were north, north-east or north-west orientated shores (Table 6). Substrata were combinations of cobbles, small boulders, pebbles and granule material (Table 6).

Table 6 Description of shallow subtidal study sites in Queen Charlotte Sound and Tory Channel.

Site no.	Site name	Dominant substrata	Aspect
1s	Long Island	Cobble/pebble	North-west
2s	Blumine (north)	Cobbles/small boulders/pebbles	North, North-west
3s	Spencer Bay	Cobbles/pebbles/small boulders	South, South-east
4s	Double Bay	Cobble/small boulder	North
5s	Patten Passage	Cobble/pebble/granule	North-east
6s	Blumine (south)	Cobble/pebble	South
7s	Clark Point	Cobble/small boulder	North, North-west

4.3.2 Densities of Kina (*Evechinus chloroticus*)

Kina densities exhibited relatively consistent patterns throughout the study. Long Island and Clark Point densities were high compared to the other five sites that remained at relatively low densities throughout the 1015 day study (Figure 17). At Clark Point, kina density peaked at day 245 (30th October 1995) and again in January and August 1997 (Figure 17). These peaks were short lived, with numbers falling to the base levels three months after the peaks. The pooled kina density data is presented in Figure 18. These data suggest that kina densities grouped from all sites represent a relatively stable population over the study duration. There pooled density appears to decline in between following the November 1996 sample (Figure 18). This decline is due to the addition of the four new sites which all supported relatively low densities of kina compared to the original three sites used by Davidson (1996, 1997). Their inclusion effectively lowered the pooled mean values presented in Figure 18.

4.3.3 Densities of Black-Foot Paua (*Haliotis iris*)

Paua were either not present or were very uncommon from six of the seven study sites (Figures 19, 20). At Clark Point, paua were recorded in higher numbers but still in relatively low densities compared to many areas in the outer parts of Queen Charlotte Sound (Davidson 1995). At Clark Point, paua densities varied throughout the study period, peaking at just under 1 per m² on four occasions, but were mostly below 0.25 per m². Paua were patchily distributed at Clark Point and were almost exclusively found in the shallows (i.e. < 2 m depth).

4.3.4 Densities of Cats-Eye Snail (*Turbo smaragdus*)

Overall, pooled cats-eye densities from the seven sites exhibited a relatively consistent pattern throughout the 731 day study (Figure 22), but varied between sites (Figure 21). Cats-eye densities were consistently lowest from Long Island and Clark Point. Data for sites where snail densities were above 2 per m² were variable throughout the study. Data from Double Bay suggest there natural peaks and troughs in cats-eye densities may exist (Figure 21). Pooling the data evened-out these individual site variations leaving a relatively consistent animal density throughout the study period (Figure 22).

5.0 DISCUSSION

Cast Animals

Data collected by Davidson (1996, 1997) were combined with data collected from the same sites and a number of new sites over a one year period during the present study. Results showed that the range of species and their densities washed ashore remained at low levels throughout the year compared to areas along the Picton/Wellington ferry route as documented by Davidson (1996, 1997).

Relatively consistent cast animal data were recorded from all seven sample sites which were widely spread throughout the northern entrance to Queen Charlotte Sound. These data are probably representative of the species and the densities that wash ashore at comparable sites throughout the study area. Results recorded from the three additional sites sampled during the present study were consistently within the range of values recorded from the existing sites supporting this hypothesis.

Intertidal Communities

Data collected by Davidson (1996, 1997) were combined with data collected during the present study from the northern entrance suggest that numbers of species, individual molluscs and mobile mollusc species remained relatively consistent, with no major prolonged fluctuations. Only at low tide stations did the mean number of mollusc individuals fluctuate. This phenomenon may be related to a vertical migration of animals on the shore or a movement of animals towards larger substrata during the warmer months. This fluctuation appeared relatively short in duration. The explanation for such movement is unknown, but may be related to a response to environmental variables such as thermal stress. These fluctuations occurred at north and south aspect sites suggesting that storm events were unlikely to be responsible for this phenomenon.

Shallow Subtidal Animals

Pooled cats-eye snail densities exhibited no major fluctuations over the sample period, however, snail densities at individual sites did show variation. Variation at the same site over the study period and between sites was obvious.

Cats-eye snails were uncommon from sites where kina were consistently most common (Long Island and Clark Point). This result may be due to competition between grazers, but is more likely driven by particular environmental variables acting at these different sites.

Paua were absent or rare at six of the seven study sites. Of all the study sites, paua were most common at Clark Point, but densities were relatively low and varied considerably throughout the study. Observations at Clark Point suggest that paua are patchily distributed and move up the shore into very shallow water often in spring to take advantage of sea lettuce beds that are common as a sublittoral fringe at this site. In general, where present, paua were restricted to shallow habitats (<2 m depth) in the northern entrance.

Kina were recorded from all sites in relatively consistent densities both between sites and throughout the duration of the study. Densities at Long Island and Clark Point were consistently high compared to all other sites. At these two sites, peaks and troughs in kina densities were recorded. These events appear to be related to movements of kina up the shore to take advantage of food rather than storm events resulting in urchins being washed ashore. At all other study sites, kina densities remained relatively consistent.

Use of Data for Impact Detection

The present report presents a variety of intertidal and shallow subtidal data collected from between four and seven sites over a period of between 731 and 1015 days from the northern entrance of Queen Charlotte Sound. The principal aim of this study was to establish a baseline set of data from a wide area in Queen Charlotte Sound that could be used in the detection of any environmental change particularly as a result of wakes generated by shipping. Due to the long temporal and wide spatial level of sampling, it is probable that these data provide an accurate representation of the present state of the environment in the northern entrance of Queen Charlotte Sound.

A variety of factors should be considered prior to these data being used for the purposes of impact assessment:

- most site data is relatively consistent throughout the study, however, at some sites peaks and troughs do occur; and
- variation between sites is often low, but this variation does exist and in some cases lead to significant differences.

It is therefore recommended that impact assessment studies consider the following.

Spatial considerations:

- where possible, existing sites should be adopted in any specific study, but where adequate numbers of sites are used, the selection of a study area within the overall study area may not be critical;
- spatial issues should be investigated at an appropriate number of control sites;
- bedrock substrata should not be used unless a separate study is initiated to establish a baseline data set for this substrata;
- shores dominated by cobble/small boulder substrata should be selected for comparison with the present study;

- sites should be selected from within the study area (as defined in section 2.0)(note: sheltered shores in inner Queen Charlotte Sound, Pelorus Sound, Port Underwood and Croisilles Harbour may be comparable to the present data set, and should be tested prior to this data being applied to these areas); and
- a variety of shore aspects should be adopted.

Temporal considerations:

- the time scale of impact studies using this baseline data should be variable depending on the nature of the study but as a guide, based on the temporal variation recorded during the present study, should be undertaken over a minimum of six months;
- control sites should be used to investigate any temporal patterns; and
- studies should preferably be initiated at least six months prior to the start of any potential impact in order to strengthen the base-line data set.

Ongoing Biological Monitoring and Base-line Establishment

With the establishment of the present base-line data set there arises the opportunity to:

1. utilize the data set as part of a state of the environment monitoring programme;
2. strengthen the baseline data set by testing its applicability to wider areas within the Sounds including Pelorus Sound, Port Underwood and Croisilles Harbour and areas where potential risk may exist e.g. Port Picton, Waikawa Marina and Bay, Havelock Harbour, Elaine Bay or areas in the Sounds where logging will occur.

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Appendix 5 Grid references for all sample sites.

Cast animal study sites located in the northern entrance of Queen Charlotte Sound.

Site no.	Site name	South	East
1c	Long Island	41 07 75	174 16 42
2c	Blumine (north)	41 09 75	174 14 02
3c	Spencer Bay	41 11 28	174 11 24
4c	Double Bay	41 12 68	174 11 96
5c	Snake Point (north)	41 11 81	174 10 43
6c	Blumine (south)	41 10 85	174 15 06
7c	Clark Point	41 08 26	174 17 32

Intertidal animal study sites located in the northern entrance to Queen Charlotte Sound.

Site no.	Site name	South	East
1I	Long Island	41 07 60	174 16 24
2I	Blumine Island (north)	41 09 75	174 14 02
3I	Spencer Bay	41 11 28	174 11 24
4I	Snake Point (north)	41 11 81	174 10 43
6I	Patten Passage (South)	41 10 08	174 17 62
6I	Blumine Island (south)	41 10 85	174 15 06

Shallow subtidal study sites in Queen Charlotte Sound and Tory Channel.

Site no.	Site name	South	East
1s	Long Island	41 07 75	174 16 42
2s	Blumine (north)	41 09 75	174 14 02
3s	Spencer Bay	41 11 28	174 11 24
4s	Double Bay	41 12 68	174 11 96
5s	Patten Passage	41 10 08	174 17 62
6s	Blumine (south)	41 10 85	174 15 06
7s	Clark Point	41 08 26	174 17 32