# An Exploratory Survey for Littleneck Clams (*Protothaca staminea*) in the Broughton Archipelago, British Columbia—2006


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by

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In response to reports fisheries managers have received from First Nations and commercial diggers about declining littleneck clam (*Protothaca staminea*) stocks in the Broughton Archipelago region, Fisheries and Oceans Canada (DFO) staff and ‘Na̱mg̱is representatives explored 12 sites on 9 beaches in Area G in September 2006. The beaches surveyed included: Claydon Bay, Carriden Bay, Carter Passage, Alder Island, Grave Island, Betty Cove, Midsummer Island, Maple Cove (in Port Elizabeth), and Karlukwees. Distributions of littleneck clams were determined by digging exploratory holes. Clams were collected for biological data and histopathological examination. Where few clams were found, we kept clams either observed on the surface or found by digging. Where clams were numerous, we dug 0.25 $m^2$ quadrats to determine density estimates.

Commonly encountered bivalves included butter clams (*Saxidomus gigantea*), cockles (*Clinocardium nuttallii*), macomas (*Macoma inquinata* and *M. nasuta*), softshell clams (*Mya arenaria*), and horse clams (*Tresus capax*). All beaches had littleneck clams, but generally in low abundance. Horse mussels (*Modiolus modiolus*) were found in the substrate at Alder Island. Claydon Bay and Karlukwees had black sediments which stained the shells of bivalves living there. High concentrations of worms were noted in sediments at Grave Island. We observed shell debris and macro-algae on most beaches. Algal mats (*Ulva* sp.) seemed particularly thick at Betty Cove and Alder Island.

In total we collected 199 littleneck clams, on average 18 clams from each site. We dug only 2 quadrats (0.25 $m^2$) due to the difficulty in finding dense concentrations of littleneck clams. From this work and other statistically rigorous surveys done in 2006 by a consultant, littleneck clam densities were estimated to be in the range of 3-12 legal clams/$m^2$ (a legal size littleneck clam is one whose length is ≥38 mm). We present clam biological data which include length/weight relationships, and length and age frequencies. Of the 92 littleneck clams examined macroscopically, almost all (approximately 90%) were considered healthy and had no infectious pathogens. The parasites observed have been reported in other clam stocks in BC. Fourteen percent of the littleneck clams had conchiolin deposits (an indicator of irritation or stress) on the inside of the valves. The histopathological examination of 25 littleneck clams did not find *Perkinsus* spp., *Marteilia* spp., *Haplosporidium* spp., *Bonamia* spp. or *Mikrocytos mackini* and there was no pathology associated with the infections observed. Three clams had some of the highest intensity ratings observed to date for Coccidia (*Margolisiella kabatai*) and Apicomplexan cysts. Butter clams were kept from Alder Island and examined macroscopically (n=9) and microscopically (n=5). All butter clams were considered to be healthy.

A review of the literature finds evidence that littleneck clam stocks at the Burdwood Group, Deep Harbour, Alder Island, Carriden Bay, and Claydon Bay could be in decline.

The implications of disease/parasites, over-harvesting, and macro-algae mats to littleneck clam populations are discussed. But, at this point, it is not known whether these, or some other unidentified environmental factors, are contributing to the littleneck clam stock decline reported in the Broughton Archipelago region.

## RESUME

Dunham, J.S., Koke, B., Gillespie, G.E., and Meyer, G. 2007. An exploratory survey for littleneck clams (*Protothaca staminea*) in the Broughton Archipelago, British Columbia—2006. Can. Manuscr. Rep. Fish. Aquat. Sci. 2787: viii + 33 p.

En réponse à des rapports, présentés aux gestionnaires des pêches par des Premières nations et des pêcheurs commerciaux de coquillages, faisant état du déclin des stocks de palourde du Pacifique (*Protothaca staminea*) dans la région de l’archipel de Broughton, des employés de Pêches et Océans Canada (MPO) et des membres du peuple de la Namgis First Nation ont exploré 12 sites à 9 plages de la zone G en septembre 2006. Les plages suivantes ont été recensées : Claydon Bay, Carriden Bay, Carter Passage, Alder Island, Grave Island, Betty Cove, Midsummer Island, Maple Cove (à Port Elizabeth) et Karlukwees. Nous avons établi la répartition de la palourde du Pacifique en creusant des trous d’exploration. Nous en avons recueilli des échantillons aux fins de collecte de données biologique et d’examen histopathologique. Lorsque peu d’individus étaient trouvés, nous avons gardé ceux présents à la surface ou déterrés, et lorsqu’ils étaient nombreux, nous avons creusé des quadrats de 0,25 m$^2$ en vue d’estimer la densité.

Parmi les bivalves les plus communs que nous avons trouvés s’inscrivaient la palourde jaune (*Saxidomus gigantea*), la coque (*Clinocardium nuttallii*), les macomas (*Macoma inquinata* et *M. nasuta*), la mye (*Mya arenaria*) et la fausse-mactre (*Tresus capax*). La palourde du Pacifique était présente sur toutes les plages, mais généralement en faible nombre. La modiole (*Modiolus modiolus*) était présente dans le substrat de la plage à Alder Island. Les plages de Claydon Bay et de Karlukwees contenaient des sédiments noirs qui tachaient les coquilles des bivalves. Les sédiments de la plage de Grave Island contenaient des concentrations élevées de vers. Des morceaux de coquillages et des macroalgues étaient parsemés sur la plupart des plages. Les tapis d’algues (*Ulva* sp.) semblaient particulièrement épais sur la plage de Betty Cove et d’Alder Island.

Au total, nous avons récolté 199 palourdes du Pacifique, 18 en moyenne à chaque site. Nous n’avons creusé que deux quadrats (0,25 m$^2$) car nous avons eu de la difficulté à trouver des gisements denses. D’après les résultats de cette recherche et d’autres recensements statistiquement rigoureux effectués en 2006 par un consultant, la densité estimative de ce bivalve se chiffre entre 3 à 12 individus de taille réglementaire par m$^2$ (la taille réglementaire est de $\geq$ 38 mm). Nous présentons des données biologiques sur l’espèce, y compris les relations entre la longueur et le poids, ainsi que les fréquences de longueur et d’âge. Environ 90 % des 92 individus soumis à un examen macroscopique étaient en santé et ne portaient aucun agent pathogène infectieux. Les parasites observés ont été signalés chez d’autres stocks de bivalves en C.-B. Des dépôts de conchioline (un indicateur d’irritation ou de stress) marquaient l’intérieur des valves de 14 % des individus récoltés. L’examen histopathologique de 25 spécimens n’a pas révélé la présence de *Perkinsus* sp., *Marteilia* sp., *Haplosporidium* sp., *Bonamia* sp. ou *Mikrocytos mackini*, ni d’une pathologie associée aux infections observées. Trois individus portaient des densités de kystes de coccidies (*Margolisiella kabatai*) et d’autres parasites du

phylum Apicomplexa se situant parmi les plus élevées qui aient été observées à date. L’examen macroscopique (n = 9) et microscopique (n = 5) de palourdes jaunes récoltées à Alder Island a révélé qu’elles étaient toutes en santé.

Une revue de la littérature a révélé que les stocks de palourde du Pacifique trouvés dans les eaux du Burdwood Group, de Deep Harbour, d’Alder Island, de Carriden Bay et de Claydon Bay pourraient être en déclin.

Nous tentons d’établir les répercussions des maladies, des parasites, de la surpêche et des tapis de macroalgues sur les populations de palourde du Pacifique. Nous ne savons pas si, à ce point-ci, ces facteurs ou d’autres facteurs d’environnement non identifiés contribuent au déclin du stock de palourde du Pacifique signalé dans la région de l’archipel de Broughton.

# INTRODUCTION

First Nations people inhabiting the Broughton Archipelago region are concerned that their traditional clam beds are being degraded. Their concerns are based on recent harvesters' observations of changes in intertidal ecosystems and traditional ecological knowledge (TEK) of the area. The changes First Nations people have observed to intertidal areas in their traditional territories include:

- declines in native littleneck clam (*Protothaca staminea*) stocks.
- thick sediments on some beaches, which have buried the historic 'top' (shell fragments and defined strata). Some beaches that used to be firm are now gummy and some have turned brown in color.
- a sulphur-like smell. Particular beaches have been described as smelling like a sewer or skunky.
- stained (black) butter clam shells with orange mantles. First Nation Fishery Guardians claim that the meat in the clams has changed from being white and firm to black/brown and soft.
- unknown species of worms that no one has seen before.
- expanded mussel populations which cover the clams (possibly *Modiolus* sp.) and grow on nets (possibly *Mytilus* sp.).

First Nations people raised their concerns with DFO as early as 2003, and perhaps earlier. No one knows for certain what might be causing the observed changes, but salmon farming, harvesting activities, forestry practises, and climate change have all been suggested as possible contributing factors.

In response to concerns identified by First Nations people and at community and clam sectoral meetings, Fisheries and Oceans Canada (DFO) Marine Ecosystems and Aquaculture Division and Resource Management staff, along with 'Namgis representatives, conducted an exploratory survey of a number of beaches in commercial clam harvest license area G (or Statistical Management Area 12). The aim of this exploratory survey was to collect clams for biological and histological analyses and, where possible, obtain estimates of clam densities. Herein, we report on the biological analyses of the samples, health status of the clams collected, clam densities, and field observations about beach substrates.

## HISTORIC LITTLENECK CLAM LANDINGS IN AREA G

Before 1971, generally only butter clams (*Saxidomus gigantea*) were targeted by commercial fishers. Butter clam landings started declining after 1967 as market preference turned to steamer clams (littlenecks and Manilas; *Venerupis philippinarum*). Butter clam landings dropped considerably in 1980 and, in 1981, for the first time littleneck clam landings surpassed butter clam landings (Fig. 1; Harbo *et al*. 1997).

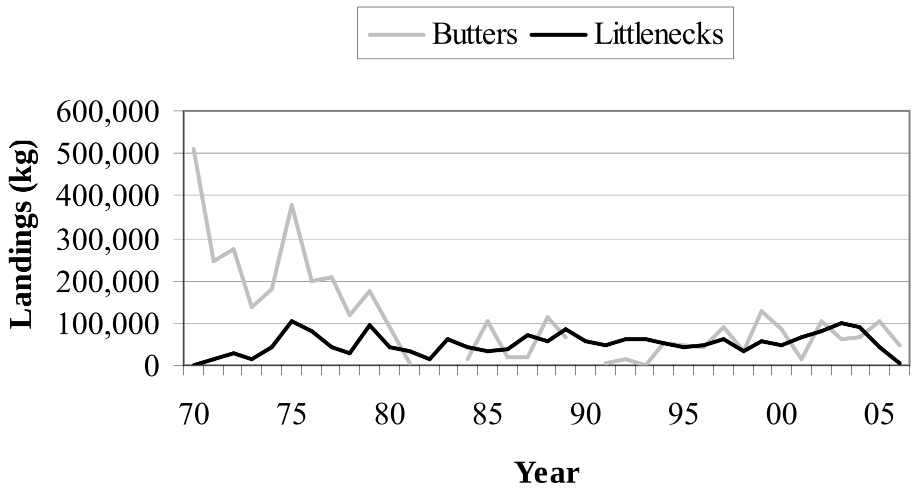


Figure 1. Area G butter and littleneck commercial clam landings[1] (kg), 1970-2006.

It was not until the early 1970s when significant landings were reported for littleneck clams in Area G (Figures 1 and 2). There have been considerable fluctuations in littleneck clam landings since 1970. The average annual landing for littleneck clams between 1970 and 2005 is 51,911 ± 24,892 kilograms. It is important to note that landings are often market driven and not necessarily related to recruitment.

Since 1970, littleneck clam landings have displayed the following trends: landings rapidly increased in the early 1970s to a peak in 1975 after which they dropped quickly

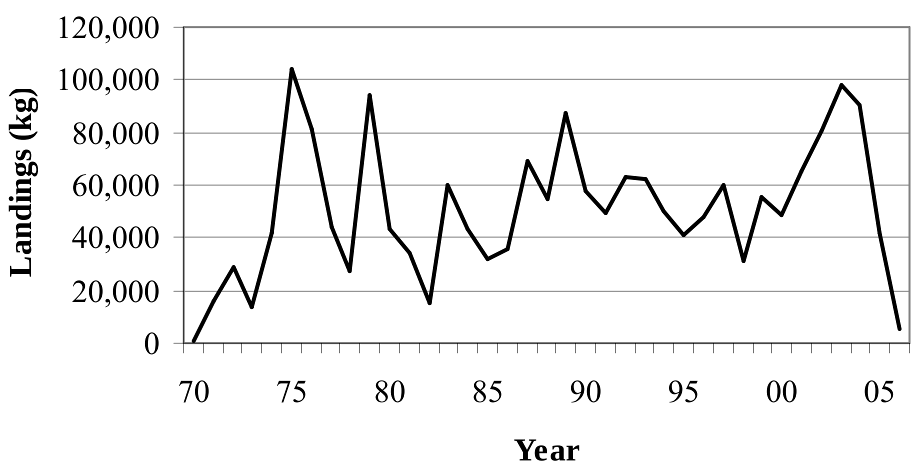


Figure 2. Area G littleneck commercial clam landings (kg), 1970-2006.

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[1]Landing data 1970-1994 are from Harbo *et al*. (1997) as reported on sales slips. Landing data 1995-2006 are from fisheries managers who obtained in-season landing data from buyers.

until 1978; they increased in 1979 after which they dropped quickly until 1982; they generally increased from 1983-89 and then declined to a low in 1998; they increased steadily until 2003 after which they dropped to current 2006 levels.

In 2005, when the annual landing was 41,681 kg, experienced harvesters reported declining littleneck clam stocks to DFO. Diggers who typically only harvested littleneck clams due to their higher value were switching to harvesting butter clams even though the sole buyer in the area had advised they were not interested in buying butter clams. Reports of reduced littleneck clam stocks have continued in 2006 when the landing was 5,372 kg, although effort has also been reduced (all fall and winter openings were cancelled due to few clams being available and poor BC markets). The 2006 littleneck clam landing was far below the lows recorded in 1998 and 1982 and the mean landing for the last 35 years.

## MANAGEMENT OF LITTLENECK CLAM STOCKS IN AREA G

The commercial littleneck clam fishery in Area G is managed primarily by limited entry licensing, a minimum size limit (38 mm), periodic seasonal openings, and set aside First Nations Food, Social, and Ceremonial (FSC) access areas. The fishery is generally open more than 100 days each year and it is not managed to target or limit reference points. Landing data are provided in-season by commercial buyers who must hold a Federal Registration and follow a Quality Management Program (QMP) in order to verify harvest locations and to purchase and process any bivalve shellfish. Before product is removed from a particular beach, it must be tagged with the digger's name, date, harvest location, and subarea. All product harvested must be verified for the location of harvest and this is done by the buyer who designates individuals as "verifiers" (in most cases the digger with the vessel used for transport). The buyer provides a summary spreadsheet after each buy identifying where they were told the harvest came from. In reality this is generally a paper exercise and there is no legal tool to enforce it other than through an audit by the Canadian Food Inspection Agency (CFIA) on a QMP or Hazard Analysis Critical Control Point (HACCP) plan for each registered plant. Data provided from the buyers are used by fisheries managers to track in-season effort, harvest locations, and landings. Sales slips are also required in the fishery and must be submitted to the Regional Data Unit. Conservation and Protection (C and P) officers conduct patrols and attend the commercial "buys" to ensure the primary conservation tool—the minimum size limit—is respected and to ensure that fishers do not access contaminated areas and tag their product.

First Nations are limited to a maximum possession per day, per family (typically 34 kg) but can be permitted to harvest more. The recreational fishery is managed by a licence requirement and daily bag limits. First Nations FSC and recreational landings from the area are not known.

Although data quality varies, in general in most years the Area G in-season landing data from the processors track closely to the sales slip data. This is likely a result of the limited (single) buyer participation in the area for the last several years. The consistency between in-season landing and sales slip data suggests the information is reasonably accurate and complete.

## MATERIALS AND METHODS

Survey methods were similar to those used in previous years for exploratory intertidal bivalve research (Bourne *et al.* 1994, Gillespie and Bourne 2005a). Our objective was to maximize the number of beaches explored during a tide, rather than survey one beach in detail. Results of these surveys give estimates of clam distribution and abundance in surveyed areas and not statistically rigorous stock estimates.

Through consultation with First Nations and commercial clam diggers, 9 beaches (12 sample sites) throughout the Broughton Archipelago region were identified as areas of concern: Claydon Bay, Carriden Bay, Carter Passage, Karlukwees, Alder Island, Grave Island, Betty Cove, Midsummer Island, and Port Elizabeth (Maple Cove)[1] (Fig. 3). Beaches surveyed occur in an area roughly 240 $km^2$ and are spread throughout the Broughton Archipelago region. Beaches at Alder Island and Claydon Bay are terraced and are two of the 353 clam gardens identified by Dr. John Harper in 1995 while conducting aerial coastal habitat surveys in the Broughton Archipelago.

During September 6-8, 2006, three DFO staff and 'Namgis representatives visited the sample sites during low tide periods in the morning (tide range 0.5 to 0.6m). Each site was explored by at least two DFO staff who assessed the presence and absence of littleneck clams by digging numerous exploratory holes. Beach areas were estimated by eyeball estimation and the slope, type of substrate, and area of each site recorded.

At sites where littleneck clam abundance was low, collection of individuals was carried out by observation only. This sampling method preferentially selected for larger clams that were easier to see than smaller clams. When clams were found in patches of sufficient abundance to allow density estimates to be taken, survey quadrats (0.25 $m^2$) were selected in an *ad hoc* fashion without formal randomization. Quadrats were dug with rakes to a depth of 15 cm and the substrate worked through the fingers and reworked back into the quadrats. All detectable clams (generally ≥20 mm) were removed, placed in plastic bags, and labelled.

Littleneck clams were collected from each site for biological data and examination[2] for diseases/parasites by the Histology Lab at the Pacific Biological Station (PBS). Our sampling objective for the histology work was to collect approximately 30 littleneck clams from each site.

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[1]It was brought to our attention at the clam sectoral meeting in October after the survey was completed that there is another beach at the head of Port Elizabeth the 'Namgis had identified as a potential survey site, and not Maple Cove where we visited (R. Mountain pers. comm. 2006).

[2]It is important to emphasize the scope of the histopathological examination is limited to the detection of pathology, symbionts, parasites, or infectious organisms that can impact the health of bivalve molluscs. The laboratory at the PBS is not equipped to conduct any tests concerning chemicals, pollutants, or human health concerns.

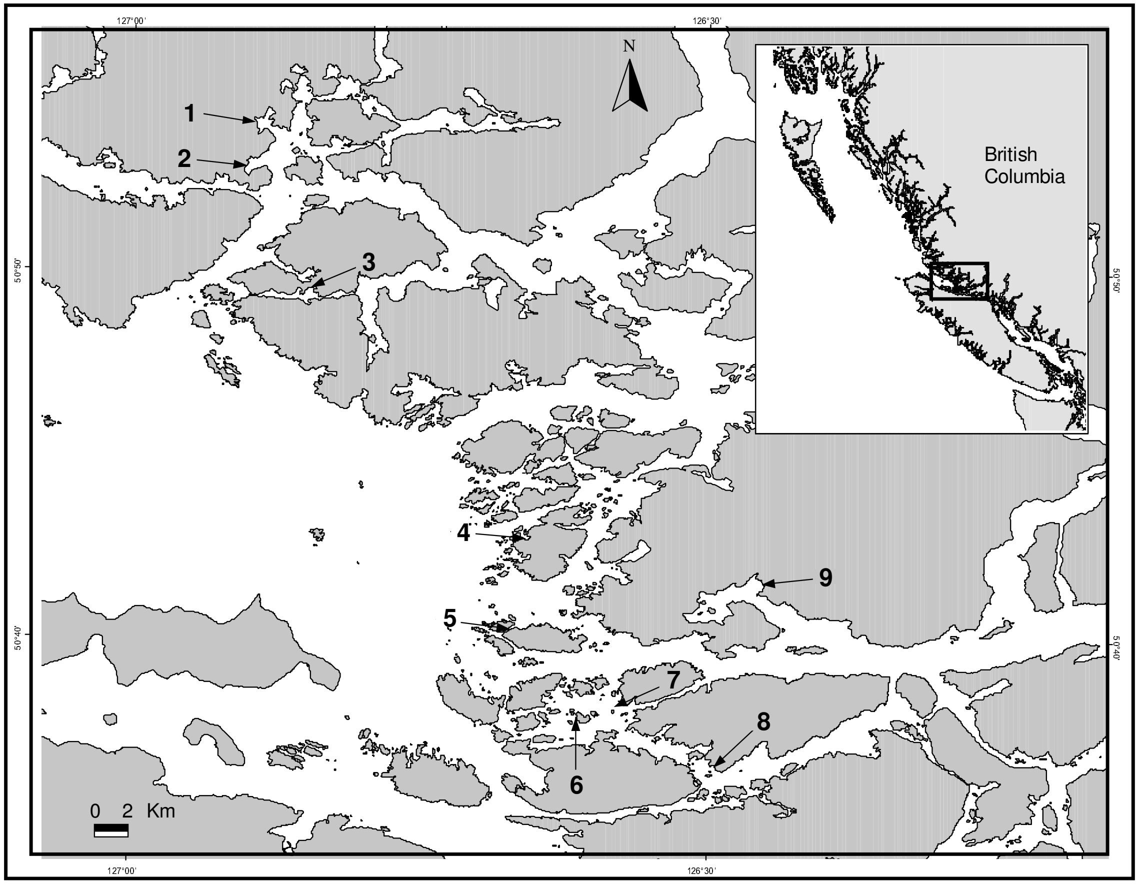


Figure 3. The Broughton Archipelago region and the nine beaches visited to collect littleneck clams, September 2006. 1 = Claydon Bay, 2 = Carriden Bay, 3 = Carter Passage, 4 = Betty Cove, 5 = Midsummer Island, 6 = Alder Island, 7 = Grave Island, 8 = Karlukwees, 9 = Maple Cove (Port Elizabeth).

Butter clams were collected from the Alder Island site at the request of the ‘Namgis First Nation to be analyzed for diseases.

All clams were kept alive in mesh bags and transferred to a seawater tank at PBS on September 8. Total length of each clam (longest anterior-posterior length) was measured to the nearest millimetre (mm) with vernier callipers. Ages were determined by counting annuli (Quayle and Bourne 1972). Clams were weighed to the nearest 0.1 gram.

Histology work began September 14. Clam health was categorized subjectively by experienced staff in the Histology Lab. Their definitions for clam health are defined as follows:

- *Normal / Healthy*: valves are closed tightly.
- *Weak / Moribund*: Valves either open easily during shucking or are gaping and do not close when disturbed; however, the tissues are not decomposing (the mantle margin usually still has a slight tactile response when probed).
- *Dead*: Valves are gaping and tissues are obviously decomposing and “stinky” (these specimens are usually in advanced stage of decomposition and are not of any value for histopathological examination).
- *Plump*: tissues are extremely fat and completely fill the internal shell volume.
- *Average*: tissues are of average “fatness”.
- *Stunted*: based on shell morphology observations (thick shell with numerous tightly spaced growth check rings).
- *Irritated*: conchiolin deposits present.

# RESULTS

## FIELD OBSERVATIONS

Bivalves common on the beaches we visited included cockles *(Clinocardium nuttallii*), butter clams (*Saxidomus gigantea*), macomas (*Macoma inquinata* and *M. nasuta*), and horse clams (*Tresus capax*). All beaches surveyed had littleneck clams, which were generally in low abundance. Horse mussels (*Modiolus modiolus*) were found in the substrate at Alder Island confirming observations put forward by First Nation harvesters and others. Please refer to Appendix 1 for field notes describing each beach site visited and substrate types.

We observed the non-indigenous softshell clam (*Mya arenaria*) at 6 of the 12 sites. One live *M. arenaria* was found at Alder Island. Many *M. arenaria* shells were seen at Maple Cove in Port Elizabeth. A few shells were observed in Claydon Bay, Carter Passage, Betty Cove, and Karlukwees. No Manila or varnish clams (*Nuttallia obscurata*) were observed.

Often shells from a variety of bivalve species and a layer of macro-algae (*Ulva* sp.) were present on the surface of the beaches. Two sites, Betty Cove and Alder Island, had what we perceived to be a thick covering of macro-algae (Appendix 2).

Beaches where we observed the sediment to be black and, subsequently, stained the bivalve shells living there were, in particular, Karlukwees and both Claydon Bay sites. A derelict barge at Karlukwees might be impacting the intertidal area there.

## BIOLOGICAL DATA

### Littleneck clams

In total, 199 littleneck clams were collected from 12 sites throughout the Broughton Archipelago. On average 18 ± 12 littleneck clams were collected at each site (maximum 36, minimum 2). Due to the low densities of littleneck clams encountered, only two quadrats (0.25 $m^2$) were dug: one at Carter Passage for littleneck clams and one at Alder Island for butter clams.

Figures 4-6 outline the results of the biological data for littleneck clams. Please note that the sample sizes of clams are small.

Sampled clam length/weight relationships for each site show that, for a particular size of littleneck (for example a 45 mm clam), this clam would weigh the most at Claydon Bay (35 g) and Carriden Bay (34 g), the least at Carter Passage (30 g), Alder Island (30 g), and Grave Island (29 g), and an intermediate amount at Karlukwees (32 g).

For the northern beaches, Claydon Bay and Carriden Bay clams had similar length/weight relationships (Fig. 4). Claydon Bay clams were generally larger (47-54 mm) than those from Carriden Bay and Carter Passage (40-45 mm). Claydon Bay clams were 6-8 years old, Carriden Bay clams 4-7 years old, and Carter Passage clams 3-6 years old.

We dug one quadrat at Carter Passage and found 12 legal littleneck clams/$m^2$ (16 clams/$m^2$ including all sizes). *M. nasuta* and *M. inquinata* were also collected in the quadrat, *M. nasuta* being 3 times more prevalent than *M. inquinata*.

Sampled clam populations at Alder and Grave Islands were similar in terms of length/weight relationships, size, and age structure (3-6 years; Fig. 5). Clams collected on the surface at Port Elizabeth were generally larger and older. Due to the very low densities of littleneck clams at Betty Cove and Midsummer Island, only two clams were collected from each site. Their biological data are listed in Table 1.

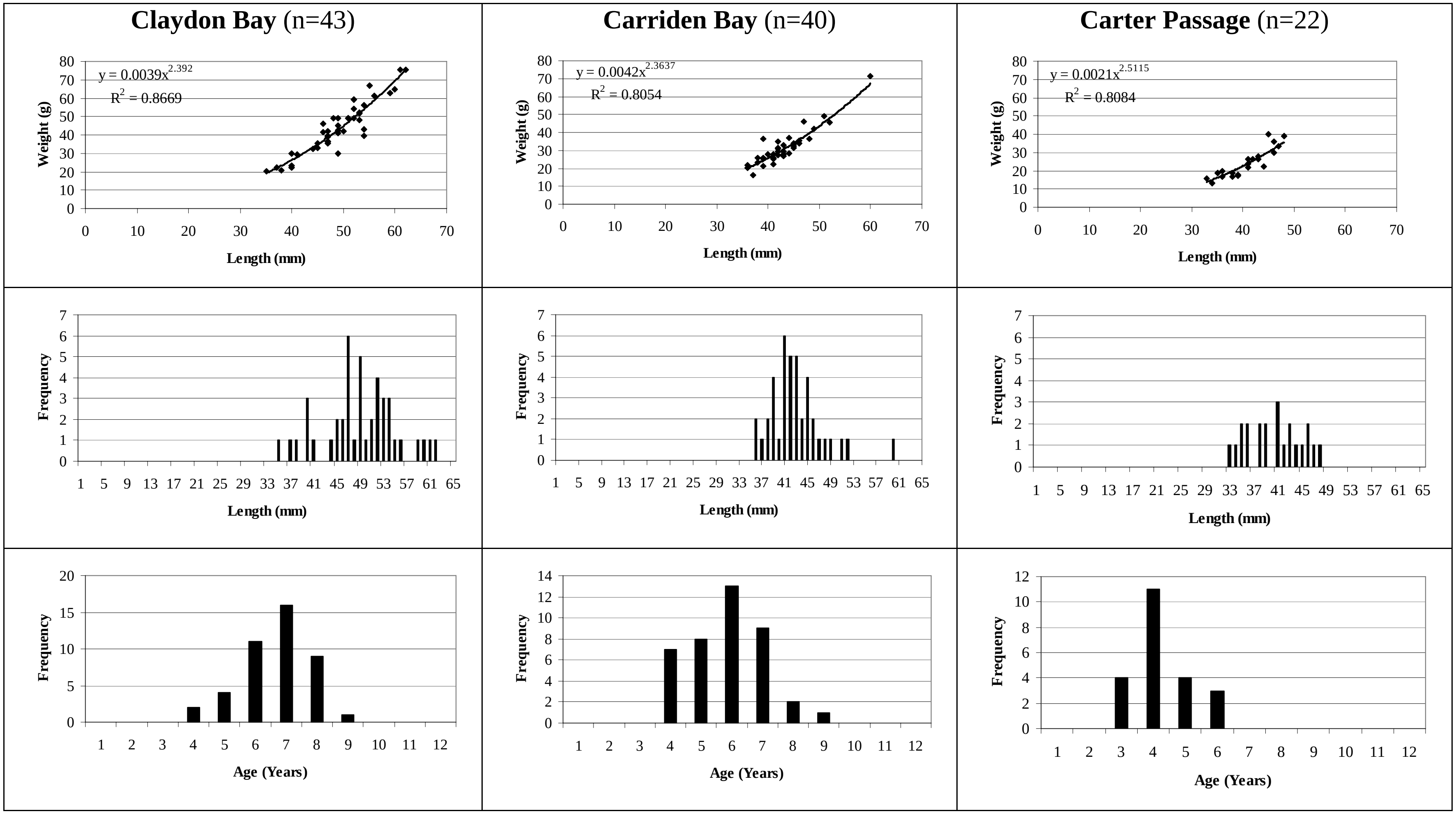


Figure 4. Biological data for littleneck clams collected in the Broughton Archipelago region at Claydon Bay, Carriden Bay, and Carter Passage, September 2006.

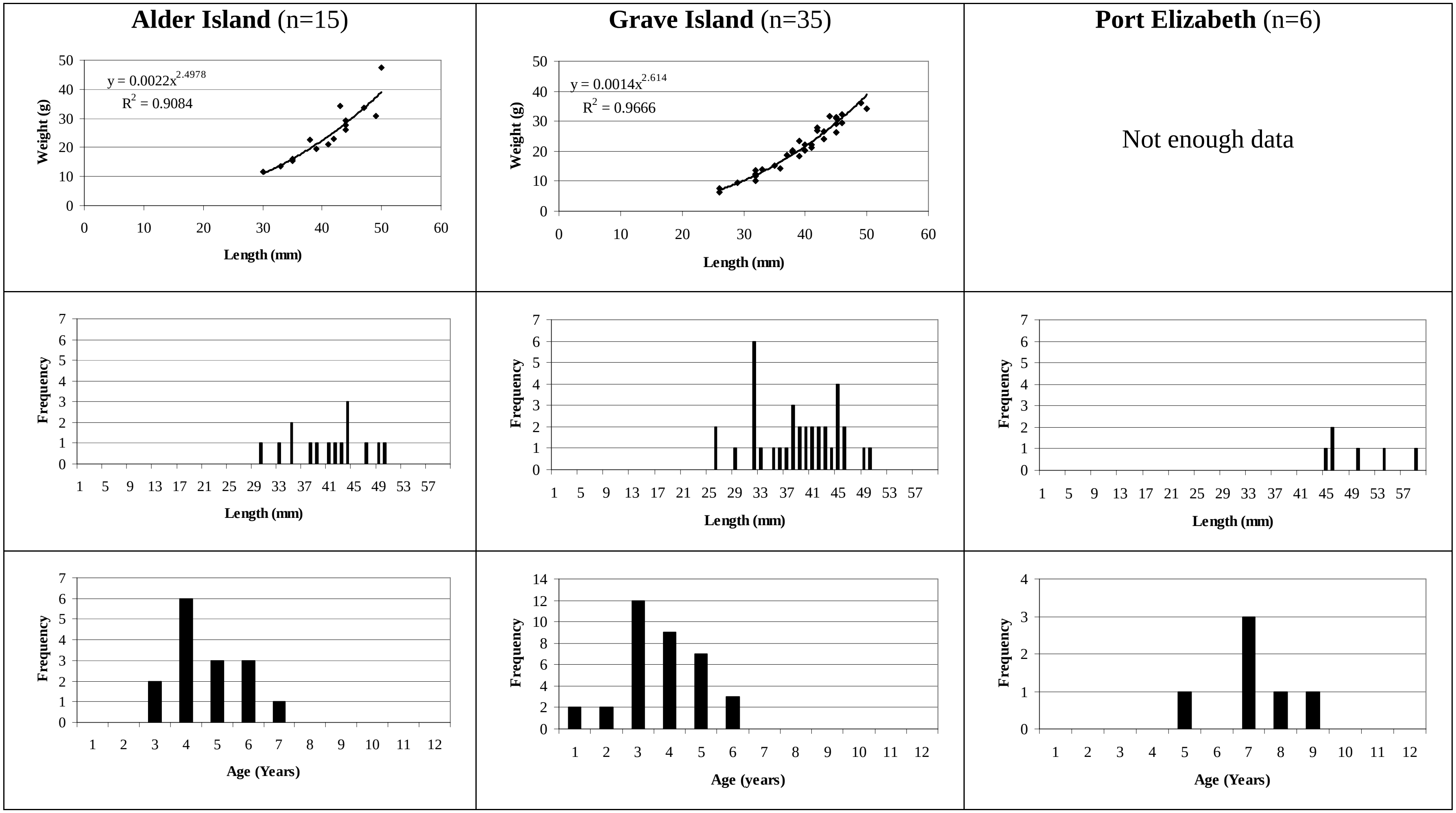


Figure 5. Biological data for littleneck clams collected in the Broughton Archipelago region at Alder Island, Grave Island, and Port Elizabeth, September 2006..

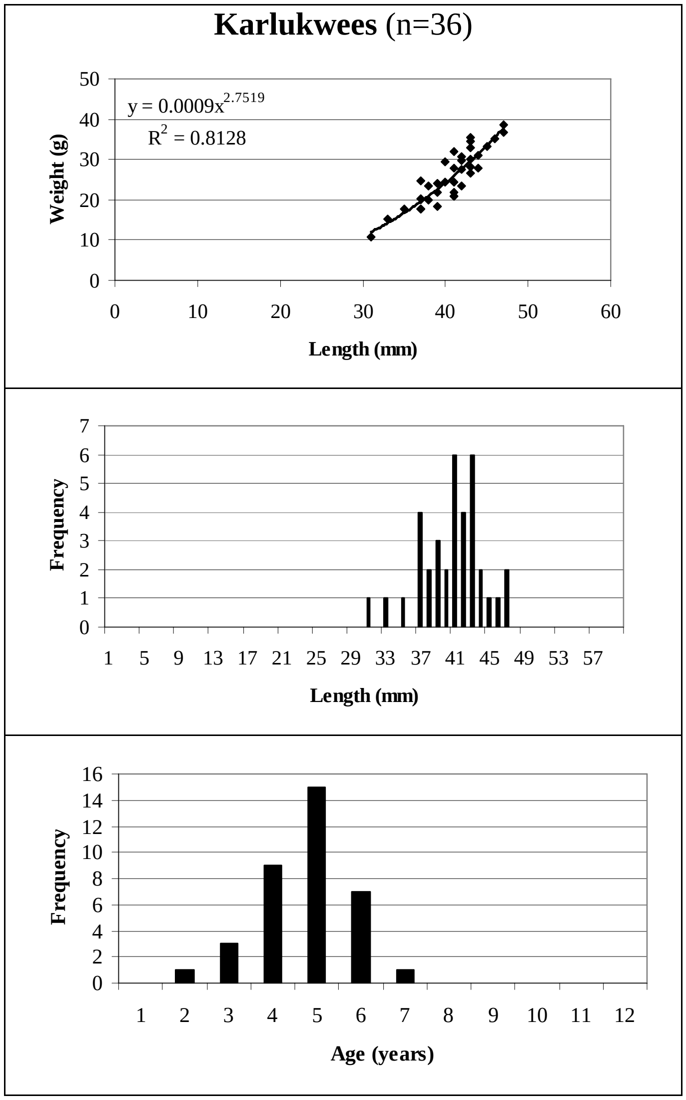


Figure 6. Biological data for littleneck clams collected in the Broughton Archipelago region at Karlukwees, September 2006.

Table 1. Biological data for littleneck clams collected in the Broughton Archipelago region at Betty Cove and Midsummer Island, September 2006.

| Site | Length (mm) | Weight (g) | Age (years) | Comments |
|---|---|---|---|---|
| Betty Cove | 35 | 19.9 | 6 | Stunted |
| | 45 | 31.8 | 6 | |
| Midsummer Is | 38 | 22 | 4 | |
| | 34 | 13.8 | 3 | |

Littleneck clams collected at Karlukwees were about 42 mm long and 4-6 years old (Fig. 6).

As illustrated in the length frequency graphs (Figures 4-6) no clams were collected smaller than 30 mm in length. This reflects our size selective sampling method rather than demonstrating a lack of recruitment. We dug few quadrats because of the low densities of littleneck clams encountered. In our search for clams to collect, bigger clams were easier to see and thus probably collected more frequently than smaller clams.

Necropsy and macroscopic observations of littleneck clams: Please refer to Appendix 3 for the Shellfish Health Report produced by the Histology Lab for littleneck clams.

In total, a subsample of 92 littleneck clams (18 surface, 74 buried) from all the beaches was examined. The breakdown of the results for macroscopic observations is as follows (Table 2):

> *Surface*: 3 plump, 1 plump stunted, 1 plump irritated, 3 average, 2 average stunted, 3 average irritated, 5 weak.
>
> *Buried*: 52 plump, 1 plump stunted, 3 plump irritated, 9 average, 4 average stunted, 5 average irritated.

Please note that 8 clams were collected at Claydon Bay (Beach #2), but 5 died prematurely and were discarded.

Almost all the littleneck clams (90%) collected throughout the Broughton Archipelago region were considered healthy. Healthy clams had either plump or average meat, some of which were stunted or possibly irritated (stressed), as evident by conchiolin deposits on the inside of the valves. Conchiolin is an albuminoid secreted by the mantle that serves to form a matrix in the shells of molluscs. Fourteen percent of the clams had conchiolin deposits.

Table 2. Macroscopic examination results for littleneck clams (n=92) collected in the Broughton Archipelago region, September 2006.

| Beach | Buried? | No. Collected | No. Histology | Overall Healthy No. (%) | | | | | | Weak or Moribund No. (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Plump | | | Average | | | |
| | | | | Normal | Stunted | Irritated | Normal | Stunted | Irritated | |
| Claydon Bay #1 | No | 2 | 2 | | | | | 2 (100) | | |
| Claydon Bay #1 | Yes | 25 | 10 | 9 (90) | | 1 (10) | | | | |
| Claydon Bay #2 | No | 8 | 3 | | | | | | | 3 (100) |
| Claydon Bay #2 | Yes | 10 | 10 | 7 (70) | | | | 2 (20) | 1 (10) | |
| Carriden Bay #1 | No | 8 | 5 | 1 (20) | 1 (20) | | 2 (40) | | | 1 (20) |
| Carriden Bay #1 | Yes | 21 | 5 | 3 (60) | | | 1 (20) | 1 (20) | | |
| Carriden Bay #2 | Yes | 11 | 5 | 3 (60) | | | 1 (20) | | 1 (20) | |
| Carter Passage | No | 2 | 2 | 1 (50) | | | 1 (50) | | | |
| Carter Passage | Yes | 16 | 10 | 7 (70) | 1 (10) | | 1 (10) | | 1 (10) | |
| Karlukwees | Yes | 36 | 10 | 8 (80) | | | 1 (10) | 1 (10) | | |
| Alder Island | Yes | 15 | 10 | 6 (60) | | 1 (10) | 1 (10) | | 2 (20) | |
| Grave Island #2 | Yes | 35 | 10 | 6 (60) | | | 4 (40) | | | |
| Betty Cove | Yes | 2 | 2 | 1 (50) | | 1 (50) | | | | |
| Midsummer Island | Yes | 2 | 2 | 2 (100) | | | | | | |
| Port Elizabeth | No | 6 | 6 | 1 (17) | | 1 (17) | | | 3 (50) | 1 (17) |
| Total | | 199 | 92 | | | | | | | |

Microscopic and histological examination of littleneck clams: Clams selected (n = 25) were those considered the most probable for pathogen detection. These clams came from sites where the clams appeared weak or moribund, or were healthy, but had only average meat and conchiolin deposits. Two sites of interest were Claydon Bay (Beach #2) and Port Elizabeth (Maple Cove).

The littleneck clams collected from the surface at Claydon Bay died sooner than clams collected at other sites, even though they were all handled in the same manner. Consequently, these clams appeared to be less vigorous than the other clams. Half the clams from Port Elizabeth (all collected from the surface) had thick conchiolin deposits on the shells suggesting they were experiencing some form of irritation or stress. The sex ratio of the clams selected was 12 male, 12 female, and 1 spent.

None of the following pathogens of concern (known to cause mortality in bivalves) were detected by histopathological examination: *Perkinsus* spp., *Marteilia* spp., *Haplosporidium* spp., *Bonamia* spp. or *Mikrocytos mackini*. There was no pathology associated with the infections described in the Shellfish Health Report (Appendix 3); however, three of the specimens did have some of the highest intensity ratings observed to date for Coccidia (*Margolisiella kabatai*) and Apicomplexan cysts.

## Butter Clams

We dug one 0.25 $m^2$ quadrat at Alder Island low in the intertidal zone. Scaling our findings to 1$m^2$ we found 16 legal and 28 sublegal butter clams/$m^2$. A wide range of sizes (44-111 mm) and ages (3-15 years) were observed (Fig. 7).

One sample of butter clams from Alder Island was collected for the Histology Lab (Appendix 4 - Shellfish Health Report).

Necropsy and macroscopic observations of butter clams: In total, 9 butter clams were examined. All appeared to be plump and healthy with no abnormalities observed.

Microscopic and histological examination of butter clams: Five butter clams (3 males and 2 females) underwent histopathological examination. No pathology was observed and all of the listed parasites and symbionts have been previously recorded at comparable intensities in other bivalve populations from BC. In addition, none of the following pathogens of concern (known to cause mortality in bivalves) were detected: *Perkinsus* spp., *Marteilia* spp., *Haplosporidium* spp., *Bonamia* spp. or *Mikrocytos mackini*.

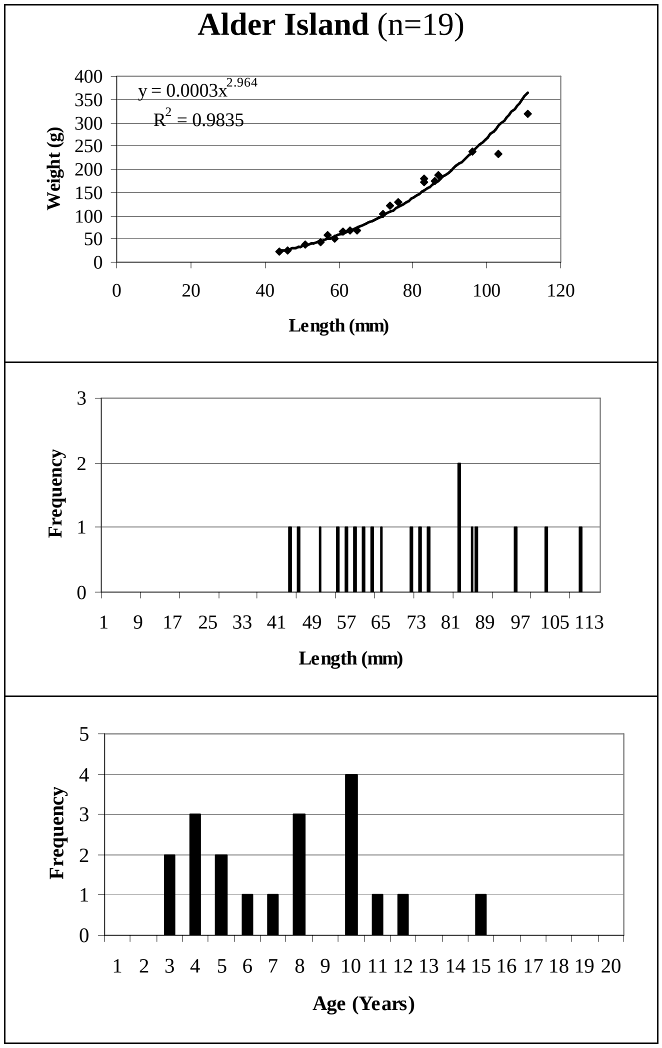


Figure 7. Biological data for butter clams collected in the Broughton Archipelago region at Alder Island, September 2006.

# DISCUSSION

## LITTLENECK CLAM ABUNDANCE

There is some evidence from past intertidal exploratory surveys in the Broughton Archipelago region that littleneck clam stocks might be in decline. Survey results since 1991 are summarized in Appendix 5. Those sites where surveys have been done at two or more time periods include: Shoal Harbour (surveyed in 1991 and 2002), the Burdwood Group (1991, 2002, 2006), Deep Harbour (1991, 2002, 2006), Port Harvey (1993, 1996), Hadley Bay (1993, 1994), and the Cluxewe River (2002, 2004). Please note the following limitations to the data reviewed: 1) repeated surveys at one location might not have occurred at the same specific beach site and, 2) in general few quadrat samples were dug; consequently, conclusions derived from data trends are not based on rigorous statistical analyses.

There are two sites (the Burdwood Group and Deep Harbour) where littleneck clam data have been documented at three points in time (including 2006) making these sites the best for providing clues to trends in littleneck clam abundance in the area. In the Burdwood Group, littleneck clam densities were fairly high in 1991 (Bourne *et al*. 1994) and 2002 (Gillespie and Bourne 2005a), but few clams were found in 2006 even though 24 quadrats were dug (Pacificus Biological Services Ltd 2006). In Deep Harbour, littleneck clam densities have remained fairly stable since 1991 (Bourne *et al.* 1994), although there is some evidence in 2006 that recruitment has diminished, judging by the few sublegal size clams found (Pacificus Biological Services Ltd 2006).

Sites listed in Appendix 5 that were previously surveyed and then recently explored by the authors in 2006 include Karlukwees (surveyed in 1991; Bourne *et al*. 1994), Alder Island (1991; Bourne *et al*. 1994), and Maple Cove (1994; Heritage *et al*. 1998). We arrived at Karlukwees late for the optimal low tide so much of the lower intertidal area—the best place to find littleneck clams—was not accessible. Regardless, we succeeded in finding a number of clams for histopathological examination, which leads us to believe the littleneck clam population might be similar to that reported in 1991. On the other hand, we did not find many littleneck clams on Alder Island, which contradicts data collected in 1991 when higher densities were reported on this island. At Maple Cove we collected some littleneck clams, mostly on the surface. Our findings there seem similar to those reported in 1994 when only a “few” littleneck clams were found.

In April and May 2006, Pacificus Biological Services Ltd. conducted clam surveys for the Kwicksutaineuk-ah-kwa-mish, Tsawataineuk, and Gwawaenuk Bands at Claydon Bay and Carriden Bay (Pacificus Biological Services Ltd. 2006). Their Claydon Bay survey site was located at the nearby Indian Reserve, a slightly different location than where we visited. They surveyed 1 stratum and 32 quadrats. Legal littleneck clams were reported to be in low densities, the highest being 4 clams/$m^2$ (7 clams/$m^2$ including all sizes). They reported difficulty ageing the littleneck clams. Butter clams were more abundant, but small in size and light in weight. At Carriden Bay they surveyed 3 strata and 70 quadrats in the same area where we visited. Low densities of legal littleneck clams were found, the highest being 3 clams/m$^2$ (4 clams/m$^2$ including all sizes). Butter clams were much more common. To put the low littleneck clam densities observed into context, they are far below the threshold (30 legal clams/m$^2$) that DFO uses to close beaches to commercial fishing in the depuration clam fishery that targets Manila and littleneck clams (Gillespie 2000, Gillespie *et al*. 2005).

In summary, by comparing past exploratory clam surveys to recent ones done by the authors and Pacificus Biological Services, there is evidence to suggest that littleneck clam stocks may have experienced some sort of decline since 1991 at the Burdwood Group, Deep Harbour, Alder Island, Carriden Bay, and Claydon Bay. Since these sites are spread throughout the Broughton Archipelago region, the littleneck clam stock decline might be widespread and not a local phenomenon.

It is not yet clear whether littleneck clam recruitment is currently down in the Broughton region. In BC, littleneck clams spawn from April to October and their larvae are pelagic for approximately 3 weeks, finally settling at the size of 0.26-0.28 mm (Gillespie and Kronlund 1999). Recruitment is naturally sporadic because its success depends on many factors: the number of adult spawners, water currents and temperature, larval survival (food, predators), etc. The survey work done by Pacificus Biological Services in 2006 indicates that recruitment might be down since their diggers found few sublegal littleneck clams on six Broughton beaches. Finding many small young clams on a beach is indicative of good recruitment. However, Gillespie *et al*. (2005) showed that diggers sometimes miss small clams 29-34 mm in size. Because of their finding, the authors recommended additional training, supervision, and improved quality assurance during Industry surveys. In order to precisely measure littleneck clam recruitment, more focused surveys are required whereby quadrat diggings are screened and small clams carefully collected.

It is important to realize that, although we observed low densities of littleneck clams on all the beaches we visited throughout the Broughton Archipelago, it is unknown whether all sites historically supported high densities of littleneck clams. Previous exploratory surveys throughout the BC coast show that littleneck clams were the most common bivalve encountered (Heritage *et al*. 1998, Gillespie and Bourne 2005b). But sites other than Claydon Bay, Carriden Bay, and Carter Passage might traditionally have been harvested by First Nations people for butter clams and cockles, and possibly never supported high densities of littleneck clams. Thompson (1914) reported the most important clam species in the Queen Charlotte Sound area was the butter clam. He also found cockles and littleneck clams on most beaches, but did not provide density estimates.

Maple Cove in Port Elizabeth supported predominately cockles and butter clams in 1994 (Heritage *et al*. 1998) and the beach had a similar composition of clams in 2006. Betty Cove and Alder Island were likely important clam-bearing areas because they have important historic ties to local First Nations. Betty Cove was closed to the commercial fishery in 1992 in order to assure First Nations access to clams for FSC purposes. The beach was selected based on recommendations from the Kwakiutl Territories Fisheries Commission (KTFC) (Harbo *et al.* 1997). Thompson (1914) stated the residents from Mama-liliculla went to Alder Island for their clams and the island remains an important FSC beach today. But whether dense stocks of littleneck clams ever existed at Betty Cove and Alder Island remains unclear.

## LITTLENECK CLAM STOCK HEALTH

Almost all the littleneck clams we collected were considered to be healthy. However, the occurrence of conchiolin deposits inside the shells of 14% of the clams may warrant further investigation if the clam populations continue to decline on the beaches of concern. Although conchiolin deposits inside clam shells are a non-specific response to irritation, in *Tapes* (*Venerupis*) clams in Europe this is a sign of brown ring disease (Bower *et al*. 1994). To date, this disease has not been observed in clams (including Manila clams) in BC, but further investigations into its possible occurrence in the Broughton Archipelago should be undertaken if littleneck clam populations continue to decline without another plausible explanation.

Stunting appears to be common in littleneck clams and has been observed throughout BC, particularly in the North Coast. The shells on stunted clams are thick and heavy and the ventral margins thickened. The posterior and anterior edges of the shells tend to be involuted. There are many false checks on the surface of the shells (Bourne and Cawdell 1992). Why some clams are stunted is not understood, but it might occur in areas outside optimal habitats (in the mid to upper parts of beaches). We observed littleneck clams throughout the intertidal zone. This may be due to the absence of other introduced bivalves like Manila and varnish clams; Broughton littleneck clams might face less competition and, therefore, be able to successfully exploit other areas in the intertidal zone. Other possible explanations for stunting include density dependent factors, environmental factors, cold temperatures, and genetic factors. Complicating the issue around stunting is the fact that fast growing clams are often found in the same area as stunted clams (Bourne and Heritage 1997, Heritage *et al*. 1998, Gillespie and Bourne 2005b).

The parasites and symbionts found in the Broughton littleneck clams have been previously observed / recorded from littleneck clam populations in BC. Although several clams had very high concentrations of Apicomplexan cysts, these cysts are not known to be associated with disease (Desser and Bower 1997). The coccidian was reported associated with numerous littleneck clams on the surface of a beach in Sequim Bay, Washington during the summer of 1980 (Morado *et al*. 1984). In the Broughton area, littleneck clams were often observed at the surface and the significance of this is unknown. N. Bourne (pers. comm. 2006) has seen littlenecks, Manilas, butters, and cockles at the surface on several occasions in a number of areas on the coast, but never attempted to explain his observations.

## LITTLENECK CLAM HARVESTING

There have been four peaks and subsequent declines in commercial littleneck clam landings during the past thirty-five years (1975, 1979, 1989, and 2003) in Area G. Whatever caused the first three drops in landings is unknown, although landings are often market driven and not necessarily related to recruitment events. However, because of the numerous reports in 2005 and 2006 from experienced harvesters and long-standing First Nation participants, it is possible the current drop in littleneck clam landings is directly related to declining stock levels and not market conditions.

On one hand, harvesting activities alone might not be the only factor affecting littleneck clam stocks. The reasons supporting this statement are: the Broughton Archipelago region is large and generally difficult to access, the number of legitimate participants is limited and, despite repeated and regular C and P attendance at the clam buys, there have been very few undersized charges. Also, it appears that the absence of littleneck clams is not isolated to known productive beaches or specific age classes.

On the other hand, over-harvesting might be occurring on beaches well known to First Nation, commercial, and recreational harvesters, such as Alder Island, Deep Harbour, Claydon Bay, and Carriden Bay. Historically, it appears when approximately 100 tonnes of littleneck clams are removed from the area in a year there is a subsequent multi-year decline in commercial landings. Without more precise reporting that tells fisheries managers what particular pocket beach product comes from, and with no collaborative stock monitoring program in place, it is difficult for managers to monitor and effectively control harvest activities or be able to know what the harvest rates are on particular beaches. Research done on Manila clam stocks in the Strait of Georgia for the depuration fishery showed some beaches that were harvested at a 50% Total Allowable Catch (TAC) experienced stock declines, and this rate is lower than the 60% harvest rate believed to occur in conventional commercial fisheries managed with size limits and fishery-based closure criteria (Gillespie and Bond 1997, Gillespie 2000). At present, the clam depuration fishery is managed with a maximum 40% TAC, with most beaches being harvested at a 10 or 20% TAC (Gillespie *et al.* 2005).

## BEACH SUBSTRATES

In the Pacific northeast, littleneck clams are found from Cabo San Lucas, Baja California Sur to the Aleutian Islands (Coan *et al.* 2000). Generally, however, they are abundant only north of Oregon. Thus, Broughton littleneck clams are located near the center of their range. Geographic distribution slightly affects littleneck clam growth rates probably because colder water temperatures slow their growth (Bourne and Cawdell 1992). That is why littleneck clam growth rates are slower in the Alert Bay area than in the Strait of Georgia (Bourne *et al.* 1994).

As well, at a local level, clam growth varies by beach and position on a particular beach (Gillespie and Bourne 2000). Littleneck clams are often found in the low to mid intertidal beach level in mixed gravel, sand, and mud substrates (Quayle and Bourne 1972, Bourne and Cawdell 1992, Bourne and Heritage 1997, Coan *et al*. 2000). Clams settling at other tidal elevations and in different substrates may see their growth negatively affected because of exposure to predators and food availability. For example, as discussed, stunted clams are often found at higher tidal elevations. At the sites we visited, substrates varied from being mostly sand to a mixture of sand, gravel, mud, and shell. Often there were numerous small pockets on a particular beach with varying mixes of these substrate types. We also found black sediments and stained black clams on several beaches, in particular Claydon Bay and Karlukwees. Black sediments are often indicative of anoxic conditions and such conditions are common in intertidal areas (N. Bourne pers. comm. 2006). Worms were present on all beaches, although there were very high concentrations in mounds of shelly/sand on Grave Island. Horse mussels were found in the substrate at Alder Island. Most beaches had shell debris on the surface.

Macro-algae were prevalent on almost all the beaches; the quantity and vitality of the mats would be influenced by the time of year and various environmental conditions. We observed particularly thick algal mats at Betty Cove and Alder Island. Robinson *et al*. (2005) showed algal mats do negatively affect softshell clam recruitment, behaviour, growth, and survival, so extensive algal mats at these two sites could be deleteriously affecting those clams they cover. Sometimes a thick layer of macro-algae like *Ulva* sp. may indicate that eutrophication, which is an increase in the rate of supply of nutrients to an ecosystem, might be occurring. But whether this is happening at these sites is unknown at this time, as is a possible source of nutrients, be it natural or anthropogenic in origin.

In conclusion, reports from First Nations and commercial harvesters made to DFO managers indicate littleneck clam stocks in the Broughton Archipelago region are presently in decline. In response, DFO staff and ‘Namgis representatives explored 12 sites in the region and collected littleneck clams to obtain biological information, density estimates, and determine whether disease or parasites were responsible for the stock’s apparent decline. Our results support reports that littleneck clam populations are low. Most of the littleneck clams examined were healthy, so a disease outbreak is not likely the reason why stocks are depressed. More focused research is needed on the impacts of harvesting and other human activities on littleneck clam populations. In the meantime we suggest littleneck clam resource management in the Broughton Archipelago region would benefit from:

1. beach inventories,
2. surveys to track stock trends over time,
3. the collection and analysis of biological information (especially recruitment),
4. the collection of environmental data (beach substrate type, organic matter content, community structure, etc.).

## ACKNOWLEDGEMENTS

We thank T. Johansson and the ‘Namgis First Nation for organizing and participating in the field survey. S. Davies assisted with the histological examinations. K. Fong prepared the map in Figure 3. D. Stucchi, J. Chamberlain, T. Sutherland, J. Boutillier, and R. Harbo reviewed drafts of this report. K. Marcus and R. Webb provided useful comments.

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## Appendix 1

Field notes for beaches explored in the Broughton Archipelago region, September 2006.

| Location | Lat/Long | Date/Time | Approx Size (ha) | Beach Description | Bivalves Live | Bivalves Shell | Comments |
|---|---|---|---|---|---|---|---|
| Claydon Bay Beach #1 West side of bay | 50°55.642 N 126°53.944 W | Sept. 9 0715 | 5 | Clam terrace<br>Gentle slope<br>Substrate black, sand/mud/gravel<br>Much shell on surface<br>Much *Ulva* sp., little eelgrass | CN<br>SG<br>PS<br>MI<br>T siphons | MA | Looks similar to Alder Island<br>Found very few PS |
| Claydon Bay Beach #2 Head of bay | 50°56.041 N 126°54.111 W | Sept. 9 0750 | 8 | Gentle slope<br>Substrate black, sand/gravel<br>Much shell on surface | CN<br>SG<br>PS<br>MI<br>TC | | Similar to beach #1<br>Low density of PS |
| Carriden Bay Beach #1 | 50°54.264 N 126°54.504 W | Sept. 9 0830 | 3 | Gentle slope<br>Substrate sandy, some shell<br>Colonies of tube worms in low intertidal<br>Light layer of *Ulva* sp. | SG<br>PS<br>CN<br>MI | | Low densities of PS<br>Some PS on surface |
| Carriden Bay Beach #2 Head of bay | 50°54.680 N 126°54.378 W | Sept. 9 0910 | 5 | Gentle slope<br>Substrate sandy up to creek, sandy/shelly across creek | SG<br>PS<br>CN<br>MI<br>T | | A cleaner, sandy beach<br>Better PS habitat across creek.<br>Coho in creek |
| Carter Passage | 50°50.510 N 126°50.985 W | Sept. 9 1000 | 1 | Gentle slope<br>Substrate sand/mud/gravel<br>Some eelgrass, very little *Ulva* sp. | PS<br>SG<br>MN<br>MI<br>CN | TC<br>MA | Lots of shell debris in higher intertidal |

Clam codes: *Clinocardium nuttallii* (CN), *Saxidomus gigantea* (SG), *Protothaca staminea* (PS), *Macoma inquinata* (MI), *Macoma nasuta* (MN), *Tresus* spp. (T), *Tresus capax* (TC), *Mya arenaria* (MA)

**Appendix 1** (con't)

Field notes for beaches explored in the Broughton Archipelago region, September 2006.

| Location | Lat/Long | Date/Time | Approx Size (ha) | Beach Description | Bivalves Live | Bivalves Shell | Comments |
|---|---|---|---|---|---|---|---|
| Alder Island | 50°36.233 N<br>126°37.052 W | Sept. 6<br>0655 | 2 | Clam terrace<br>Gentle slope<br>Substrate mud/gravel/shell<br>Lots of eelgrass, extensive *Ulva* sp. covering, fine sediment cover prevalent | CN<br>SG<br>MI<br>MN<br>MA<br>PS<br>MM | TC | Primarily butter and cockle beach<br>PS in higher intertidal |
| Grave Island Beach #1 | 50°37.003 N<br>126°35.289 W | Sept. 6<br>0830 | 0.1 | Gentle/moderate slope<br>Substrate shell/sand, full of worms | PS<br>SG<br>MI<br>TC<br>MN<br>CN<br>MT | | |
| Grave Island Beach #2 | 50°36.994 N<br>126°35.275 W | Sept. 6<br>0850 | 0.6 | Gentle slope<br>Sand and gravel pockets<br>Eelgrass in lower intertidal, some *Ulva* sp. covering | SG<br>MI<br>MN<br>PS | | PS in higher intertidal |
| Betty Cove | 50°42.277 N<br>126°39.851 W | Sept. 8<br>0700 | 9 | Gentle slope<br>Boulder field in low/mid intertidal and sandy in high intertidal<br>Thick layer of *Ulva* sp. in low to mid intertidal<br>Sediment under *Ulva* sp. a sludgy sand/mud. A number of different worm species<br>Tube worms common | PS<br>CN<br>MN<br>MI | SG<br>MA | Macomas abundant, few PS and few clams in general<br>Looked similar to Alder Island<br>A few (<10) dead mackerel were observed |

Clam codes: *Clinocardium nuttallii* (CN), *Saxidomus gigantea* (SG), *Protothaca staminea* (PS), *Macoma inquinata* (MI), *Macoma nasuta* (MN), *Tresus* spp. (T), *Tresus capax* (TC), *Mya arenaria* (MA), *Mya truncata* (MT), *Modiolus modiolus* (MM).

## **Appendix 1** (con't)

Field notes for beaches explored in the Broughton Archipelago region, September 2006.

| Location | Lat/Long | Date/Time | Approx Size (ha) | Beach Description | Bivalves | | Comments |
|---|---|---|---|---|---|---|---|
| | | | | | Live | Shell | |
| Midsummer Island | 50°39.133 N<br>126°40.881 W | Sept. 8<br>0815 | 2.5 | A channel between Midsummer and Cedar Islands<br>Gentle slope<br>Cobble/boulder in middle, more sandy on the fringes, changing to clay on one end<br>Dense *Ulva* sp. mats, other seaweeds like sea sacs (*Halosaccion glandiforme*) present | CN<br>SG<br>PS<br>MI | | Impression that beach looked well flushed (open at both ends)<br>Intertidal area submerged during high tide |
| Port Elizabeth (Maple Cove) | 50°40.949 N<br>126°27.939 W | Sept. 8<br>0930 | 7 | Gentle slope<br>Sand, much eelgrass<br>Creek on NE side | CN<br>PS | SG<br>CN<br>MA<br>MN | Lots of cockle shells on surface, and live PS |
| Karlukwees | 50°34.725 N<br>126°29.865 W | Sept. 6<br>0930 | 3.5 | Moderate slope<br>Gravel and cobble with sandy pockets<br>Substrate black in middle near barge, lighter on either side of beach.<br>*Ulva* sp. present in water in low intertidal | SG<br>PS<br>MI<br>CN | MA | A derelict barge there may be leaking contaminants<br>Clam shells (CN, SG, PS) stained black<br>Did not get here at low tide so some of the beach not explored. |

Clam codes: *Clinocardium nuttallii* (CN), *Saxidomus gigantea* (SG), *Protothaca staminea* (PS), *Macoma inquinata* (MI), *Macoma nasuta* (MN), *Tresus* spp. (T), *Tresus capax* (TC), *Mya arenaria* (MA), *Mya truncata* (MT)

## Appendix 2

Macro-algae on the beach at Betty Cove.

Digging for clams at Alder Island.

**Appendix 3**

Fisheries and Oceans   Pêches et Océans   Canada

# SHELLFISH HEALTH REPORT

Pacific Biological Station
Nanaimo, B.C.
V9T 6N7

## *Sample Information*

| | |
|---|---|
| Case No.: | 7871 (Page 891) |
| Collection Date: | September 6 to 8, 2006 |
| Location: | Broughton Archipelago (see table below for specific locations) |
| Species: | Littleneck Clams (*Protothaca staminea*) |
| Size / Age: | Shell length 26 to 60 mm / wild stock mixed year classes |
| History: | Collected by Jason Dunham, transported live to PBS, held in seawater tank until processing on September 14 &15, 2006. |
| Purpose: | Investigate the cause of declining populations |
| Contact Info.: | Jason Dunham, Pacific Biological Station, Nanaimo, B.C. |

## *Necropsy / Macroscopic Observations (Sample Size = 92)*

| Location | # Collected | # Sampled | Sp. # | Abnormalities (all specimens with no comments appeared normal and healthy) |
|---|---|---|---|---|
| Claydon Bay # 1 (Surface) | 2 | 2 | 14-15 | Sp. # 14 & 15 stunted / thick shell growth |
| Claydon Bay # 1 | 25 | 10 | 16-25 | Sp.# 16 minor conchiolin inside shell near siphon |
| Claydon Bay # 2 (Surface) | 8 | 3 | 1,2 & 13 | Sp.# 1 & 2 were gaping / dead (fixed by Jason on Sept.9/06)<br>Sp.# 13 gaping / moribund with minor conchiolin inside shell<br>Additional 5 were discarded (dead and decomposing) |
| Claydon Bay # 2 | 10 | 10 | 3-12 | Sp.# 3 damage to ventral edge of shell with minor conchiolin<br>Sp.# 5 stunted / thick shell growth<br>Sp.# 7 stunted / thick shell growth + brown coloured mantle |
| Carriden Bay #1 (Surface) | 8 | 5 | 38-42 | Sp.# 38 gaping / moribund – early stage decomposition<br>Sp.# 41 stunted / thick shell growth |
| Carriden Bay #1 | 21 | 5 | 43-47 | Sp.# 44 stunted / thick shell growth |
| Carriden Bay #2 | 11 | 5 | 48-52 | Sp.# 50 Extensive conchiolin deposit inside shell adjacent to siphon |
| Carter Passage (Surface) | 2 | 2 | 26-27 | |
| Carter Passage | 16 | 10 | 28-37 | Sp.# 29 conchiolin deposit inside shell adjacent to siphon<br>Sp.# 36 stunted / thick shell growth |
| Karlukwees | 36 | 10 | 57-66 | Sp.# 59 stunted / thick shell growth |
| Alder Is. | 15 | 10 | 83-92 | Sp.# 83 minor conchiolin deposit on shell edge near siphon |

| | | | | |
|---|---|---|---|---|
| | | | | Sp.# 85 moderate conchiolin deposit adjacent to siphon<br>Sp.# 86 conchiolin deposit inside shell adjacent to siphon |
| Grave Is. | 35 | 10 | 67-76 | Sp.# 69 dark orange coloured tissue |
| Betty Cove | 2 | 2 | 55-56 | Sp.# 55 conchiolin deposit inside shell |
| Midsummer Is. | 2 | 2 | 53-54 | |
| Port Elizabeth (Surface) | 6 | 6 | 77-82 | Sp.# 77 & 81 extensive conchiolin deposit along mantle margin<br>Sp.# 78 minor conchiolin deposit inside shell<br>Sp.# 79 conchiolin deposit inside shell adjacent to siphon<br>Sp.# 82 weak – opened easily and tissues emaciated |

**Microscopic Observations / Histological Examination** (Sample Size = 25)

- 25/92 specimens with varying abnormalities and stress indicators (as noted in the table above) were selected for histological examination because they were considered to be the most probable for pathogen detection.
- Sex ratio: 12 male, 12 female and 1 spent

Pathology:
- 3/25 (#1, 2 & 38) had moderate to extensive tissue necrosis of the gill, kidney and muscle tissue associated with systemic secondary bacterial infection. In all 3 specimens the gills were necrotized to the point of being devoid of epithelium. However no aetiological agent was detected and this condition is suspected to be the result of post mortem degenerative change.
- 1/25 (#77) had minor diffuse haemocyte infiltration in the connective tissue near the junction of the siphon, mantle and adductor muscle. In addition the digestive gland epithelial cells of this specimen appeared to be highly vacuolated. However no aetiological agents were detected in association with these conditions.
- 2/25 (#7 & 55) had elevated levels of brown-orange coloured pigment granules in the gills, labial palps, gut epithelium and connective tissues, however no aetiological agent was detected

Parasites and Symbionts:
- 8/25 (7 light and 1 moderate) Rickettsia-like prokaryotes (RLP) were detected in the gill epithelial cells.
- 3/25 (light) Rickettsia-like prokaryotes (RLP) were detected in the digestive gland epithelial cells.
- 7/25 (5 light and 2 moderate) Nematopsis-like spores (APX) were detected in the connective tissues of gill, gonad and visceral mass.
- 8/25 (4 light, 2 moderate and 2 heavy) Coccidia (*Margolisiella kabatai*) were detected in the kidney
- 1/25 (light) Rhynchodida-like ciliates were detected attached to the gill epithelium
- 8/25 (7 light and 1 moderate) protozoa (ciliates) were detected adjacent to the external surfaces of the gills and mantle.
- 11/25 (9 light, 1 moderate and 1 heavy) Apicomplexan cysts (containing banana-shaped zoites) were detected primarily in the connective tissue of the visceral mass.
- Intensity ratings: Light 1 to 9 / section, Moderate 10 to 50 / section and Heavy > 50 / section

## *Conclusions*

All of the above parasites and symbionts have been previously observed / recorded from littleneck clam populations in British Columbia. There was no pathology associated with any of these infections however 3 of the specimens did have some of the highest intensity ratings observed to date for Coccidia (*Margolisiella kabatai*) and Apicomplexan cysts. Although the Apicomplexan cysts are not known to be associated with disease (see Desser, S.S. and S.M. Bower. 1997. The distribution, prevalence, and morphological features of the cystic stage of an apicomplexan parasite of native littleneck clams (*Protothaca staminea*) in British Columbia. The Journal of Parasitology 83: 642-646), the coccidian was associated with numerous littleneck clams on the surface of the beach in Sequim Bay, Washington during the summer of 1980 (see Morado, J.F., A.K. Sparks and S.K. Reed. 1984. A coccidian infection of the kidney of the native littleneck clam *Protothaca staminea*. Journal of Invertebrate Pathology 43: 207-217).

No parasites or infectious organisms were detected that would help to explain the cause of the declining populations. None of the following pathogens of concern (known to cause mortality in bivalves) were detected: *Perkinsus* spp., *Marteilia* spp., *Haplosporidium* spp., *Bonamia* spp. or Mikrocytos *mackini* by histopathological examination. However, the occurrence of conchiolin deposits inside the shell of 14% of the clams may warrant further investigation if the clam populations continue to decline on the beaches of concern. Although a conchiolin deposit inside the shell of clams is a non-specific response to irritation, in *Tapes* (*Venerupis*) clams in Europe this is a sign of Brown Ring Disease (see http://www.pac.dfo-mpo.gc.ca/sci/shelldis/pages/brdcc_e.htm). To date, this disease has not been observed in clams (including Manila clams) in BC but further investigations into its possible occurrence in the Broughton Archipelago should be undertaken if littleneck clam populations continue to decline without another plausible explanation.

The above results indicate that further histological examination of this sample is not warranted. However, the tissue samples from the 67 normal / healthy littleneck clams were preserved and have been embedded in paraffin and will be archived for future reference if the need arises.

Dr. Susan Bower (250) 756-7077 / Gary Meyer (250) 756-7034 Date

*Please note: this report applies solely to the animals examined and should not be* considered as a certificate of health for the entire stock or population. Such certification cannot be absolute and would require repeat sampling and monitoring to guidelines specified by the World Animal Health Organisation (OIE).

**Appendix 4**

Fisheries and Oceans / Pêches et Océans

Canada

# SHELLFISH HEALTH REPORT

Pacific Biological Station
Nanaimo, B.C.
V9T 6N7

## *Sample Information*

| | |
|---|---|
| Case No.: | 7872 (Page 891) |
| Collection Date: | September 6 to 8, 2006 |
| Location: | Alder Island |
| Species: | Butter Clam (*Saxidomus giganteus*) |
| Size / Age: | 63 to 87 mm / wild stock mixed year classes |
| History: | Collected by Jason Dunham, transported live to PBS, held in seawater tank until processing on September 15, 2006. |
| Purpose: | General health check requested |
| Contact Info.: | Jason Dunham, Pacific Biological Station, Nanaimo, B.C. |

## *Macroscopic Observations (Sample Size = 9)*

- All 9 appeared healthy and fat (tissues completely filling shell volume)

**Microscopic Observations / Histological Examination** (Sample Size = 5)

- Sex ratio: 3 male and 2 female
- 5/5 (2 moderate and 3 heavy) Rickettsia-like prokaryotes (RLP) were detected in the gill epithelial cells.
- 3/5 (1 light and 2 moderate) Rickettsia-like prokaryotes (RLP) were detected in the digestive gland and or intestine epithelial cells.
- 5/5 (3 light and 2 moderate) Nematopsis-like spores (APX) were detected in the connective tissues of gill, gonad and visceral mass.
- 1/5 (light) Rhynchodida-like ciliates were detected attached to the gill epithelium.
- 1/5 (light) encysted Trematode metacercaria were detected in connective tissue.
- 1/5 (light) metazoan (copepods) were detected externally / adjacent to tissues.
- Intensity ratings: Light 1 to 9 / section, Moderate 10 to 50 / section and Heavy > 50 / section

## *Conclusions*

No pathology was observed and all of the above parasites and symbionts have been previously recorded at comparable intensities in other bivalve populations from British Columbia. In addition, none of the following pathogens of concern (known to cause mortality in bivalves) were detected: *Perkinsus* spp., *Marteilia* spp., *Haplosporidium* spp., *Bonamia* spp. or Mikrocytos *mackini* by histopathological examination.

Dr. Susan Bower (250) 756-7077 / Gary Meyer (250) 756-7034 Date

Please note: this report applies solely to the animals examined and should not be considered as a certificate of health for the entire stock or population. Such certification cannot be absolute and would require repeat sampling and monitoring to guidelines specified by the World Animal Health Organisation (OIE). The scope of this examination is limited to the detection of pathology, symbionts, parasites or infectious organisms that can impact the health of shellfish. It does not include any tests concerning chemicals, pollutants or human health concerns.

## Appendix 5

Observations of littleneck clam abundance in the Broughton Archipelago region (1991-2006).

| Date | Location | Site | No. Quadrats | Littleneck Abundance (Legals/m$^2$) | Reference |
|---|---|---|---|---|---|
| 1991 | West Gilford Island | Monday Anchorage | 7 | 4-100 | Bourne *et al.* (1994) |
| | | Head Viner Sound | 7 | 8-136 | |
| | | Fox Island Group | 2 | 0 | |
| | | Shoal Harbour | 2 | 4 | |
| | | Burdwood Group | 3 | 4-136 | |
| | | Deep Harbour | 2 | 24, 284<br>Many sublegals | |
| | Indian Channel | Harbledown Island | 3 | 12-76 | |
| | | Harbledown Island | 2 | 4, 16 | |
| | | Mound Island | 1 | 68 | |
| | | Karlukwees | 2 | 16, 36<br>Many sublegals | |
| | | Alder Island | 2 | 52, 100 | |
| 1993 | Drury Inlet | 5 beaches | 5 | 0-232<br>Common and abundant<br>Many sublegals on some beaches | Bourne and Heritage (1997) |
| | Nowell Channel – Fife Sound | Cockatrice Bay | | Present | |
| | | Dobbin Bay | | Present | |
| | | Booker Lagoon (4 beaches) | Pooled | 0-124<br>Generally abundant | |
| | | Eden Island | | Present | |
| | Port Harvey | | | Some | |
| | Havannah Channel | Near Whitebeach Point | | No littlenecks mentioned.<br>Not a clam beach | |
| | | Boughey Bay | | Few | |
| | | Burial Cove | | Few | |
| | Chatham Channel | Hadley Bay | | No littlenecks mentioned | |
| | Port Neville | 3 beaches | | Abundant | |

**Appendix 5** (con't)

Observations of littleneck clam abundance in the Broughton Archipelago region (1991-2006).

| Date | Location | Site | No. Quadrats | Littleneck Abundance (Legals/m$^2$) | Reference |
|---|---|---|---|---|---|
| 1994 | Port Elizabeth | Maple Cove | | Few, stunted | Heritage *et al.* (1998) |
| | | 2 beaches near head | | Fair concentrations | |
| | Chatham Channel | Cutter Cove | | Some | |
| | | Pearley Lagoon | | Stunted | |
| | | Hadley Bay | | Reasonable concentrations, stunted | |
| 1996 | Port Harvey | Near head | | Some shell? | |
| | | Near Mist Islets | | Many large old ones, good growth | |
| | | IR | | Stunted | |
| 2002 | West Gilford Island | Burdwood Group | 2 | 116, 128<br>Many sublegals | Gillespie and Bourne (2005)a |
| | | Deep Harbour | 1 | 22 | |
| | | Shoal Harbour | 1 | 96 | |
| | Broughton Strait | Cluxewe River | 4 | 0-4 | |
| | | Nimpkish River | | No littlenecks mentioned | |
| 2004 | Broughton Strait | Cluxewe River | | Shell | Gillespie and Bourne (2005)b |
| 2006 | Wells Pass | Tracey Harbour | 41 | 1.6-2.3<br>Few sublegals | Pacificus Biological Services Ltd (2006) |
| | Grappler Sound | Carriden Bay | 70 | 0.3-2.9<br>Few sublegals | |
| | | Claydon Bay | 32 | 4<br>Few sublegals | |
| | West Gilford Island | Burdwood Group | 24 | 0<br>Few sublegals | |
| | | Deep Harbour | 30 | 15<br>Few sublegals | |
| | Retreat Passage | Carrie Bay | 20 | 3<br>Few sublegals | |