Survey of Northern Abalone, *Haliotis kamtschatkana*, Populations in Southeast Barkley Sound, British Columbia, October 2002

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SURVEY OF NORTHERN ABALONE, *Haliotis kamtschatkana*, POPULATIONS IN SOUTHEAST BARKLEY SOUND, BRITISH COLUMBIA, OCTOBER 2002

by

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ABSTRACT

Lessard, J., D. Brouwer, and J.P. Mortimor. 2004. Survey of northern abalone, *Haliotis kamtschatkana*, populations in southeast Barkley Sound, British Columbia, October 2002. Can. Manuscr. Rep. Fish. Aquat. Sci. 2685: 11 p.

A survey was conducted to provide an estimate of the population size of emergent northern abalone (*Haliotis kamtschatkana*) on the east side of Edward King Island, Deer Group, Barkley Sound, British Columbia, during October 16-18, 2002. The estimated mean density for emergent abalone of all sizes was 0.295/m^2, while the estimated mean density for abalone 81-120 mm in shell length (SL) was 0.123/m^2. The estimated total population number (and lower 90% confidence interval) of emergent abalone for all sizes was 21,075 individuals (15,744). The total population number (and 90% confidence interval) of emergent abalone of the 81-120 mm SL size range was estimated to be 8,791 individuals (6,220). This survey is compared to an earlier one conducted in July 2000 at the same location.

RÉSUMÉ

Lessard, J., D. Brouwer, and J.P. Mortimor. 2004. Survey of northern abalone, *Haliotis kamtschatkana*, populations in southeast Barkley Sound, British Columbia, October 2002. Can. Manuscr. Rep. Fish. Aquat. Sci. 2685: 11 p.

Un relevé a été effectué du 16 au 18 octobre 2002 pour estimer une population d'ormeaux nordiques (*Haliotis kamtschatkana*) émergents dans le sud-est de la baie Barkley (Colombie Britannique) où leur présence est connue. La densité moyenne des ormeaux de toutes tailles échantillonnés a été estimée à 0,295/m^2, et celle des ormeaux de longueur allant de 81 à 120 mm, à 0,123/m^2. La population total d'ormeaux émergents de toutes tailles a été estimé à 21 075 (limite inférieure de l'intervalle de confiance à 90%: 15 744), et celle des ormeaux de longueur allant de 81 à 120 mm, à 8 791 (6 220). Les données recueillies lors d'un relevé précédent au même endroit sont comparées.

INTRODUCTION

The northern, or pinto, abalone, *Haliotis kamtschatkana*, in British Columbia (BC) is currently listed as a "threatened species" (*i.e.*, "a species likely to become endangered if limiting factors are not reversed") by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The northern abalone fishery was closed in 1990 to First Nations, recreational divers and commercial fishers, due to conservation concerns (Campbell 1997). For these reasons, all removals of northern abalone are considered a severe conservation risk.

As part of the strategy to rehabilitate northern abalone in BC, initial attempts have included the development of aquaculture methodology for use in stock rebuilding initiatives (Toole *et al.* 2002). This necessitates the removal of some mature abalone from the wild from a number of areas to provide broodstock for seed production at aquaculture facilities in BC. To estimate the abundance of abalone stocks in areas of interest, an independent assessment using conventional survey methodology was required. Protocols to determine abalone abundance and appropriate collection practices were developed in 1999 and used in the initial broodstock collections for aquaculture (Lucas *et al.* 2002a,b,c,d,e). These protocols were reviewed and modified based on the results of early broodstock surveys and collections (Lessard *et al.* 2002). From this review a precautionary approach was recommended where the maximum number of abalone that can be removed from any given site should be less than 1% of the lower 90% confidence limit of the mature abalone population in the 81-120 mm shell length (SL) size range estimated at that site. This recommendation differs from the early protocols where the size range made available for collections was 91-110 mm SL.

The objectives of this study were to determine densities, size frequencies, and population numbers of emergent northern abalone at east Edward King Island for future broodstock collection(s) and compare these results to a previous broodstock survey completed in 2000 (Lucas *et al.* 2002e).

MATERIALS AND METHODS

FIELD METHODS

This survey was conducted during daylight on October 16 - 18, 2002, near Bamfield, BC (Fig. 1). One location, east Edward King Island, was selected based on a previous survey (Lucas *et al.* 2002). The transect survey method (Lessard *et al.* 2002) was used for this study. Transects were randomly placed along the width of shoreline where the abalone population was to be estimated. To avoid bias, these transect positions were determined before field work began. The primary sampling unit was a transect, made up of a cluster of secondary units, or quadrats. Each transect was 1 m wide and variable in length, depending on the slope of the seafloor. Prior to entering the water, a lead line was laid perpendicular to shore from the boat from about 12 m to 0 m from chart datum. The secondary sampling unit consisted of a 1 m x 1 m square quadrat that was placed along the transect. Divers moved the quadrat parallel to the transect line, from deep to shallow, and the number of "emergent" or "exposed" abalone, shell length (SL in mm) of each abalone, depth, substrate type, and macroalgal cover were recorded every 2 m. Substrate was not moved to search for cryptic abalone, since the majority of mature animals (*i.e.*, ≥70 mm SL) are exposed (Sloan and Breen 1988; Cripps and Campbell 1998).

ANALYTICAL METHODS

All gauge depths were converted to depth (m) at chart datum. The survey results were analyzed according to Fisheries and Oceans Canada methodology (Lessard *et al.* 2002). For each site, the estimated mean density, $\bar{d_s}$ (number/m^2), of abalone was calculated as:

$$\bar{d_s} = \frac{\sum_t ((c_t / q_t) * L_t)}{\sum_t L_t} \quad (1)$$

The standard error of the mean density, se_s, was calculated as:

$$se_s = \sqrt{1 - \frac{n}{T}} * \sqrt{\frac{\sum_t ((c_t / q_t) * L_t - d_s * L_t)^2}{n * (n-1) * \bar{L}^2}} \quad (2)$$

where:
n is the number of transects,
c_t is the number of abalone counted in transect t,
q_t is the number of quadrats sampled in transect t,
L_t is the length of transect t,
$\bar{L}$ is the mean transect length,
T is the total possible number of transects that can be sampled in the surveyed area and is equal to the *site width*, defined as the distance between the two furthest shoreline points used when generating random transects.

The expression $\sqrt{1 - \frac{n}{T}}$ is nearly equal to one, because the sample size n is usually small compared to T. This method accounts for the variable length of transects and for the variable proportion of quadrats surveyed along each transect.

To estimate the mean density (Equation 1) and standard error (Equation 2) for a specific size group (i) (*i.e.*, 81-120 mm SL), the value c_t was substituted with c_{ti}, the counts of size group i in transect t.

At each site, the lower 90% confidence intervals of the mean density (*L90CI*), for all sizes or for a particular size group (81-120 mm SL) of abalone, were calculated using bootstrap methods (Davidson and Hinkley 1997).

The estimated total number of abalone at each site (X), the population, was calculated as:

$$X = L90CI * A \quad (3)$$

where A is the estimated area (m^2) of the surveyed site and was calculated as:

$$\bar{L} * T \quad (4)$$

The population estimates were necessary to determine the number of abalone that could be collected for broodstock. However, the population estimates in 2000 and 2002 were not tested for differences as these values were derived from density and area estimates. The latter are somewhat artificial values based on the mean transect length and site width. Mean SL were compared between the 2000 and 2002 surveys by a two samples t-test. Density estimates were not normally distributed and a Kolmogorov-Smirnov two-sample non-parametric test was used to compare between the two surveys.

RESULTS

BROODSTOCK SURVEY OCTOBER 2002

Edward King Island is moderately exposed to winds and storms, with normal ground swells. The substrate consisted of boulders and bedrock, with some cobble, gravel, sand and shell (see Table 1 in Lucas *et al.* 2002e). The slope of the substrate ranged from 8 - 49% (Table 1). The macroalgal canopy consisted mostly of *Nereocystis luetkeana* along with some *Macrocystis integrifolia.* The predominant macroalgal understory species were *Laminaria* spp. followed by *Pterygophora californica, Phyllospadix scouleri*, and *Eisenia arborea.* Articulated coralline algae were the most common turf algae and encrusting coralline algae were abundant as bottom cover.

The depths surveyed ranged from 0 to 13 m from datum (Table 1). One hundred eight abalone were counted in 365 quadrats along the 15 transects surveyed. All transects surveyed had emergent abalone. The densities of emergent abalone ranged from 0.094 to 0.684 abalone/m^2 for all sizes and 0.000 to 0.400 abalone/m^2 for the 81-120 mm SL size range.

COMPARISON BETWEEN THE JULY 2000 AND OCTOBER 2002 SURVEYS

When looking at the 2000 survey data in Lucas *et al.* (2002e), errors were found and corrected. The results used in the analyses and comparisons of this document are from the corrected values.

At east Edward King Island, the shell lengths of abalone ranged from 38 to 114 mm in 2000 and from 20 to 122 mm in 2002 (Fig. 2). The mean size of emergent abalone in 2000 was 87 mm SL which was significantly larger ($P<0.001$) than the mean SL of 74 mm in 2002.

The estimated mean total density of emergent abalone of all sizes was 0.295± 0.051/m^2 in 2002 and was not significantly different (P>0.5) from the density of 0.235± 0.049/m^2 that was estimated in 2000 (Table 2). For the mature animals in the size range of 81-120 mm SL, the mean density of 0.123±0.027/m^2 in 2002 was not significantly different (P>0.1) from the 2000 estimate of 0.179±0.044/m^2. The mean population estimate of 21,075 emergent abalone in 2002 was almost identical to the population estimate in 2000 (21,161). In 2002, the mean estimate of the number of emergent abalone in the 81-120 mm SL size range was 8,791 which was about half of that estimated in 2000 (16,086). This difference was due to a shorter mean transect length, used in estimating the surveyed area, and to a smaller density of abalone in the 81-120 mm SL size range (Table 2).

DISCUSSION

The mean SL in 2002 was significantly smaller than the mean in 2000. This was probably due to an increase in the proportion of small animals in 2002 and a greater proportion of large abalone in 2000 (Fig. 2). The proportion of the 81-120 mm SL abalone was 76% of the total density in 2000 compared to 42% in 2002. As a result of this difference, as well as a decrease in the mean transect length, the calculated number of abalone that could be collected for broodstock was smaller in 2002, despite a small increase in total density. The decrease in the proportion of abalone within the 81-120 mm SL size range could be a result of two previous broodstock collections at this location. A total of 53 abalone were collected in the 90-110 mm size range after the 2000 survey (Lessard *et al.* 2002). Most likely other factors - such as sea otters and sea star predation, survey season and poaching - also contributed to the decrease in the proportion of larger abalone as the number of abalone removed was small. Although cryptic abalone were not searched for in these surveys, the 2002 results showed some encouraging recruitment (abalone <70 mm SL) (Fig. 2). The decrease in mean transect length is probably due to transect placement as the depth range is similar between both surveys (Table 1 and -1 to 15 m in 2000 (Lucas *et al.* 2002)). Using the mean transect length to estimate the surveyed area was found to be more conservative (smaller area, therefore smaller population estimates) than other methods (Lessard *et al.* 2002).

A conservative estimate of the 81-120 mm SL population numbers of 6,220 emergent abalone was provided by the lower 90% confidence interval (L90CI) for the mean. The resulting potential number of abalone (*i.e.*, <1 % of estimated L90CI (Lessard *et al.* 2002)) to be removed for broodstock is 62 individuals.

The total emergent abalone density estimated from the 2002 survey was lower than the estimate of 0.56/m^2 in 1984 at the same location (Emmett and Jamieson 1988). The 2002 total density estimate was also lower than the estimate of 0.37/m^2 (day time) found at Eagle Bay, near Bamfield (Mortimor *et al.* 2003), but higher than densities found at other locations in the Deer Group (0.04-0.22/m^2, Watson 1993; 0.01-0.07/m^2, Lucas *et al.* 2002). Since these low densities are well below those recommended to ensure sustainable populations (Breen 1986; Campbell 1997), the removal of any abalone from these areas must be considered with caution.

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Table 1. Dive summary for abalone transects surveyed off east Edward King Island, Barkley Sound, October 16-18, 2002.

		Time		Bottom	Depth (m)		Slope	# of	Transect	Total # of Abalone		Density (#/m^2)	
Transect	Date	Start	Finish	Time (min)	Min	Max	(%)	Quadrats	Length (m)	all sizes	81-120 mm	all sizes	81-120 mm
1	Oct 16	09:11	10:12	61	0	9	12	37	73	4	4	0.108	0.108
2	Oct 16	09:42	10:41	59	2	13	49	11	21	6	1	0.545	0.091
3	Oct 16	10:35	10:55	20	1	8	24	16	31	8	1	0.500	0.063
4	Oct 16	11:21	12:07	46	4	8	16	13	25	5	1	0.385	0.077
5	Oct 16	11:05	11:34	29	0	9	24	20	39	8	2	0.400	0.100
6	Oct 16	12:06	12:50	44	0	6	9	37	73	7	3	0.189	0.081
7	Oct 16	12:42	13:26	44	1	9	30	15	29	6	6	0.400	0.400
8	Oct 16	13:02	14:00	58	0	8	10	44	87	5	2	0.114	0.045
9	Oct 16	14:13	14:39	26	3	9	29	11	21	5	2	0.455	0.182
10	Oct 16	14:30	14:55	25	0	10	27	19	37	13	5	0.684	0.263
11	Oct 16	15:00	15:36	36	0	7	11	32	63	3	0	0.094	0.000
12	Oct 17	09:46	11:05	79	2	10	10	34	67	15	6	0.441	0.176
13	Oct 17	12:27	13:25	58	1	8	16	23	45	11	8	0.478	0.348
14	Oct 18	09:44	10:42	58	0	8	15	27	53	3	2	0.111	0.074
15	Oct 18	11:35	12:20	45	2	6	8	26	51	9	2	0.346	0.077

Table 2. Mean densities and population estimates of emergent abalone from east Edward King Island, Barkley Sound, BC, in July 2000 and October 2002.

	2000	**2002**
Number of Transects	11	15
Mean Transect Length	59.9	47.7
Shore Width	1,500	1,500
Surveyed Area (m^2)	89,864	71,500
Density Total (abalone/m^2)		
Mean	0.235	0.295
SE	0.049	0.051
L90% CI	0.161	0.220
Density 81-120 mm (abalone/m^2)		
Mean	0.179	0.123
SE	0.044	0.027
L90% CI	0.114	0.087
Population all sizes		
Mean	21,161	21,075
L90% CI	14,423	15,744
Population 81-120 mm SL		
Mean	16,086	8,791
L90% CI	10,209	6,220
Allowable for collection (1%)	102	62

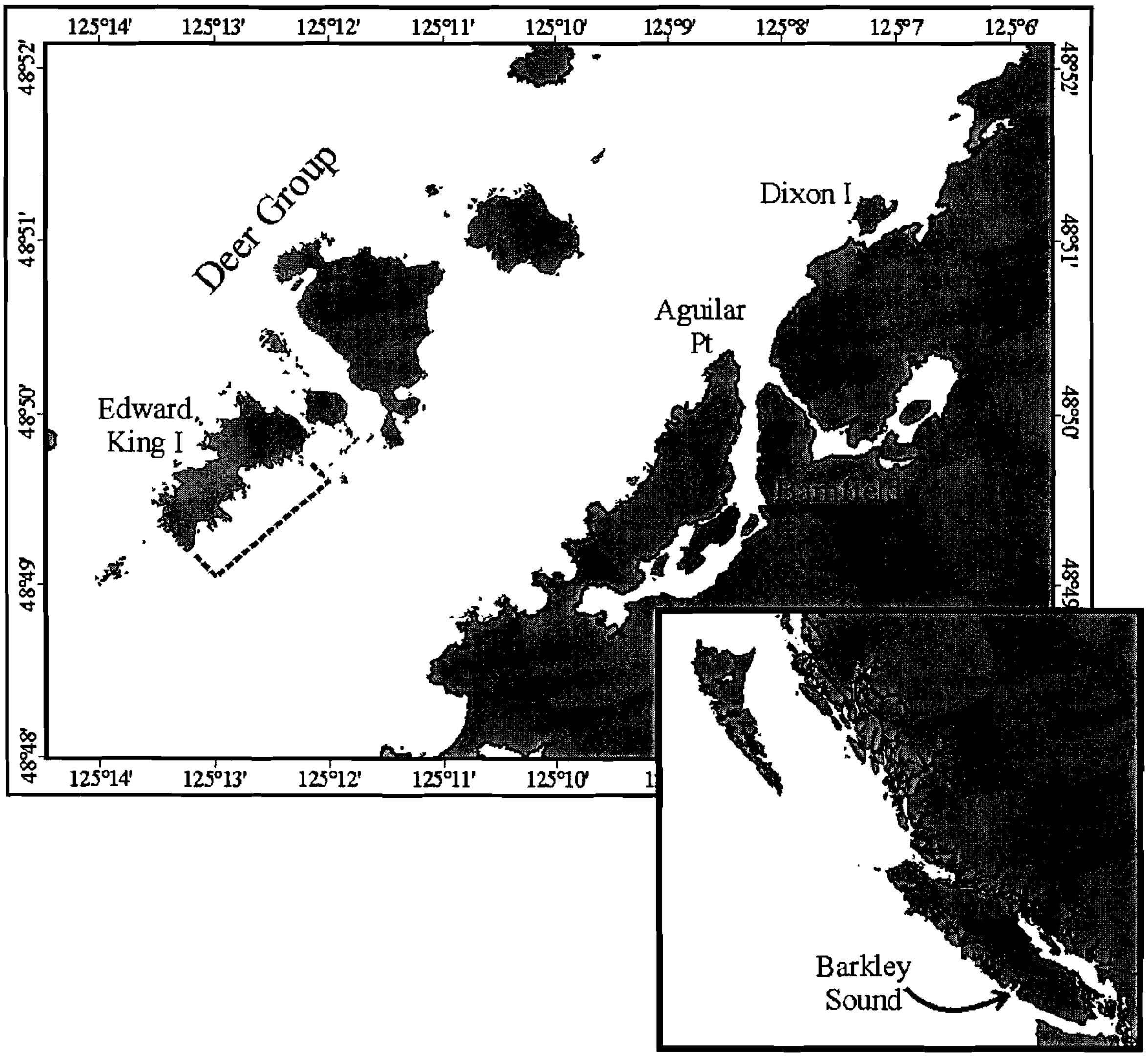

Figure 1. Abalone survey area (dashed line), Edward King Island, Barkley Sound, BC.

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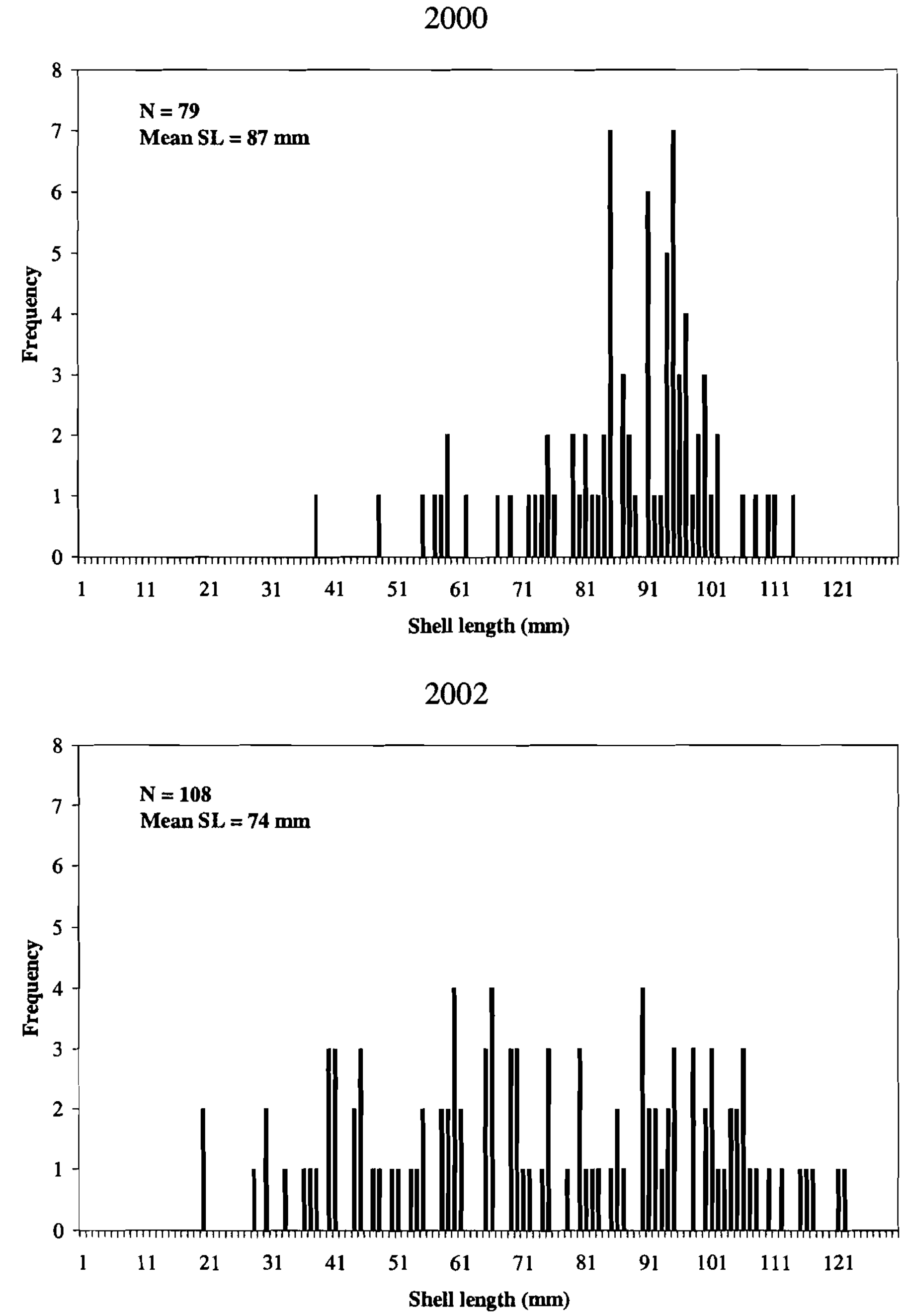

Figure 2. Size frequencies of emergent abalone found in quadrats during dive surveys off east Edward King Island, Barkley Sound, BC, are shown for July 2000 and October 2002. Number of abalone (N) and mean shell length (SL) in mm are shown.