

# **Resurvey of Abalone Populations at Tribal Group, Simonds Group and Stryker Island, Central Coast of British Columbia, 1998**

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RESURVEY OF ABALONE POPULATIONS AT  
TRIBAL GROUP, SIMONDS GROUP AND STRYKER ISLAND,  
CENTRAL COAST OF BRITISH COLUMBIA, 1998

by

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## ABSTRACT

Lucas, B.G., A. Campbell, and K. Cripps. 1999. Resurvey of abalone populations at Tribal Group, Simonds Group and Stryker Island, central coast of British Columbia, 1998. Can. Manuscr. Rep. Fish. Aquat. Sci. 2487: 18 p.

Transect surveys were conducted to determine population size structure and density for northern abalone, *Haliotis kamtschatkana*, in the Tribal, Simonds and Stryker Island Groups on the central coast of British Columbia during May and June, 1998. Size frequencies and mean shell length (SL) of abalone decreased with depth in all areas. Adult abalone ( $\geq 70$  mm SL) were more abundant in  $< 5$  m depths, whereas small juveniles ( $< 50$  mm SL) were found at all depths, but less frequently at intertidal depths. Exposed abalone densities ranged from 0 - 3.58 per  $\text{m}^2$ , with a mean for all areas of 0.42 per  $\text{m}^2$ . Mean densities were greater for all size groups in the Tribal Group than at Stryker Island, and were greater than all size groups except "legal" ( $\geq 100$  mm SL) in the Simonds Group. Comparisons between 1997 and 1998 surveys for all three areas combined indicated that, although mean densities were generally lower in 1998, the differences between the two years were not statistically significant. Persistently low densities of exposed abalone warrant continued concern for the conservation of *H. kamtschatkana* in this area of the central coast of British Columbia.

## RÉSUMÉ

Lucas, B.G., A. Campbell, and K. Cripps. 1999. Resurvey of abalone populations at Tribal Group, Simonds Group and Stryker Island, central coast of British Columbia, 1998. Can. Manuscr. Rep. Fish. Aquat. Sci. 2487: 18 p.

Nous avons effectué, en mai et en juin 1998, des relevés sur transects pour déterminer la structure par taille et la densité des populations d'orveau nordique (*Haliotis kamtschatkana*) dans les groupes d'îles Tribal et Simonds, et l'île Stryker, dans la zone centrale de la côte de Colombie-Britannique. La fréquence des tailles et la longueur moyenne de la coquille (LMC) des orveaux diminuaient en fonction de la profondeur dans toutes les zones. Les orveaux adultes ( $\geq 70$  mm LMC) étaient plus abondants à des profondeurs de moins de 5 m, tandis que les petits juvéniles ( $< 50$  mm LMC) se retrouvaient à toutes les profondeurs, mais moins fréquemment dans la zone intertidale. Les densités des orveaux exondés étaient de 0 à 3,58 au  $m^2$ , avec une moyenne de 0,42 au  $m^2$  dans toutes les zones. Pour toutes les grandeurs, les densités moyennes étaient plus élevées dans les îles Tribal que dans l'île Stryker; et elles étaient plus élevées pour toutes les grandeurs, sauf pour la taille « légale » ( $\geq 100$  mm LMC), dans les îles Simonds. La comparaison des relevés de 1997 et de 1998 pour les trois zones a montré que, même si en général les densités moyennes étaient moins élevées qu'en 1997, les différences entre les deux années n'étaient pas statistiquement importantes. Les densités des orveaux exondés restent faibles, et la préservation d'*H. kamtschatkana* demeure très préoccupante dans cette région de la Colombie-Britannique.

## INTRODUCTION

The 'northern' or 'pinto' abalone, *Haliotis kamtschatkana*, generally occurs in patchy distribution on exposed and semi-exposed coasts from Sitka Island, Alaska to Baja California, including British Columbia (B.C.) (Sloan and Breen 1988). Northern abalone were harvested by first nations, and in commercial and recreational fisheries in B.C. until 1990, when the fishery was closed due to conservation concerns after surveys indicated that the abundance of northern abalone had declined (Winther et al. 1995; Thomas and Campbell 1996). Abalone stocks in the Heiltsuk First Nation's traditional fishing area were surveyed during 1980 (Breen and Adkins 1982), 1993 (Thomas and Campbell 1996), and 1997 (Campbell et al. 1998) using the standard, broad-scale survey design established by Breen and Adkins (1979). A random transect method (Cripps and Campbell 1998) was used to survey abalone populations in the Tribal Group, Simonds Group, and Stryker Island in 1997 (Campbell and Cripps 1998).

Monitoring abalone populations on a frequent basis (e.g., yearly) can provide time-series trends on abalone population characteristics such as changes in density and recruitment. The objectives of this study were to estimate the density of abalone using the random transect method during 1998, to determine any relationships between depth and abalone size and density, and to compare changes in abalone populations between the 1997 and 1998 transect surveys conducted in the Heiltsuk traditional fishing areas (Fig. 1).

## METHODS

The positions of the transects surveyed in this study were approximately the same as those surveyed in 1997 (Campbell and Cripps 1998), with the addition of six new transects. In 1997 and for new transects, transect locations were randomly placed on a nautical chart by positioning a metric ruler, marked in mm, along the length of shoreline to be surveyed. A random numbers table was used to select the position along the ruler where survey transects were to be placed. For transects previously surveyed, transect origin was located using GPS. The transect survey method (Cripps and Campbell 1998) was used for both studies. The primary sampling unit was a "transect", made up of a cluster or variable number of secondary units. Each transect was one meter wide and variable in length, depending on the slope of the substrate, from the intertidal zone to approximately 8 m below chart datum. All depth recordings were converted to depth at datum. The secondary sampling unit consisted of a 1 m x 1 m square quadrat that was placed on the right side of the transect line. Lead line was deployed from the transect origin, and perpendicular to the isopleths, to an estimated depth of approximately 8 m. Divers flipped the quadrat parallel to the transect line, from deep to shallow, and the number of "emergent" or "exposed" (visible on rocks) abalone, shell length (SL in mm) of each abalone, depth, substrate type, and dominant algal cover was recorded for every second quadrat. All kelp, sea urchins and starfish were removed from the quadrat to ensure abalone were easily detectable. However, boulders were not moved to examine for cryptic abalone. Caution was exercised to ensure that

abalone in upcoming quadrats were not disturbed. Sampling only exposed abalone is an efficient sampling strategy, since the majority of mature abalone (i.e.,  $\geq 70$  mm SL) are exposed (Campbell 1996).

The mean density,  $d$  (number/m<sup>2</sup>), was calculated as:

$$d = \frac{\sum_i c_i}{\sum_i a_i} \quad (1)$$

The standard error of the mean density,  $se(d)$ , was calculated as:

$$se(d) = \sqrt{1 - n/N} \sqrt{\frac{\sum_i (c_i - da_i)^2}{n(n-1)a^2}} \quad (2)$$

where for each  $i^{\text{th}}$  transect,  $c_i$  = the number of abalone observed in a transect,  $a_i$  = the area of the transect surveyed (number of quadrats) in square meters,  $a$  = the mean transect area for all transects,  $n$  = the number of transects sampled, and  $N$  = the total population of possible transects. This method accounted for the variable length of transects. Means and standard errors of densities by depth range and abalone size class were also calculated by subsampling each transect. The depth ranges were (1)  $< 0$  m, (2) 0 - 1.50 m, (3) 1.51 - 3.00 m, (4) 3.01 - 4.50 m, (5) 4.51 - 6.00 m, (6) 6.01 - 7.50 m and (7)  $> 7.50$  m. The size classes were “small juveniles” 10 – 49 mm SL, “large juveniles” 50 – 69 mm SL, “mature”  $\geq 70$  mm SL [i.e., about 100 % of abalone would be mature (Campbell et al. 1992)], “prerecruit” 92 - 99 mm SL, “legal”  $\geq 100$  mm SL, “new recruit” 100 - 106 mm SL and “total” which included all sizes. Although some of the size categories overlap, they were included in the analyses so that the results could be compared with previous surveys of abalone from these and other areas. The number of abalone measured for SL at one site did not match the number of abalone recorded by divers, because two individuals were not accessible. Consequently, densities by size category ( $D_i$ ) were calculated as:

$$D_i = P_i D \quad (3)$$

where the proportion of abalone in each size category ( $P_i$  = the number per category  $i$  divided by the total abalone measured in the sample) was multiplied by the total density of abalone ( $D$ ) counted by divers from all quadrats at that site (Campbell et al. 1998).

## RESULTS

### SURVEY LOGISTICS SUMMARY

The number of transects surveyed off the Tribal Group was 30, the Simonds Group was 32, and Stryker Island was 28 (Tables 1, 2). The mean length of transect was 24.8 m for the Tribal Group, 34.3 m for the Simonds Group, and 36.5 m for Stryker Island.

## POPULATION SIZE STRUCTURE

Small juvenile exposed abalone (< 50 mm SL) made up 41.5 %, 24.8 % and 25.2 % of the population for Tribal Group, Simonds Group and Stryker Island, respectively. The length frequency distribution of exposed abalone indicated that the majority (> 85%) of animals sampled at all locations were < 100 mm SL (Fig. 2, Table 3). The number of juvenile abalone found probably does not accurately reflect the true proportion of juveniles because of the difficulty of detecting small juvenile individuals, which prefer cryptic habitats (Sloan and Breen 1998). Adult abalone ( $\geq 70$  mm SL) were 41.2 %, 50.5 % and 38.1 % of the population for Tribal Group, Simonds Group and Stryker Island, respectively. The percentage of legal abalone ( $\geq 100$  mm SL) was greater for the Simonds Group (14.6 %) than for the Tribal Group (7.8 %) and for Stryker Island (6.1 %).

Size frequencies and mean SL of abalone generally decreased as depth increased (Figs. 3A, 3B, 3C, 4). Adult abalone were more abundant < 5 m depths, whereas small juveniles (< 50 mm SL) were found at all depths, but less frequently at intertidal depths (Figs. 3A, 3B, 3C).

## DENSITY ESTIMATES

### Comparison between areas

Mean densities per transect ranged from 0 to 3.58 total exposed abalone per m<sup>2</sup> (Table 1, Fig. 5). Total mean densities of abalone of different size groups for all depths were greater for the Tribal Group than those at Stryker Island, and were greater for all size groups except "legal" ( $\geq 100$  mm SL) than those in the Simonds Group during 1998 (Table 4). Abalone densities were generally highest in depths < 3 m, although abalone were found at all depths surveyed (Fig. 6).

### Comparison between 1997 and 1998

For all areas combined, there were no statistically significant differences in mean density estimates for any size group of abalone between 1997 and 1998, despite decreases in mean density for most size groups (Table 4). However, in the Tribal Group, mean density estimates increased between 1997 and 1998 for all size groups of abalone, except large juveniles (50 – 69 mm SL). There were significant increases in total abalone (33 %; Wilcoxon signed rank test,  $p = 0.049$ ) and in mature abalone (29%; Wilcoxon signed rank test,  $p = 0.042$ ) between 1997 and 1998 in the Tribal Group (Table 4). In the Simonds Group, mean density estimates decreased between 1997 and 1998 for all size groups of abalone, although the differences were not statistically significant except for prerecruit densities (61% decrease; Wilcoxon signed rank test,  $p = 0.041$ ). At Stryker Island, although mean density estimates generally decreased between 1997 and 1998 for all size groups of abalone, the differences were not statistically significant (Table 4).

## DISCUSSION

This study showed that mean size and density of abalone varied with depth. Most exposed abalone in these areas were smaller than “legal” size (<100 mm SL). Small abalone were distributed throughout the surveyed depth range (-1 – 11 m), but larger animals were more likely to be found in the 0 – 3 m depth range. Mean abalone size and density declined with depth, as in previously reported studies (Sloan and Breen 1988; Campbell and Cripps 1998; Cripps and Campbell 1998). This trend is probably caused by adult abalone preferences for shallow water for spawning (Breen and Adkins 1980; Campbell and Cripps 1998). Although previous studies reported juvenile *H. kamtschatkana* were generally found deeper than adults (Breen and Adkins 1979, 1982; Sloan and Breen 1988), this study suggested that juveniles were evenly distributed throughout all subtidal depths.

Considerable variation was found in mean abalone densities between areas and between transects within areas. Northern abalone distributions are known to be patchy, due to their aggregating behaviour (Sloan and Breen 1988).

In general, densities were not significantly different between the 1997 and 1998 surveys. Although the mean density for all areas combined decreased between May 1997 and May 1998, mean density increased in the Tribal Group and decreased in the Simonds Group and Stryker Island during the same period. This difference between areas may be caused by variations in environmental factors, natural mortality, disease, predation, or illegal harvesting. The significant increases in estimated densities of total ( $0.468/\text{m}^2$  to  $0.659/\text{m}^2$ ) and mature ( $0.188/\text{m}^2$  to  $0.271/\text{m}^2$ ) abalone in the Tribal Group represent a change in only a small number of abalone. The increase in total abalone may be primarily due to small juveniles that were too small to detect during the previous survey. The increase in mature abalone may be due to growth of large juveniles. Some differences may also arise from minor variations in transect origins caused by GPS imprecision. The proportion of mature abalone in all areas was lower in 1998 than in 1997.

The estimated mean total density, for all areas combined, of exposed abalone found in this study ( $0.420/\text{m}^2$ ) appears to be similar to the densities found in previous surveys of abalone on the central coast. Using the same transect method, similar densities were found at Dallain Point and Higgins Pass ( $0.391/\text{m}^2$  and  $0.429/\text{m}^2$ , respectively) (Cripps and Campbell 1998). Slightly higher densities were found using the “Breen” method (Breen and Adkins 1979) in the central coast in 1993 ( $0.53/\text{m}^2$ ) (Thomas and Campbell 1996), and in 1997 ( $0.44/\text{m}^2$ ) (Campbell et al. 1998). The “Breen” method tends to give higher density estimates because the survey is limited to depth ranges where abalone are naturally more abundant (Campbell et al. 1998).

This survey showed abalone population densities continue to be low, despite closure of the fishery since 1990. Although the decreases in density observed in this study for all areas combined are not statistically significant, the densities of exposed prerecruit and new recruit abalone ( $0.026/\text{m}^2$  and  $0.020/\text{m}^2$ , respectively) are still well below recommended replacement levels ( $0.55/\text{m}^2$  and  $0.45/\text{m}^2$ , respectively) (Breen 1986). More research to determine growth, mortality, and recruitment rates is required to accurately estimate abalone productivity and the

ability of abalone populations to recover from previous exploitation. Consequently, there still remain conservation concerns for *H. kamtschatkana* along the central coast of B.C.

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Table 1. Dive survey summary for abalone transects surveyed in the Tribal Group, Simonds Group and Stryker Island, during May and June 1998.

Transect	Date	Time		Bottom Time	Depth (m)		Number of Quadrats	Total # of Abalone	Density (No./m2)
		Start	Finish		Min	Max			
Tribal Group									
101	May-29	11:49	11:57	0:08	0.79	10.58	6	1	0.17
102	May-29	12:06	12:30	0:24	-0.61	10.52	9	23	2.56
103	May-29	12:38	12:55	0:17	0.09	9.69	9	15	1.67
105	May-29	13:05	13:25	0:20	-0.58	9.11	13	10	0.77
106	May-29	13:33	13:45	0:12	-0.21	9.08	9	2	0.22
107	May-30	10:31	10:42	0:11	-0.73	9.54	10	10	1.00
108	May-30	10:04	10:23	0:19	-0.58	10.85	15	5	0.33
109	May-29	14:00	14:21	0:21	-1.34	9.63	14	16	1.14
110	May-29	14:27	14:54	0:27	-0.61	8.63	19	26	1.37
111	May-30	10:50	11:02	0:12	-0.88	9.72	12	4	0.33
112	May-29	15:18	15:27	0:09	-0.73	7.89	10	0	0.00
113	May-29	15:02	15:08	0:06	-0.18	8.14	13	0	0.00
114	May-30	13:12	13:30	0:18	-0.91	9.88	11	2	0.18
115	May-30	11:25	11:35	0:10	-0.09	10.24	8	6	0.75
116	May-30	11:25	11:35	0:10	-0.40	10.24	8	1	0.13
117	May-30	11:06	11:15	0:09	-0.18	9.81	11	1	0.09
118	May-31	13:51	14:13	0:22	-1.10	9.69	17	4	0.24
119	May-31	13:26	13:43	0:17	-0.03	9.75	11	3	0.27
120	May-31	13:07	13:20	0:13	-0.30	9.78	14	0	0.00
121	May-31	12:36	12:55	0:19	-0.88	9.72	16	2	0.13
122	May-31	12:14	12:31	0:17	-0.64	9.66	12	3	0.25
123	May-31	11:40	12:03	0:23	-1.07	9.75	9	6	0.67
124	May-31	11:28	11:45	0:17	-1.19	8.47	20	4	0.20
125	May-30	15:30	15:48	0:18	-2.47	6.83	9	5	0.56
126	May-31	9:55	10:23	0:28	-1.86	9.11	19	12	0.63
127	May-30	14:42	15:23	0:41	-0.67	10.21	12	43	3.58
128	May-30	14:00	14:36	0:36	0.85	10.09	16	17	1.06
129	May-31	10:34	10:45	0:11	-1.34	8.90	8	7	0.88
130	May-31	10:54	11:17	0:23	-1.07	9.08	13	8	0.62
131	May-30	9:42	9:56	0:14	-0.88	9.94	16	7	0.44
Simonds Group									
201	Jun-4	9:34	9:59	0:25	-1.43	8.38	19	13	0.68
202	Jun-3	13:24	13:37	0:13	-2.16	8.44	13	9	0.69
203	Jun-3	13:48	14:16	0:28	-1.01	9.81	35	19	0.54
204	Jun-3	17:53	18:21	0:28	-0.98	8.69	25	7	0.28
205	Jun-3	17:14	17:45	0:31	-1.31	8.93	43	4	0.09
206	Jun-3	16:51	17:04	0:13	-1.10	9.02	13	5	0.38
207	Jun-3	16:07	16:20	0:13	-1.28	9.11	12	12	1.00
208	Jun-3	16:28	16:42	0:14	-1.31	9.08	11	7	0.64
209	Jun-1	12:15	12:35	0:20	-0.82	9.08	15	9	0.60
210	Jun-1	11:40	12:06	0:26	-1.65	8.84	19	4	0.21
211	Jun-1	11:20	11:31	0:11	-1.89	8.69	9	2	0.22
212	Jun-1	10:49	11:12	0:23	-1.58	7.83	22	6	0.27
213	Jun-1	10:01	10:39	0:38	1.65	8.05	29	1	0.03
214	Jun-1	16:05	16:38	0:33	-1.13	8.63	20	18	0.90
215	Jun-4	11:29	11:42	0:13	-2.13	8.53	10	4	0.40

Table 1 (cont'd)

Transect	Date	Time		Bottom Time	Depth (m)		Number of Quadrats	Total # of Abalone	Density (No./m2)
		Start	Finish		Min	Max			
Simonds Group (cont'd)									
216	Jun-4	11:14	11:23	0:09	-0.61	8.84	8	2	0.25
217	Jun-4	10:54	11:05	0:11	-1.52	8.53	14	1	0.07
218	Jun-4	9:00	9:24	0:24	-1.92	8.84	14	2	0.14
219	Jun-3	11:46	12:08	0:22	-0.55	8.20	11	6	0.55
220	Jun-3	12:50	13:07	0:17	-2.35	8.53	13	5	0.38
221	Jun-3	11:26	11:40	0:14	-2.19	8.72	8	0	0.00
222	Jun-2	13:46	14:08	0:22	-1.40	9.08	12	10	0.83
223	Jun-2	13:06	13:36	0:30	-1.65	8.84	28	11	0.39
224	Jun-2	12:28	12:57	0:29	-0.43	9.17	22	5	0.23
225	Jun-1	11:52	12:19	0:27	-1.55	8.93	17	3	0.18
229	Jun-2	10:44	11:05	0:21	0.46	9.17	11	3	0.27
230	Jun-1	14:32	15:07	0:35	-1.34	9.48	19	14	0.74
231	Jun-1	13:11	13:31	0:20	-0.30	10.00	10	8	0.80
232	Jun-1	15:36	15:50	0:14	-1.62	9.78	9	1	0.11
233	Jun-1	15:54	15:59	0:05	-1.68	9.02	8	0	0.00
234	Jun-4	11:49	12:04	0:15	-1.77	8.56	11	6	0.55
235	Jun-4	10:11	10:46	0:35	-1.52	8.60	39	9	0.23
Stryker Island									
301	May-28	9:38	9:49	0:11	0.30	10.27	10	3	0.30
302	May-28	9:57	10:08	0:11	0.40	10.39	12	4	0.33
303	May-28	11:23	11:30	0:07	-0.34	10.39	7	0	0.00
304	May-28	10:19	10:35	0:16	0.15	10.49	31	1	0.03
305	May-28	10:46	11:17	0:31	-0.24	10.52	32	13	0.41
306	May-27	14:30	14:53	0:23	0.27	7.22	29	7	0.24
307	May-26	14:57	15:07	0:10	-0.18	6.55	15	3	0.20
308	May-26	13:45	13:55	0:10	0.34	7.16	6	12	2.00
309	May-26	14:04	14:37	0:33	0.27	6.95	36	3	0.08
310	May-26	13:18	13:35	0:17	0.27	7.53	18	6	0.33
311	May-26	12:52	13:10	0:18	-1.80	7.92	15	4	0.27
312	May-26	12:00	12:42	0:42	0.18	8.81	24	0	0.00
313	May-26	11:00	11:16	0:16	0.09	9.78	12	3	0.25
314	May-26	10:23	10:46	0:23	-0.40	8.72	18	7	0.39
315	May-26	9:56	10:11	0:15	0.00	10.79	9	5	0.56
316	May-27	10:38	10:54	0:16	1.52	9.88	15	6	0.40
317	May-27	10:05	10:30	0:25	0.18	9.11	47	6	0.13
318	May-27	11:03	11:15	0:12	1.01	9.39	7	5	0.71
319	May-28	13:04	13:27	0:23	-0.58	10.76	15	15	1.00
320	May-27	11:25	11:41	0:16	-0.21	9.75	8	6	0.75
321	May-27	11:50	12:01	0:11	-0.21	9.72	7	4	0.57
322	May-27	12:11	12:37	0:26	-0.49	9.39	35	7	0.20
323	May-27	12:42	12:53	0:11	-0.76	8.87	13	2	0.15
324	May-27	13:02	13:17	0:15	-0.85	8.53	10	13	1.30
325	May-27	13:28	13:43	0:15	0.24	8.11	20	1	0.05
326	May-26	11:28	11:50	0:22	-0.46	9.36	16	11	0.69
327	May-27	13:52	14:16	0:24	-0.82	7.74	26	2	0.08
328	May-27	9:43	9:58	0:15	0.58	9.11	12	0	0.00

Table 2. Summary statistics of transect survey of exposed abalone from Tribal Group, Simonds Group and Stryker Island during May and June 1998. Values in brackets are standard errors.

Details per transect	Tribal Group	Simonds Group	Stryker Island
Dates	May 29 - 31	June 1 - 4	May 26 - 28
Number of transects	30	32	28
Mean transect length (m)	24.80	34.25	36.46
Mean depth (m)	4.07 (0.17)	3.87 (0.13)	4.45 (0.13)
Mean number of quadrats	12.30 (0.67)	17.16 (1.62)	18.04 (2.00)
Mean minutes/transect	17.72 (1.48)	21.20 (1.53)	18.34 (1.52)
Mean minutes/quadrat	1.44 (0.42)	1.24 (0.37)	1.02 (0.36)

Table 3. Mean shell length (mm SL) of exposed abalone of different size groups for all transect surveys of the Tribal Group, Simonds Group and Stryker Island during May and June 1998. N = number of abalone. Values in brackets are standard errors.

Size Group	(mm SL)	N	% of Total	Shell Length
<b>Tribal Group</b>				
Mature	>= 70	100	41.2	87.5 (1.1)
Pre Recruit	92 - 99	17	7.0	95.1 (0.5)
New Recruit	100 - 106	15	6.2	102.7 (0.5)
Legal	>= 100	19	7.8	104.8 (1.1)
	all sizes	243	100.0	57.9 (1.9)
<b>Simonds Group</b>				
Mature	>= 70	104	50.5	91.2 (1.4)
Pre Recruit	92 - 99	14	6.8	95.6 (0.7)
New Recruit	100 - 106	10	4.9	102.8 (0.6)
Legal	>= 100	30	14.6	110.0 (1.2)
	all sizes	206	100.0	69.3 (1.9)
<b>Stryker Island</b>				
Mature	>= 70	56	38.1	85.0 (1.6)
Pre Recruit	92 - 99	6	4.1	94.5 (1.2)
New Recruit	100 - 106	4	2.7	102.0 (1.2)
Legal	>= 100	9	6.1	106.3 (1.8)
	all sizes	147	100.0	62.8 (1.8)

Table 4. Mean density (number/m<sup>2</sup>) of exposed abalone of different size groups for all depths from Tribal Group, Simonds Group and Stryker Islands during 1997 and 1998. Values in brackets are standard errors. Means of densities from different years followed by the same letter, in the same row, are not significantly different (Wilcoxon signed rank test,  $\alpha = .05$ ,  $p > 0.05$ ). Means followed by different letters, in the same row, are significantly different (Wilcoxon signed rank test,  $\alpha = 0.05$ ,  $p \leq 0.05$ ).

Area	Size Group	mm SL	1997	1998
All areas	Small Juveniles	10 - 49	0.112 (0.021)a	0.128 (0.029)a
	Large Juveniles	50 - 69	0.134 (0.021)a	0.104 (0.014)a
	Mature	$\geq 70$	0.258 (0.045)a	0.183 (0.022)a
	Pre Recruit	92 - 99	0.044 (0.010)a	0.026 (0.006)a
	New Recruit	100 - 106	0.025 (0.008)a	0.020 (0.006)a
	Legal	$\geq 100$	0.050 (0.019)a	0.041 (0.009)a
	Total	all sizes	0.520 (0.060)a	0.420 (0.049)a
	Transects		81	90
Tribal Group	Small Juveniles	10 - 49	0.115 (0.029)a	0.257 (0.101)a
	Large Juveniles	50 - 69	0.167 (0.042)a	0.117 (0.030)a
	Mature	$\geq 70$	0.210 (0.051)a	0.271 (0.051)b
	Pre Recruit	92 - 99	0.037 (0.012)a	0.046 (0.014)a
	New Recruit	100 - 106	0.006 (0.004)a	0.041 (0.018)a
	Legal	$\geq 100$	0.011 (0.007)a	0.051 (0.020)a
	Total	all sizes	0.494 (0.089)a	0.659 (0.138)b
	Transects		29	30
Simonds Group	Small Juveniles	10 - 49	0.107 (0.028)a	0.091 (0.020)a
	Large Juveniles	50 - 69	0.124 (0.032)a	0.093 (0.019)a
	Mature	$\geq 70$	0.289 (0.079)a	0.189 (0.039)a
	Pre Recruit	92 - 99	0.056 (0.019)a	0.022 (0.009)b
	New Recruit	100 - 106	0.040 (0.018)a	0.018 (0.007)a
	Legal	$\geq 100$	0.094 (0.041)a	0.055 (0.017)a
	Total	all sizes	0.536 (0.086)a	0.375 (0.051)a
	Transects		32	32
Stryker Island	Small Juveniles	10 - 49	0.119 (0.062)a	0.076 (0.023)a
	Large Juveniles	50 - 69	0.106 (0.029)a	0.108 (0.029)a
	Mature	$\geq 70$	0.272 (0.103)a	0.111 (0.020)a
	Pre Recruit	92 - 99	0.034 (0.016)a	0.016 (0.007)a
	New Recruit	100 - 106	0.025 (0.012)a	0.008 (0.005)a
	Legal	$\geq 100$	0.029 (0.015)a	0.018 (0.007)a
	Total	all sizes	0.528 (0.156)a	0.295 (0.067)a
	Transects		20	28

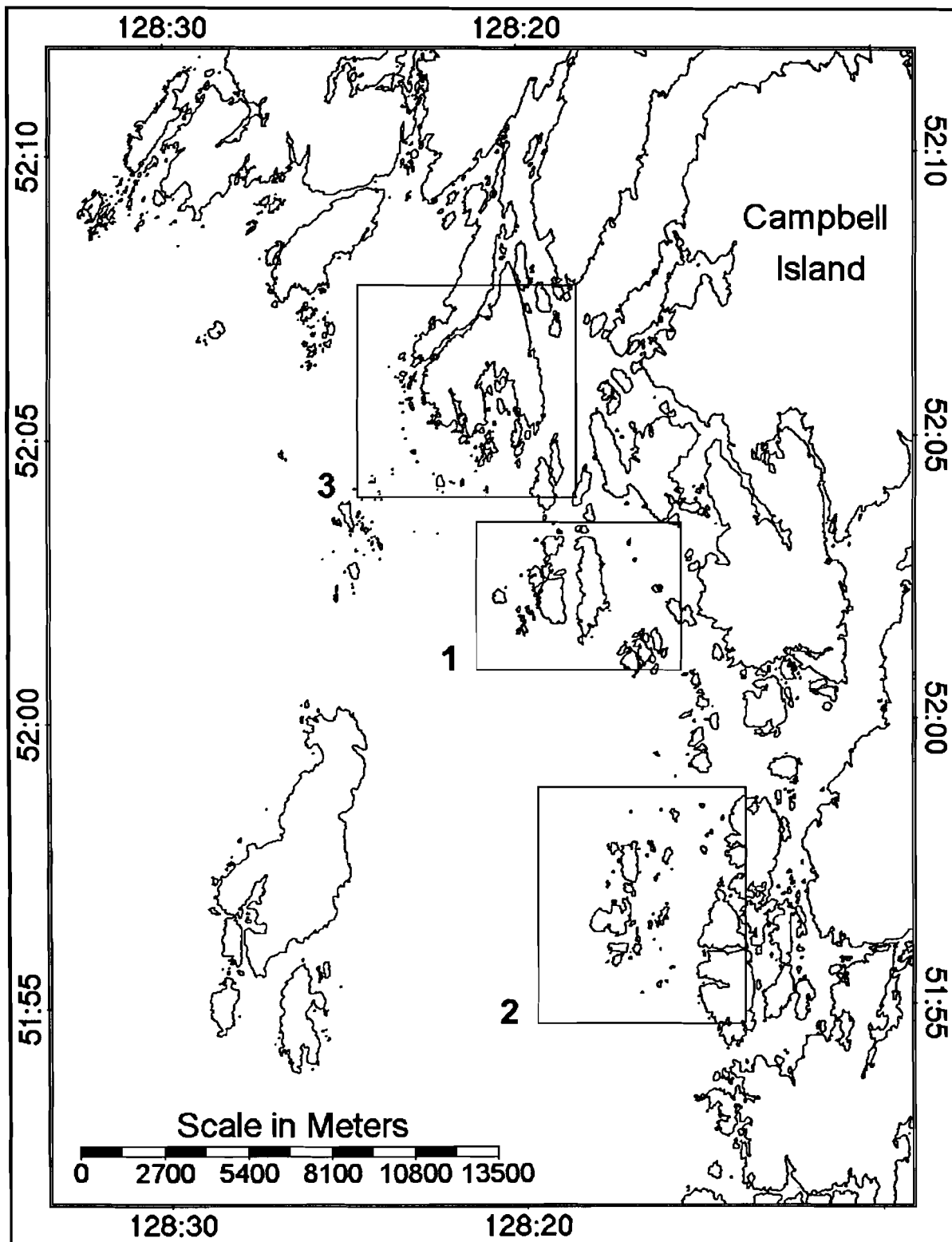


Figure 1. General location of study areas (1) Tribal Group (in statistical area 7 – 18), (2) Simonds Group (in statistical area 7 – 25), and (3) Stryker Island (in statistical area 7 – 18 and 7 – 19), in the central coast of British Columbia surveyed for abalone during May and June 1998.

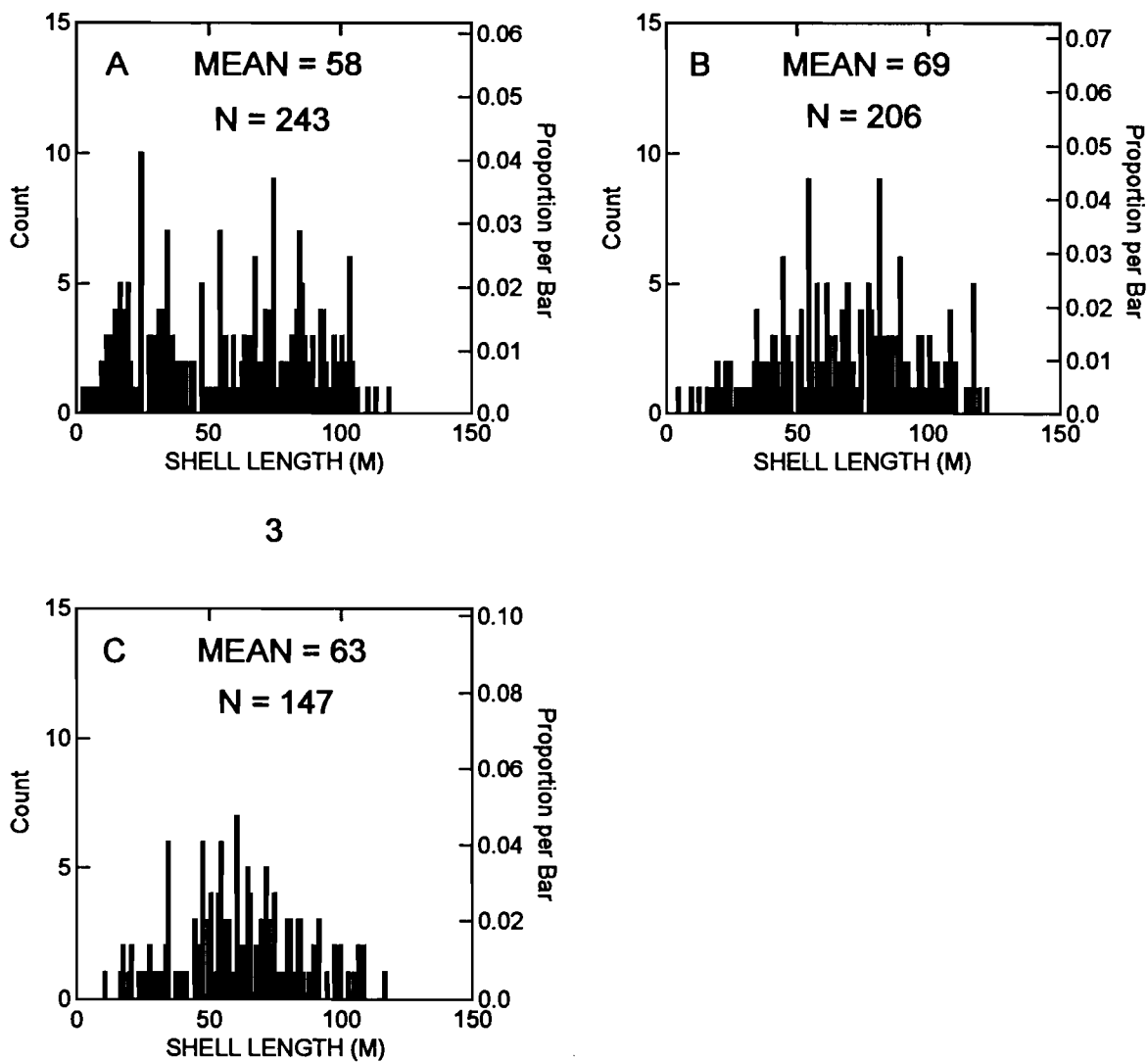


Figure 2. Size frequencies of exposed abalone from (A) Tribal Group, (B) Simonds Group, and (C) Stryker Island surveyed during May and June, 1998.

# TRIBAL GROUP

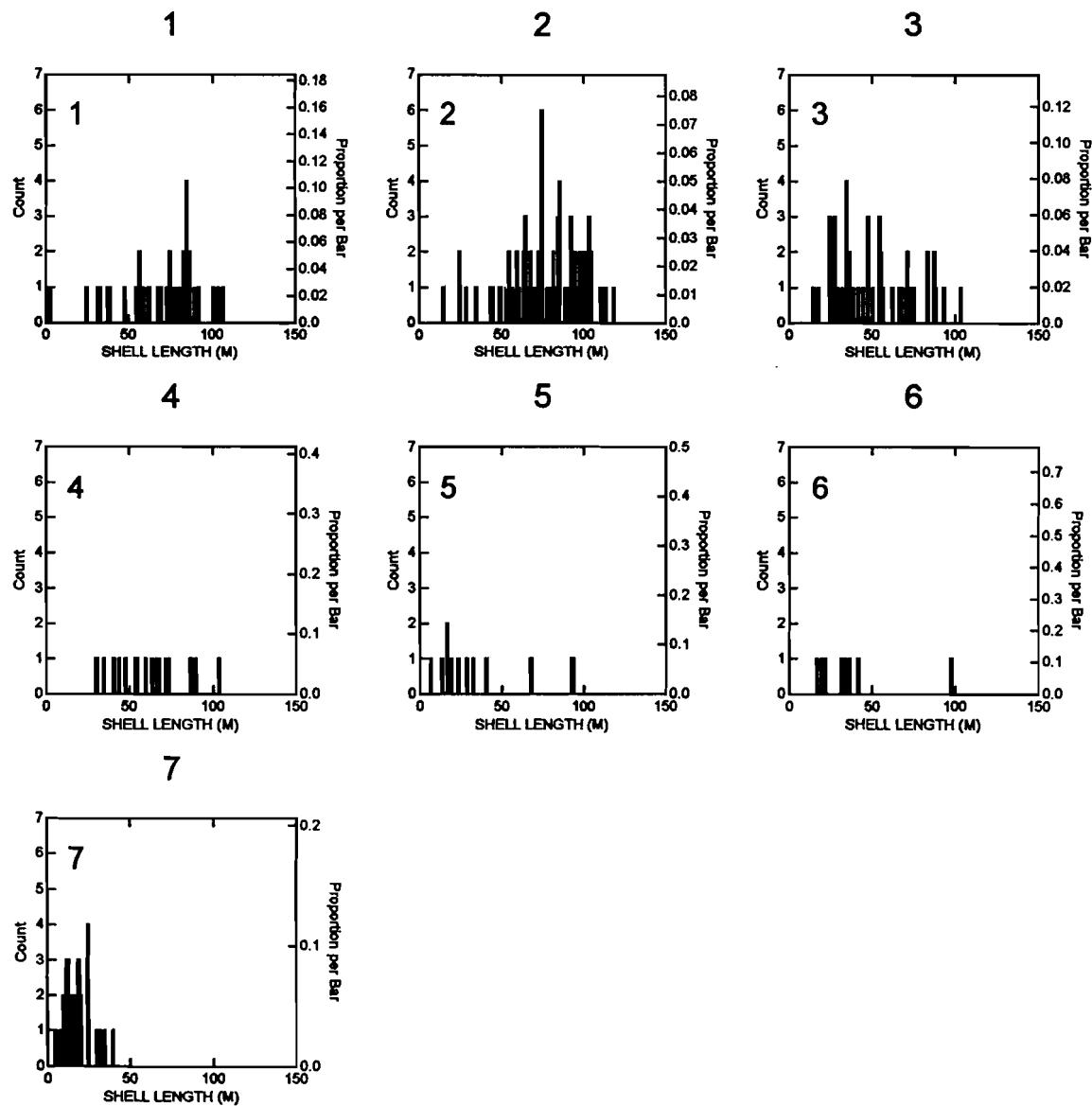


Figure 3A. Size frequencies by depth category of exposed abalone from the Tribal Group, surveyed during May 1998. Depth category (1) < 0 m, (2) 0 – 1.50 m, (3) 1.51 – 3.00 m, (4) 3.01 – 4.50 m, (5) 4.51 – 6.00 m, (6) 6.01 – 7.50 m and (7) > 7.50 m.

# SIMONDS GROUP

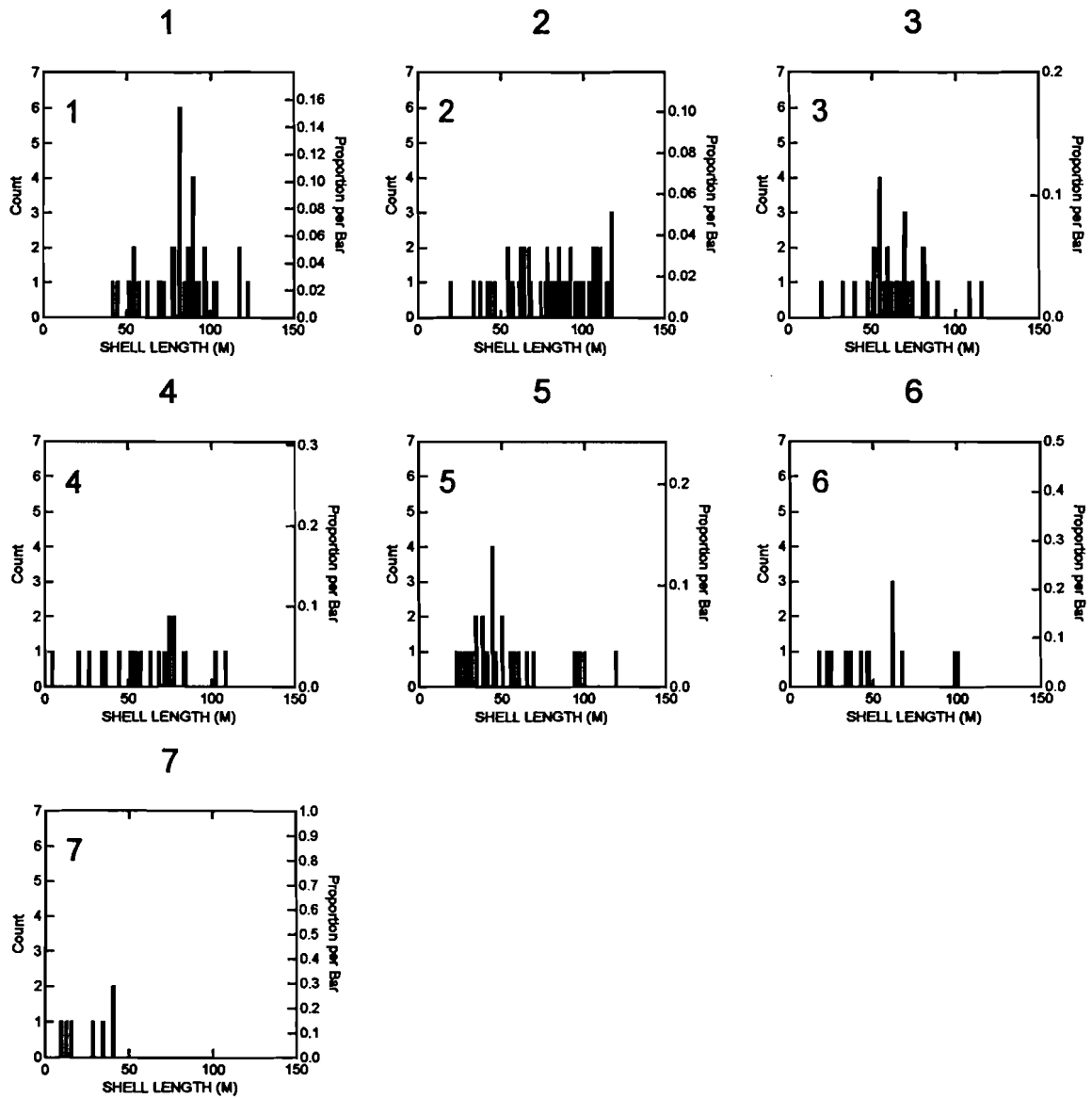


Figure 3B. Size frequencies by depth category of exposed abalone from the Simonds Group, surveyed during June 1998. Depth category (1) < 0 m, (2) 0 – 1.50 m, (3) 1.51 – 3.00 m, (4) 3.01 – 4.50 m, (5) 4.51 – 6.00 m, (6) 6.01 – 7.50 m and (7) > 7.50 m.

# STRYKER ISLAND

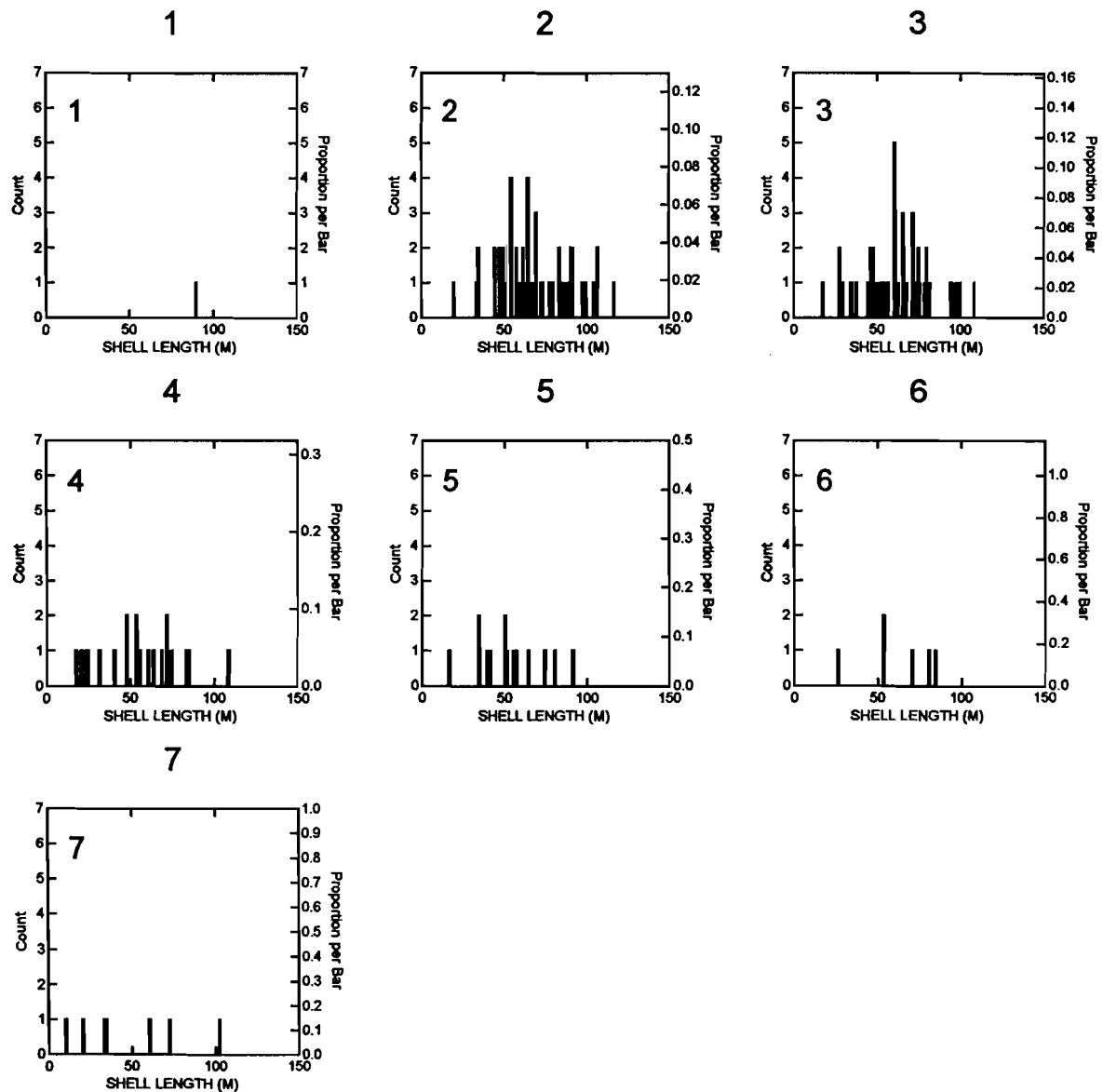


Figure 3C. Size frequencies by depth category of exposed abalone from Stryker Island, surveyed during May 1998. Depth category (1)  $< 0$  m, (2)  $0 - 1.50$  m, (3)  $1.51 - 3.00$  m, (4)  $3.01 - 4.50$  m, (5)  $4.51 - 6.00$  m, (6)  $6.01 - 7.50$  m and (7)  $> 7.50$  m.

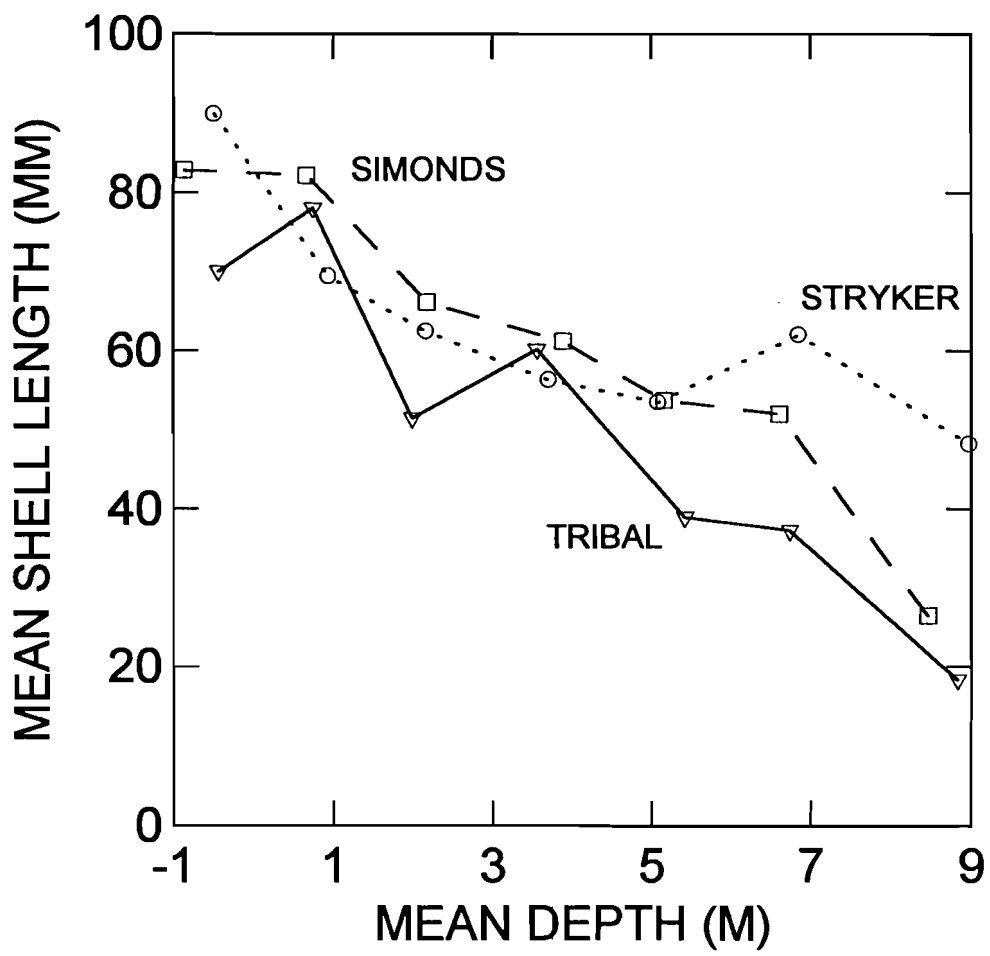


Figure 4. Mean shell length of exposed abalone by mean depth in the Tribal Group, Simonds Group, and Stryker Island during May and June, 1998. Mean depth shown for each of seven depth categories (1) < 0 m, (2) 0 – 1.50 m, (3) 1.51 – 3.00 m, (4) 3.01 – 4.50 m, (5) 4.51 – 6.00 m, (6) 6.01 – 7.50 m and (7) > 7.50 m.

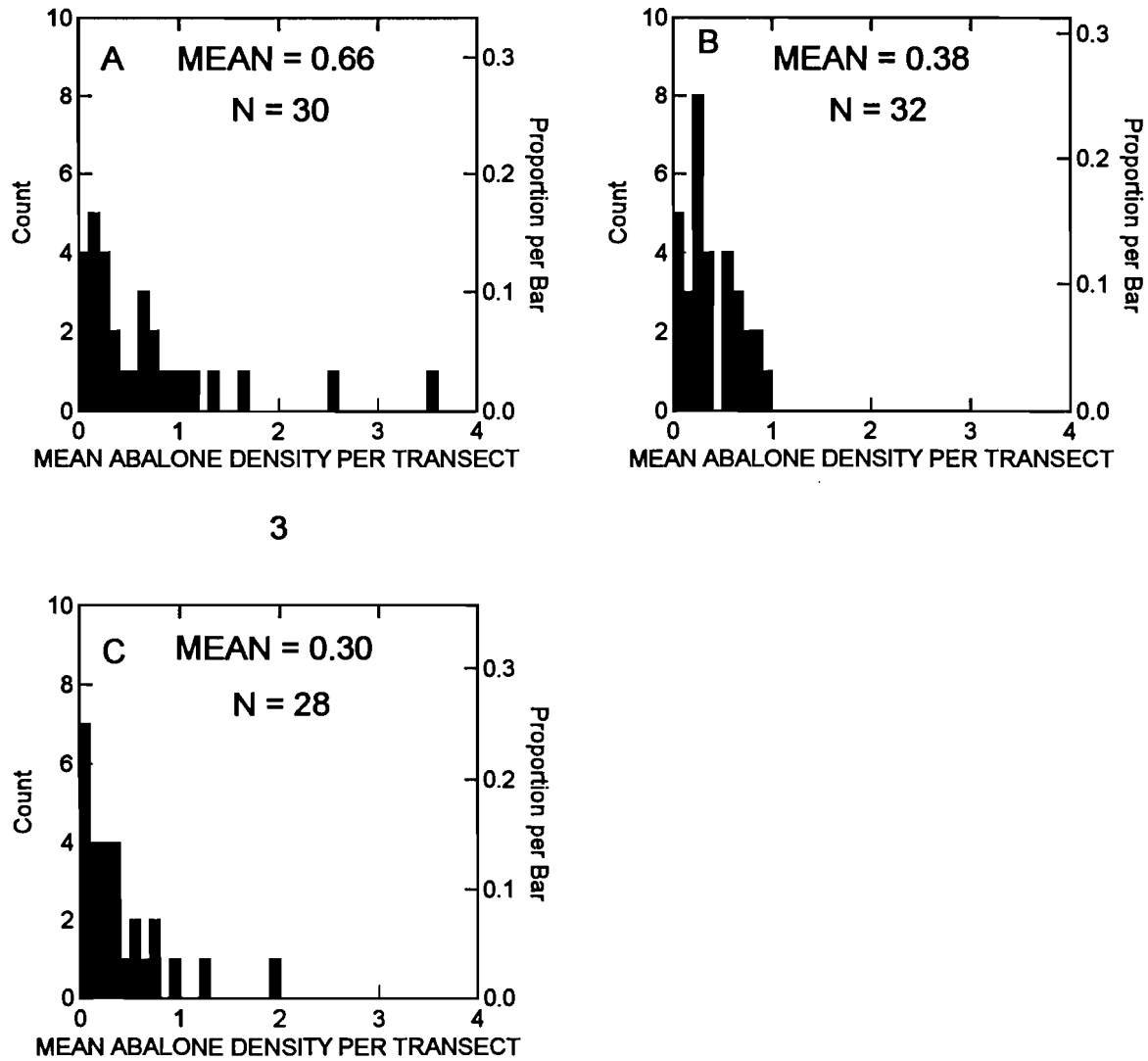


Figure 5. Frequency distribution of mean densities (number per  $m^2$ ) of exposed abalone per transect for all depths combined from (A) Tribal Group, (B) Simonds Group, and (C) Stryker Island surveyed during May and June, 1998.

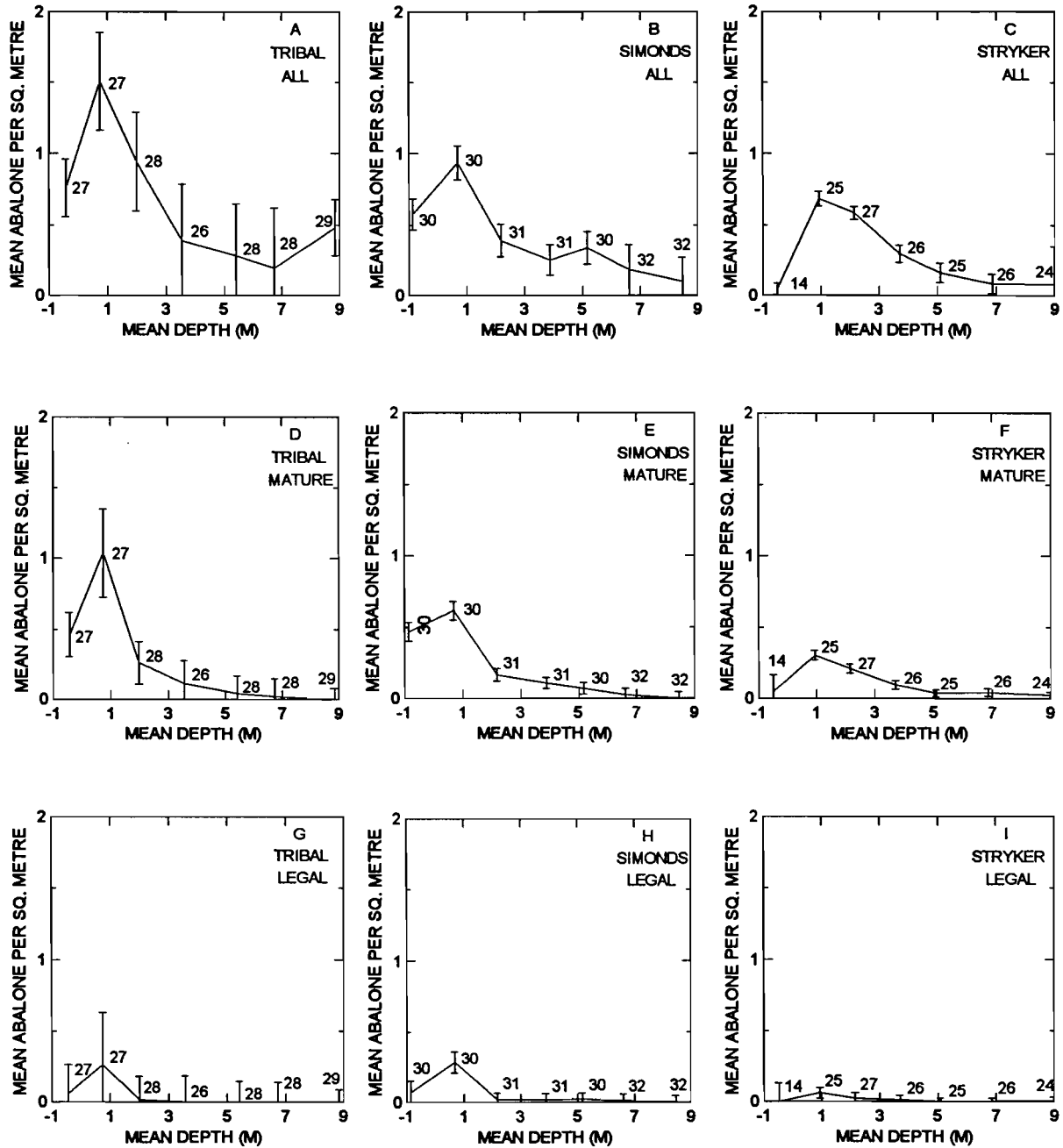


Figure 6. Mean densities of exposed abalone by size group and depth from the Tribal Group, Simonds Group and Stryker Island, respectively for (A, B, C) all sizes, (D, E, F) mature sizes ( $\geq 70$  mm SL), and (G, H, I) legal sizes ( $\geq 100$  mm SL) surveyed during May and June 1998.