Lingcod (*Ophiodon elongatus*) Nest Density SCUBA Survey in the Strait of Georgia, January 16 – April 26, 2001

J. R. King and B. W. Beaith

Fisheries and Oceans Canada
Science Branch, Pacific Region
Pacific Biological Station
Nanaimo, British Columbia
V9R 5K6

2001

Canadian Technical Report of Fisheries and Aquatic Sciences 2374

Pêches et Océans Canada
Sciences

Fisheries and Oceans Canada
Science

Canada

Canadian Technical Report of Fisheries and Aquatic Sciences

Technical reports contain scientific and technical information that contributes to existing knowledge but which is not normally appropriate for primary literature. Technical reports are directed primarily toward a worldwide audience and have an international distribution. No restriction is placed on subject matter and the series reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries and aquatic sciences.

Technical reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Numbers 1 - 456 in this series were issued as Technical Reports of the Fisheries Research Board of Canada. Numbers 457 - 714 were issued as Department of the Environment, Fisheries and Marine Service Technical Reports. The current series name was changed with report number 925.

Technical reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

Rapport technique canadien des sciences halieutiques et aquatiques

Les rapports techniques contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles, mais que ne sont pas normalement appropriés pour la publication dans un journal scientifique. Les rapports techniques sont destinés essentiellement à un public international et ils sont distribués à cet échelon. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques du ministère des Pêches et des Océans, c'est-à-dire les scences halieutiques et aquatiques.

Les rapports techniques peuvent être cités comme des publications complètes. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports techniques sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annual des publications scientifiques et techniques du Ministère.

Les numéros 1 à 456 de cette série ont été publiés à titre de rapports techniques de l'Office des recherches sur les pêcheries du Canada. Les numéros 457 à 714 sont parus à titre de rapports techniques de la Direction générale de la recherche et du développement, Service des pêches et de la mer, ministère de l'Environnement. Les numéros 715 à 924 ont été publiés à titre de rapports techniques du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 925.

Les rapports techniques sont produits à l'échelon regional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Canadian Technical Report of

Fisheries and Aquatic Sciences 2374

2001

LINGCOD *(OPHIODON ELONGATUS)* NEST DENSITY SCUBA SURVEY IN THE STRAIT OF GEORGIA, JANUARY 16-APRIL 26, 2001

J. R. King and B. W. Beaith

Fisheries and Oceans Canada

Science Branch, Pacific Region

Pacific Biological Station

Nanaimo, British Columbia

V9R 5K6

Cat. No. Fs 97-6/2374E ISSN 0706-6457

King, J. R., and B. W. Beaith. 2001. Lingcod (*Ophiodon elongatus*) nest density SCUBA survey in the Strait of Georgia, January 16-April 26, 2001. Can. Tech. Rep. Fish. Aquat. Sci. 2374: 21 p.

ABSTRACT

King, J. R., and B. W. Beaith. 2001. Lingcod (*Ophiodon elongatus*) nest density SCUBA survey in the Strait of Georgia, January 16-April 26, 2001. Can. Tech. Rep. Fish. Aquat. Sci. 2374: 21 p.

Dives were conducted at Dodd Narrows and Snake Island in the Strait of Georgia between January 16-April 26, 2001 in order to provide lingcod (*Ophiodon elongatus*) nest density estimates. Exploratory dives were conducted on January 16, 2001 at Snake Island and several nests were observed. Exploratory dives at Dodd Narrows were conducted on January 16, February 6 and February 20, 2001. Throughout the whole narrows, only 3 nests were observed. To estimate nest density, 74 dives were completed on 18 days between January 23-April 6, 2001 at the Snake Island reef. Nests began to appear on the reef in mid-January and lasted until late April with a peak spawning period in mid-February. An exploratory dive conducted on April 26, 2001 at Snake Island did not reveal any new nests. In total, at Snake Island, 107 nests located within a total area of approximately 23,236 m^2 with density estimates per quadrat ranging from 0.0000-0.0287 nests/m^2 and a median nest density of 0.0032 nests/m^2 and a mean nest density of 0.0058 nests/m^2.

The preferred nesting sites at Snake Island reef were those found primarily in areas with a flat or gradual slope, in water shallower than 10 m, and in habitats with open, barren areas mixed with rocks, boulders and crevices. At the Snake Island reef, there were 84 males observed guarding 107 nests, with males ranging in total length from 28 cm to 77 cm with an mean length of 62 cm. Males were observed to remain within the nesting area for a short amount after the nests had disappeared.

RÉSUMÉ

King, J. R., and B. W. Beaith. 2001. Lingcod (*Ophiodon elongatus*) nest density SCUBA survey in the Strait of Georgia, January 16-April 26, 2001. Can. Tech. Rep. Fish. Aquat. Sci. 2374: 21 p.

Des relevés en plongée, effectués dans le passage Dodd Narrows et à l'île Snake, dans le détroit de Géorgie, entre le 16 janvier et le 26 avril 2001, visaient à obtenir des estimations sur la densité des nids de morue-lingue (*Ophiodon elongatus*). Des plongées exploratoires ont eu lieu à l'île Snake le 16 janvier 2001, et plusieurs nids ont été observés. Dans le passage Dodd Narrows, les plongées exploratoires ont été menées les 16 janvier, 6 février et 20 février 2001. Dans l'ensemble du passage, seuls trois nids ont été observés. Pour estimer la densité des nids, nous avons réalisé 74 plongées sur 18 jours, entre le 23 janvier et le 6 avril 2001 sur le récif de l'île Snake. Les nids ont commencé à apparaître sur le récif à la mi-janvier, et ils ont duré jusqu'à la fin d'avril, avec un pic de fraye à la mi-février. Une plongée exploratoire effectuée le 26 avril 2001 à l'île Snake n'a révélé aucun nouveau nid. Au total, à l'île Snake, 107 nids ont été dénombrés dans une zone d'une superficie totale de 23 236 m^2 environ; l'estimation de la densité par quadrat était de 0,0000-0,0287 nid/m^2, la densité médiane était de 0,0032 nid/m^2, et la densité moyenne de 0,0058 nid/m^2.

Les sites préférés pour les nids sur le récif de l'île Snake étaient installés sur un fond plat ou en pente douce, par moins de 10 m de fond, et dans des habitats présentant des zones dénudées alternant avec des rochers, des blocs et des crevasses. Au récif de l'île Snake, on a observé 84 mâles gardant 107 nids, les mâles présentant une longueur totale allant de 28 cm à 77 cm, avec une longueur moyenne de 62 cm. On a observé que les mâles demeuraient dans la zone de nidification pendant une courte période après la disparition des nids.

INTRODUCTION

Lingcod have traditionally been a very important species in British Columbia's commercial fishery. Commercial exploitation began during the 1880's, and the fishery grew steadily from 1910 until 1930 averaging nearly 2500 tonnes per year, peaking at 5300 tonnes coastwide in 1944 (Cass et al. 1990). The majority of these historical landings were primarily from the Strait of Georgia, with major fishing centres operating out of Comox, Nanaimo, and Vancouver. Strait of Georgia catch levels then declined steadily, reaching an all-time low in the late 1980's and ultimately resulting in the closure of the Strait of Georgia commercial fishery in 1990. A recreational fishery still exists in the Strait of Georgia and harvests, on average, approximately 30 tonnes of lingcod per year (King and Surry, 2000).

Since the closure of the commercial fishery in 1990 the main source of abundance information has come from annual creel surveys and intermittent nest density SCUBA surveys. Nest density surveys were conducted in 1978, 1990, 1991 and 1994 (Low and Beamish, 1978; Yamanaka and Richards, 1995). This present nest density survey is intended to augment the data that is available from the creel surveys, and provides a relative index of abundance in comparison to estimates derived from previous nest density surveys (Low and Beamish, 1978; Yamanaka and Richards, 1995).

Dodd Narrows (Figure 1) was the site of the first lingcod nest density survey in 1978 (Low and Beamish 1978). In 1990, Dodd Narrows was re-visited and no lingcod nests were found so an alternate survey site, the reef at Snake Island (Figure 1), was selected for the study (Yamanaka and Richards, 1995). Subsequent nest density surveys were completed in 1991 and in 1994 on the Snake Island reef (Yamanaka and Richards, 1995). In January and February, 2001, exploratory dives were conducted at Dodd Narrows and Snake Island. Three dives (January 16, February 6 and February 20, 2001) were conducted throughout Dodd Narrow, and only 3 nests were observed. At Snake Island reef, several nests were observed during an exploratory dive (January 16, 2001) on a small portion of the reef. Consequently the Snake Island reef was seen as a more suitable location for the 2001 survey, due to low levels of observed lingcod in Dodd Narrows and the opportunity to compare the results of this survey to past surveys at Snake Island.

METHODS

The Snake Island reef was divided into 8 sections (Figure 2). For each dive a section was randomly selected. A surface deployed anchor buoy was released according to both a GPS position and a diveable depth (<60 ft.) on the reef. Two divers descended from the marker buoy to the cannonball and then attached a 10 m quadrat line to the fixed base of the marker buoy. The team of two divers would then swim a circumference, with a radius of 10 m, around the fixed point searching for egg nests. Upon the discovery of a nest the following information was recorded: the depth (ft) at which the nest was located; location of the nest (uncovered, beneath overhanging rocks, within a horizontal or vertical crevice); the volume (to the nearest 0.5 L) of the nest as visually estimated; stage of egg development; presence of a guarding male and its total length (cm). Egg development stages were described by colour and were classified as 0=pinkish (newly laid), 1=creamy white (new), 2=white (intermediate), 3=grey-white (old), 4=eyed eggs (almost hatched), 5=hatched. The length of the guarding male was estimated using measuring tape pulled alongside the male. Individual nests were numbered using galvanised spikes and flagging tape. Each nest spike was numbered sequentially and placed near the nest in a location that was visible to divers passing-by, but not intrusive to the guarding males. Male lingcod were observed to continue to guard their nests in the presence of the markers, and on several occasions lingcod were observed to be in actual contact with the markers flagging tape. The lingcod appeared unaffected by the presence of the markers used. At the end of each quadrat dive, the depth of the cannonball (ft), visibility (m), and the number of non-nest guarding lingcod in the quadrat were recorded. The slope of the quadrat was recorded (flat, gradual or steep). The habitat was described using the categories: rocky, barren, sandy, cobbles, boulders, sandstone, and flora. Three categories were ranked by order of presence to best describe the habitat, with the dominant habitat feature being ranked higher than secondary and tertiary features. Depths were measured with the divers' depth gauges and were later converted to meters.

Depending on the weather, 1-6 quadrats were completed each day. After exploratory dives, systematic sampling began January 23, 2001, ended April 6, 2001, and occurred between the hours of 9:00 and 14:00 PST. It was intended to dive at least once a week during the sampling period, with the most intense sampling taking place from mid-February to mid-March during the peak nesting period with 3-4 dives per week. Other commitments occasionally made this unattainable, but all efforts were made to maintain a solid time-series for the sampling frequency during the survey.

RESULTS

NEST OBSERVATIONS

Seventy-four quadrat counts at Snake Island (Figure 1) were completed over 18 days during the period of January 23-April 6, 2001. During an exploratory dive on April 26, 2001 no unflagged nests were observed. One hundred and seven nests were located within a total area of approx. 23,236 m² with an overall median nest density of 0.0032 nests/m², a range of 0.0000-0.0287 nests/m², and a mean estimate of 0.0058 nests/m². When comparing nest density estimates from 2001 to previous surveys, consideration was given to the fact that these surveys were completed at slightly different periods during the spawning season (Table 2).

During exploratory dives, male lingcod were observed to be territorial by mid-January. Nests began to appear on the reef in mid-January and lasted until early April with a peak spawning period in February (Table 1). The last date in which a newly laid nest (egg colour=creamy white) was found was March 6, 2001 (Table 3). There were 84 males observed guarding 107 nests, with males ranging in length from 28 cm to 77 cm. The lower range, 28 cm, may be a rcording error since it is a length well below the expected length for mature males. When the lower length is excluded the average length of nest guarding males was 62 cm (Table 3). Of the 107 nests found, 87% of all observed nests were guarded, and of those guarded nests, 24% of males were guarding multiple nests (Table 3). Seventy-six percent of discovered nests were beneath overhanging rocks, 10% were within a vertical crevice, 7% in a horizontal crevice and 7% of nests were in the open (Table 3).

HABITAT

The habitat found at Snake Island reef is understandably quite different as depth varies. The upper 10 m of the reef is composed mainly of sandstone and is quite flat and open with very little foliage. There are rocky areas, some small boulders (<1 m diameter), outstanding sandstone formations, and good visibility in the water column exists before the plankton bloom in the Strait of Georgia commences. As depth increases (>10 m) the bottom becomes more rocky, with an increase in boulder size (>1 m diameter) and a reduction in visibility due to decreased light penetration. Large concentrations of *Agarum spp.*, which were absent in the upper 10 m, can be found in many of the lower parts of the reef >10 m. There is an increase in bottom slope for most areas of the reef, particularly on the west side.

The number of random visits to each section was approximately equal (mean=9) with the exception of only 5 visits to section 1 (Table 4). Giving consideration to the number of visits to each section by standardising to 10 visits to each section, sections 1 and 5 were the most productive and sections 2 and 6 were the least productive (Table 4). Quadrats with high nest counts were generally described as flat or gradual slope, in water shallower than 10 m, and in habitats with open, barren areas mixed with rocks, boulders and crevices (Table 1). Large amounts of *Agarum* spp. were not present (Table 1). Generally, these habitat types were found primarily in reef sections 3, 4 and 5 (Figure 2). Though most of section 1 would not be characterised by these descriptions, the quadrats in section 1 with high number of nest counts did have this type of habitat (Table 1). Typically, the size of males guarding nests in sections 1, 3-5 were larger than those elsewhere (Table 5). The shallowest part of the reef was found in section 3. Sections 2, 6 and 8 were deeper than 3, 4 and 5 (Figure 2), contained uneven rocky substrate, and had higher concentrations of algae, primarily (*Agarum spp.*) and decreased visibility (Table 1). Sections 1 and 7 were the deepest of the 8 sections (Figure 2), with the steepest substrate slope mixed with rocky and uneven terrain, a reduction in visibility and an increase in algal (*Agarum spp.*) presence.

NEST PREDATION

Nests were observed to be actively preyed upon by invertebrates and sculpin species while the guarding lingcod was present. The most common predator seen was *Calistoma ligatum* in numbers <10 per nest. Green urchins (*Strongylocentrotus droebrachiensis*) and hermit crabs (*Pagurus spp.* primarily *Pagurus beringanus*) were also observed to be actively preying on nests in numbers <5. Sculpins (*Artedius harringtoni* and *Jordania zonope*) were also observed to feed undisturbed upon lingcod nests in numbers <5. Predators also included the seastars *Pycnopodia helianthodes* and *Dermasterius imbricata*, in solitary numbers. Kelp greenlings (*Hexagrammos decagrammus*) were observed in proximity to guarded nests but were not observed to actively engage in feeding upon the nests. Lingcod were observed to actively chase kelp greenlings away from nest sites. Unguarded nests were observed to suffer higher predation levels than guarded nests from invertebrates, primarily *Calistoma ligatum* in numbers >20 and <30, and *Pagurus spp.*<10. Unguarded nests were not observed to be actively fed upon by fish in the area, although any predatory fish could have easily moved away unnoticed from a nest to avoid divers, and therefore not observed in our survey.

LINGCOD PREDATION

Two male lingcod carcasses were found within 2 m of unoccupied nesting sites in quadrat 29, section 5. Lengths of the males found confirmed that they were most likely the guarding males of the proximal nests. The lingcod had only the bellies removed and the remainder of the fish was left untouched. The two carcasses were found within 5 m of each other. California sea lions (*Zalophus californianus*) were observed within the reef area during the quadrat dive, and are assumed to have preyed upon the guarding males.

NEST DEVELOPMENT

Newly spawned eggs were an opaque pinkish-white colour, and as the larval lingcod began to develop within the egg the colour progressed through a creamy white to white to grey-white in colour. Larval lingcod become visible within the egg case prior to hatching. Egg hatching appeared to commence on the outside of the nest and progresses inward. Egg cases appeared empty on the outside before eggs on the inside were eyed. Samples of 10 mL of eggs were collected from the outside of the first 100 nests and were retained in seawater. When hatching did occur within a sample, the entire sample hatched simultaneously (within 3 hours). This expedited rate of nest hatching is similar to that found by Low and Beamish (1978). Males were observed to remain within the nesting area for a short amount of time after the nests had disappeared (Table 6). Nest volumes were observed to decrease over time suggesting that predation and larval hatching can obviously affect nest size (Table 6). Nest volumes were also observed to increase in size suggesting that eggs may be deposited in multiple batches, possibly over a period of days. One nest was observed to be grey-white on the first visit and after three weeks the nest was revisited and found to be pinkish white in colour, suggesting that newer eggs had been laid down recently, possibly on top or in place of the previous eggs seen (Table 6). It is likely that a nest guarding male mates with more than one female, with eggs deposited within the existing nest.

DISCUSSION

When attempting to compare similar survey times, the 2001 survey produced a median nest density estimate that was lower than those found in previous surveys. However, it is important to note that the nesting survey design has varied each year though the maximum range was higher. In 1978, the entire survey area in Dodd Narrows was mapped with underwater lead lines and each lingcod nest within that area was counted (Low and Beamish, 1978). This produced an actual nest density for the survey area in Dodd Narrows, and not an estimate of nest density. In 1990, nest density estimates were calculated by using 50-60 m leadline transects, arbitrarily placed on the reef, with divers searching 7 m on opposite sides of the transect line (Yamanaka and Richards, 1995). Upon completion of a transect, the transect was moved to another location on the reef. It is not described how the locations on the reef were selected. In 1991 circular quadrats (10 m radius) were arbitrarily placed on the reef using the anchor as the first base point (Yamanaka and Richards, 1995). The quadrat was searched and upon completion divers would then swim at least 20 m away in any direction and arbitrarily select another base point for the following plot. It is not described how the starting locations on the reef were selected. In 1994 surface-deployed anchor buoys were used to mark locations on the reef which were used as the base points for circular quadrats with a 10 m radius (Yamanaka and Richards, 1995). Again, it is not described how the starting locations on the reef were selected. This variance makes direct comparisons of density estimates between surveys, and between years, difficult especially since there appears to be a preferred area of the Snake Island reef for spawning sites.

We have used a survey methodology similar to that used in 1991 and 1994, but with modifications, namely the systematic approach to randomly selected quadrat sites and the marking of individual nests. Marking nests allows divers to differentiate newly discovered nests from previously visited nests. This avoids overestimation of nest densities caused by duplicate counts or by unknowingly repeating quadrat areas, and allows a comparison of nest development over time when individual nests are encountered again. We have made an attempt in 2001 to provide random and even coverage of the reef and to avoid quadrat repetitions within a reef section. Though in previous years, attempts to cover the entire reef were made, the use of a Global Positioning System for exact locations was not possible. This, coupled with the lack of nest markers, may have resulted in repetitive counting of nests in the same general location. If those locations were preferred habitat for spawning, an inflation of the nest density estimate would be the result and the opposite would be true if the locations were less preferred habitat sites. The 2001 survey estimate may be lower due to our attempt to provide even coverage of the reef.

There was a noticeable difference in the nest densities found among each of the individual sections on the reef. At the Snake Island reef, certain sections typically contained more nests and larger nest guarding males. These areas were guarded by larger than average males. Sections 3-5 of the reef were most typical of the preferred spawning habitat, though the highest nest counts were in section 1. Sections 3-5 can be described as generally flat or with a gradual slope, with a lot of barren space, rocks and some boulders (Table 1). There was very little sandy substrate or coverage by large flora (e.g. *Agarum*) in these sections. The habitat of these quadrat areas suggest that lingcod require, along with rocky crevices for egg deposition, open spaces with improved visibility for spawning behaviour or for effective nest guarding. If it is assumed that reef areas with the above characteristics represent a preferred spawning habitat, future surveys might consider focusing on preferred sections of habitat for a core nest density index, as well as considering other surrounding habitat as a peripheral spawning habitat that would be used when there are surplus spawners. When lingcod abundance is low, it is likely that there would be few nests occurring in the peripheral sections. However, when abundance is high, more nests may be found in the peripheral sections. On any given survey day, an attempt should be made to dive one preferred habitat site and one peripheral habitat site, with random selections for additional dives. If lingcod spawning abundance improves, there may be a slight increase in the core nest density index and a more dramatic increase in the nest density estimates for peripheral sites.

In 2001, exploratory dives in Dodd Narrows revealed much lower nest counts than the 77 nests in 4400 m^2 found in 1978 (Low and Beamish 1978). Possible causes for the severe decline in lingcod nests in the Dodd Narrows region may be increases in fishing pressure, marine traffic and industrial utilisation of the area. Log floats associated with a nearby pulp mill provide haul-outs for large numbers of California sea lions (*Zalophus californianus*). This seasonal increase in local sea lion residency could result in an increased predation on resident and spawning lingcod.

FUTURE SURVEYS

Assessing the developmental colour stages of lingcod eggs can only be accurately be done using an underwater light source. Depending on the surface conditions, depth and the time of year the clarity of the water can be quite low in coastal British Columbia. Colours with shorter wavelengths (reds) are filtered out quickly in the upper water column and makes it possible to incorrectly assess the colour of newly spawned eggs, which are pink in colour, without the use of underwater lights.

Nest volumes should be more accurately estimated using in situ measurements or by comparing an object of known volume to the egg nest. Visual estimates, while easy to make, are difficult to do correctly, and become unreliable when estimated by multiple participants. Estimates of volume accuracy to the nearest 0.5 L would be adequate, and this could easily be accomplished by using 0.5 L and 1 L plastic bottles. The dives are conducted in shallow enough depths that the effects of pressure (< 2 atmospheres) in decreasing the bottles' size would be negligible. We found that occasionally between visits nest volume increased (Table 3), rather than decreased, as might be expected if some hatching occurred. Measurements of the nests (e.g. length, width, depth) may be time consuming and more difficult than a visible comparison to an object with a known volume, but would still be more accurate than a visual estimate.

The employment of a standardised nesting survey would allow more reliable comparisons of data collected by various research teams on different surveys. It would also allow better comparisons of surveys done spatially and temporally. We propose that the 2001 survey methodology be used in future surveys as a standardised survey method with the above noted considerations. One improvement to consider might be the use of smaller section areas so that subjective selection within a section (in order to provide even coverage) is minimized.

Finally, it is important to note that dive surveys have a limited application to providing indices for the relative abundance of lingcod. Lingcod are a non-migratory species, that likely remain associated with a particular reef throughout the spawning portion of its lifetime. Recreational fishing could impact the number of mature lingcod living on or near a reef, therefore impacting the number of nests observed in a given year. Future survey programs should consider the use of several reefs in an area, including if possible any 'no-take' reefs where no recreational fishing occurs for comparison of nest density trends.

ACKNOWLEDGEMENTS

Thanks to Lesley MacDougall, Greg Workman, Peter Midgely, Jonathan Hepples and George Horonowitz for helping out on the survey. Thanks to Doug Brouwer for the provision of dive equipment.

REFERENCES

Cass, A. J. , R. J. Beamish, and G. A. McFarlane. 1990. Lingcod (*Ophiodon elongatus*). Can. Spec. Publ. Fish. Aquat. Sci. 109: 40 p.

King, J. R., and A. M. Surry. 2000. Lingcod stock assessment and recommended yield options for 2001. Can. St. Assess. Sec. Res. Doc. 2000/164: 50 p.

Low, C. J., and R. J. Beamish. 1978. A study of the nesting behaviour of lingcod (*Ophiodon elongatus)* in the Strait of Georgia, British Columbia. Fish. Mar. Serv. Tech. Rep. 43: 27 p.

Yamanaka, K. L., and L. J. Richards. 1995. Lingcod egg mass surveys. pp. 41-51 *In:* Stocker, M. and J. Fargo [eds.]. Groundfish Stock Assessments for the west coast of Canada in 1994 and recommended yield options for 1995. Can. Tech. Rep. Fish. Aquat. Sci. 2069: 440 p.

Table 1. Data for Snake Island reef quadrats including date sampled, section area (see Figure 2), the latitude and longitude of the buoy marker, quadrat depth (m) as measured by depth gauge at the buoy line, visibility (m) in the water column, the number of unflagged nests observed (number in parentheses denote total nests i.e. including previously observed and flagged), the number of newly observed nests with guarding males, and the number of males observed in the quadrat that were not guarding a nest. The slope (flat, gradual and steep) of the quadrat was estimated for the majority of the quadrat. The top three habitat descriptions for each quadrat is included..

Date	Quadrat number	Section number	Latitude	Longitude	Quadrat depth (m)	Visibility (m)	Number of unflagged nests (total nests)	Number of guarded nests	Number of non-guarding males	Slope	Habitat description		
											Primary	Secondary	Tertiary
23-Jan-01	1	2	491242.90	1235303.20	12.5	5	1	1		Gradual	Rocky	Boulders	*Agarum*
23-Jan-01	2	5	491241.90	1235308.20	10.7	5	5	3		Gradual	Rocky	Boulders	*Agarum*
24-Jan-01	3	6	491237.00	1235304.00	8.8	8	1	0		Flat	Barren	Boulders	
24-Jan-01	4	5	491239.00	1235308.00	15.8	8	1	1		Flat	Rocky	*Agarum*	
24-Jan-01	5	1	491247.00	1235306.00	12.5	5	1	1		Flat	Rocky	*Agarum*	
30-Jan-01	6	8	491234.30	1235306.00	11.0	15	1	1	3	Flat	Boulders	*Agarum*	
30-Jan-01	7	4	491241.40	1235303.50	11.3	15	1	1	1	Steep	Barren		
30-Jan-01	8	4	491239.70	1235304.50	11.6	10-12	1	1	1	Steep	Barren	Rocky	Sandy
31-Jan-01	9	3	491244.90	1235304.80	8.8	8-10	1	1	4	Flat	Barren	Boulders	Sandy
31-Jan-01	10	6	491237.60	1235303.00	14.9	8-10	0	0	6	Gradual	Rocky	Sandy	*Agarum*
09-Feb-01	11	5	491238.40	1235307.20	9.1	12	0	0	6	Gradual	Sandy	Rocky	Boulders
09-Feb-01	12	3	491242.70	1235305.20	6.7	10	6	5	3	Gradual	Rocky	Boulders	*Agarum*
09-Feb-01	13	4	491240.50	1235302.10	14.9	5	0	0	1	Flat	Sandy	Cobble	Flora
09-Feb-01	14	3	491241.60	1235305.00	7.6	10	1	1	3	Gradual	Barren	Boulders	Rocky
09-Feb-01	15	2	491241.80	1235300.30	13.7	8	1	0	1	Flat	Flora	Rocky	Sandy
13-Feb-01	16	3	491244.40	1235305.30	9.8	8	0 (1)	0	1	Flat	Barren	Sandy	Rocky
13-Feb-01	17	3	491242.90	1235306.20	9.4	10	1 (2)	0	1	Gradual	Barren	Rocky	*Agarum*
13-Feb-01	18	7	491236.80	1235308.10	11.3	8	2	2	0	Steep	Flora	Boulders	
13-Feb-01	19	8	491233.00	1235306.90	10.7	10	1	1	1	Gradual	Flora	Rocky	
14-Feb-01	20	4	491240.00	1235304.70	7.6	8	3 (4)	3	1	Flat	Barren	Rocky	
14-Feb-01	21	5	491241.60	1235306.50	7.9	10	6	5	1	Flat	Rocky	Barren	
14-Feb-01	22	5	491244.40	1235304.90	7.9	10	2 (3)	2	0	Flat	Rocky	Barren	
14-Feb-01	23	7	491238.00	1235307.20	8.2	8	2	2	1	Gradual	Rocky	Barren	*Agarum*
19-Feb-01	24	8	491235.90	1235305.30	9.8	15	2	1	2	Steep	*Agarum*	Barren	Rocky
19-Feb-01	25	5	491240.70	1235308.60	11.3	10	1	1	2	Steep	Boulders	Barren	*Agarum*
19-Feb-01	26	7	491237.50	1235308.20	10.4	10	2	2	1	Gradual	*Agarum*	Rocky	
19-Feb-01	27	2	491244.40	1235302.30	8.8	10	1	1	3	Flat	Barren	Rocky	*Agarum*
21-Feb-01	28	4	491239.40	1235305.70	6.1	11	3	3	3	Flat	Barren	Boulders	

Table 1 (cont'd)

Date	Quadrat number	Section number	Latitude	Longitude	Quadrat depth (m)	Visibility (m)	Number of unflagged nests (total nests)	Number of guarded nests	Number of non-guarding males	Slope	Habitat description		
											Primary	Secondary	Tertiary
21-Feb-01	29	5	491240.70	1235306.60	5.8	11	7 (8)	4	2	Flat	Barren	Boulders	
21-Feb-01	30	2	491243.80	1235303.90	7.0	10	1	1	2	Flat	Barren		
21-Feb-01	31	3	491244.00	1235305.50	8.8	10	0 (1)	0	2	Flat	Rocky	Barren	Sandy
21-Feb-01	32	4	491240.90	1235305.70	5.2	10	0 (2)	0	4	Flat	Barren	Rocky	
22-Feb-01	33	8	491235.50	1235307.60	11.0	8	0	0	1	Gradual	*Agarum*	Rocky	Sandy
22-Feb-01	34	4	491239.00	1235305.60	7.6	8	4	4	2	Gradual	Barren	Boulders	
22-Feb-01	35	3	491242.50	1235304.40	6.4	8	0	0	1	Flat	Barren		
22-Feb-01	36	6	491237.90	1235305.90	6.1	8	4	4	4	Gradual	Barren	Boulders	
22-Feb-01	37	5	491239.90	1235307.90	13.7	8	1	1	1	Steep	*Agarum*	Boulders	Rocky
22-Feb-01	38	5	491240.80	1235302.50	13.7	8	0	0	2	Flat	*Agarum*	Rocky	
23-Feb-01	39	2	491244.30	1235303.40	9.4	10	0	0	0	Gradual	Barren	Sandy	Rocky
23-Feb-01	40	1	491247.30	1235304.90	12.8	8	3	3	1	Steep	*Agarum*	Boulders	
23-Feb-01	41	7	491238.30	1235307.40	9.4	10	1	1	2	Flat	Rocky	Barren	*Agarum*
23-Feb-01	42	1	491246.80	1235304.00	8.5	8	5	4	1	Gradual	Barrren	Rocky	*Agarum*
23-Feb-01	43	3	491243.50	1235304.70	5.2	10	9	8	1	Flat	Rocky	Barren	Flora
26-Feb-01	44	8	491235.40	1235306.20	9.8	6	1	1	1	Flat	Barren	*Agarum*	Boulders
26-Feb-01	45	6	491238.20	1235304.90	7.9	6	0	0	1	Flat	Barren		
26-Feb-01	46	3	491243.50	1235304.50	7.6	6	0 (3)	0	3	Flat	Rocky	Barren	*Agarum*
26-Feb-01	47	5	491239.20	1235308.30	8.8	6	1	1	1	Gradual	Barren	Boulders	Rocky
06-Mar-01	48	7	491237.20	1235306.50	7.3	7	2	2	2	Flat	Barren	Rocky	*Agarum*
06-Mar-01	49	8	491231.90	1235307.30	12.5	11	3	3	0	Gradual	Rocky	Boulders	*Agarum*
06-Mar-01	50	6	491236.90	1235304.90	9.8	7	0	0	2	Flat	Barren	*Agarum*	
06-Mar-01	51	8	491233.10	1235306.90	9.8	7	1 (2)	2	1	Gradual	Boulders	*Agarum*	
07-Mar-01	52	6	491237.60	1235305.00	8.5	7	1	1	0	Flat	Barren	*Agarum*	
07-Mar-01	53	1	491246.00	1235304.80	10.7	7	3	3	2	Steep	Rocky	Boulders	Flora
07-Mar-01	54	2	491244.50	1235302.60	7.6	11	1	1	0	Flat	Barren	Boulders	
07-Mar-01	55	2	491242.20	1235304.10	10.4	8	1	1	2	Flat	*Agarum*	Rocky	
14-Mar-01	56	4	491241.80	1235305.20	7.9	3	2 (3)	1	1	Gradual	Sandstone	Boulders	
14-Mar-01	57	8	491234.80	1235307.10	9.8	3	3	3	2	Gradual	Boulders	*Agarum*	
14-Mar-01	58	5	491239.70	1235306.40	6.4	4	2	2	1	Gradual	Boulders	*Agarum*	
14-Mar-01	59	7	491236.60	1235307.10	8.5	5	1	1	1	Flat	Rocky	Boulders	*Agarum*
14-Mar-01	60	3	491242.00	1235306.00	6.4	4	1	1	1	Flat	*Agarum*	Boulders	
22-Mar-01	61	6	491237.50	1235305.80	6.4	4	0 (2)	0	1	Gradual	Sandstone	*Agarum*	
22-Mar-01	62	2	491243.00	1235305.20	5.2	4	0 (4)	0	0	Gradual	Sandstone	Boulders	*Agarum*

Table 1 (cont'd)

Date	Quadrat number	Section number	Latitude	Longitude	Quadrat depth (m)	Visibility (m)	Number of unflagged nests (total nests)	Number of guarded nests	Number of non-guarding males	Slope	Habitat description		
											Primary	Secondary	Tertiary
22-Mar-01	63	7	491237.80	1235307.10	7.9	4	0	0	0	Gradual	Sandstone	*Agarum*	
22-Mar-01	64	3	491243.70	1235306.30	7.6	5	0	0	1	Flat	Sandstone	*Agarum*	*Laminaria*
22-Mar-01	65	8	491233.70	1235305.00	14.3	9	0	0	0	Flat	Sandstone	Sandy	
30-Mar-01	66	1	491245.40	1235306.50	12.5	8	0	0	2	Flat	*Agarum*	Boulders	Rocky
30-Mar-01	67	5	491241.70	1235307.70	9.8	8	1	1	3	Gradual	*Agarum*	Boulders	Rocky
30-Mar-01	68	2	491243.80	1235304.80	6.4	8	0 (3)	0	4	Flat	Barren	Boulders	*Agarum*
30-Mar-01	69	4	491240.70	1235304.00	8.8	8	0	0	3	Gradual	Barren	Boulders	
06-Apr-01	70	7	491237.40	1235307.20	9.4	8	0	0	2	Steep	Flora	*Agarum*	Rocky
06-Apr-01	71	6	491236.90	1235305.70	5.8	10	0 (1)	1	4	Gradual	Rocky	Barren	*Agarum*
06-Apr-01	72	2	491243.10	1235303.30	7.0	10	0	0	0	Flat	Barren	Sandstone	
06-Apr-01	73	5	491241.00	1235307.00	6.1	10	0	0	6	Gradual	Sandstone	Boulders	Rocky
06-Apr-01	74	2	491243.40	1235304.60	5.8	10	0 (7)	2	11	Gradual	Boulders	Sandstone	*Agarum*

Table 2. Summary of nest densities (nests/m^2) estimated during comparable time periods from the 5 nest density surveys.

Survey Year	Time Period	Number of nests	Nest density estimate	2001 Survey comparable period	Number of nests	2001 Nest density estimate
1978	Dec 1-Jun 6	78	0.0177 [a]	Jan 23- Apr 6	117	0.0032
1990	Feb 16-Mar 16	104	0.0043	Feb 13-Mar 14	86	0.0032
1991	Mar 18-Mar 21	14	0.0032	Mar 14-Mar 22	9	0.0016
1994	Feb 10-Mar 15	78	0.0064	Feb 9-Mar 14	94	0.0032

[a] Nest density for 1978 is an actual density, not an estimate, since all nests in the survey area were counted. All other years are median nest density estimates.

Table 3. Data for each nest observed. Note that numbers are not sequential due to logistic constraints in some instances. The numbers associated with a nest correspond to the flag number used in the field. The quadrat and section that each nest was observed in is noted. The depth (m) of the nest location, the estimated volume (to the nearest 0.5 L) along with the location of the nest, the colour of the eggs, the presence of a male guarding one nest (M1), guarding two nests in sequential order (M2) or an unguarded nest (M0), and the total length (cm) of the guarding male are included. The nest location codes include: out in the open=0, under rock=1, in horizontal crevice=2, in vertical crevice=3. Egg development is coded by the following: 0=pinkish white (newly laid), 1=creamy white (new), 2=white (intermediate), 3=grey white (old), 4=eyed eggs (nearly hatched), 5=hatched. If a male was present, but no length is indicated, then measurement was not possible.

Date	Nest number	Quadrat number	Section number	Nest depth (m)	Nest location	Nest volume (L)	Egg colour	Male present	Length of male (cm)
23-Jan-01	1	1	2	12	2	3.0	1	M1	
23-Jan-01	2	2	5	9	2	1.0	1	M1	73
23-Jan-01	3	2	5	9	0	3.0	1	M0	
23-Jan-01	4	2	5	9	2	3.0	1	M1	58
23-Jan-01	5	2	5	13	3	3.0	1	M1	66
23-Jan-01	6	2	5	12	2	3.0	1	M0	
24-Jan-01	7	3	6	9	0	2.0	3	M0	
24-Jan-01	8	4	5	16	2	3.0	1	M1	66
24-Jan-01	9	5	1	12	1	3.0	1	M1	
30-Jan-01	10	6	8	11	1	3.0	1	M1	28
30-Jan-01	11	7	4	11	1	3.0	2	M1	73
30-Jan-01	12	8	4	12	1	3.0	2	M1	68
31-Jan-01	13	9	3	9	2	3.0	2	M1	59
09-Feb-01	15	12	3	6	1	2.0	1	M2	72
09-Feb-01	16	12	3	6	1	1.5	2	M2	72
09-Feb-01	17	12	3	8	1	1.5	1	M0	
09-Feb-01	18	12	3	7	1	1.0	2	M1	
09-Feb-01	19	12	3	6	1	1.5	2	M1	66
09-Feb-01	20	12	3	6	1	1.0	2	M1	60
09-Feb-01	21	14	3	7	1	2.5	2	M1	63
09-Feb-01	22	15	2	14	3	1.5	2	M0	
13-Feb-01	23	17	3	9	1	2.0	2	M0	
13-Feb-01	24	18	7	10	3	2.0	2	M1	
13-Feb-01	25	18	7	10	3	0.5	2	M1	65
13-Feb-01	26	19	8	11	2	2.0	4	M1	60
14-Feb-01	27	20	4	8	1	3.0	1	M1	66
14-Feb-01	28	20	4	7	1	3.0	2	M2	64
14-Feb-01	29	20	4	7	1	1.5	1	M2	64
14-Feb-01	30	20	4	7	1	2.5	4	M1	66

Table 3 (cont'd)

Date	Nest number	Quadrat number	Section number	Nest depth (m)	Nest location	Nest volume (L)	Egg colour	Male present	Length of male (cm)
14-Feb-01	31	21	5	7	1	3.0	4	M1	59
14-Feb-01	32	21	5	8	1	3.0	4	M0	
14-Feb-01	33	21	5	8	1	2.0	2	M1	66
14-Feb-01	34	21	5	9	1	1.5	2	M1	64
14-Feb-01	35	21	5	9	1	1.5	2	M2	58
14-Feb-01	36	21	5	9	2	2.0	3	M2	58
14-Feb-01	37	22	5	8	1	1.5	2	M1	60
14-Feb-01	38	22	5	7	1	3.0	1	M1	64
14-Feb-01	39	23	7	8	1	2.0	3	M2	71
14-Feb-01	40	23	7	9	1	1.5	4	M2	71
19-Feb-01	41	24	8	8	2	1.0	0, 1	M1	
19-Feb-01	42	24	8	13	0	0.5	0, 1	M0	
19-Feb-01	43	25	5	12	1	2.5	3	M1	53
19-Feb-01	44	26	7	9	3	3.0	4	M1	53
19-Feb-01	45	26	7	9	3	1.0	0, 1	M1	69
19-Feb-01	46	27	2	9	1	1.0	2	M1	
21-Feb-01	47	28	4	6	1	2.0	2	M1	66
21-Feb-01	48	28	4	6	1	2.0	4	M1	64
21-Feb-01	49	28	4	6	1	1.5	4	M1	67
21-Feb-01	50	29	5	6	1	2.0	3	M0	
21-Feb-01	51	29	5	6	0	1.5	4	M0	
21-Feb-01	54	29	5	6	1	1.0	4	M0	
21-Feb-01	55	29	5	6	1	2.0	4	M2	60
21-Feb-01	56	29	5	6	1	2.0	2	M2	60
21-Feb-01	57	29	5	5	1	2.5	2	M1	77
21-Feb-01	58	29	5	5	2	2.5	1	M1	58
21-Feb-01	59	30	2	8	1	1.5	2	M1	59
22-Feb-01	60	34	4	7	1	2.0	4	M2	65
22-Feb-01	61	34	4	7	1	3.0	4	M2	65
22-Feb-01	62	34	4	7	1	2.0	4	M1	66
22-Feb-01	63	34	4	8	1	2.0	4	M1	58
22-Feb-01	64	36	6	7	1	2.0	2	M1	58
22-Feb-01	65	36	6	7	1	2.0	3	M1	61
22-Feb-01	66	36	6	7	1	1.5	4	M1	66
22-Feb-01	67	36	6	7	1	2.0	4	M1	58
22-Feb-01	68	37	5	14	1	2.0	3	M1	65
23-Feb-01	69	40	1	13	1	2.5	4	M1	71
23-Feb-01	70	40	1	13	1	2.5		M1	67
23-Feb-01	71	40	1	15	1	3.0	2	M1	61
23-Feb-01	72	41	7	9	1	0.5	3	M1	66
23-Feb-01	73	42	1	8	0	0.5	4	M0	

Table 3 (cont'd)

Date	Nest number	Quadrat number	Section number	Nest depth (m)	Nest location	Nest volume (L)	Egg colour	Male present	Length of male (cm)
23-Feb-01	74	42	1	7	1	1.5	2	M1	69
23-Feb-01	75	42	1	9	1	2.0	1	M1	56
23-Feb-01	76	42	1	7	1	2.0	3	M2	
23-Feb-01	77	42	1	7	1	2.0	2	M2	
23-Feb-01	78	43	3	5	1	2.5	4	M1	64
23-Feb-01	79	43	3	5	1	2.0	4	M1	58
23-Feb-01	80	43	3	5	1	3.0	4	M2	52
23-Feb-01	81	43	3	5	1	1.5	2	M2	52
23-Feb-01	82	43	3	7	1	0.5	2	M1	51
23-Feb-01	83	43	3	5	2	2.5	4	M1	63
23-Feb-01	84	43	3	5	1	2.0	4	M2	56
23-Feb-01	85	43	3	5	3	2.0	4	M2	56
23-Feb-01	86	43	3	5	1	1.5	4	M0	
26-Feb-01	87	44	8	10	1	1.5	4	M1	58
26-Feb-01	88	47	5	12	1	3.0		M1	61
06-Mar-01	89	48	7	9	1	1.5	3	M2	65
06-Mar-01	90	48	7	7	1	1.0	3	M2	65
06-Mar-01	91	49	8	13	1	2.0	4	M2	62
06-Mar-01	92	49	8	13	1	2.5	2	M1	60
06-Mar-01	93	49	8	13	1	2.0	4	M2	62
06-Mar-01	94	51	8	12	1	1.0	3	M1	68
07-Mar-01	95	52	6	8	1	1.0	4,5	M1	53
07-Mar-01	96	53	1	12	0	1.5	4	M1	56
07-Mar-01	97	53	1	8	1	2.0	4	M1	58
07-Mar-01	98	53	1	11	1	2.5	4	M1	66
07-Mar-01	99	54	2	9	1	3.0	4	M1	45
07-Mar-01	100	55	2	12	1	1.5	4	M1	
14-Mar-01	101	56	4	10	1	3.0	4,5	M1	51
14-Mar-01	102	56	4	7	0	1.0	4	M0	
14-Mar-01	103	57	8	10	1	3.0	4,5	M1	66
14-Mar-01	104	57	8	9	1	0.5	4	M1	63
14-Mar-01	105	57	8	10	1	1.5	3	M1	
14-Mar-01	106	58	5	5	1	2.5	4	M1	68
14-Mar-01	107	58	5	5	1	4.0	4,5	M1	59
14-Mar-01	108	59	7	8	0	2.0	3	M1	54
14-Mar-01	109	60	3	7	1	3.0	4,5	M1	58
30-Mar-01	110	67	5	10	1	3.5	4,5	M1	68

Table 4. Number of quadrat counts and total number of nests counted in each section over the survey.

Section	Number of quadrat counts	Number of nests	Number of nest standardised to 10 quadrat visits
1	5	12	24
2	11	6	5
3	11	19	17
4	9	15	17
5	13	27	21
6	8	6	8
7	8	10	13
8	9	12	13

Table 5. Summary of total length (cm) of nest guarding males present in each section.

Section	Mean	Minimum	Maximum
1	63	56	71
2	54	45	59
3	60	51	72
4	65	51	73
5	63	53	77
6	59	53	66
7	64	53	71
8	62	58	68
All	62	45	77

Table 6. Nest volume (L), egg development, presence of a guarding male for nests that were revisited during the survey. Egg development is coded by the following: 0=pinkish white (newly laid), 1=creamy white (new), 2=white (intermediate), 3=grey white (old), 4=eyed eggs (nearly hatched), 5=hatched.

	Initial visit				Revisit				Revisit			
Nest number	Date	Volume (L)	Egg colour	Male present	Date	Volume (L)	Egg colour	Male present	Date	Volume (L)	Egg colour	Male present
13	31-Jan-01	3.0	2	M1	14-Feb-01		3	M1	21-Feb-01		3	M1
16	09-Feb-01	1.5	2	M2	13-Feb-01		2	M1				
17	09-Feb-01	1.5	1	M0	13-Feb-01	1.5	4	M1				
18	09-Feb-01	1.0	2	M1	22-Mar-01	1.5	4,5	M1				
20	09-Feb-01	1.0	2	M1	14-Mar-01	1.0	4,5	M1				
25	13-Feb-01	0.5	2	M1	06-Mar-01	3.0	3	M1				
32	14-Feb-01	3.0	4	M0	21-Feb-01		2	M1				
37	14-Feb-01	1.5	2	M1	26-Feb-01		4	M1	30-Mar-01	2.0	4,5	M1
38	14-Feb-01	3.0	1	M1	26-Feb-01		4,5	M1				
48	21-Feb-01	2.0	4	M1	23-Feb-01	1.0	1	M0				
55	21-Feb-01	2.0	4	M2	06-Apr-01			M0				
60	22-Feb-01	2.0	4	M2	06-Apr-01	0.5	4,5	M1				
64	22-Feb-01	2.0	2	M1	22-Mar-01	3.0	4,5	M1				
66	22-Feb-01	1.5	4	M1	07-Mar-01	1.0	4,5	M1	06-Apr-01			M0
67	22-Feb-01	2.0	4	M1	22-Mar-01	2.5	4,5	M1				
79	23-Feb-01	2.0	4	M1	22-Mar-01	1.5	4	M1	06-Apr-01			M0
80	23-Feb-01	3.0	4	M2	06-Apr-01	0.25	5	M0				
82	23-Feb-01	1.5	2	M2	30-Mar-01			M0				
83	23-Feb-01	2.5	4	M1	06-Apr-01	1.0	4,5	M1				
84	23-Feb-01	2.0	4	M2	26-Feb-01		4	M2	06-Apr-01			M0
85	23-Feb-01	2.0	4	M2	26-Feb-01		4		06-Apr-01	4		M2
87	26-Feb-01	1.0	4	M1	22-Mar-01	1.5	4	M0	06-Apr-01	4		M0
90	06-Mar-01	1.0	3	M2	22-Mar-01	3.0	4,5	M1				
93	06-Mar-01	2.0	4	M2	22-Mar-01	3.5	4	M1				

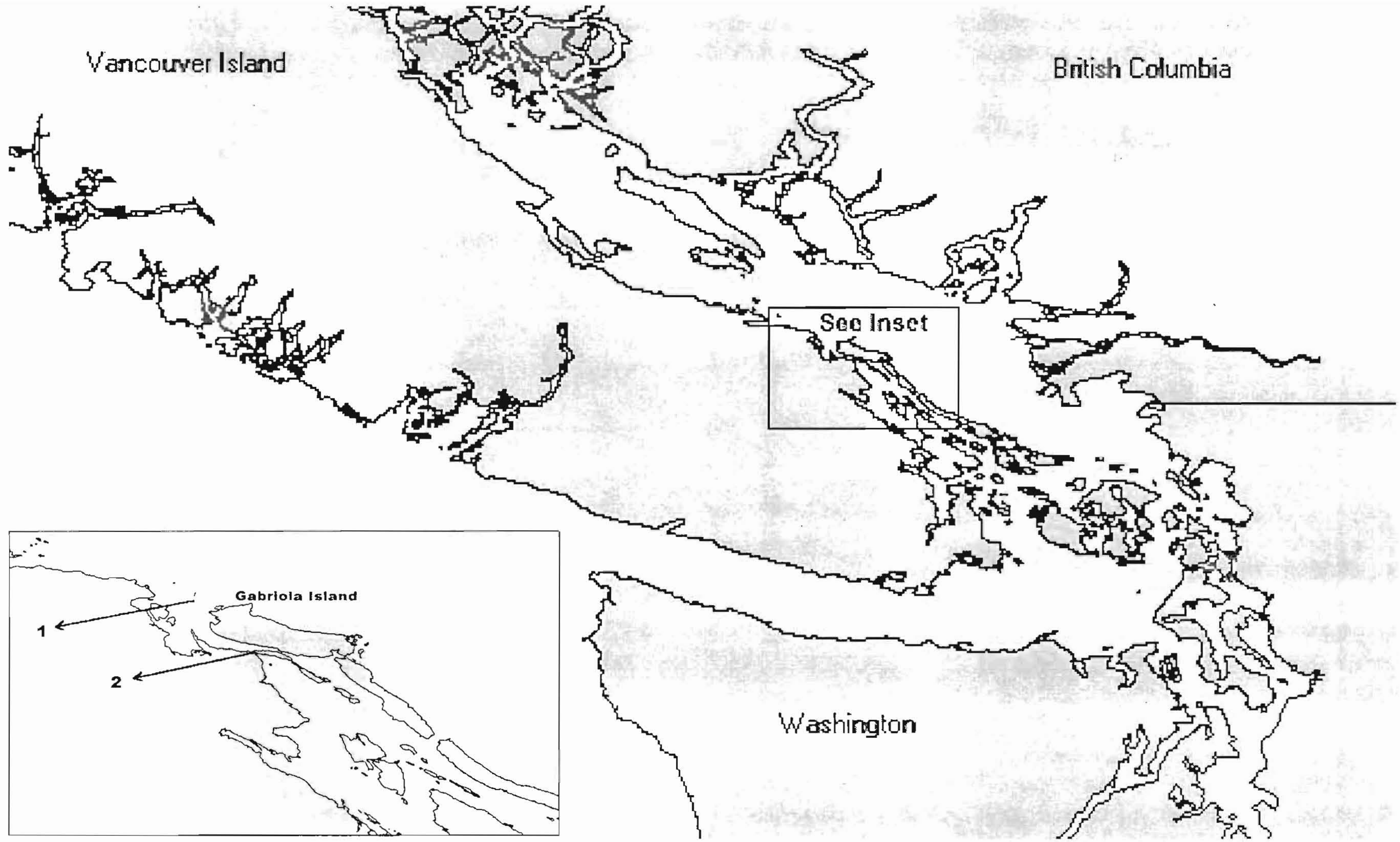

Fig. 1. Location of areas examined for lingcod nests. Inset includes primary investigation area with study sites Snake Island reef (1), Dodd Narrows (2).

This page left blank purposely.

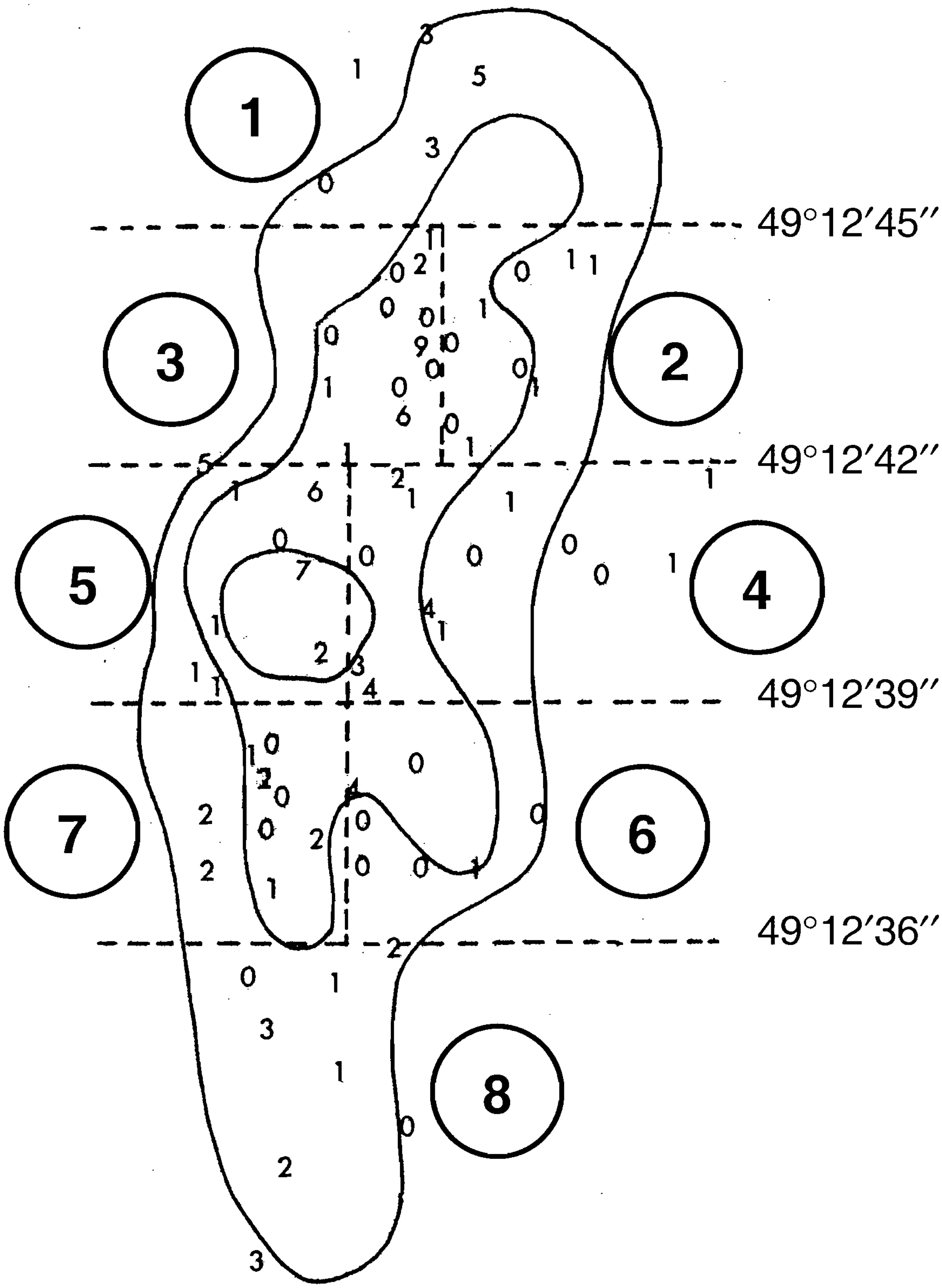

Fig. 2. Outline of the Snake Island reef, depth contours in 5 m increments. Sections of the reef are numbered in circles, with dotted lines denoting boundaries. The longitude separating section 2 from 3 in 123°53′04.5″, while sections 4 and 6 are spearated from 5 and 7 respectively by 123°53′06.5″. The approximate center of each quadrat is labelled corresponding to the total number of nests found.