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Recent trends in the abundance and distribution of sea otters (*Enhydra lutris*) in British Columbia

Tendances récentes relatives à l'abondance et à la répartition des loutres de mer (*Enhydra lutris*) en Colombie-Britannique

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ABSTRACT

A total of 4,712 sea otters was counted in British Columbia in 2008 (4,110 on west coast Vancouver Island and 602 on the central B.C. coast) up from 3,185 in 2004. The central B.C. coast was also surveyed in 2007 and 642 sea otters were counted. Along Vancouver Island the population increased at a rate of 15.0% year^{-1} from 1977 to 2008. However, it is evident that growth was more rapid up to 1995 (1977 to 1995, 19.0% year^{-1}) and slowed substantially thereafter to 8.4% year^{-1}. On the central B.C. coast the population increased at a rate 11.4% year^{-1} from 1990 and 2008. Range expansion continues to contribute to population growth. On the central B.C. coast, range expansion was evident to the southeast and to the north, notably Aristizabal Island. On Vancouver Island expansion into inlet habitat in Esperanza Inlet occurred in 2008.

RÉSUMÉ

Au total, 4 712 loutres de mer ont été dénombrées en Colombie-Britannique en 2008 (4 110 sur la côte ouest de l'île de Vancouver et 602 sur la côte centrale de la Colombie-Britannique), soit une hausse comparativement au total de 3 185 loutres de mer recensées en 2004. La côte centrale de la Colombie-Britannique a également fait l'objet d'un recensement en 2007 et 642 loutres de mer y ont été dénombrées. Le long de la côte de l'île de Vancouver, la population a augmenté à un rythme de 15,0 p. 100 par année^{1} de 1977 à 2008. Cependant, il est évident que la croissance a été plus rapide jusqu'en 1995 (de 1977 à 1995, 19,0 % par année^{1}) et qu'elle a ralenti considérablement par la suite atteignant un rythme de 8,4 p. 100 par année^{1}. Le long de la côte centrale de la Colombie-Britannique, la population a augmenté à un rythme de 11,4 p. 100 par année^{1} de 1990 à 2008. L'agrandissement de l'aire de répartition continue à contribuer à la croissance de la population. Le long de la côte centrale de la Colombie-Britannique, l'agrandissement de l'aire de répartition était évident au sud-est et au nord, notamment à l'île Aristizabal. Sur le littoral de l'île de Vancouver, l'expansion de l'habitat jusque dans l'inlet Esperanza a été observée en 2008.

Introduction

Sea otters occur in coastal areas of the North Pacific. Historically they ranged from Baja California northward along the eastern Pacific Rim, through the Aleutian Islands and Kurile Islands to Northern Japan. The Maritime Fur trade of the 18th and 19th Century led to extirpation of the sea otter from most of its range by 1911 and by 1929 in British Columbia (Cowan and Guiguet 1960; Kenyon 1969). Small remnant colonies survived along the California coast and among the Aleutian and Kurile Islands and eventually became re-established. With the exception of California, however, areas to the south of the Gulf of Alaska remained unoccupied until translocation efforts commenced in the late 1960's and sea otters were re-introduced to parts of southeast Alaska, British Columbia, Washington and Oregon (Jameson *et al.* 1982). All but the Oregon re-introduction effort were successful in establishing sea otters (Jameson *et al.* 1982). The Canadian re-introduction effort comprised three translocation events between 1969 and 1970 of 89 animals that were released into Checleset Bay, west coast Vancouver Island (Bigg and MacAskie 1978).

The sea otter feeds on benthic invertebrates that are obtained by diving to the seafloor. Most foraging occurs in depths of 30m or less, although the sea otter is capable of foraging to depths of 100m (Estes 1980; Riedman and Estes 1990; Bodkin *et al.* 2004). Most sea otters occupy relatively shallow waters and as such are found within 1 to 2 km of shore unless extensive shallow areas stretch further offshore (Riedman and Estes 1990; Laidre *et al.* 2002; Burn and Doroff 2005). In British Columbia (B.C.) most sea otters occupy areas exposed to the open Pacific Ocean, and are found particularly in areas characterized by jagged shorelines with clusters of small islets and reefs and shallow variable depths (< 50m). They are less frequently encountered along stretches of relatively straight coastline (Gregr *et al.* 2008).

Sea otters exhibit site fidelity occupying small over-lapping home ranges that extend from a few to tens of kilometres of coastline (Loughlin 1980; Garshelis *et al.* 1984; Jameson 1989). Otters spend a considerable part of each day in resting aggregations termed rafts that may form habitually on the water in the same area over periods of years (Ribic 1982; Jameson 1989; Ralls and Siniff 1990). Re-sightings of tagged animals indicate that some individuals raft together in the same location of periods of years (DFO unpubl.). Rafts are often associated with reefs and kelp beds. Some rafts can include over 200 animals in B.C. and rafts of 1,000 animals are reported from Alaska (Burn and Doroff 2005; DFO unpubl.). The aggregating behaviour of sea otters tends to result in a clumped distribution.

Sea otters segregate by gender to raft, and male and female rafts occur in separate areas (Reidman and Estes 1990). Male rafts tend to occupy the front, or periphery of the population range. Range expansion occurs in growing populations and is apparent when rafts of males appear in previously unoccupied habitat (Garshelis *et al.* 1984; Jameson 1989). Female rafts establish in new areas once male rafts have moved on (Loughlin 1980; Garshelis *et al.* 1984; Wendell *et al.* 1986).

Knowledge of population abundance and trends in population growth are essential for the management and conservation of sea otter populations. In California and Washington annual surveys of sea otters are carried out to monitor the relative size, growth and range of occupation of these small recovering populations (Jameson and Jeffries 2006; USGS 2008). In Alaska, three management stocks are recognized from the

Aleutian Island to the Canada-U.S. border. These stock areas are large, consequently, population surveys are completed by sub-sections often over multiple years (USFW 2008a; 2008b; 2008c). Sea otter surveys of the southwestern stock (Aleutian Islands and Alaskan Peninsula) date back to 1959 in some sub-sections and the time series of surveys has been crucial to detect recent population declines in the Aleutian Islands and recent changes in distribution along the Alaskan Peninsula (Doroff *et al.* 2003; Burn and Doroff 2005).

Surveys of the sea otter population in B.C. are made to obtain estimates of relative abundance, to estimate trends in growth and to monitor changes over time in the range of occupancy of this recovering population. The B.C. sea otter population was first surveyed in 1977 and subsequently at 1- 3 year intervals although in some years not all of the population range was covered. In 1989 a report was received of a raft of sea otters among the Goose Island Group on the central B.C. coast (B.C. Parks 1995). Since 1990 the central B.C. coast region has been surveyed at 1 to 3 year intervals as well.

Until 1988, surveys were made mostly from fixed-wing aircraft (Bigg and MacAskie 1978; Morris *et al.* 1981, MacAskie 1987). Since 1988 a standardized survey approach has been used that employs small boats and since 2001 has been developed and tested to also include the use of helicopters as an alternate platform to facilitate coverage of large areas and remote areas (Watson 1993; Watson *et al.* 1997; Nichol *et al.* 2005).

Sea otters now range along much of the west coast of Vancouver Island as well as eastward into northern Queen Charlotte Strait. Nichol *et al.* (2005) analysed survey data collected between 1977 and 2004 and concluded that along Vancouver Island, the population had increased at 15.6% year^{-1}, from a minimum of 70 animals in 1977 to 2,765 otters in 2004. This growth rate estimate was lower than that given by Watson *et al.* (1997) for the period 1977 to 1995 (18.6% year^{-1}) and it appeared that growth on Vancouver Island slowed after 1995. By 2001, sea otters on the central B.C. coast had expanded their range from the Goose Island Group north eastward to the edge of Milbanke Sound and the population had increase at 12.4% per annum from a minimum of 56 animals in 1990 to 420 otters in 2004 (Nichol *et al.* 2005). There was less certainty about the growth rate estimate for the central B.C. coast because of variation among annual counts and the resultant poorer fit of the regression compared to data from Vancouver Island. Variable survey conditions or less knowledge of the occupied range were presented as possible factors (Nichol *et al.* 2005).

In 2008, the occupied range on Vancouver Island and on the central B.C. coast was surveyed from small boats. Extensive surveys were also made of areas adjacent to the occupied range, particularly on the central B.C. coast, to improve knowledge of the range of occupation. The central B.C. coast was also surveyed in 2007 by small boat. In this report updated population estimates and population growth rates are presented for the B.C. sea otter population incorporating the new survey data from 2007 and 2008.

Methods

Survey Area

For population assessment, the sea otter range in B.C. is divided into segments. Segments are geographic areas that can typically be surveyed in a day by boat, although some segments delineated in the past now take more than one day to complete because of greater numbers of sea otters than in the past. The boundaries of segments are described by geographic places, e.g. points of land. Within segments survey coverage is defined by established survey routes. Outside the occupied range, it is not uncommon to encounter occasional single animals. However, the criterion used to define range expansion and thus occupation, is the presence of a raft of sea otters in a previously unoccupied area during the period of surveys. To monitor range expansion, particularly on the central B.C. coast, surveys were also made in areas adjacent to occupied habitat or in areas from which a report had been received of a sea otter raft. Over time new survey segments are added as the sea otter range expands. Year-round, Fisheries and Oceans Canada (DFO) solicits reports of sea otter sightings from other researchers, fisheries patrol vessel personnel, fisheries enforcement officers, coastal residents and fishermen. Reconnaissance surveys are also made in years between population surveys to monitor distribution (DFO unpubl.). Survey coverage including designated segments and the additional areas surveyed in 2008 are shown in Fig. 1.

Survey Method

Within segments survey routes followed the coastline and included coverage of waters around all islets and reefs. Survey routes were recorded by interfacing a GPS device with navigation software (Nobeltec Visual Navigation Suite, Nobeltec Corporation) and the route was consistent among survey years. In 2007 and 2008 surveys were conducted by two or three observers and one boat driver. The small vessels used were 5.5-m welded aluminum boats or a 6.5-m rigid hull inflatable boat. Observers searched for and counted sea otters on either side of the boat, recording both the number of sea otters and their location. The boat traveled at speeds of less than 10 knots (18.5 km/hour). Speed was altered as required and the boat was stopped frequently to search complex areas with binoculars and to obtain counts of rafts.

Rafts of sea otters were counted using 7X50 binoculars and 14X40 stabilized binoculars. Female rafts were distinguished from male rafts by the presence of pups. Rafts were counted by all observers. Each person assessed the raft size independently, then compared counts and recounted the raft to obtain the best overall repeatable count. This value was often among the higher of the initial estimates, because counts were made as the boat and otters rose and fell in the ground swell and high counts were obtained when an observer achieved an unobstructed view of the sea otter raft.

Sea and weather conditions were recorded during surveys and were categorized as follows. *Good* to *Excellent* survey conditions existed when sea state ranged from flat calm (Beaufort 0) to swells up to 1 m and wind speeds less than 10 knots (18 km/hr) (Beaufort 3). *Fair* conditions were defined generally as seas 1 to 1.5 m or when wind speeds ranged from 10 to 15 knots (28 km/hr) (Beaufort 4). *Poor* conditions were generally defined as seas greater than 1.5 m or wind speeds greater than 15 knots (28 km/hr). High overcast created ideal lighting conditions due to reduced sun glare. Surveys did not commence in *Poor* conditions or when visibility was obscured particularly through

binoculars, e.g. rain or fog. *Good* to *Excellent* conditions were sought, however sea states often changed during the course of a survey. If conditions deteriorated, the survey was repeated at a later date whenever possible.

Boat surveys generally started at daybreak and continued until the survey was completed, or until survey conditions deteriorated. If it was not possible to complete the segment in one day, the segment was counted in subsections. Details of how surveys are carried out from helicopter are described in Nichol *et al.* (2005).

In 2007 and 2008 surveys were conducted from May through early September during periods of suitable weather. In previous years surveys were conducted between April and September. No seasonal changes in distribution of sea otters during these months are evident from previous survey effort.

The precision of replicate counts obtained by this survey method in *Good* to *Excellent* survey conditions has been estimated (*CV* = 7-12%) (Nichol *et al.* 2005). The resulting population count provides an index of abundance, as some portion of the population is missed and not accounted for. This includes animals that are underwater or behind a swell during observations and animals that are outside the surveyed area.

Analytical Methods

Annual survey segment counts and counts from new areas that were found to be occupied by rafts of sea otters were summed to obtain a minimum population size. Where more than one survey of an area had been made, the survey made under the best conditions, which generally yielded the higher count, was selected. Not included, were counts of single otters occasionally encountered in new areas surveyed in 2008 and 2007 where no rafts were encountered.

Population growth was estimated for Vancouver Island for the period 1977 to 2008 and the central mainland coast, 1990 to 2008. Among some of the survey years prior to 2007 there were small gaps in coverage due to weather or for other logistical reasons. To address this problem an estimate was made of the number of animals in missed segments by interpolation using the exponential equation that best fit a maximum of four counts preceding and/or succeeding the missing count. Interpolation was restricted to survey years in which the missing segment had not been missed for more than two consecutive years and where at least 70% of the resulting population estimate for the year was based on actual counts. Only 2 of 7 years with interpolated values, had less than 90% of their total estimate based on actual counts and only 7 of 19 annual totals included interpolated values. Each annual population estimate was then weighted in regression analyses according to the square root of the proportion of the total population segments actually counted that year. In this way the annual estimates that included interpolated values were given less weight in regression than complete population counts. Where gaps in coverage were extensive (e.g. Vancouver Island 1996 to 2000 and 2005 to 2007) the year was excluded from analysis.

Annual rates of change in abundance between 1977 and 2008 were estimated by linear regression of ln (counts) versus time to obtain the best fit to the log transformed exponential growth equation:

$$\ln N_t = \ln N_0 + rt$$

where N_0 represents the initial population size and r the intrinsic rate of growth.
Finite rates of growth α were derived from the slope r (intrinsic rate) of the regression equation by:

$$\alpha = e^r - 1$$

The Student's t test was used to determine whether the slopes of simple log-linear regressions were significantly different (Zar 1984).

Changes in population growth between 1977 and 2008 were evaluated by fitting piecewise linear regressions to the logarithmically transformed counts on time:

$$\ln N_t = \ln N_0 + r_1 t + r_2(t-x)Y_t$$

Where x represents the year in which growth rate changed, r_1 represents the intrinsic rate of growth before the change, and r_2 represents the amount by which the rate is adjusted after the change. Y_t is a variable assigned 0 for years before the change in growth and 1 for years after. All possible regressions were fitted and those in which both coefficients were significant were evaluated by the resulting unadjusted r^2 values.

Results

Surveys of Vancouver Island were completed between June 18th and September 3rd, 2008. On the central B.C. coast surveys were completed between July 16th and July 26th, 2007 and between May 18th and May 30th, 2008. Conditions were *Good* to *Excellent* during 71% of the survey effort on Vancouver Island, 56% in 2008 on the central B.C. coast and 47% of the effort on the central B.C. coast in 2007 (Table 1).

Vancouver Island

A total of 4,110 sea otters were counted in the occupied range along Vancouver Island in 2008 (Table 2). The finite rate of growth, based upon a log-linear regression, was 15.0% year^{-1} (SE = 0.300 r^2 = 0.950, $F_{(1, 17)}$= 322.14 P< 0.0001). This estimate is not significantly different from 15.6% year^{-1} estimated previously for the period 1977 to 2004 ($t_{0.05(2),33}$ = -0.496, P < 0.05) (see Nichol *et al.* 2005). A piece-wise regression in which the population rate changed after 1995 provided a better fit (SE = 0.205, r^2 = 0.978, $F_{(2,16)}$ = 353.13, P < 0.0001), with growth of 19.0% year^{-1} from 1977 to 1995 and 8.4% year^{-1} thereafter thru 2008 (Fig. 2). Range expansion into Esperanza Inlet was evident in 2008, one of three new areas surveyed (Fig. 3, Fig. 1 area j).

Central B.C. coast

A total of 602 sea otters were recorded during surveys of the occupied range and newly occupied areas on the central B.C. coast in 2008. In 2007, 642 animals were counted (Table 2). A log-linear regression (1990 to 2008) indicates a growth rate on the central B.C. coast of 11.4% year^{-1} (SE = 0.356 r^2 = 0.801; $F_{(1,10)}$ = 40.32 P < 0.0001) (Fig. 4). The growth rate is not significantly different from 12.4% year^{-1} estimated previously for the period 1990 to 2004 ($t_{0.05(2),18}$ = -0.287, P < 0.05) (see Nichol *et al.* 2005).

In 2007 range expansion, evidenced by the presence of a male raft, had occurred in the entrance to Seaforth Channel. Small rafts of sea otters were encountered in Kildidt

Sound in 2008, but not in 2007, although not all of Kildidt Sound was covered in 2007. Range expansion to Aristizabal Island was evident in 2008 (Fig. 3, Fig. 1 areas b,e,f).

Discussion

The B.C. sea otter population increased to a minimum of 4,712 animals by 2008 (4,110 Vancouver Island and 602 Central B.C. coast) from 3,180 in 2004 (2,673 Vancouver Island and 420 Central B.C. coast). Growth rates have not changed significantly since previously estimated. Growth on Vancouver Island has continued at a rate of 15.0% $year^{-1}$ (1977 to 2008) although by a piece-wise regression it is evident that growth was rapid at 19.0% $year^{-1}$ up to 1995 and dropped thereafter to 8.4% $year^{-1}$.

Rates of 17-20% per year during the early decades following reintroduction have been reported for reintroduced populations in southeast Alaska, Washington, and B.C. (Estes 1990; Watson *et al.* 1997). Rapid growth is thought to be fuelled by an abundance of prey that arose in the absence of sea otters following extirpation of historic populations (Estes and Duggins 1995; Bodkin *et al.* 1999). Like Vancouver Island, rates of population increase in Washington State and in southeast Alaska have slowed; to 8.0% $year^{-1}$ (1989-2006) in Washington state and to "stable" in southeast Alaska (Jameson and Jeffries 2006; USFW 2008a).

On the central B.C. coast the number of sea otters has continued to increase at 11.4% $year^{-1}$ (1990 and 2008), a rate not significantly different from 12.4% $year^{-1}$ (1990 to 2004) calculated previously (Nichol *et al.* 2005). The fit of the regression is not as good as the log-linear regression fit for the Vancouver Island data reflecting more variability among survey counts, although the fit is slightly improved since 2004 (Nichol *et al.* 2005).

Less survey effort and therefore less knowledge of the occupied range was a possible factor presented previously to explain the variability among survey counts (Nichol *et al.* 2005). Surveys of new areas in 2007 and 2008 documented range expansion in less than half the areas. Where range expansion had occurred, only male rafts were observed, indicating fairly recent occupation, since the presence of female and pup rafts would indicate longer occupation (Garshelis *et al.* 1984). It is unlikely that the range expansion observed had occurred earlier than 2006 or 2007. Thus it is unlikely that significant parts of the occupied range were missed during previous surveys from 2001 to 2004. A longer time series of surveys and continued survey effort on the central B.C. coast are needed to clarify the growth trend.

Range expansion continues to contribute to sea otter population growth in B.C. Most of the population along Vancouver Island and on the central B.C. coast occupies exposed coastal habitat, characterized by complex coastlines resulting from embayments, clusters of islands, islets and variable shallow depths (< 50 m) with reefs. These features are likely proxies for good foraging habitat and areas that can provide some protection during rough conditions (Gregr *et al.* 2008). On Vancouver Island occupation of some inland waterway habitat, which is comparatively protected, is a recent occurrence in the re-establishment of sea otters in B.C. Rafts of sea otters were first counted in the inner areas of Quatsino Sound in 2001, Since then the number of otters in that area has increased. Expansion into Esperanza Inlet was evident in 2008. Incidental sightings of rafts of sea otters in the area were received through the winter of 2007/2008, whereas rafts were not seen during surveys in 2005 and 2006 (DFO unpubl.). So far only rafts of

males have been observed in inland waterways. Occupation of such habitat may occur as exposed complex habitat in adjacent areas nears carrying capacity. Certainly the Nuchatlitz and Calata segments, adjacent to Esperanza Inlet, support high densities of sea otters.

On the central B.C. coast, northward expansion has left a large geographic gap between the established range which is south of Milbanke Sound and the newly occupied area to the north, Aristizabal Island (Fig. 5). The habitat at Aristizabal Island is exposed and complex and is similar to that of the Goose Group and the McMullin to Cape Mark area. “Jumps” like this, observed, in the range of the southern sea otter (*Enhydra lutris nereis*) are attributed to variation in habitat quality which is a plausible explanation here as well (Tinker *et al.* 2008; Reidman and Estes 1990; Lubina and Levin 1988). Occupation of inland waterway habitat on Vancouver Island and historical, pre-fur trade, observations of sea otters in inland waterways on the northern B.C. coast, suggest that in time, with continued population growth, a greater variety of habitat types will be occupied and such gaps in distribution will eventually be filled (Lamb 1984; Gregr *et al.* 2008).

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Table 1. Kilometres of survey effort and survey conditions in 2007 and 2008.

		Kilometres surveyed			Kilometres by conditions, segments and new areas (%)				Kilometres by conditions segments only (%)			
	Year	Segments	New areas	Total	Excellent	Good	Fair	Poor	Excellent	Good	Fair	Poor
Vancouver Island	2008	1206	93	1298	196 (15)	732 (56)	287 (22)	83 (6)	141 (12)	732 (61)	287 (24)	46 (4)
Central BC coast	2007	296	46	343	141 (42)	19 (5)	131 (38)	52 (15)	141 (48)	19 (6)	85 (29)	52 (18)
Central BC coast	2008	489	350	839	157 (19)	313 (37)	320 (38)	46 (6)	115 (23)	139 (28)	189 (39)	46 (10)

Table 2. Maximum segment counts for the British Columbia sea otter population used in abundance and trend analysis. Interpolated values are italicized and underlined. Subscripts indicate the survey platform used: fixed-wing aircraft- 1, helicopter- 2, small boat- 3.

Segment	1977	1978	1980	1982	1984	1987	1988	1989	1990	1991	1992	1993	1994	1995	2001	2002	2003	2004	2008
Queen Charlotte Strait															74^{3}	56^{2}	34^{3}	97^{3}	218^{3}
Kains to Cape Scott															152^{3}	0^{2}	29^{3}	*60*	148^{3}
Quatsino Sound														1^{3}	52^{3}	16^{2}	39^{3}	86^{3}	197^{3}
Brooks Bay								12^{3}	8^{3}	28^{3}	116^{2}	245^{3}	96^{3}	235^{3}	489^{3}	166^{2}	409^{3}	440^{3}	750^{3}
Checleset Bay	55^{1}	51^{1}	60^{1}	97^{1}	196^{3}	234^{1}	201^{3}	329^{3}	288^{3}	230^{3}	257^{3}	272^{3}	413^{3}	530^{3}	663^{3}	667^{2}	683^{3}	740^{3}	882^{3}
Mission Group											4^{2}				83^{3}	*72*	80^{3}	111^{3}	179^{3}
Kyuquot Sound								25^{2}	173^{3}	50^{3}	74^{3}	91^{3}	397^{3}	240^{3}	372^{2}	417^{3}	293^{3}	296^{3}	461^{3}
Catala Island										0^{3}	182^{3}	4^{3}	5^{3}	11^{3}	80^{2}	89^{3}	101^{2}	104^{3}	173^{3}
Nuchatlitz Inlet									5^{2}	23^{3}	19^{3}	139^{3}	149^{3}	149^{3}	344^{2}	260^{2}	391^{3}	457^{3}	721^{3}
Esperanza Inlet																			73^{3}
Nootka Island	15^{1}	16^{1}	14^{1}	19^{1}	149^{1}	136^{1}	153^{3}	216^{2}	138^{2}	*155*	*149*	159^{3}	128^{3}	237^{3}	85^{2}	92^{2}	99^{3}	*107*	49^{3}
Estevan Peninsula														20^{3}	50^{2}	65^{2}	74^{3}	*84*	86^{3}
Clayoquot Sound															229^{3}	234^{2}	183^{2}	181^{3}	173^{3}
Subtotal Vanc. I.	70	67	74	116	345	370	354	582	612	486	801	910	1188	1423	2673	2134	2415	2765	4110
Goose Group									56^{3}	104^{3}	168^{3}	135^{3}			129^{3}	33^{2}	*32*	31^{2}	176^{3}
Kildidt Sound																			24^{3}
McMullins - Cape Mark															378^{3}	202^{2}	362^{3}	389^{2}	327^{3}
Seaforth , Idol to Ivory																			7^{3}
Aristizabal Island																			68^{3}
Subtotal Central coast									56	104	168	135			507	235	394	420	602
Total B.C.	70	67	74	116	345	370	354	582	668	590	969	1045	1300	1527	3180	2369	2809	3185	4712

Table 2. cont'd.

Additional central B.C. coast counts used

Segment	1996	1998	2007
Kildidt Sound			6[3]
Goose Group	88[3]	126[3]	128[3]
McMullins to Cape Mark	171[3]	303[3]	455[3]
Seaforth, Idol to Ivory			53[3]
Aristizabal Island			
Subtotal Central coast	259	429	642

SOURCES

1977: Bigg and MacAskie 1978
1978: Morris *et al.* 1981
1980: Farr unpubl.
1982: Bigg unpubl.
1984: MacAskie 1987
1987: Bigg and Olesiuk unpubl.
1988: Watson 1993
1989: Watson 1993, MacAskie unpubl.
1990: Watson 1993, Powers 1991 unpubl.
1991: Watson 1993
1992: Watson *et al*. 1997, BC Parks
1993: Watson *et al* 1997
1994: Watson *et al*. 1997
1995: Watson *et al*. 1997
1996: Watson unpubl.
1998: Watson unpubl.
2001-2008: DFO, Watson

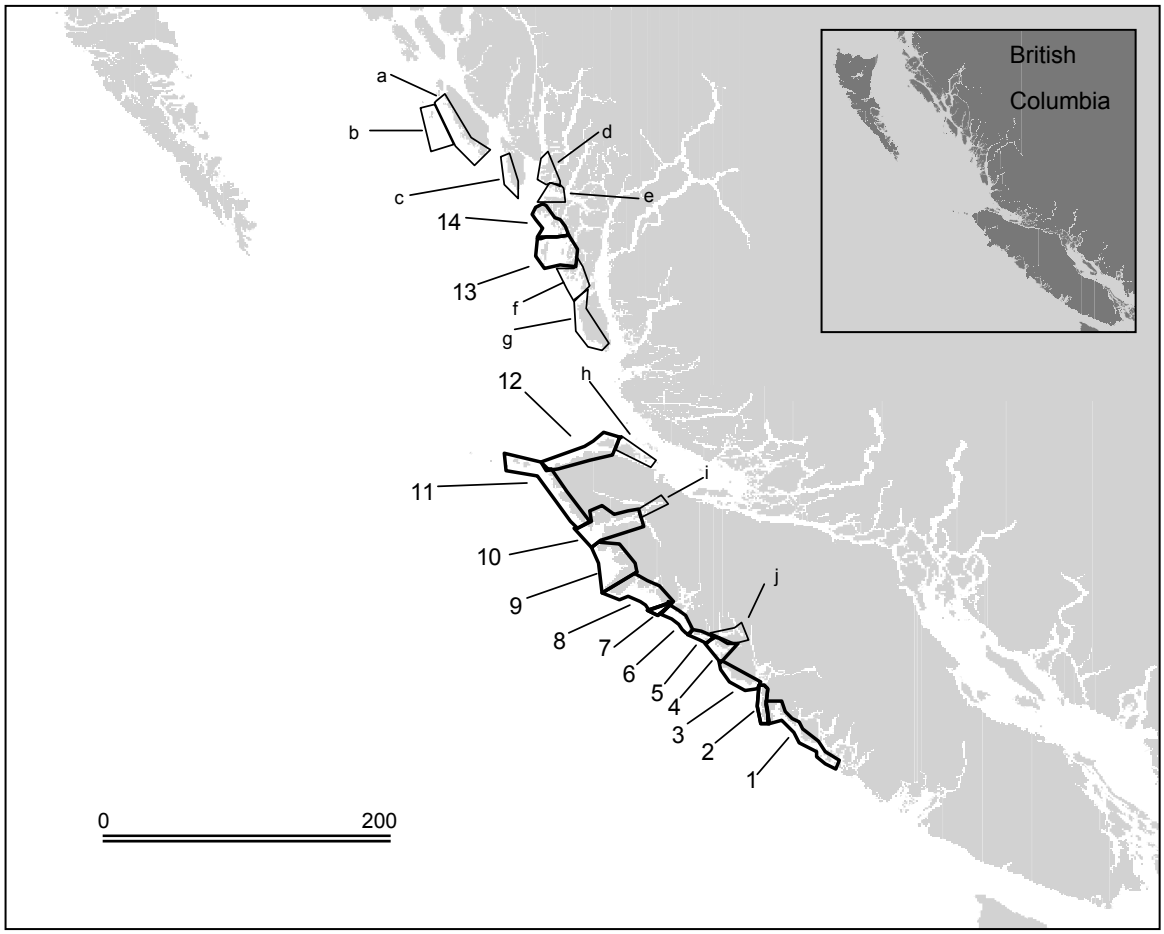
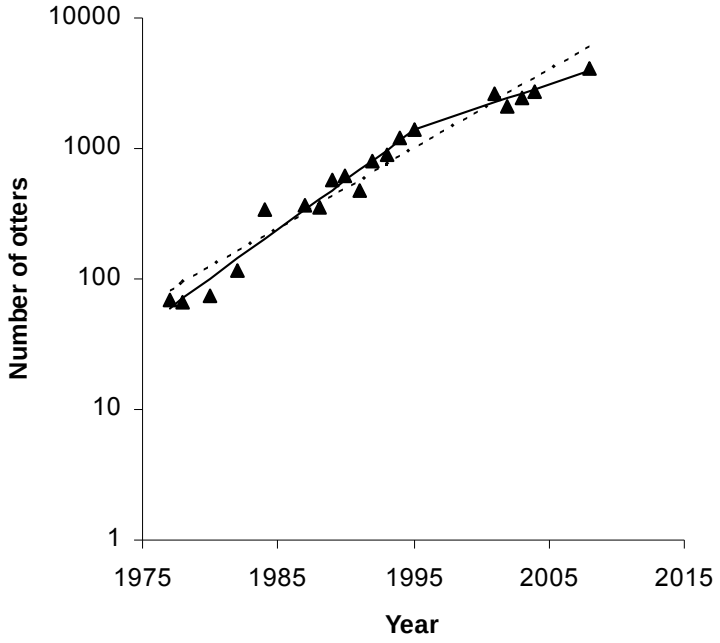


Figure 1. Survey coverage in 2008. Established survey segments: 1. Clayoquot Sound, 2. Estevan Peninsula, 3. Nootka Island, 4. Nuchatlitz Inlet, 5. Catala Island, 6. Kyuquot Sound, 7. Mission Group, 8. Checleset Bay, 9. Brooks Bay, 10. Quatsino Sound, 11. Kains to Cape Scott, 12. Queen Charlotte Strait, 13. Goose Group, 14. McMullins to Cape Mark. New areas surveyed to assess range expansion: a. Aristizabal inshore, b. Aristizabal offshore, c. Price Island, d. Ivory Island north, e. Entrance to Seaforth, f. Kildidt Sound, g. Calvert Island, h. Nigei Island to Doyle Island, i. Rupert Arm, j. Esperanza Inlet.

A



B

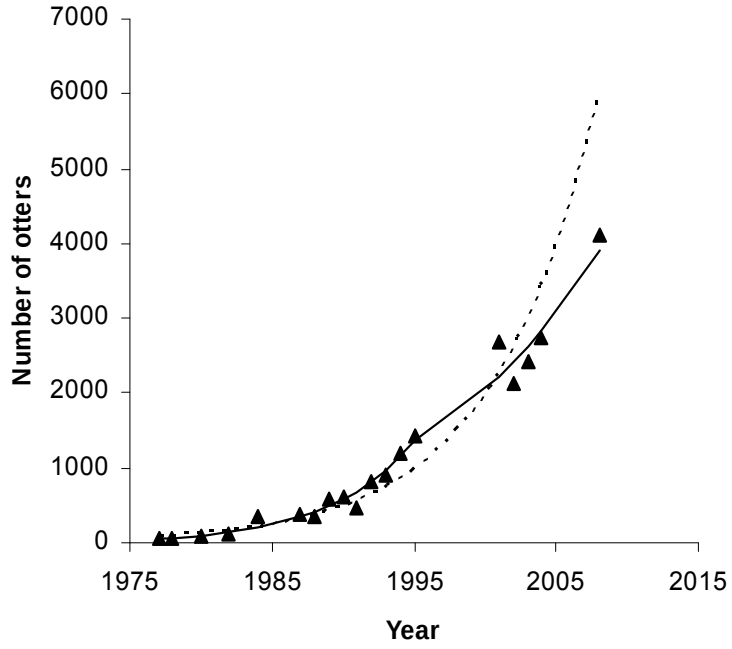


Figure 2. **A** Trend in sea otter population growth on Vancouver Island. Dashed line represents a simple log-linear regression (growth 15.0% yr^{-1} r^2 = 0.950, n = 19). Black line represents a piece-wise regression (growth 19.0% yr^{-1} from 1977 to 1995 and 8.4% yr^{-1} 1995 to 2008, r^2 = 0.978, n =19). Triangles represent survey counts. **B** Trends and survey counts plotted on an ordinal scale.

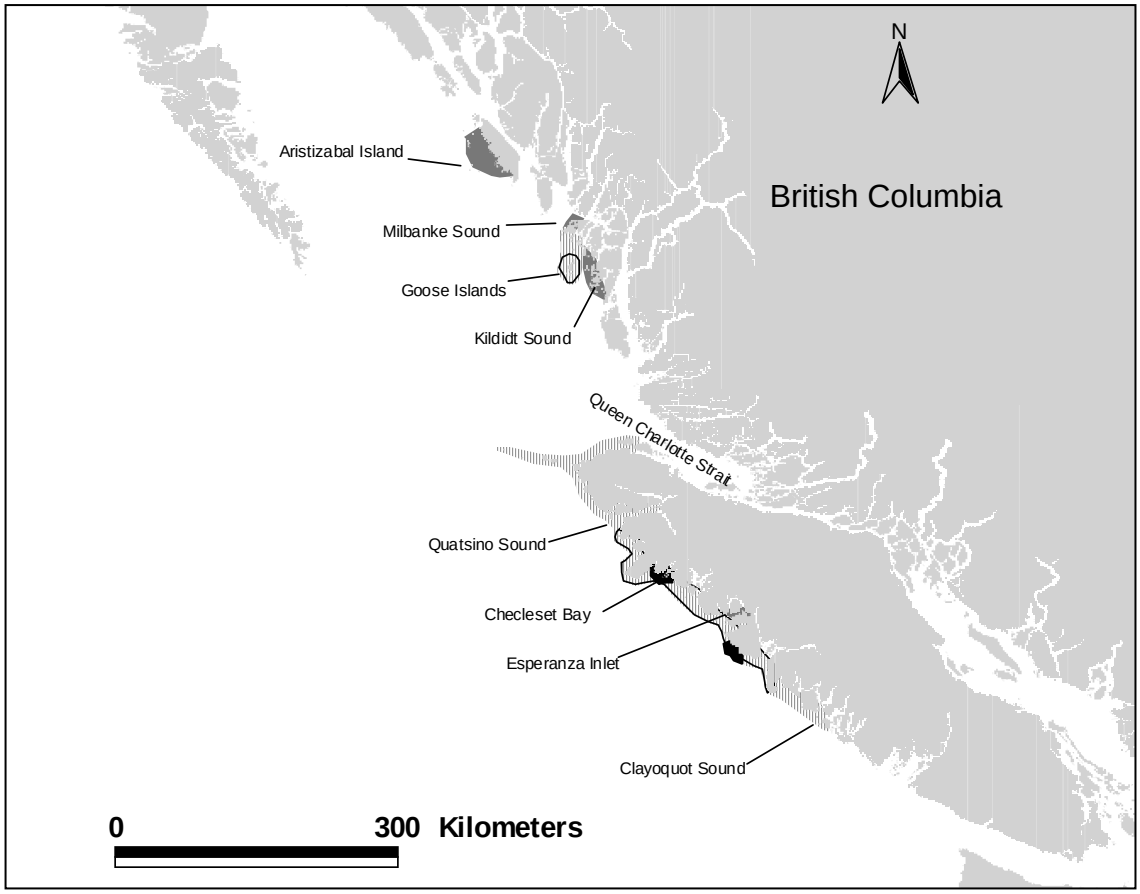


Figure 3. Range of sea otters in British Columbia and place names mentioned in the text. Black shaded areas: range in 1977. Black outline: range by 1995. Patterned area: range by 2001/2004. Dark grey area: range expansion by 2008.

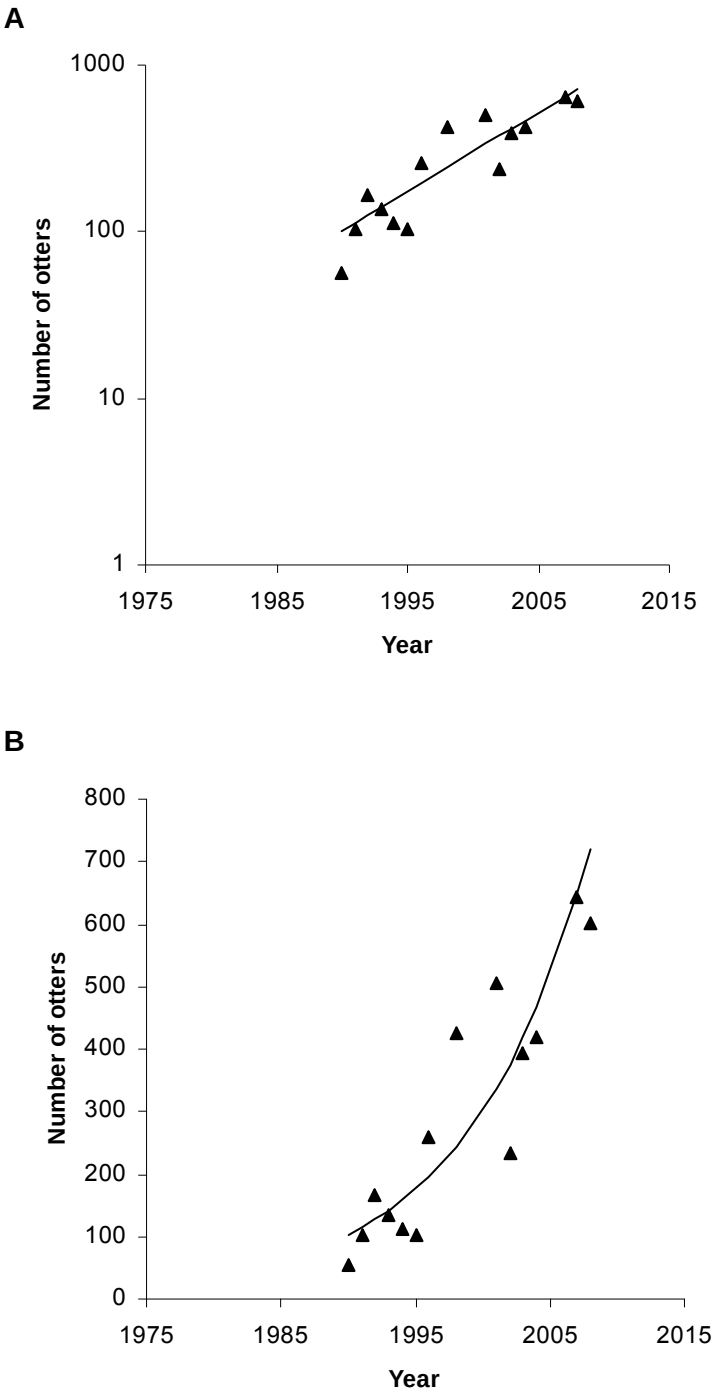


Figure 4. **A** Trend in sea otter population growth on the central B.C. coast. Line represents a simple log-linear regression (growth 11.4% yr^{-1} from 1990 to 2008, r^2 = 0.801, n = 11). Triangles represent survey counts. **B** Growth trend and survey counts plotted on an ordinal scale.