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Ecosystem Models of Northern British Columbia For The Time Periods 2000, 1950, 1900 and 1750

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by

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Coasts under Stress

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DIRECTOR'S FOREWORD

MORE THAN ONE ROUTE TO HEAVEN

Imagine a shipwreck after escaping from Moors in Morocco, being rescued by sailors from Sicily, meeting St Francis of Assisi, delivering a brilliant impromptu address, and eventually taking over as head of the new Franciscan order after St Francis' death in 1226. This is the life story of a remarkable Portuguese man, Saint Antony of Padua (1195 - 1231), the Patron Saint of Lisbon, and an excuse for an annual festival in that city every June 13th.

St Antony of Padua Preaching to the Fishes At Rimini, a 3m-wide panel of *azulejos*, blue ceramic tiles (Moorish technology) for which the Portuguese are justly famous. The panel is located just behind the main door of the Church of St Antony in Alfama, an old Moorish district of Lisbon. St Antony's skill as a Franciscan preacher is evident from the attentive deportment of the fishes, compared to the unruly line of Italian heretics on the bridge behind.

St Antony inherited both the vow of utter poverty, and St Francis' trick of getting animals to listen to him. His logic and style made him particularly effective in converting educated heretics - there were a lot of those in 13th century Italy – and in a sermon at Rimini he is reputed to have rebuked inattentive heretics by extolling the good behaviour of fishes in schools. In one version, he actually preaches to the fish (Figure 1). In an era where advanced science and technology under Islam were an unspoken challenge to the meager achievements of Christianity at the end of the Dark Ages, many were tempted to experiment with amalgams of the two religions (the Knights Templar are an example of this). St Antony's message was that you can only have one religion (i.e., his) if you want to reach heaven.

But, as Dr Villy Christensen has pointed out, ECOPATH Models are not like religion, you are allowed to have more than one on your route to mass-balance heaven. Hence, this report, and its companion volume on Newfoundland, presents 4 different ECOPATH models for each of the west and east coasts of Canada.

The models describe the state of the marine ecosystem at four snapshots in time, from the present day to a time long past before contact of aboriginal peoples with Europeans. In the case of Northern British Columbia, these times are 2000; 1950, before modern catch data were kept; 1900, before the major expansion of industrial fisheries; and 1750, probably before Europeans arrived.

This material is the culmination of 2 years of work, and represents our best shot at describing the recent and historical past in these two environments. Doubtless, all of these models can be further improved, but these versions embody our closest approach to the perfection of 'heaven' to date. At a later stage, the more recent of the models can be tuned using their ability to emulate historical estimates of biomass from surveys, VPAs and the like, but this process is unlikely to be possible before such estimates began around 1950. The older ecosystem models have to rely on the constraints imposed by mass-balance itself, and as such, they are less certain than the recent models.

Information used in the models has derived from the workshops reported in Pitcher *et al.* (2002), and on further consultations with experts on each group on both coasts. In addition, a great of archival and historical material have been sifted and used wherever possible to improve the biomass. For example, compared to the ancient past, some animals have gone locally extinct (e.g. walrus in Newfoundland). The static mass-balance models model reported here will be employed as baselines in dynamic simulations using Ecosim, aimed at determining what fisheries might be sustained by each of these marine ecosystems were they to be restored today - part of the Back to the Future policy research method.

Further information about *Back to the Future* research may be found on the web site *www.fisheries.ubc.ca/projects/btf.* This report forms part of the research output from the *Coasts Under Stress* (Arm 2) project, a *Major Collaborative Research Initiative of the Canadian Government*, led by Dr Rosemary Ommer.

The Fisheries Centre Research Reports series publishes results of research work carried out, or workshops held, at the UBC Fisheries Centre. The series focusses on multidisciplinary problems in fisheries management, and aims to provide a synoptic overview of the foundations, themes and prospects of current research. Fisheries Centre Research Reports are distributed to appropriate workshop participants or project partners, and are recorded in the Aquatic Sciences and Fisheries Abstracts. A full list appears on the Fisheries Centre's Web site, www.fisheries.ubc.ca, from where copies of most reports may be downloaded free of charge. Paper copies are available on request for a modest cost-recovery charge.

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ABSTRACT

Four *Ecopath with Ecosim* models were constructed to represent the marine ecosystem of northern British Columbia as it appeared in the years 1750, 1900, 1950 and 2000. The time periods were selected to characterize distinct epochs in the progression of exploitation and ecosystem structure (as required under *Back to the Future* methodology). Historical, archival and archeological information were used to construct the past models, as well as traditional ecological knowledge gained from community interviews. Approximately 150 species and genera are included, with many more implicit in the models. These players are grouped into 53 functional model groups, arranged by trophic similarity and habitat preference; special distinction is given to commercially important animals. Biomass, production, consumption and diet are among the parameters used to describe each group, as well as period-appropriate fisheries, bycatch and discards. The static *Ecopath* models described in this report represent the basis of dynamic *Ecosim* models, which can be used to test hypotheses regarding ecosystem structure/function and management strategies.

INTRODUCTION

The 2000, 1950, 1900 and 1750s models of Hecate Strait were adapted from Beattie (2001) with some changes to the model structure to satisfy the aims of the "Coasts Under Stress" project. The total area of the ecosystem being modelled is approximately 70,000 km^2. The model suggested by Beattie (2001) was also adapted to include recreational fisheries for salmon, halibut, lingcod and inshore rockfish, as well as the inclusion of newer market prices and the bycatch for the shrimp trawl fisheries. Organisms that compose our functional groups are detailed in Appendix G. The changes in biomass are given over the four models in the description of each group, and the P/B and Q/B ratios of 2000 and 1950 were similar, while that of 1900 and 1750 were presumed to be similar. The biomass, P/B and Q/B estimates used in this model are given in Appendix C. Diet estimates for past models are based on the 2000 model, but have been adapted to include the differences in diet that would occur prior to large-scale commercial fishing. Final diet matrices are listed in Appendix D. Unless otherwise stated, values were left to be similar to that of the present day model. Landings are listed in Appendix F.

MODEL GROUPS

1) Sea Otters

Sea otters have been part of the Hecate Strait ecosystem at the time of first contact, and were very important to First Nations people, thus we included them in these models. Sea otters are also making a comeback in some parts of British Columbia, and might be more important in the ecosystem in the future.

Vasconcellos and Pitcher (2002a) suggest that the biomass at present as well as in the 1900s (and 1950s) was very low. We assume a biomass of 0.1 kg•km^{-2}, which might still be too high. For pre-contact estimates of sea otter biomass, Kenyon (1975) estimated the total virgin population size between 100,000 and 150,000 animals. Assuming that the Hecate Strait covers approximately 1/20th of sea otter coastal range, Vasconcellos and Pitcher (2002a) estimate a population size in the pre-contact period of approximately 5,000 animals for the Hecate Strait. With an average weight of 22.4 kg (Bodkin *et al.*, 1998) the density of sea otters in the pre-contact period is estimated at 1.6 kg•km^{-2}. Riedman and Estes (1998) suggested that the otter populations grew at a rate of about 15% per year during the early phase of their recovery. Only an annual increase of 13% could be accommodated as biomass accumulation in the 1950 model, because of limiting production.

Bodkin *et al.* (1998) estimated an instantaneous mortality rate of 0.13 yr^{-1} based on an average age of 7 years in the Prince William Sound area. We use the same P/B ratio for the 1950, 1900 and 1750 models. Riedman and Estes (1998) estimated a consumption rate of between 23 and 33% per day (84-120 per year) for adults. We use the average (101.5 yr^{-1}) as the Q/B for this compartment in all time period models. Riedman and Estes (1998) suggested that the diet of sea otters consists of 50% epifaunal invertebrates, 20% small crabs, 1% large crabs, 10% shallow water benthic fish, 10% juvenile pollock and 9% squid.

Irwin (1984) suggested that First Nations hunted sea otters with harpoons and clubs. It is assumed that prior to the intensive exploitation of sea otters that began around 1740, sustainable harvesting rates were adopted, in the order of the rate of population growth of 2.5% per year (Kenyon 1975), and we assume a catch of about 0.2 kg•km^{-2} for the 1750 model. According to Vasconcellos and Pitcher (2002a) sea otter kills in the early 1900s can be considered insignificant,

Table 1: Seasonal diet of Mysticetae. Source: Trites and Heise (1996).

Compartment	Summer	Winter diet	Average	Post-
Krill	0.043	0.316	0.180	0.226
Copepods	0.009	0.074	0.042	0.020
Bivalves	0.047	0.026	0.037	0.037
Polychaetes	0.047	0.026	0.037	0.037
Amphipods	0.844	0.471	0.658	0.658
Sandlance	0.002	0.026	0.014	0.014
Herring	0.008	0.061	0.035	0.100

and as they were nearly extinct by 1920 we assume that no other catches of sea otters were taken.

2) Mysticetae

The baleen whales include the blue whale, fin whale, sei whale, humpback whale, right whale, and gray whale (Gregr 2002). Gregr (2002) gives population estimates for baleen whales and sperm whales. Using the mean weight per species from Trites and Pauly (1998), the biomasses of Mysticetae for the 2000, 1900 and 1750 time periods were calculated as 1.339 t•km^{-2}, 1.54 t•km^{-2} and 2.67 t•km^{-2} respectively. The 1950 biomass was assumed to be the same as present day because whales were already depleted by that time according to Gregr (2002).

Trites and Heise (1996) suggested that the P/B ratio should be half of the 4% maximum rate of population increase, thus we use a P/B ratio of 0.02 yr^{-1} and we use the same P/B ratio for all time periods (although it might be lower in the earlier models due to the larger blue and humpback whales that were present at that time). Trites and Heise (1996) suggested a Q/B ratio of 13 yr^{-1} in summer and 5.1 yr^{-1} in winter. For the 2000 and 1950 models we used the average between these ratios (9.1 yr^{-1}) while for the 1900 and 1750 models, we used a value of 8 yr^{-1}, to incorporate the larger blue and humpback whales that were present at that time. The diet of Mysticetae was adapted from Tables H and I in Trites and Heise (1996). Table 1 below shows their seasonal breakdown. See Appendix D Table D1 for diet matrix used in Ecopath.

First Nations people harpooned Gray whales according to Irwin (1984), and if we assume that they caught about two per year, it gives a catch of approximately 0.5 kg•km^{-2}•yr^{-1} in the 1750 model. Gregr (2002) suggests that there was a limited catch of baleen whales from after WWII until 1967. Revised versions of these models will include a 1900 and (a much smaller) 1950 catch.

3) Odontocetae

The toothed whales include the sperm whale, Baird's beaked whale, northern right whale dolphin, Pacific white-sided dolphin, Dall's porpoise, harbour porpoise and killer whale. Trites and Heise (1996) give the number of toothed whales (excluding sperm whales) and average weight of each species in Northern B.C. (Table 2). The average sperm whale biomass is approximately 19 tonnes (150 sperm whales according to Gregr, (2002)), thus the total biomass of toothed whales was 0.061 t•km^{-2}. This value was used for present day and 1950. As in Beattie *et al.* (1999), we consider that the biomass of killer whales, dolphins and porpoises in the Hecate Strait was ca. 20% larger during the early 1900s than at present time (estimation based on fishers and aboriginal people. Gregr (2002) suggests that the number of sperm whales was similar at that time. Thus, the biomass in 1900 was estimated at 0.066 t•km^{-2} and we assume that the biomass in 1750 was the same as that of the early 1900s (see Appendix C).

We assume that the P/B of toothed whales will be higher than that of baleen whales, but lower than that of seals and sea lions. A P/B of 0.04 yr^{-1} was adopted for all time periods. Trites and Heise (1996, Tables F and G) suggested a Q/B of 15.6 yr^{-1} for toothed whales in the summer and 15.3 yr^{-1} in the winter, thus an average of 15.5 yr^{-1} was used in all models. The diet of toothed whales was adapted from Beattie (2001) by assuming that 1/6th of the predation on forage fish was directed to eulachon (Vasconcellos and Pitcher 2002e).

4) Seals and sea lions

The seals and sea lions in the Hecate Strait include Steller sea lions and harbour seals. Northern fur seals, northern elephant seals and California sea lions sometimes visit the northern parts of BC (Vasconcellos and Pitcher 2002b). Beattie (2001) suggested that the present biomass of seals and sea lions is approximately 0.052 t•km^{-2}, and according to Vasconcellos and Pitcher (2002b), present biomass is approximately 75% of what it was around 1900,

Table 2: Numbers, mean weight and biomass of toothed whales. Source: Trites and Heise (1996).

Species	Weight (kg)	Number	Biomass (tonnes)
Dall's porpoise	341	1000	341
Harbour porpoise	31	1000	31
Pacific white sided	79	2000	158
Northern right	412	100	41
Killer whales	2195	100	219
Transient killer whales	2195	34	75

thus the biomass in 1900 was approximately 0.069 t•km^{-2}. Vasconcellos and Pitcher (2002b) also suggest that the number of seals and sea lions in B.C. increased during the late 1800s and early 1900s due to a reduction in the native population that hunted them, and therefore the biomass of seals and sea lions around 1750 was probably similar to what it is at present (0.05 t•km^{-2}). Biomass in the 1950 model was based on 11,653 animals in British Columbia, an average of three estimates compiled by Pike (1958) (estimates were from Dept. Fish 1955, Dept. Fish 1956, Fish Res. Bd. 1956). Numbers were converted to biomass using average weight provided by Trites and Heise (1996). Vasconcellos and Pitcher (2002b) estimate a biomass accumulation of 3.5% per year from estimates of 25% for 1989-2000 done by Bigg (1985). Biomass accumulation was therefore calculated as 0.0018 t•km^{-2}•yr^{-1} for the 2000 model.

Trites and Heise (1996) suggest that the maximum rate of population growth for pinnipeds is about 12% and the P/B for all models was assumed to be half that at 0.06 yr^{-1}. The same authors estimate a Q/B for seals and sea lions of 15.3 yr^{-1} in summer and 14.8 yr^{-1} in winter. We use 15.1 yr^{-1} in all models.

The diet of seals and sea lions in the initial diet matrix were adapted from Trites and Heise (1996, Tables H and I) by assuming that 1/6th of the predation on forage fish was directed to eulachon (Vasconcellos and Pitcher, 2002e). Sharks were replaced with dogfish and hake with Pacific Ocean perch, as there aren't many sharks or hake in Hecate Strait. The salmon and rockfish in the diet were also broken down according to the biomass estimates of their groups in the system for each of the four models. Appendix D Table D3 gives the final diet matrix.

Seals and sea lions were hunted by First Nations people (Vasconcellos and Pitcher, 2002b), so we add a catch of 0.1 kg•km^{-2}•yr^{-1} to the 1750 model as no First Nations catch estimate is available. Further, seals are routinely shot during salmon gillnet operations according to Ainsworth (pers. comm.), although kills are rare. We added a value of 0.1 kg•km^{-2}•yr^{-1} to include this discard of seals by salmon gillnet fishermen.

5) Seabirds

Seabirds present in the Hecate Strait include gulls, grebes, Cassin's auklet, tufted puffin, common murre, rhinoceros auklet, marbled murrelet, pigeon guillemot, merganser spp., pelagic cormorants, sooty shearwater, northern fulmar, double-crested cormorant and the common loon (Kaiser, 2002). Although it would be preferable to differentiate between species that breed in the region and species that are non-breeding seasonal residents, and to differentiate between different trophic feeders (i.e. planktivores vs. piscivores), seabirds were kept in one group in this model. It would be advisable to make these changes in the next phase of the modeling.

Kaiser (2002) suggests that until 1900 the effect of contact between native people and Europeans may have been of benefit to seabirds; they expanded as epidemic and cultural disaster overtook the native population, many parts of the coast became depopulated, and European foods became commonplace. However, in the twentieth century, human activity often had a negative impact on the marine birds of British Columbia (Kaiser 2002). Thus, it is assumed that the biomass of seabirds would be higher in 1900 than in 1750, or any subsequent years. Kaiser (2002) gives the biomass of seabirds that are currently feeding on the Hecate Strait as 516 tonnes (0.007 t•km^{-2}), which is what we used for the 1750 model – and similar to Haggan *et al.* (1999) we double the 1750 biomass for the 1900 model (0.014 t•km^{-2}). Biomass for the 1950 model was taken as an intermediate value, the average of 1900 and present day – this assumes a gradual transition. Wada and Kelson (1996) suggested a P/B of 0.1 yr^{-1} for seabirds and we use this ratio for all four time periods. Wada and Kelson (1996) suggested a Q/B for seabirds of 112 yr^{-1} in summer and 98.4 yr^{-1} in winter. We use the average (105.2 yr^{-1}) in all four models.

The diet of seabirds in the 2000 model was adapted from Beattie (2001) by dividing the 30% consumed by forage fish into 25% forage fish and 5% eulachon (Vasconcellos and Pitcher, 2002e) – listed in Appendix D Table D4. Discards were reduced to 0.3% from 1% to balance the model. For the 1750 model, the diet was adapted from p. 57 in Pauly *et al.* (1996) as no discards or detritus were consumed and the structure of the ecosystem was probably very different. Benthos in Pauly, Christensen *et al.* (1996) were divided into small crabs and epifaunal invertebrates, and small pelagics were divided into forage fish (50%), eulachon (15%), and adult/juvenile herring (15 and 20% respectively). Small and large herbivorous zooplankton was assumed to be copepods (Pauly, Christensen *et al.* 1996).

6) Transient (migratory) salmon

Transient salmon include sockeye, chum and pink salmon, which migrate through the system on their way to spawning areas. Vasconcellos and

Pitcher (2002c) use the ratio between catch and exploitation rate to calculate the biomass of transient salmon at 0.588, 0.754, 0.840 and 1.0 t•km^{-2} for 2000, 1950, 1900 and 1750 respectively. Newlands (1998) calculated a P/B value of 2.48 yr^{-1} for transient salmon and that is used for the 2000 and 1950 models. The P/B ratios for 1900 and 1750 (Table 3) were calculated as the sum of fishing mortality (F = Catch / Biomass) and natural mortality rate (determined in Appendix B Table B1).

Christensen (1996) gave annual Q/B ratios for pink, sockeye and chum of 12.2, 4.6 and 8.2 yr^{-1} respectively, and an average of 8.33 yr^{-1} was used in the 2000 and 1950s models. The Q/B estimates for 1900 and 1750 were calculated in Appendix B Table B2 as approximately 3.72 yr^{-1}.

Transient salmon feed mostly on zooplankton, but outside of the ecosystem. Migratory species such as these are problematic during dynamic simulations since the abundance of their food is independent of systemic fluctations. As for the static model detailed here, transient salmon must receive some diet to get the correct trophic level. Thus, we add 0.1% euphausiids and 0.05% amphipods to their diet, with the remaining 99.85% being imported to the system. The diet of transient salmon remained the same for all four models.

Vasconcellos and Pitcher (2002) suggested that the average catch of transient salmon for 1995-1997 was approximately 29 thousand tonnes (0.412 t•km^{-2}) and the same reference gives the proportion of catches by gear type in the Hecate Strait during 1997. Recreational catch is based on an unpublished DFO survey (2000) summarized in Forrest (2002). Table 4 shows the estimated catches of transient salmon in the 2000 model. The 1950 commercial catch for transient salmon (sockeye, pink and steelhead trout) was taken from DFO catch statistics (DFO 1995), representing total 1951 catch in 10 statistical areas that comprise Hecate Strait, Dixon Entrance and Queen Charlotte Islands. The historical record for transient salmon apportions catch into gillnets, seine and troll. The latter was split evenly in the model between salmon troll and salmon troll freezer. Together with a small recreational fishery (estimated by Forrest (2002)), total catch of transient salmon in 1950 was 0.398 t•km^{-2}•yr^{-1} (see Appendix F for catch information). Vasconcellos and Pitcher (2002c) estimate the catch of transient salmon in 1900-1905 to be 0.126 t•km^{-2}•yr^{-1}. This value was used in the 1900 model. Chum and humpback salmon were fished by First Nations people with hook and line, harpoon, spear, traps (weir, stone weir) dip nets, basket traps, or fall traps, and eaten fresh and smoked, or dried (Irwin 1984). Hewes (1973) estimates that First Nations caught approximately 6,400 tonnes of salmon in pre-contact times and we opted to split this catch equally between transient (0.046 t•km^{-2}•yr^{-1}) and resident salmon.

Table 4: Catches of transient salmon in the 2000 model.

Gear	Proportion catch	Transient salmon catch (t•km^{-2})
Gillnet	0.455	0.187
Seine	0.461	0.190
Troll	0.017	0.007
Troll freezer	0.067	0.028
Recreational		0.002
Total	1	0.414

7-8) Coho and chinook salmon

Beattie (2001) calculated the biomass for coho and chinook salmon in the 2000 model as 0.024 t•km^{-2} and 0.018 t•km^{-2} respectively. In the 1950 model, these were 0.067 t•km^{-2} and 0.026 t•km^{-2} respectively, based on the ratio between catch and exploitation rate offered by DFO historical statistics. Vasconcellos and Pitcher (2002 c) estimate a biomass decrease of ca. 70% and 85% of coho and chinook salmon between 1900 and the present, which gives biomasses of 0.08 t•km^{-2} and 0.12 t•km^{-2} for coho and chinook in 1900. Similarly, Vasconcellos and Pitcher (2002c) estimate that the biomass of coho and chinook salmon was 20% higher in the pre-contact period than in the early 1900s. Thus the biomass of coho and chinook in the pre-contact period is estimated at 0.096 t•km^{-2} and 0.144 t•km^{-2}, respectively. We assume that both the coho and chinook populations are at present in an annual decline of around 10%, which gives negative biomass accumulations of -0.24 kg•km^{-2}•yr^{-1} and –0.18 kg•km^{-2}•yr^{-1} respectively in the 2000 model. No biomass accumulations were given for 1950, 1900 or 1750.

Beattie (2001) uses monthly estimates of 23% and 18% respectively, for the increase in body size of coho and chinook (obtained from Newlands (1998)). This gives P/B ratios of 2.76 yr^{-1} for coho and 2.16 yr^{-1} for chinook, which we used for both the 2000 and 1950 models. However, fishing

Table 3: Estimation of P/B ratios for transient and resident salmon.

Group	Biomass (t•km^{-2}) 1900	Biomass (t•km^{-2}) 1750	Catch (t•km^{-2}•yr^{-1}) 1900	Catch (t•km^{-2}•yr^{-1}) 1750	F (year^{-1}) 1900	F (year^{-1}) 1750	M (year^{-1})	P/B (year^{-1}) 1900	P/B (year^{-1}) 1750
Transient	0.84	1.008	0.125	0.046	0.140	0.045	0.470	0.621	0.517
Coho	0.08	0.096	0.012	0.023	0.150	0.238	0.918	1.069	1.157
Chinook	0.12	0.144	0.019	0.023	0.156	0.159	0.207	0.363	0.366

Table 5. Catches by gear types for 2000.

Gear	Proportion by gear type		Catch ($t{\bullet}km^{-2}{\bullet}yr^{-1}$)	
	Coho	Chinook	Coho	Chinook
Gillnet	0.166	0.194	0.0010	0.0006
Seine	0.061	0.023	0.0004	0.0001
Troll	0.268	0.266	0.0016	0.0008
Troll freezer	0.505	0.512	0.0030	0.0015
Recreational			0.0012	0.0006
Total	1	1	0.0072	0.0036

mortality was much lower prior to commercial fishing (1750 and 1900 models) and therefore we used P/B ratios calculated from the sum of F and M, where F = Catch / Biomass and M is from Appendix B Table B1. Beattie (2001) suggests that the Q/B ratio of both coho and chinook should be calculated by Ecopath using a P/Q ratio of 0.2. This gives a Q/B ratio of 13.8 yr^{-1} and 10.8 yr^{-1} respectively for coho and chinook. Appendix B Table B2 shows Q/B ratios calculated for the 1900 and 1750 models. These are 3.99 yr^{-1} for coho and 2.82 yr^{-1} for chinook, lower than the 1950 and 2000 models because older individuals were more abundant at that time.

The diet (for all models) of coho and chinook was adapted from Beattie (2001), eulachon having been extracted from the forage fish compartment. It was assumed that 1/6th of the predation on forage fish in Beattie (2001) was directed at eulachon (Vasconcellos and Pitcher, 2002e). See Appendix D Table D5 and D6 for coho and chinook diet information.

Beattie (2001) gives a 2000 catch of 0.006 $t{\bullet}km^{-2}{\bullet}yr^{-1}$ and 0.003 $t{\bullet}km^{-2}{\bullet}yr^{-1}$ for coho and chinook salmon respectively. This was converted to the various gears in our model by using the proportion of catches by gear type in the Hecate Strait during 1997 (Vasconcellos and Pitcher 2002c) (Table 5). Recreational catch for both groups is based on unpublished data from a 2000 survey (Forrest 2002). There were 0.027 $t{\bullet}km^{-2}{\bullet}yr^{-1}$ of chinook taken by the sport fishery in 2000, and 0.005 $t{\bullet}km^{-2}{\bullet}yr^{-1}$of coho. The 1950 commercial catch was taken from DFO's statistical catch record, representing the 1951 catch in 10 statistical areas that comprise Hecate Strait, Dixon Entrance and Queen Charlotte Islands (DFO 1995). The historical records for coho and chinook apportion catch for gillnet, seine and troll. The latter was split evenly in the model between salmon troll and salmon troll freezer fleets. Recreational catch in 1950 was assumed to be 9% of present day according to Forrest (2002). Total catches for coho and chinook in 1950, including recreational, are therefore 0.061 and 0.0214 $t{\bullet}km^{-2}{\bullet}yr^{-1}$ respectively. Vasconcellos and Pitcher (2002c) suggest a catch of 0.012 $t{\bullet}km^{-2}{\bullet}yr^{-1}$ for coho and 0.018 $t{\bullet}km^{-2}{\bullet}yr^{-1}$ for chinook in 1900-1905. Hewes (1973) estimated that First Nations caught approximately 6,400 tonnes of salmon in pre-contact times; we opted to split this catch equally between transient and resident salmon (0.046 $t{\bullet}km^{-2}{\bullet}yr^{-1}$ each). Further, we assumed that 50% of that catch came from coho and chinook respectively (thus 0.023 $t{\bullet}km^{-2}{\bullet}yr^{-1}$ each in 1750). See Appendix F for complete catch information by time period.

Beattie (2001) obtained values on discards of salmon from DFO's observer program database for 1997 (see Appendix A Table A2). Discarded coho and chinook salmon in the 2000 model amounted to 0.038 tonnes and 0.684 tonnes, respectively, which calculates to discards of 0.001 $kg{\bullet}km^{-2}{\bullet}yr^{-1}$ and 0.01 $kg{\bullet}km^{-2}{\bullet}yr^{-1}$.

9-10) Juvenile and adult squid

Squid were split into juvenile and adult compartments due to the overwhelming effect of cannibalism in the models. The biomasses of both juvenile and adult squid were estimated with the inclusion of an ecotrophic efficiency of 95% for all four models. Beattie (2001) used the P/B ratio (6.023 yr^{-1}) of the flying squid *Onychoteuthis borealijaponica*, which is used for both juvenile and adult squid in all models. The same author calculates a Q/B ratio of 34.675 yr^{-1} for two other *Loligo* species (*L. pealei, L. vulgaris*) and we use this ratio for both juvenile and adult squid in all four models.

The diet of squid was adapted from Beattie (2001) by assuming that 1/6th of the predation on forage fish was directed at eulachon (Vasconcellos and Pitcher 2002e). The diet of adult squid remained the same for all four models, while that of juvenile squid was adapted with the addition of adult herring in the 1750 model to balance forage fish. Final diet matrices appear in Appendix D Table D7.

Opal squid, *Loligo opalescens*, are at present fished primarily as bait for sablefish, crabs and halibut, by using primarily seine nets (DFO 1999g) while a new fishery for the neon flying squid *Ommastrephes bartrami* is currently being promoted (DFO 1999h), but has not yet acquired significance. A very small catch of 0.001 $kg{\bullet}km^{-2}$ was added to the herring seine fleet to represent the catch of adult squid. Squid are also taken and retained by the groundfish fishery (Beattie 2001) in the 2000 model – 0.022 $kg{\bullet}km^{-2}$ was recorded by the DFO observer program database for 1997. No squid were caught in the 1950s, 1900s or 1750s. Beattie (2001) obtained values on discards of squid of 0.002 $kg{\bullet}km^{-2}$ from DFO's observer program database for 1997 (see Appendix A Table A2).

11) Ratfish

The biomass of ratfish is not available for any of the time periods. Biomass for 1750 and 1900 was calculated by assuming an ecotrophic efficiency of 95%. However, the 1950 and 2000 biomass was assumed to be similar to the average biomass estimated from Fargo *et al.* (1990) for 1984-1987 (Beattie 2001) (Table 6).

Beattie (2001) suggests that the P/B of ratfish should be similar to that of dogfish (0.099 yr^{-1}), that was used for the 2000 and 1950 models. However, for the 1900 and 1750 models, the M of 0.199 yr^{-1}, calculated in Appendix B Table B1 was used as the P/B of ratfish, as there was no fishery for the species during those two time periods. Beattie (2001) calculates a Q/B ratio for ratfish of 1.4 yr^{-1} using a W_{inf} of 1000g and average temperature of 6°C. We use this value for all four models as no newer data are available. The diet composition obtained from Beattie (2001) was used in all four models and adapted by assuming that 1/6th of the predation on forage fish was directed to eulachon (Vasconcellos and Pitcher 2002e), and dividing the benthic invertebrates in Beattie (2001) into carnivorous and detritivorous invertebrates for our model structure.

Ratfish is caught and retained by the groundfish fishery in the 2000 model (Beattie 2001) – 0.052 kg•km^{-2}•yr^{-1} was recorded by the DFO observer program database for 1997. No catch is recorded for ratfish in the DFO Commercial Catch Statistics record (DFO 1995). The 1950 catch was assumed to be negligible. Beattie (2001) obtained values on discards of ratfish by the groundfish trawl fisheries of ca. 0.01 t•km^{-2} from DFO's observer program database for 1997 (see Appendix A Table A2). Hay *et al.* (1999) suggest that ratfish are caught as bycatch to the shrimp trawl fishery. We use the estimate obtained by Hay *et al.* (1999) for ratfish bycatch (0.01 t•km^{-2}) as a discard from the ratfish compartment in the 2000 and 1950 models (See Appendix A Table A1).

12) Dogfish

The estimate of dogfish biomass given by Beattie (2001) (0.909 t•km^{-2}) is used for our 2000 model, while the biomass of dogfish in 1900 was calculated by assuming an ecotrophic efficiency of 72% (similar to that of the 2000 model) and the 1750 biomass (1.36 t•km^{-2}) was assumed to be 50% higher than the biomass at present (Vasconcellos and Pitcher 2002d). The end of World War II saw a revived liver oil fishery for dogfish, especially along the East coast of the Queen Charlotte Islands (British Columbia History Supplement for Special Centennial Newspaper Editions, 1958). An arbitrary 40% reduction from the pre-contact abundance was assumed in the 1950 model, due to the post-war fishery. The biomass estimate used in the 1950 model was 0.8 t•km^{-2}.

Table 6: Biomass of ratfish. Source: Fargo et al. (1990).

Year	Standing crop (tonnes)
1984	28,644
1986	54,292
1987	14,157
Average	23,771
Biomass (t•km^{-2})	0.517

Beattie (2001) calculates a P/B ratio for dogfish in 2000 of 0.099 yr^{-1} from natural mortality (0.094 yr^{-1}) obtained from Wood *et al.* (1979) and fishing mortality of 0.005 yr^{-1} obtained from the DFO Fishery Observer Database. This value was also used for 1950. However, the natural mortality of 0.11 yr^{-1} calculated in Appendix B Table B1 was used for the 1750 model and a fishing mortality of 0.03 yr^{-1} (similar to the 1950 and 2000 Fs) was added to give a P/B of 0.14 yr^{-1} for the 1900 model.

The Q/B ratio used in the 2000 and 1950 models (2.72 yr^{-1}) for dogfish was obtained from Beattie (2001), but for the 1900 and 1750 models, the Q/B calculated in Appendix B Table B2 (3.33 yr^{-1}) was used. The diet obtained from Beattie (2001) was adapted for the 2000 and 1950 models by assuming that 1/6th of the predation on forage fish was directed to eulachon (Vasconcellos and Pitcher 2002e) and the proportion of the diet attributed to benthic invertebrates was divided into infaunal carnivorous invertebrates and infaunal invertebrate detritivores. Transient salmon was included in the diet of dogfish for these models, and the percentage of coho and chinook was reduced to balance those compartments.

The dogfish fishery started around 1872, and by 1900-1905 0.017 t•$km^{-2}$was caught annually with longlines (Vasconcellos and Pitcher 2002d). By the 1940s they were being caught with longlines, trawlers and gillnets (Vasconcellos and Pitcher 2002d). In the 2000 model, longlines and trawlers mostly catch dogfish; DFO information indicates a catch of 0.0226 t•km^{-2}•yr^{-1} by longlines from 1995-1997 and 0.3 kg•km^{-2}•yr^{-1} caught as bycatch and retained by the groundfish trawl fishery during 1997 (Beattie 2001). As mentioned earlier, a post-war fishery had developed for these animals. Although no catch records are available, the 1950 catch was assumed to be 150% of the present day value (0.0339 t•km^{-2}•yr^{-1}total catch). Like the present day model, catch was divided between longline and groundfish trawl, the latter receiving about 1% of the total. Beattie (2001) obtained values on discards of dogfish by the groundfish trawl fisheries of 0.009 t•km^{-2}•yr^{-1} from DFO's observer program database for 1997 (see Appendix A Table A2). Dogfish is also caught as bycatch (0.6 kg•km^{-2}•yr^{-1} see Appendix A Table A1) to the shrimp trawl fishery (Hay *et al.* 1999). There are no data available on discards by the salmon gillnet fishery, but some sets had more dogfish than salmon, and they were very often killed by the fishermen (Ainsworth, *pers. comm.*). An estimate of 2% of the salmon catch (or 0.008 t•km^{-2}•yr^{-1}) is used as the discard of dogfish in the salmon gillnet fishery in the present day model. A total discard rate of 0.019 t•km^{-2}•yr^{-1}is estimated for the 1950 model. This amount includes bycatch from the salmon gillnetting fleet (2% of salmon catch) and groundfish trawl fleet (same as in 2000 model).

13-14) Juvenile and adult pollock

Walleye pollock was split into adult and juveniles to reduce cannibalism in the model. Beattie (2001) used the 11-22,000 tonnes of pollock in the Hecate Strait obtained from Saunders and Andrews (1996) and 37% of the pollock stock being juveniles (Niggol, 1982) to calculate both juvenile and adult walleye pollock biomasses of 0.132 t•km^{-2} and 0.359 t•km^{-2} respectively. These values are used in the 1950 and 2000 models. The biomass of adult and juvenile pollock was estimated for both the 1900 and 1750 models by assuming an ecotrophic efficiency of 95%. The estimates of P/B of 0.263 yr^{-1} for adults and 1.061 yr^{-1} for juvenile walleye pollock, obtained from Beattie (2001) were used for the 1950 and 2000 models, while the natural mortality estimates calculated in Appendix B Table B1 (adult = 0.15 yr^{-1}, juvenile = 0.23 yr^{-1}) were used as P/B estimates for the 1750 and 1900 models.

Beattie (2001) obtained a Q/B ratio of 1.168 yr^{-1} for adult pollock and 0.98 yr^{-1} for juveniles, but decided to have the Q/B for juveniles calculated (5.31 yr^{-1}), by assuming a P/Q ratio of 20% as the Q/B for juveniles was too low. These ratios were used in the 2000 and 1950 models. The Q/B values estimated in Appendix B Table B2 were used for adult and juvenile pollock in 1900 and 1750. The diet estimates were obtained from Beattie (2001) (see Appendix D Table D10). Decapods, euphausiids and mysids were all assumed to be euphausiids, while larvaceans, amphipods and gastropods were considered to be epifaunal invertebrates. Fish was considered to be forage fish and split into 1/6th eulachon and 5/6th forage fish (Vasconcellos and Pitcher 2002e).

Groundfish trawlers catch 0.007 t•km^{-2}•yr^{-1} in the 2000 model after Beattie (2001) (see Appendix A Table A2). Beattie (2001) obtained values on discards of pollock by the groundfish trawl fisheries of 0.002 t•km^{-2}•yr^{-1} from DFO's observer program database for 1997. Pollock is also caught as bycatch (0.0002 t•km^{-2}•yr^{-1}, see Appendix A Table A1) to the shrimp trawl fishery (Hay *et al.* 1999). These values were included in the 1950 and 2000 models.

15-16) Forage fish and eulachon

Forage fish consist mainly of sandlance, although pilchards, anchovy, capelin, chub mackerel, shad and smelts are also present (Beattie 2001). Eulachon was removed from this compartment and all diet references to forage fish were split into 1/6th eulachon and 5/6th forage fish (Vasconcellos and Pitcher 2002e). As with Beattie (2001) the biomass of forage fish was not available, and the biomass of both forage fish and eulachon in all four models were estimated by setting the ecotrophic efficiency of these compartments to 95%.

Beattie (2001) uses the average of adult and juvenile herring P/B ratios for forage fish (1.432 yr^{-1}). We use that value for forage fish and eulachon in our 1950 and 2000 models. The natural mortality calculated in Appendix B Table B1 for forage fish (0.595 yr^{-1}) was used as its P/B ratio in the 1900 and 1750 models, while that calculated for eulachon (0.557 yr^{-1}) was increased to 0.6 yr^{-1} to consider catch for the 1750 and 1900 models. Beattie (2001) uses the average of adult and juvenile herring Q/B ratios for forage fish (8.395 yr^{-1}), and we use that value for both forage fish and eulachon in the 2000 model. The Q/B of 6.61 yr^{-1} calculated in Appendix B Table B2 for forage fish was used for both forage fish and eulachon in the 1900 and 1750 models. The diet of forage fish was obtained from Beattie (2001), and was used in all four models. This value was adapted for eulachon, reducing the proportion of euphausiids in their diet in order to balance the model. We also assume that they do not feed on detritus and that copepods are more important in their diet. Final diet matrix for forage fish and eulachon is provided in Appendix D Table D11.

There was a small recreational fishery for capelin in the past, specifically for the Georgia Strait area and this is probably also true for the Hecate Strait (Vasconcellos and Pitcher 2002f). A (seine net) reduction fishery for sardine began in 1917 and caught 70 tonnes that year. The catch increased to

80,558 tonnes in 1943, but was reduced to 444 tonnes in 1947 (Schweigert 1987). The latter was used for our 1950 forage fish group (0.006 t•km^{-2}•yr^{-1}). However, at present no forage fish is caught except for eulachon, for which the total catch in British Columbia is approximately 366 tonnes (or 0.005 t•km^{-2}•yr^{-1}) and we assume that approximately 3/5^{ths} of that is taken from the Hecate Strait. First Nations people harvest eulachon with herring rakes, seine, dip and bag nets after which they dried or smoked them and extracted their oil (Irwin 1984). Vasconcellos and Pitcher (2002e) assumed a tentative catch of 3,000 tonnes per year for the early 1900s by assuming that catches were one order of magnitude higher than in the present time, and also suggested that the pre-contact (1750) catch was probably similar (0.043 t•km^{-2}•yr^{-1}). Beattie (2001) obtained values on discards of forage fish by the groundfish trawl fisheries from DFO's observer program database for 1997 (see Appendix A Table A2) and we split the discard into forage fish (0.04 kg•km^{-2}•yr^{-1}) and eulachon (0.007 kg•km^{-2}•yr^{-1}) using the 1/6th eulachon rule that we employ for diets (Vasconcellos and Pitcher 2002e). Eulachon is also discarded by the shrimp trawl fishery, and Hay *et al.* (1999) calculated that shrimp trawlers on the central coast discard approximately 90 tonnes (0.001 t•km^{-2}•yr^{-1}) of eulachon each year. The discards of other forage fish species by the shrimp trawl fishery were not significant (Table 4 in Hay *et al.* 1999).

17-18) Juvenile and adult herring

Herring was the focus of a reduction fishery early in the 20th century and is important to First Nations people (Jones 2000; Beattie 2001). Herring was split into adult and juvenile compartments to reduce the effects of cannibalism in the model. The 2000 biomass of adult and juvenile herring was obtained from Beattie (2001) at 2.265 t•km^{-2}. Biomass for the 1950 model is 0.748 t•km^{-2} based on DFO archival records. The biomass of juvenile and adult herring in the 1900 and 1750 models was estimated by assuming an ecotrophic efficiency of 95%. A negative biomass accumulation was accepted for 1950 adult herring of 50% per year, in light of the damaging reduction fishery that continued until the mid-1960s.

The 2000 and 1950 P/B ratios for juveniles (2.19 yr^{-1}) and adults (0.683 yr^{-1}) were obtained from Beattie (2001). Natural mortality is calculated in Appendix B Table B1 (adult = 0.792 yr^{-1} and juvenile 1.173 yr^{-1}) were used for the 1900 and 1750 models. The P/B of adult herring was considered marginally higher than M due to First Nations catches in 1750 and a small fishery in 1900 – we assume that the P/B of adult herring is 0.8 yr^{-1} for both models. The 2000 Q/B ratios for juveniles (10.95 yr^{-1}) and adults (5.84 yr^{-1}) were obtained from Beattie (2001), and those calculated in Appendix B Table B2 (adult = 7.5 yr^{-1} and juvenile = 11.3 yr^{-1}) were used for the 1900 and 1750 models. The diet of juvenile and adult herring was obtained from Beattie (2001) and used in all four models (Appendix D Table D12).

Table 7: Herring catch (tonnes) by region. Source: Sweigert and Fort. (1999).

Catch	Queen Charlotte Sound	Prince Rupert	Central Coast	Total
1994/95	0	2,877	10,308	13,185
1995/96	0	4,178	5,209	9,387
1996/97	0	6,815	4,806	11,621
1997/98	2100	4,218	9,965	16,283
1998/99	3792	3,114	8,738	15,644
Average				13,224

Herring is caught as bycatch to the groundfish trawl fishery (0.002 t•km^{-2}•yr^{-1} – see Appendix A Table A2 obtained from Beattie 2001). Schweigert and Fort (1999) give catches of herring from the Queen Charlotte Sound, Prince Rupert and the Central Coast. We divide this catch into gillnet (64% or 0.12 t•km^{-2}•yr^{-1}) and seine net (36% or t•km^{-2}•yr^{-1}) catches based on data from DFO (Sweigert and Fort, 1999) (Table 7). The herring fishery in Prince Rupert (DFO 2001a) and on the Central Coast (DFO 2001b) started around the turn of the century, but only became large at the start of the dry salt fishery in the mid 1930s, while in the Queen Charlotte Islands catches were first reported in 1937 (DFO 2001c; Jones 2000). Thus, we estimate that the catch was well below the approximately 66,000 tonnes caught in all three areas combined from 1951-1960, and we assume that it was similar to the approximately 0.25 million pounds, or 0.002 t•km^{-2}•yr^{-1}, caught by First Nations in pre-contact times (Carrothers 1941). Catches for the 1950 model were taken from DFO catch statistics (DFO 1995). Herring is caught and discarded by the groundfish trawl fishery in the 2000 model (0.003 t•km^{-2}•yr^{-1} – see Appendix A Table A2 obtained from Beattie, 2001).

19-20) Pacific ocean perch: juvenile and adult

Pacific Ocean perch has been an important part of the groundfish fishery in British Columbia, and was targeted from the early 1960s by domestic and international fisheries (Beattie 2001). The

2000 biomass of both juvenile (0.065 t•km^{-2}•yr^{-1}) and adult Pacific Ocean perch (1.819 t•km^{-2}•yr^{-1}) was obtained from Beattie (2001), while the 1750 and 1900 biomasses for adults and juveniles were estimated by assuming an ecotrophic efficiency of 95%. A negative biomass accumulation of approximately 18% (-0.3 t•km^{-2}•yr^{-1}) was calculated for Pacific Ocean perch in the 2000 model, from the B1996/B0 values obtained from Walters and Bonfil (1999).

The 1950 and 2000 P/B ratios for juveniles (0.672 yr^{-1}) and adults (0.144 yr^{-1}) were obtained from Beattie (2001), and the natural mortality calculated in Appendix B Table B1 was used as P/B estimates in 1900 and 1750 (0.23 yr^{-1} for adults and 0.34 yr^{-1} for juveniles). Lower P/B for juveniles in the 1900 and 1750 models are justified because, although few fisheries target them, many are killed as bycatch and by other fishery activities.

The 1950 and 2000 Q/B ratios for juveniles (3.21 yr^{-1}) and adults (2.14 yr^{-1}) were obtained from Beattie (2001) and the ratios calculated in Appendix B Table B2 were used in the 1900 and 1750 models (4.08 yr^{-1} for adults and 6.12 yr^{-1} for juveniles). The diets of juvenile and adult Pacific Ocean perch were obtained from Beattie (2001) and used for all four models. Note that P/Q juveniles in the 1950 and 2000 models = 0.209; P/Q juveniles in the 1900 and 1750 models = 0.05. In future revisions of the model these might be maintained at the same level.

Catches of Pacific Ocean perch by the groundfish trawl fishery (0.065 t•km^{-2}•yr^{-1} – see Appendix A Table A2) in the 2000 model were obtained from Beattie (2001). The 1950 catches for this group are based on red and rock cod, taken from DFO commercial catch statistics for 1951 (DFO 1995). Pacific Ocean perch was caught and discarded in the 1950 and 2000 model by the groundfish trawl fishery (0.002 t•km^{-2}•yr^{-1} – see Appendix A Table A2 obtained from Beattie (2001)).

21) Inshore rockfish

Inshore rockfish include copper rockfish, quillback rockfish, tiger rockfish, China rockfish and yelloweye rockfish. The 1950 and 2000 biomass of inshore rockfish (0.1 t•km^{-2}) was obtained from Beattie (2001), while those of the 1900 and 1750 models were calculated by assuming an ecotrophic efficiency of 95%. (Some argue that lower EEs might apply to high trophic level fish in the models of the past.)

The 1950 and 2000 P/B ratio for inshore rockfish (0.19 yr^{-1}) was obtained from Beattie (2001), and the natural mortality (0.18 yr^{-1}), calculated in Appendix B Table B1, was used as the P/B ratio for inshore rockfish in the 1900 and 1750 models. The 1950 and 2000 Q/B ratio for inshore rockfish (5.688 yr^{-1}) was obtained from Beattie (2001), and the Q/B ratio (3.7 yr^{-1}) calculated in Appendix B Table B2 was used in the 1900 and 1750 models. The diet of inshore rockfish was obtained from Beattie (2001), used in all four models and adapted for the new model groupings by assuming that 1/6th of the proportion of forage fish in their diet is obtained from eulachon (Vasconcellos and Pitcher 2002e). Adult herring was reduced as a diet component in the 1950 model to 0.050; the difference was transferred to commercial shrimp, infaunal carnivorous invertebrates and euphausiids.

The 2000 catches of inshore rockfish include 0.3 kg•km^{-2}•yr^{-1} (Appendix A Table A2) taken by the groundfish trawl fishery, 0.003 t•km^{-2}•yr^{-1} caught by the groundfish hook and line fishery, 0.004 t•km^{-2}•yr^{-1} by the halibut hook and line fisheries (Beattie 2001) and 0.004 t•km^{-2}•yr^{-1} taken by the recreational fishery (adapted from Forrest 2002) to total 0.01 t•km^{-2}•yr^{-1}. Catch records do not extend as far back as 1950 for rockfish groups, so commercial catch for that model was arbitrarily assumed to be one half of the present value, and recreational catch was assumed to be 9% of the current recreational value (after Forrest 2002) to total 0.0037 t•km^{-2}•yr^{-1}. Inshore rockfish is caught and discarded by the groundfish trawl fishery (0.2 kg•km^{-2}•yr^{-1} – see Appendix A Table A2 obtained from Beattie (2001)).

22-23) Piscivorous rockfish: juvenile and adult

Piscivorous rockfish include species that feed mainly on fish and large invertebrates: rougheye, shortraker, short and longspine thornyheads, black, blue, chillipepper and dusky rockfish. The 2000 biomasses of both juvenile (0.007 t•km^{-2}) and adult piscivorous rockfish (0.654 t•km^{-2}) were obtained from Beattie (2001), while those of the 1900 and 1750 models were estimated by assuming an ecotrophic efficiency of 95%. Biomass for the 1950 model for adult piscivorous rockfish (0.753 t•km^{-2}) was calculated by Ecopath assuming an EE of 0.95. The 1950 biomass of juveniles (0.008 t•km^{-2}) was arrived at by assuming the same ratio of juveniles to adults as in the 2000 model. A negative biomass accumulation of approximately 1% (0.007 t•km^{-2}•yr^{-1}) was calculated for adult piscivorous rockfish in the 2000 model from the B1996/B0 values obtained from (Walters and Bonfil 1999). This value was removed from the 1950 model.

The 1950 and 2000 P/B ratios of both juvenile ($0.261\ yr^{-1}$) and adult piscivorous rockfish ($0.037\ yr^{-1}$) were obtained from Beattie (2001). The natural mortality estimated in Appendix B Table B1 for adult ($0.296\ yr^{-1}$) and juvenile ($0.440\ yr^{-1}$) piscivorous rockfish were much higher than those obtained from Beattie (2001), and gave very low biomass estimates for these species, so we use the P/B ratios obtained from Beattie (2001) for all four models. The 1950 and 2000 Q/B ratios for both juvenile ($1.89\ yr^{-1}$) and adult piscivorous rockfish ($1.26\ yr^{-1}$) were obtained from Beattie (2001) and were again much lower than those calculated in Appendix B Table B2. We used the estimates from Beattie (2001) for all four models. The diet of adult and juvenile piscivorous rockfish were obtained from Beattie (2001), used for all four models and adapted for the new model groupings by assuming that $1/6^{th}$ of the proportion of forage fish in their diet is obtained from eulachon (Vasconcellos and Pitcher 2002e).

In the 2000 model adult piscivorous rockfish was caught by the groundfish trawl fishery ($0.02\ t{\bullet}km^{-2}{\bullet}yr^{-1}$ – see Appendix A Table A2 obtained from Beattie (2001)) and the groundfish hook and line fishery ($0.002\ t{\bullet}km^{-2}{\bullet}yr^{-1}$ for rougheye rockfish obtained from Beattie (2001)). Forrest (2002) summarizes the recreational catch of rockfish from an unpublished DFO survey; this amount was evenly distributed between the two adult (piscivorous) rockfish groups in this model, inshore rockfish and piscivorous rockfish. In balancing the model, this quantity was reduced slightly to $0.002\ t{\bullet}km^{-2}{\bullet}yr^{-1}$ in the present group. Total present-day catch for this group is therefore $0.028\ t{\bullet}km^{-2}{\bullet}yr^{-1}$. Catch records do not extend as far back as 1950 for rockfish groups, so commercial catch for the 1950 model was arbitrarily assumed to be one half of the present value, and recreational catch was assumed to be 9% of the current recreational value (after Forrest (2002)) to total $0.011\ t{\bullet}km^{-2}{\bullet}yr^{-1}$. Piscivorous rockfish was caught and discarded by the groundfish trawl fishery ($0.3\ kg{\bullet}km^{-2}{\bullet}yr^{-1}$ – see Appendix A Table A2 obtained from Beattie (2001)) in the 2000 model.

24-25) Planktivorous rockfish: juvenile and adult

Planktivorous rockfish feed primarily on zooplankton and are mainly pelagic (Beattie 2001), they include: yellowmouth, red-stripe, widow, yellowtail, darkblotch, canary, splitnose, sharpchin, Puget sound, bocaccio and shortbelly rockfish. The 2000 biomasses of juvenile ($0.136\ t{\bullet}km^{-2}$) and adult planktivorous rockfish ($1.2\ t{\bullet}km^{-2}$) were obtained from Beattie (2001), while those of the 1900 and 1750 models were estimated by assuming an ecotrophic efficiency of 95%. The 1950 estimate for adult planktivorous rockfish ($1.664\ t{\bullet}km^{-2}$) was also arrived at by assuming an ecotrophic efficiency of 95%. This value falls approximately halfway between the 1900 and 2000 estimates. The biomass estimate for juvenile planktivorous rockfish ($0.189\ t{\bullet}km^{-2}$) was arrived at by assuming the same ratio of adults to juveniles as in the 2000 model. A negative biomass accumulation of approximately 8% ($-0.095\ t{\bullet}km^{-2}{\bullet}yr^{-1}$) was calculated for adult planktivorous rockfish from the B1996/B0 values obtained from Walters and Bonfil (1999). This value was omitted from the 1950 model.

The 1950 and 2000 P/B ratios of both juvenile ($0.261\ yr^{-1}$) and adult planktivorous rockfish ($0.068\ yr^{-1}$) were obtained from Beattie (2001) and these values were much lower than the values calculated in Appendix B Table B1 for natural mortality, so we used the values obtained from Beattie (2001) for all four models. The 1950 and 2000 Q/B ratios for both juvenile ($3.21\ yr^{-1}$) and adult planktivorous rockfish ($2.14\ yr^{-1}$) were obtained from Beattie (2001) and these values were much lower than the values calculated in Appendix B Table B2, so we used the values obtained from Beattie (2001) for all four models. The diets of adult and juvenile planktivorous rockfish were obtained from Beattie (2001) and adapted for the new model groupings by assuming that $1/6^{th}$ of the proportion of forage fish in their diet is obtained from eulachon (Vasconcellos and Pitcher 2002e). These estimates were used for all four models.

In the 2000 model, the groundfish trawl fishery caught $0.076\ t{\bullet}km^{-2}{\bullet}yr^{-1}$ of adult planktivorous rockfish (Appendix A Table A2 obtained from Beattie (2001)). There is no recreational catch for planktivorous rockfish, since they do not respond to baited hooks. Total present catch for the adult group is then $0.076\ t{\bullet}km^{-2}{\bullet}yr^{-1}$. Catch records do not extend as far back as 1950 for rockfish groups, so commercial catch for the 1950 model was arbitrarily assumed to be one half of the present value, and recreational catch was assumed to be 9% of the current recreational value (after Forrest (2002)) to total $0.036\ t{\bullet}km^{-2}{\bullet}yr^{-1}$. Planktivorous rockfish was caught and discarded in the 1950 and 2000 model by the groundfish trawl fishery ($0.005\ t{\bullet}km^{-2}{\bullet}yr^{-1}$ – see Appendix A Table A2 obtained from Beattie (2001)). Large amounts of rockfish are also caught as bycatch to the salmon gillnet fishery according to Beattie (*pers. comm.*), and he assumes a value of $0.001\ t{\bullet}km^{-2}{\bullet}yr^{-1}$ for discards from this fishery in the 2000 model.

26-27) Juvenile and adult turbot (=arrowtooth flounder)

The turbot, or arrowtooth flounder, has a large biomass in this system (Beattie 2001). The 1950 and 2000 biomass estimates of both juvenile (0.218 t•km^{-2}) and adult turbot (1.5 t•km^{-2}) were obtained from Beattie (2001) while their biomasses were estimated by assuming an ecotrophic efficiency of 95% in the 1900 and 1750 models. Vasconcellos and Fargo (2002) suggest that the unfished equilibrium biomass of turbot was estimated at 56,000 tonnes which is similar to the biomass estimated for adult turbot in 1900, however our estimates of biomass in 1750 were three times as large.

The P/B ratios of both juvenile (0.33 yr^{-1}) and adult turbot (0.22 yr^{-1}) were obtained from Beattie (2001) and used in all four models. The Q/B ratios for both juvenile (2.172 yr^{-1}) and adult turbot (1.983 yr^{-1}) were obtained from Beattie (2001) and used in all four models. The diets of juvenile and adult turbot were obtained from Beattie (2001) and adapted for the new model groupings by assuming that 1/6th of the proportion of forage fish in their diet is obtained from eulachon (Vasconcellos and Pitcher 2002e). The 1950 diet for juvenile and adult turbot was assumed to be similar to 2000. In 1750 (and 1900) no discards were available, and the discards consumed by juvenile turbot in the 2000 model were added to epifaunal invertebrates, while the discards consumed by adult turbot in the 2000 model were added to shallow water benthic fish.

In the 2000 model, adult turbot is caught by the groundfish trawlers (0.02 t•km^{-2}•yr^{-1} – see Appendix A Table A2 obtained from Beattie (2001)). DFO commercial catch statistics from 1951 (DFO 1995) were accepted for the 1950 adult turbot group (0.00288 t•km^{-2}•yr^{-1}), all caught by groundfish trawlers. Adult turbot is caught and discarded by the groundfish trawl fishery in the 2000 model (0.03 t•km^{-2}•yr^{-1} – see Appendix A Table A2 obtained from Beattie (2001)). Turbot is also caught as bycatch (0.7 kg•km^{-2}•yr^{-1}, see Appendix A Table A1) to the shrimp trawl fishery (Hay *et al.* 1999) in the 2000 model. This bycatch was removed entirely from the 1950 model, since the total catch was an order of magnitude less during that period than in the present day.

28-29) Juvenile and adult flatfish

Information on flatfish is not readily available except for those species that are taken by the groundfish trawl fishery: rock sole, English sole and dover sole (Beattie 2001). Other species that are also included in this compartment, but for which very little information is available, include: butter sole, petral sole, rex sole, slender sole, flathead sole, starry flounder and Pacific sanddab. The 2000 biomass estimates of both juvenile (0.259 t•km^{-2}) and adult flatfish (0.392 t•km^{-2}) were obtained from Beattie (2001). The 1950 biomass estimate for adult flatfish (0.221 t•km^{-2}) was obtained by assuming an EE of 0.95. Juvenile biomass (0.150 t•km^{-2}) was calculated by assuming the same proportion of juvenile to adult as in the 2000 model. Biomass for the 1900 and 1750 models were estimated by assuming an ecotrophic efficiency of 95%. Vasconcellos and Fargo (2002) suggest that the unfished equilibrium biomasses of rock sole, English sole and Dover sole were 8,500 tonnes, 5,200 tonnes and 14,000 tonnes respectively, which gives B0 of approximately 0.4 t•km^{-2}. This is similar to the biomass estimated for adult flatfish in 1900, however, the precontact biomass was more than four times that amount.

The 1950 and 2000 P/B ratio for juvenile flatfish (1.9 yr^{-1}) was based on a reported daily growth rate of 0.53% (Smith *et al.* 1995), while that of adult flatfish (0.9 yr^{-1}) was obtained from (Beattie 2001) (Table A1.26). The natural mortality of flatfish was estimated in Appendix B Table B1 and was assumed to be equal to the P/B ratios (0.38 yr^{-1} = juvenile and 0.26 yr^{-1} = adult) for the 1900 and 1750 models. The 1950 and 2000 Q/B ratios for both juvenile (6.02 yr^{-1}) and adult flatfish (4.3 yr^{-1}) were obtained from the unbalanced model of Beattie (2001), and were similar to those estimated in Appendix B Table B2 – 4.2 yr^{-1} for adults and 6.3 yr^{-1} for juveniles, which were used for the 1900 and 1750 models. The diets of juvenile and adult flatfish were obtained from Beattie (2001), adapted for the new model groupings by assuming that 1/6th of the proportion of forage fish in their diet is obtained from eulachon (Vasconcellos and Pitcher 2002e). The proportion of the diet attributed to benthic invertebrates was divided into infaunal carnivorous invertebrates and infaunal invertebrate detritivores. These estimates were used for all four models.

In the 2000 model, adult flatfish is caught by the groundfish trawl fishery (0.05 t•km^{-2}•yr^{-1}– see Appendix A Table A2 obtained from Beattie (2001)). Adult flatfish catch (0.0392 t•km^{-2}•yr^{-1}) for the 1950 model was taken from 1951 DFO catch statistics (DFO 1995). Adult flatfish is caught as bycatch (0.002 t•km^{-2}•yr^{-1}, see Appendix A Table A1) to the shrimp trawl fishery in the 2000 model (Hay *et al.* 1999).

30-31) Juvenile and adult halibut

Beattie (2001) assumes that the biomass of both juvenile and adult (0.6 t•km^{-2}) halibut is the same, and we use his estimates in the 2000 model. The 1950 model reduces this estimate to 0.429 t•km^{-2}, according to the 1950 biomass value provided by Quinn (1985). Vasconcellos and Pitcher (2002g) suggest that the biomass of halibut in the early 1900s might be higher than at present although the recovery of the stock supports the hypothesis of the same biomass in the past as at the present time. Schreiber (2002) suggests that the biomass around the turn of the century was lower than in the 1700s, so we use the 2000 biomass estimate for adult halibut obtained from Beattie (2001) for the 1900 model, and assume that the biomass in 1750 was much higher (1.0 t•km^{-2}). We estimated the biomass of juvenile halibut for both the 1750 and 1900 models by assuming an ecotrophic efficiency of 95%.

The 1950 and 2000 P/B ratios for both juvenile (0.6 yr^{-1}) and adult halibut (0.4 yr^{-1}) were obtained from Table A1.26 in Beattie (2001). The natural mortality estimates of adult (0.064 yr^{-1}) and juvenile (0.096 yr^{-1}) halibut calculated in Appendix B Table B1 were added to the fishing mortalities (1900F = 0.02 yr^{-1} and 1750F = 0.003 yr^{-1}) to calculate the P/B ratios for adults in 1900 and 1750 as 0.084 yr^{-1} and 0.067 yr^{-1} respectively, and for juveniles as 0.116 yr^{-1} and 0.099 yr^{-1} respectively. The 1950 and 2000 Q/B ratios for both juvenile (1.1 yr^{-1}) and adult halibut (1.5 yr^{-1}) were obtained from the unbalanced model of Beattie (2001), while those calculated in Appendix B Table B2 were used for the 1900 and 1750 models (adult = 1.7 yr^{-1} and juvenile = 2.5 yr^{-1}). The diets of juvenile and adult halibut were obtained from Beattie (2001) and adapted for the new model groupings by assuming that 1/6th of the proportion of forage fish in their diet is obtained from eulachon (Vasconcellos and Pitcher 2002e).

Halibut is caught in the 2000 model by the groundfish trawl fishery (0.05 kg•km^{-2}•yr^{-1} each for adult and juveniles – see Appendix A Table A2 obtained from Beattie (2001)) and the hook and line fishery (0.028 t•km^{-2}•yr^{-1}, Beattie (2001)). A small recreational catch of 0.014 t•km^{-2}•yr^{-1} is based on an unpublished survey by the DFO, summarized in Forrest (2002). Commercial catch of adult halibut for the 1950 model (0.097 t•km^{-2}•yr^{-1} groundfish trawl, 0.001 t•km^{-2}•yr^{-1} halibut hook and line) was taken from DFO catch statistics (DFO 1995). Recreational catch in 1950 was assumed to be 9% of the present day recreational catch according to Forrest (2002). Total catch was therefore 0.099 t•km^{-2}•yr^{-1} in 1950. Commercial fishing for Pacific halibut began in the 1880s and by 1909 fishermen already noticed that most of the formerly productive inshore areas had been depleted, and they began actively searching for previously unfished offshore grounds (Schreiber 2002). Rathbun (1990) gives catches of halibut in British Columbia (principally the Hecate Strait) in the late 1800s (Table 8), and we assume that 90% of his estimate (or 0.015 t•km^{-2}•yr^{-1}) comes from our area and it is divided between adult and juvenile halibut (0.008 t•km^{-2}•yr^{-1} each). It is estimated that First Nations caught as much as 1.4 thousand tonnes (or 0.019 t•km^{-2}•yr^{-1}) of halibut per year prior to the commercial fisheries (1750 model), and after 1888 they consumed over 270 tonnes annually (Carrothers 1941). All catches of halibut were split between adult and juveniles in the ratio of 1:1 (Pitcher, *pers. comm.*), thus the First Nations catch of juvenile and adult halibut in 1750 was approximately 0.009 t•km^{-2}•yr^{-1} each, while in the 1900 model it was around 0.001 t•km^{-2}•yr^{-1} . Halibut is caught and discarded (Beattie 2001) by the groundfish trawl fishery (0.0026 t•km^{-2}•yr^{-1} each for adult and juveniles (Pitcher, *pers. comm.*) (see Appendix A Table A2). This value was used in the 1950 and 2000 models.

Table 8: Catches of halibut in Hecate Strait. Source: Rathbun, 1990.

Year	Catch (pounds)	Catch (tonnes)
1890	1,376,800	625
1891	2,124,500	964
1892	2,768,000	1,256
1895	4,251,000	1,928
Average	2,630,075	1,193

32-33) Juvenile and adult Pacific cod

The 2000 biomass of adult Pacific cod was estimated by Walters and Bonfil (1999) as 0.163 t•km^{-2} and it was assumed that the biomass of juveniles was approximately 36% of the total biomass (0.089 t•km^{-2}). Biomass in the 1950 model for adult Pacific cod (0.086 t•km^{-2}) was taken from a DFO stock assessment report representing all of British Columbia. The 1950 juvenile biomass (0.047 t•km^{-2}) maintains the same ratio of adult to juvenile as in 2000. The biomass of juvenile and adult Pacific cod were estimated for both the 1900 and 1750 models by assuming an ecotrophic efficiency of 95%.

The 1950 and 2000 P/B ratios for both juvenile (1.98 yr^{-1}) and adult Pacific cod (1.32 yr^{-1}) were obtained from Beattie (2001) (Table A1.26), while the natural mortality estimates from Appendix B Table B1 (0.26 yr^{-1} for juveniles and 0.17 yr^{-1} for adults) were used as P/B ratios in the 1900 and 1750 models. The 1950 and 2000 Q/B ratios for both juvenile (7.5 yr^{-1}) and adult Pacific cod (4.0 yr^{-1}) were obtained from the unbalanced model of Beattie (2001) while the Q/B ratios estimated from Appendix B Table B2 (3.4 yr^{-1} for juveniles and 2.3 yr^{-1} for adults) were used in the 1900 and 1750 models. The diets of juvenile and adult Pacific cod were obtained from Beattie (2001) and adapted for the new model groupings by assuming that $1/6^{th}$ of the proportion of forage fish in their diet is obtained from eulachon (Vasconcellos and Pitcher 2002e) and the proportion of the diet attributed to benthic invertebrates was divided into infaunal carnivorous invertebrates and infaunal invertebrate detritivores. These estimates were used for all four models.

First Nations people caught cod by using a lure and spear (Irwin 1984) and as it is thought to be a relatively short lived, high turnover species (Sinclair 2002) we assume a catch of around 0.001 $t{\bullet}km^{-2}{\bullet}yr^{-1}$ for this species by First Nations in both the 1750 and 1900 models. In the 2000 model, adult Pacific cod is caught by the groundfish trawlers (0.02 $t{\bullet}km^{-2}{\bullet}yr^{-1}$ – see Appendix A Table A2 obtained from Beattie 2001). In the 1950 model, catches for adult Pacific cod (0.052 $t{\bullet}km^{-2}{\bullet}yr^{-1}$) are taken from DFO catch statistics (DFO 1995) for seine nets (64.1%), groundfish trawl (35.8%) and longline (0.03%). Adult Pacific cod is caught and discarded (Beattie 2001) by the groundfish trawl fishery (0.002 $t{\bullet}km^{-2}{\bullet}yr^{-1}$ - see Appendix A Table A2) in the 1950 and 2000 models.

34-35) Juvenile and adult sablefish

Sablefish is also known as black cod (Beattie 2001). The 2000 biomass estimates of both juvenile (0.1 $t{\bullet}km^{-2}$) and adult (0.3 $t{\bullet}km^{-2}$) sablefish were obtained from Beattie (2001). Official DFO stock assessment reports indicate that there was approximately twice as much adult sablefish in the early 1960s as in the present day. Multiplying the present day estimate by two provided a rough estimate of the 1950 adult biomass (0.6 $t{\bullet}km^{2}$). The same ratio was maintained between juvenile and adult biomass as in the present day model to provide a juvenile biomass estimate of 0.238 $t{\bullet}km^{-2}$. Biomasses in the 1900 and 1750 models were estimated assuming an ecotrophic efficiency of 95%.

The 1950 and 2000 P/B ratios for both juvenile (0.6 yr^{-1}) and adult sablefish (0.3 yr^{-1}) were obtained from Beattie (2001) (Table A1.26), while the natural mortality estimates from Appendix B Table B1 (0.27 yr^{-1} for juveniles and 0.18 yr^{-1} for adults) were used for P/B ratios in the 1900 and 1750 models. The Q/B ratios for both juvenile (7.0 yr^{-1}) and adult sablefish (3.7 yr^{-1}) were obtained from Beattie (2001) and used for all four models. The diets of juvenile and adult sablefish were obtained from (Beattie 2001) and adapted for the new model groupings by assuming that $1/6^{th}$ of the proportion of forage fish in their diet is obtained from eulachon (Vasconcellos and Pitcher 2002e). These estimates were used for all four models.

In the 2000 model, adult sablefish was caught by the groundfish trawlers (0.6 $kg{\bullet}km^{-2}{\bullet}yr^{-1}$ – see Appendix A Table A2 obtained from Beattie 2001) and the sablefish trap fishery (0.06 $t{\bullet}km^{-2}{\bullet}yr^{-1}$ - obtained from Beattie (2001) and DFO (1999a)). Total catch for adult sablefish was 0.00612 $t{\bullet}km^{-2}{\bullet}yr^{-1}$ in 1951 according to DFO catch statistics (DFO 1995), divided into 63% longline and 37% groundfish trawl. Adult sablefish was caught and discarded (Beattie 2001) by the groundfish trawl fishery in the 1950 and 2000 models (0.003 $t{\bullet}km^{-2}{\bullet}yr^{-1}$ - see Appendix A Table A2).

36-37) Juvenile and adult lingcod

The 2000 biomass estimates of both juvenile (0.031 $t{\bullet}km^{-2}$) and adult (0.034 $t{\bullet}km^{-2}$) lingcod were obtained from Martell (1999) as cited in Beattie (2001). The 1950 estimate of adult biomass is 0.085 $t{\bullet}km^{-2}$ (adapted from Martell (1999)). Juvenile 1950 biomass was estimated by assuming the same ratio of adult to juvenile biomass as in 2000: the estimate is 0.078 $t{\bullet}km^{-2}$. Biomass was estimated by Ecopath for the 1900 and 1750 models by assuming an ecotrophic efficiency of 95

The 1950 and 2000 P/B ratio for adult lingcod (0.8 yr^{-1}) was obtained from Beattie (2001) (Table A1.26), and that of juvenile lingcod (1.2 yr^{-1}) was assumed to be 1.5 times that of adults (see Beattie (2001); an unbalanced model). The natural mortalities estimated in Appendix B Table B1 for adult and juvenile lingcod (0.26 yr^{-1} and 0.39 yr^{-1} respectively) were used as P/B ratios in the 1900 and 1750s models. The 1950 and 2000 Q/B ratios for both juvenile (3.3 yr^{-1}) and adult lingcod (3.3 yr^{-1}) were obtained from Beattie (2001), while those calculated in Appendix B Table B2 (3.9 yr^{-1} for juveniles and 2.8 yr^{-1} for adults) were used in the 1900 and 1750 models.

The diet of adult lingcod was obtained from Beattie (2001) and was adapted for the new model groupings by assuming that $1/6^{th}$ of the proportion of forage fish in their diet is obtained from eulachon (Vasconcellos and Pitcher 2002e).

The diet of juvenile lingcod was adapted from the text of Cass *et al.* (1990), who suggested that juvenile lingcod feed on herring, forage fish, juvenile flatfish and Pacific cod (all 20%), shrimp and invertebrates (10% each), which were then adapted to include eulachon and all three of the invertebrate groups. These estimates were used for all models except 1950. In the 1950 model herring was reduced as a diet component to 0.159, to reduce predation pressure on that group. The difference was divided among juvenile lingcod, juvenile Pacific cod and juvenile planktivorous rockfish.

In the 2000 model, adult lingcod is caught with groundfish trawls (0.007 t•km^{-2}•yr^{-1}– see Appendix A Table A2 obtained from Beattie (2001)) and recreational fishermen catch both adult and juvenile lingcod. Cass, Beamish *et al.* (1990) suggest that currently, approximately 80 tonnes of lingcod is caught by scuba and 125 tonnes by recreational line fishermen, and we assume that the scuba catches (0.001 t•km^{-2}•yr^{-1}) are mostly adults and that the line fishery (0.002 t•km^{-2}•yr^{-1}) catch mostly juveniles, as Cass, Beamish *et al.* (1990) suggested that the recreational line fishery catch smaller sizes. In the 1950 model, groundfish trawl, groundfish hook and line and recreational fisheries together catch 0.05 t•km^{-2}•yr^{-1}of adult lingcod. Data for 1950 was adapted from the historical estimates of Cass, Beamish *et al.*, (1990). Lingcod was caught by First Nations people with wooden gorges, but was of minor imporance (Vasconcellos and Pitcher 2002h), and we assume a very small catch of 0.5 kg•km^{-2}•yr^{-1} for the 1750 model. Cass, Beamish *et al.* (1990) give catches for the whole of British Columbia around 1900-1905, and we use 50% of the 370 tonnes (0.003 t•km^{-2}•yr^{-1}) as the catch in the 1900 model. Adult lingcod is caught and discarded (Beattie 2001) by groundfish trawl fishermen in the 1950 and 2000 models (0.001 t•km^{-2}•yr^{-1} - see Appendix A Table A2).

38) Shallow-water benthic fish

This group includes the sculpins, blennies, poachers, gobies and the greenlings, especially rock greenling and other nearshore fishes such as eelpouts, northern clingfish, red irish lords, cabezon, cutthroat trout and white sturgeon. The 1950 and 2000 biomass estimate of shallow water benthic fish (1.5 t•km^{-2}) was obtained from Beattie (2001), while the 1900 and 1750 models were estimated by assuming an ecotrophic efficiency of 95%.

The 2000 P/B ratio for shallow water benthic fish (0.8 yr^{-1}) was obtained from Beattie (2001) (Table A1.26), while the natural mortality of 0.27 yr^{-1} calculated in Appendix B Table B1 was used as the P/B ratio of shallow water benthic fish in the 1900 and 1750 models. The 1950 and 2000 Q/B ratio for shallow water benthic fish (5.3 yr^{-1}) was obtained from Beattie (2001), while the Q/B ratio (2.1 yr^{-1}) calculated in Appendix B Table B2 was used in the 1900 and 1750 models. The diet of shallow water benthic fish was obtained from Beattie (2001) and was adapted for the new model groupings by assuming that 1/6th of the proportion of forage fish in their diet is obtained from eulachon (Vasconcellos and Pitcher 2002e) and the proportion of the diet attributed to benthic invertebrates was divided into infaunal carnivorous invertebrates and infaunal invertebrate detritivores. This estimate was used for all four models

A small amount of shallow water benthic fish is caught with groundfish trawlers in the 2000 model (0.001 kg•km^{-2}•yr^{-1} – see Appendix A Table A2 obtained from Beattie (2001)). In the 2000 model, a small amount of shallow water benthic fish is caught and discarded (Beattie 2001) by the groundfish trawl fishery (0.04 kg•km^{-2}•yr^{-1} - see Appendix A Table A2) and the shrimp fishery (0.001 kg•km^{-2}•yr^{-1} - see Appendix A Table A1 obtained from Hay *et al.* (1999)).

39) Skates

This compartment consists mostly of skates, although the few stingrays and sharks that are present in the system are also included. The skates include the big skate, longnose skate, starry skate, black skate and the deep-sea skate (Beattie 2001), while the sharks include the tope shark, great white shark, broadnose sevengill shark, bluntnose sixgill shark, blue shark and basking shark and the stingrays include the diamond stingray and Pelagic stingray (Froese and Pauly, 2002). The 1950 and 2000 biomass estimate of this compartment (0.36 t•km^{-2}) was obtained from Beattie (2001), while for the 1900 and 1750 models, the biomasses of skates were estimated using ecotrophic efficiencies of 95%.

The 1950 and 2000 P/B ratio for skates (0.31 yr^{-1}) was obtained from Beattie (2001) (Table A1.26), and the natural mortality (0.15 yr^{-1}) estimated in Appendix B Table B1 was used for the 1900 and 1750 models. The 1950 and 2000 Q/B ratio for skates (1.24 yr^{-1}) was obtained from Beattie (2001), and the ratio (1.2 yr^{-1}) calculated in Appendix B Table B2 was used for the 1900 and 1750 models. The diet of skates was obtained from Beattie (2001) and was adapted for the new model groupings by assuming that 1/6th of the proportion of forage fish in their diet is obtained from eulachon (Vasconcellos and Pitcher 2002e) and the proportion of the diet attributed to benthic invertebrates was divided into infaunal carnivorous invertebrates and infaunal invertebrate detritivores. This estimate was used for all four models.

Skates are caught with groundfish trawlers in the 2000 model (0.02 t•km^{-2}•yr^{-1} – see Appendix A Table A2 obtained from Beattie (2001)). A very small catch of skate was included in the 1950 model, 0.0895 kg•km^{-2}•yr^{-1} (DFO 1995). Only half this amount was indicated by the DFO catch records for groundfish trawl in 1951, but an equal value was arbitrarily assigned to longline, in order to account for some level of bycatch. Skates are caught and discarded Beattie (2001) by the groundfish trawl fishery (0.007 t•km^{-2}•yr^{-1} - see Appendix A Table A2) and the shrimp fishery (0.0005 t•km^{-2}•yr^{-1} - see Appendix A Table A1 obtained from Hay *et al.* (1999)) in the 1950 and 2000 models.

40-41) Large and small crabs

Crabs are divided into large crabs, with a carapace length of more than 120 mm, and small crabs – carapace length less than 120 mm. The large crabs include mostly Dungeness crab, but also the red rock crab, tanner crab and king crab, while the small crabs include the juveniles (< 120 mm carapace length) and other small crabs such as kelp crab (Beattie 2001). The biomasses of both large and small crabs were estimated by setting their ecotrophic efficiencies at 95% in all four models.

The P/B ratios of large (1.5 yr^{-1}) and small (3.5 yr^{-1}) crabs were obtained from Beattie (2001) (Table A1.26) and used in all four models. The Q/B ratios of both large and small crabs were estimated by setting their P/Q ratios at 0.3 and 0.25 respectively for all four models. The diets of large and small crab were obtained from Beattie (2001) and the proportion of the diet attributed to benthic invertebrates was divided into infaunal carnivorous invertebrates and infaunal invertebrate detritivores.

In the 2000 model, a very small amount of large crabs are caught with groundfish trawlers (0.003 kg•km^{-2}•yr^{-1} – see Appendix A Table A2 obtained from Beattie (2001)), while the main fishery for large crabs is the crab trap fishery, which catches approximately 0.053 t•km^{-2}•yr^{-1} (Beattie 2001). Forrest (2002) summarizes the recreational catch (0.0016 t•km^{-2}•yr^{-1}) of large crabs from an unpublished DFO survey. Total catch in 1951 was then 0.055 t•km^{-2}•yr^{-1}. The 1950 model applies 1951 DFO catch statistics (DFO 1995) for Hecate Strait and Dixon Entrance. Historical records indicate that only 0.0053 t•km^{-2}•yr^{-1} of large crabs were caught commercially during that time, which is an order of magnitude less than the present-day catch. About 91% was caught by trap, and the remainder by groundfish trawl. Forrest (2002) estimates the recreational catch as 9% of the present-day value. Total catch in 1951 was then 0.0054 t•km^{-2}•yr^{-1}. Both large (0.2 kg•km^{-2}•yr^{-1}) and small (0.04 kg•km^{-2}•yr^{-1}) crabs are caught and discarded (Beattie 2001) with groundfish trawl fishery (Appendix A Table A1) in the 2000 model.

42) Commercial shrimp

This group includes the penaeid prawn and shrimp: smooth shrimp, spiny shrimp, pink shrimp, coonstripe, humpback shrimp, sidestripe and prawn (Beattie 2001). The 2000 biomass estimate of this compartment (0.06 t•km^{-2}) was obtained from (Beattie 2001), and the biomass of commercial shrimp in the 1950, 1900 and 1750 models were estimated assuming an ecotrophic efficiency of 95%.

The 1950 and 2000 P/B ratio for shrimp (11.5 yr-^{1}) was obtained from Beattie (2001), Table A1.26, and for the 1900 and 1750 models it was assumed that the P/B was approximately 50% of the 2000 P/B as there was no fishing mortality. The Q/B ratio of shrimp was calculated by assuming a P/Q ratio of 25% in all four models. The diet of shrimp was obtained from Beattie (2001) and used in all four models.

In the 2000 model, a very small amount of shrimp is caught with groundfish trawls (0.001 kg•km^{-2}•yr^{-1} – see Appendix A Table A2 obtained from Beattie (2001)), while the shrimp trawl fishery catches 0.05 t•km^{-2}•yr^{-1} (Beattie 2001). The prawn trap fishery in the 2000 model harvests approximately 0.006 t•km^{-2}•yr^{-1} (Beattie 2001). Forrest (2002) cites an unpublished DFO survey that identifies a small recreational catch of commercial shrimp (0.4 kg•km^{-2}•yr^{-1}). The 1950 model assumes a catch of 0.612 kg•km^{-2}•yr^{-1}, caught entirely by shrimp trawl, after 1951 DFO catch statistics (DFO 1995). A very small amount of shrimp (0.004 kg•km^{-2}•yr^{-1} – see Appendix A Table A2) is caught and discarded (Beattie 2001) by the groundfish trawl fishery in the 2000 model.

43-45) Epifaunal, infaunal carnivorous and detritivorous invertebrates

Epifaunal invertebrates include echinoderms, molluscs, cnidarians and amphipods, while infaunal carnivorous invertebrates include mostly polychaetes, and infaunal invertebrate detritivores include the nemertea, gastropoda, pelecypoda, scaphopoda, ostracoda, cumacea, isopoda, amphipoda, decapoda, sipunculida, ophiuroidea, echinoidea, and holothuroidea that feed on detritus. The biomass of epifaunal invertebrates was estimated in all four models by assuming an ecotrophic efficiency of 95%, while that of the polychaetes were extracted from the benthic infaunal biomass given by Beattie (2001) to give biomass estimates of 13.25 $t \bullet km^{-2}$ and 34.305 $t \bullet km^{-2}$ each for carnivorous and detritivorous infauna in the 1950 and 2000 models. The biomasses of both infaunal compartments were estimated in the 1900 and 1750 models by assuming ecotrophic efficiencies of 95% for each.

The P/B ratios of epibenthic invertebrates (1.4 yr^{-1}) and detritivorous infauna (1.3 yr^{-1}) were obtained from Beattie (2001), while that of carnivorous invertebrates (2.0 yr^{-1}) was obtained from Jarre-Teichmann and Guénette (1996), and these ratios were used for all four models. The Q/B ratios of all three invertebrate groups were estimated by assuming a P/Q ratio of 0.09 (Beattie 2001) in all four models. The diets of epifaunal invertebrates and detritivorous infauna were obtained from Beattie (2001), and it was assumed that carnivorous infauna feed mostly on detritus, but also on detritivorous infauna. These estimates were used in all four models

In the 2000 model, a very small amount of epifaunal invertebrates are caught by groundfish trawlers (0.08 $kg \bullet km^{-2} \bullet yr^{-1}$ – see Appendix A Table A2, Beattie 2001), but the largest fisheries for epifaunal invertebrates (0.078 $t \bullet km^{-2} \bullet yr^{-1}$) are for sea urchins, *Stronglyocentrotus* spp., and sea cucumbers, *Parastichopus californicus* (Beattie 2001). Forrest (2002) cites an unpublished DFO survey that identifies a recreational catch of 0.00022 $t/km^2/yr$, composed of clams, oysters and other shellfish. DFO archives report that the commercial harvest of epifaunal invertebrates in 1950 was approximately 37.7% of present day. The 1950 estimate was therefore taken as 0.0294 $t \bullet km^{-2} \bullet yr^{-1}$; this amount accounts for butter clams primarily. Recreational catch in 1950 was assumed to be 9% of the present-day value after Forrest (2002). Total catch used in the 1950 model was 0.029 $t \bullet km^{-2} \bullet yr^{-1}$. Vasconcellos and Pitcher (2002i) suggest that aboriginal fisheries for invertebrates always existed, but with no estimate of catch we assume a very small catch of 0.5 $kg \bullet km^{-2} \bullet yr^{-1}$ each for epifaunal invertebrates and infaunal detritivores in the 1750 model and an even smaller catch of 0.1 $kg \bullet km^{-2} \bullet yr^{-1}$ each in the 1900 model, as there was a large reduction in First Nations people from pre-contact. Epifaunal invertebrates (0.002 $t \bullet km^{-2} \bullet yr^{-1}$) and detritivorous infaunal invertebrates (0.003 $kg \bullet km^{-2} \bullet yr^{-1}$ – see Appendix A Table A2) are caught and discarded (Beattie 2001) by the groundfish trawl fishery in the 1950 and 2000 models.

46) Carnivorous jellyfish

The 1950 and 2000 biomass estimate of jellyfish (3.0 $t \bullet km^{-2}$) was obtained from Beattie (2001), while in the 1900 and 1750 models it was estimated by assuming an ecotrophic efficiency of 95%. The P/B ratio for jellyfish (18 yr^{-1}) was obtained from Beattie (2001) (Table A1.26) and used in all four models. The Q/B ratio for jellyfish (60 yr^{-1}) was obtained from Beattie (2001) and used in all four models. Beattie (2001) suggests that the diet of jellies consists primarily of small zooplankton, zooplankton eggs and other jellies. The 10% attributed to carnivorous jellies in Beattie (2001) is split into 5% jellies and 5% copepods. This estimate was used for all four models.

Jellyfish (0.03 $kg \bullet km^{-2} \bullet yr^{-1}$: see Appendix A Table A2) are caught and discarded by the groundfish trawl fishery and large amounts of jellyfish are caught in salmon gillnets during the warmest months (Beattie 2001). No data are available, but a catch of 0.0001 $t \bullet km^{-2} \bullet yr^{-1}$ was assumed in the 1950 and 2000 models.

47-48) Euphausiids and copepods

Euphausiids in the Hecate Strait consist of three species (*Thysanoessa spinifera*, *T. longipes* and *Euphausia pacifica*) that account for 90% of biomass (Beattie 2001). Copepods include *Pseudocalanus* spp., *Oithona* spp. and *Acartia* spp. (Beattie 2001). The biomass estimates of euphausiids (8.70 $t \bullet km^{-2} \bullet$) and copepods (4.7 $t \bullet km^{-2}$) in the 1950 and 2000 models were obtained from Beattie (2001), while their biomasses were estimated for the 1900 and 1750 models by assuming an ecotrophic efficiency of 95% each. The P/B ratios for euphausiids (6.1 yr^{-1}) and copepods (27 yr^{-1}) were obtained from Beattie (2001) (Table A1.26) and used in all four models. The 1950 and 2000 Q/B ratio for euphausiids (24.8 yr^{-1}) was obtained from Beattie (2001) and that of copepods (99 yr^{-1}) was calculated by assuming a P/Q ratio of 30%. These Q/B ratios were also used for the 1900 and 1750 models. The diets of both euphausiids and copepods were obtained from (Beattie 2001) and used in all four models.

49) Corals and sponges

Sponge biomass is estimated to be approximately 300 t•km^{-2} in areas of sponge reef that have not been affected by bottom trawling and other forms of seafloor impacts (Conway 2002). The habitat in the study area that is suitable to these organisms is estimated at approximately 700 km^2 according to Conway (2002). It is estimated that 30-50 % of the total sponge reef area has been affected by trawling and other forms of seafloor impacts through fishing (Conway 2002). The areas covered by the sponge reefs or sponge mud mounds is about 700 km^2 (Conway 2002) and if a 30 – 50 % reduction in sponge populations has occurred since the initiation of bottom dragging then the biomass value we would assign to all the sponges on the sponge reefs in total would be on the order of 150 – 210 t•km^{-2}. Thus the overall biomass of corals and sponges for the Hecate Strait is 1.9 t•km^{-2} in the 2000 model and prior to trawling it was probably closer to 3.2 t•km^{-2} (1900 and 1750 model). The 1950 model uses the mean value between the 1900 and 2000 estimates, which is 2.6 t t•km^{-2}.

Conway (2002) suggested an annual P/B ratio of 0.01 yr^{-1}, which we used for all four models. A Q/B ratio of 2.0 yr^{-1} used in all four models, although no good information is available on this. We assume that the corals and sponges filter detritus from the water column.

50) Macrophytes

This compartment consists of bull kelp and giant kelp; also seaweeds and sea grasses. The 1950 and 2000 biomasses of macrophytes (5.3 t•km^{-2}) were obtained from Beattie (2001) and Sloan (2002) and suggest that the 2000 biomass is probably the same as in the 1900s, but higher in the 1750s when sea otters were abundant. It was thus assumed that the 1750s biomass (10.6 t•km^{-2}) is double that of the 1900 and 2000 models. The P/B ratio for macrophytes (5.3 yr^{-1}) was obtained from Beattie (2001) (Table A1.26) and used in all four models.

51) Phytoplankton

The biomass of phytoplankton (15.4 t•km^{-2}) was obtained from Beattie (2001) and it was assumed that the biomass was similar for all four time-periods. The P/B ratio for phytoplankton (179 yr^{-1}) was obtained from Beattie (2001) (Table A1.26) and it was assumed that primary production was similar for all four time periods.

52) Discards

Fishery discards were captured in this compartment to link birds and other discard feeders to discards. The 1950 and 2000 discard pool biomass (0.07 t•km^{-2}) was obtained from Beattie (2001) and it was assumed that nothing was discarded in 1900 or 1750.

53) Detritus

A single detritus pool (10 t•km^{-2}) was obtained from Beattie (2001) and assumed to be similar for all four models. In future improvements to the model, two detritus pools might be added, one for dissolved and one for particulate matter.

BALANCING THE MODELS

Adult herring and copepods were reduced in the diet of Mysticetae in order to balance those two groups. Accordingly, euphausids were increased in the diet of Mysticetae, as they were already a major component (84% according to Beattie, 2001).

The proportion of seals and sea lions in the diet of toothed whales was reduced to balance the 2000 model, and transient salmon was increased. Inshore rockfish was reduced as a diet component of Odontocetae, and planktivorous rockfish was increased in the 2000 model. In the 1750 model, a very small proportion of forage fish in the diet of toothed whales (0.004 kg•km^{-2}•yr^{-1}) was transferred to sea otters to incorporate the effect of the larger sea otter population on the diet of toothed whales.

To balance chinook and coho salmon in the 2000 model, their percentages in the diet of seals and sea lions were reduced, and the transient salmon was increased. Pollock was reduced in the diet for balance, and turbot and flatfish were added, and juvenile sablefish was added to the diet to take some of the pressure off adult sablefish in the 2000 model. For subsequent balancing of adult lingcod in the 1750 model, adult lingcod was added to the diet of seals and sea lions and the 0.03 was reduced from the juvenile Pacific cod in their diet. Except for minor changes required in balancing, the 1950 diet matrix remains unaltered from 2000. After balancing, the final diet matrices are given in Appendix D.

Ratfish was reduced in the 2000 diet of dogfish, and adult planktivorous rockfish was added to balance ratfish in this model. In the 1750 model the percentages of coho and chinook salmon in the diet of dogfish were reduced even more, to balance those compartments. Final ratfish diet is given in Appendix D Table D8.

The percentage of juvenile pollock in the diet of adult pollock was reduced by 5% and the remainder went to forage fish. Cannibalism in juvenile pollock was excluded and the 5.7% was added to juvenile flatfish. Final diet matrix of pollock appears in Appendix D Table D10.

In order to balance adult herring in the 1950 model it was necessary to drastically reduce it in the diet of most of its predators, particularly chinook, dogfish, inshore rockfish and lingcod. Since the 1950 diet matrix was based on 2000, it is not surprising that the much smaller biomass of herring in 1950 could not support all of its benefactors. Even still we had to accept a negative biomass accumulation of 50% per year. Although a negative biomass accumulation may be reasonable considering the damaging reduction fishery, this estimate is probably high.

The biomass accumulation for Pacific Ocean perch ($-0.3\ t•km^{-2}•yr^{-1}$) was too high and we reduced it to - $0.15\ t•km^{-2}•yr^{-1}$ to balance the present-day model. The biomass accumulation was removed entirely for the 1950 model.

To balance juvenile pollock in the 2000 model, predation by adult Pollock was shifted to juvenile turbot.

To balance juvenile planktivorous rockfish in the 2000 model, predation by inshore rockfish was added to juvenile turbot.

To balance the shallow water benthic fish in the 2000 model, the percentage eaten by adult halibut was added to adult flatfish. The discards in the 2000 diet of adult halibut were assumed to be detritus in the 1750 model, as no discards were available at that time.

To balance juvenile flatfish in the 2000 model, their contribution (20%) to the diet of large crabs was reduced to 10%, and the contribution of detritus was increased to 30%. These estimates were used for all four models.

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APPENDICES

APPENDIX A. BYCATCH AND DISCARDS

***Table A1**: Bycatch to the shrimp trawl fishery. (Source: Hay et al. 1999)*

Species	Catch (kg)	% of target species	Catch (kg•km^{-2}•yr^{-1})
Pink shrimp smooth	73.100		
Side-stripe shrimp	8.662		
Pink shrimp	3.731		
Prawn	0.370		
Coon stripe shrimp	0.315		
Total shrimp	86.177		52.000
Eulachon	7.660	0.089	4.622
Eelpouts (Shallow water benthic fish)	1.982	0.023	1.196
Arrowtooth flounder (Turbot)	1.156	0.013	0.698
Walleye pollock	0.392	0.005	0.059
Dover sole	0.303	0.004	
Flathead sole	0.901	0.010	
Rex sole	0.790	0.009	
English sole	0.550	0.006	
Slender sole	0.505	0.006	
Pacific sanddab	0.298	0.003	
Total flatfish		0.039	2.019
Spotted ratfish*	2.071	0.024	1.250
Spiny dogfish*	0.943	0.011	0.569
Longnose skate*	0.388	0.004	
Big skate*	0.482	0.006	
Total skate		0.010	0.525

***Table A2**: By-catch and discards from the groundfish trawl fishery. (Source: DFO observer database. Adapted from Beattie, 2001)*

Compartment	Catches (tonnes)		Catch (t/km^2)	
	Retained	Discarded	Retained	Discarded
Coho salmon	0.003	0.038	0.000	0.001
Chinook salmon	0.118	0.684	0.002	0.010
Squid	0.116	1.544	0.002	0.022
Ratfish	3.600	716.000	0.052	10.234
Dogfish	15.800	636.000	0.226	9.082
Pollock	469.800	171.000	6.712	2.448
Forage fish	-	3.300		0.040
Eulachon*				0.007
Adult herring	0.152	19.000	0.002	0.278
Adult Pacific Ocean perch	4547.000	153.000	64.959	2.184
Inshore rockfish	22.000	13.000	0.314	0.192
Adult piscivorous rockfish	1580.000	24.000	22.581	0.339
Adult planktivorous rockfish	5354.000	355.000	76.482	5.065
Adult turbot	1227.000	1826.000	17.527	26.089
Adult flatfish	3694.000	-	52.775	
Juvenile halibut#			0.052	2.609
Adult halibut#	7.200	365.000	0.052	2.609
Adult Pacific cod	1271.000	107.000	18.161	1.531
Adult sablefish	42.000	225.000	0.595	3.219
Adult lingcod	483.000	91.000	6.897	1.298
Shallow water benthic fish	0.043	2.800	0.001	0.040
Skates	1141.000	480.000	16.302	6.856
Large crabs	0.185	16.000	0.003	0.225
Small crabs	0.014	2.600	0.000	0.037
Shrimp	0.047	0.292	0.001	0.004
Epifaunal invertebrates	5.735	164.000	0.082	2.347
Infaunal invertebrates	-	0.203		0.003
Carnivorous jellyfish	-	2.400		0.034

* It is assumed that 1/6th of the forage fish discarded is eulachon.
# The catch of halibut was split into adult and juvenile halibut (50:50).

APPENDIX B. PARAMETER ESTIMATION

The P/B and Q/B ratios of all fish species (Tables B1 and B2) were calculated by using empirical formulas obtained from Palomares and Pauly (1998). The formula used for M is from Pauly (1980):

$$M = k^{(0.65)} * L_{oo}^{(-0.279)} * T^{(0.463)} \text{ or } \log M = 0.0066 - (0.279 * \text{Log}_{10}(L_{oo})) + (0.65431*\text{Log}_{10}(k)) + (0.4631* \text{Log}_{10}(T))$$

The formula for Q/B is from (Christensen and Pauly, 1992):

$$Q/B = 10^{6.37} * 0.0313^{Tk} * W_{oo}^{(-0.168)} * 1.38^{Pf} * 1.89^{Hd}.$$

W_{oo} was estimated from the length-weight formula ($W(g) = a * L^b$) and the values used for k, L_{oo} (cm) temperature (°C), a and b were obtained from Fishbase 2000 and references therein.

Pf was 1 for predators and zooplankton feeders and 0 for herbivores, and Hb was 1 for herbivores and 0 for predators and zooplankton feeders.

In most instances the M and Q/B estimates of juveniles were assumed to be 1.5 x that of adults and the sex ratio was assumed to be 50:50.

***Table B1**. M estimated for all fish compartments.*

#	Species	K	L_{oo}	T	M^*	$M^\#$	Juvenile M	FishBase Reference
	sockeye	0.58	69	12	0.68053	0.68951		1149
	chum male	0.27	120	12	0.35478	0.35827		
	chum female	0.3	102	12	0.39755	0.40165		1150
	pink	0.33	78.5	12	0.45502	0.4599		
6	**Transient salmon**				**0.47197**	**0.47733**		
7	**Coho**	**0.98**	**80**	**12**	**0.91832**	**0.93254**		**4937**
8	**Chinook**	**0.13**	**150.3**	**12**	**0.20718**	**0.20857**		
	Ratfish male	0.221	96	4	0.19932	0.20109		785
	ratfish female	0.196	79	4	0.19466	0.19629		785
11	**Ratfish average**				**0.19699**	**0.19869**		
	Dogfish female	0.031	125	7	0.06693	010040		1280
	Dogfish male	0.092	84.7	7	0.15131	0.22696		1280
12	**Dogfish average**				**0.10912**			
	Pollock female	0.092	94.4	7	0.1468	0.14755		960
	Pollock male	0.097	79.8	7	0.15923	0.16008		960
14	**Pollock average**				**0.15301**	**0.15382**	**0.22952**	**960**
	capelin male	0.48	20	7	0.66237	0.67052		1080
	capelin female	0.48	19	7	0.67192	0.68018		1080
	chub mackerel California	0.25	42.3	10	0.41487	0.41881		5896
	chub mackerel California 1933-34	0.221	40.5	10	0.38759	0.39107		
	chub mackerel California 1958-70	0.244	43.6	10	0.40494	0.40874		
	chub mackerel California 1939-52	0.4	40	10	0.57196	0.57856		
	slender black smelt	0.14	27	7	0.27347	0.27537		
	California anchovy	0.45	16.4	10	0.79186	0.8014		907
	South American pilchard 1937	0.57	25.1	10	0.81999	0.83073		841
	South American pilchard 1938	0.55	29.1	10	0.76879	0.77874		841
	South American pilchard 1939	0.54	29.3	10	0.75823	0.76797		841
	South American pilchard 1941	0.52	30	10	0.735	0.74432		841
	South American pilchard 1942	0.53	30.2	10	0.74278	0.75226		841
	American shad	0.13	78.5	10	0.22824	0.22976		
15	**Forage fish average**				**0.588**	**0.59489**		
16	**Eulachon**	**0.3**	**31.5**	**12**	**0.55177**	**0.55746**		
17	**Herring**	**0.48**	**27**	**12**	**0.78184**	**0.7915**	**1.17276**	**839**
19	**Pacific Ocean Perch**	**0.13**	**45.3**	**7**	**0.22558**	**0.22707**	**0.33836**	
	Copper rockfish	0.12	50	10	0.24573	0.24728		4512
	yelloweye rockfish	0.05	93.5	10	0.11681	0.1171		
21	**Inshore rockfish**				**0.18127**	**0.18219**		
	black rockfish	0.143	60	4	0.17125	0.17244		2012
	blue rockfish	0.168	38.7	10	0.32846	0.33101		1227
	chilipepper male	0.3	38.7	7	0.40592	0.41008		6998
	chilipepper female	0.18	53.2	7	0.26649	0.26863		6998
23	**Piscivorous rockfish**				**0.29303**	**0.29554**	**0.43954**	
	puget sound rockfish	0.704	13.7	7	0.94419	0.95738		27786
	puget sound rockfish	0.535	17.1	7	0.74251	0.752		27786
	yellowtail rockfish male	0.153	48.5	7	0.24604	0.24784		35371
	yellowtail rockfish female	0.157	52.3	7	0.24499	0.24682		35371

#	Species	K	L_{oo}	T	M^*	$M^\#$	Juvenile M	FishBase Reference
	shortbelly rockfish female	0.211	32.4	7	0.33933	0.34229		2707
	shortbelly rockfish male	0.298	29	7	0.43804	0.44252		2707
	bocaccio female	0.11	87.8	7	0.16825	0.16924		6998
	bocaccio male	0.13	76.6	7	0.19482	0.19611		6998
	canary rockfish	0.12	78.5	7	0.18369	0.18484		
25	**Planktivorous rockfish**				**0.3891**	**0.39323**	**0.58364**	
	butter sole male	0.36	38	4	0.35448	0.35838		4948
	butter sole female	0.26	42	4	0.279	0.28167		4948
	english sole female	0.243	41.6	4	0.26771	0.2702		1094
	english sole male	0.347	30.7	4	0.36733	0.37131		1094
	pacific sanddab	0.3	30	4	0.33633	0.33976		754
	petral sole male	0.16	49	4	0.19492	0.19638		1090
	petral sole female	0.167	58.6	4	0.19067	0.19213		1090
	rocksole male	0.12	48.8	4	0.16186	0.16287		5830
	rocksole female	0.15	55	4	0.18099	0.18229		5830
	starry flounder male	0.229	44.8	4	0.25231	0.25459		1098
	starry flounder female	0.192	51	4	0.21701	0.21881		1098
29	**Average flatfish**				**0.25478**	**0.25712**	**0.38218**	
30	**Pacific halibut**	**0.05**	**215**	**4**	**0.06369**	**0.06386**	**0.09553**	**950**
32	**Pacific cod**	**0.19**	**114**	**4**	**0.17221**	**0.17363**	**0.25832**	**5817**
34	**Sablefish**	**0.19**	**94**	**4**	**0.18174**	**0.18323**	**0.2726**	**5818**
	Lingcod female	0.18	113	7	0.21597	0.21771		34120
	Lingcod male	0.27	86.1	7	0.30325	0.30622		34120
37	**Lingcod average**				**0.25961**	**0.26196**	**0.38942**	**34120**
	green sturgeon	0.087	190	7	0.11647	0.11703		718
	cabezon	0.342	57.7	7	0.39539	0.39967		1224
	snowy snailfish	0.3	20	7	0.488	0.49301		871
	white sturgeon	0.04	350	7	0.05927	0.05936		1766
	red irish lord		53	7				
	kelp greenling	0.17	63.2	7	0.24472	0.24663		
	rock greenling		63.2	7				
	cutthroat trout summer	0.25	101.8	7	0.27528	0.27789		
	cutthroat trout winter	0.25	101.8	7				
38	**Shallowwater benthic feeders**				**0.26319**	**0.2656**		
	shortfin mako	0.07	321	7	0.08735	0.0877		6100
	broadnose sevengill shark	0.25	202	7	0.22738	0.22953		34307
	pacific angelshark female	0.162	126	7	0.19564	0.19712		6147
	pacific angelshark male	0.152	126	7	0.1877	0.18907		6147
	great white shark	0.058	653	7	0.06341	0.06361		31510
	basking shark	0.062	1000	7	0.05879	0.05899		9030
	tope shark	0.11	175	7	0.1388	0.13961		777
	blue shark male	0.18	295	7	0.16524	0.16657		6100
	blue shark female	0.25	242	7	0.2162	0.21825		6100
39	**Skates and sharks**				**0.14895**	**0.15005**		

* calculated using Pauly (1980)
\# calculated using Palomares and Pauly (1998)

***Table B2**: Calculations of Q/B for all fish compartments.*

#	Species	L_{oo}	a	b	W_{oo}	Temp. °C	Pf	Hd	Q/B	Juvenile Q/B	FishBase reference
	sockeye	69	0.019223	3	6315	3.51	1	0	3.93078		
	chum average	111	0.014083	3	19261	3.51	1	0	3.25922		
	pink	78.5	0.00336	3.3	6017	3.51	1	0	3.96276		7231
6	**Transient salmon**								**3.71759**		
7	**Coho**	**80**	**0.0112**	**3**	**5734**	**3.51**	**1**	**0**	**3.99499**		
8	**Chinook**	**150.3**	**0.01333**	**3**	**45275**	**3.51**	**1**	**0**	**2.82329**		
	Ratfish male	96			0	3.61					
	ratfish female	79			0	3.61					
	Dogfish female	125									
	Dogfish male	84.7									
12	**Dogfish average**	**104.85**	**0.00396**	**3.004**	**4650**	**3.57**	**1**	**0**	**3.33123**		**4511**
13	Pollock female	94.4	0.0059	3.03	5689	3.57	1	0	3.22032		2831
	Pollock male	79.8	0.0059	3.03	3419	3.57	1	0	3.50786		2831
14	**Pollock average**	**87.1**	**0.0059**	**3.03**	**4554**	**3.57**	**1**	**0**	**3.36409**	**5.04614**	**2831**
15	capelin male	20	0.00146	3.41	40	3.57	1	0	7.40962		1080
	capelin female	19	0.00215	3.25	31	3.57	1	0	7.73913		1080
	chub mackerel California	42.3	0.00137	3.394	453	3.53	1	0	5.61518		4530
	slender blacksmelt	27	0.007	3	138	3.57	1	0	6.01669		0
	California anchovy	16.4	0.0117	2.95	45	3.53	1	0	8.28185		1658
	South American pilchard 1937	25.1	0.00761	3	120	3.53	1	0	7.01699		0
	American shad	78.5	0.0065	2.959	2629	3.53	1	0	4.17953		3762
15	**Forage fish average**								**6.60843**		
17	**Herring**	**27**	**0.00448**	**3.127**	**134**	**3.51**	**1**	**0**	**7.50892**	**11.2634**	**12624**
19	**Pacific Ocean Perch**	**45.3**	**0.0149**	**3**	**1385**	**3.57**	**1**	**0**	**4.08294**	**6.1244**	
	Copper rockfish	50	0.017464	3	2183	3.53	1	0	4.31219		
	yelloweye rockfish	93.5	0.013841	3	11313	3.53	1	0	3.27081		
	quillback rockfish	63.2	0.029659	3	7487	3.53	1	0	3.50571		
21	**Inshore rockfish**								**3.69624**		
	black rockfish	60	0.021111	3	4560	3.61	1	0	2.92338		
	blue rockfish	38.7	0.017266	3	1001	3.53	1	0	4.91591		
	china rockfish	46.9	0.022541	3	2325	3.57	1	0	3.74258		
23	**Piscivorous rockfish**								**3.86062**	**5.79094**	
24	puget sound rockfish	13.7	0.0588	2.687	67	3.57	1	0	6.79755		27786
	puget sound rockfish	17.1	0.0588	2.687	121	3.57	1	0	6.15024		27786
	yellowtail rockfish male	48.5	0.015086	3	1721	3.57	1	0	3.93664		
	yellowtail rockfish female	52.3	0.015086	3	2158	3.57	1	0	3.78978		
	bocaccio female	87.8	0.01321	3	8941	3.57	1	0	2.98476		
	bocaccio male	76.6	0.01321	3	5937	3.57	1	0	3.19727		
	canary rockfish	78.5	0.01379	3	6671	3.57	1	0	3.13532		
25	**Planktivorous rockfish**								**4.28451**	**6.42676**	
	english sole female	41.6	0.00383	3.127	443	3.61	1	0	4.32559		4511
	english sole male	30.7	0.00383	3.127	171	3.61	1	0	5.07419		4511
	petral sole male	49	0.00418	3.135	832	3.61	1	0	3.89082		1090
	petral sole female	58.6	0.00171	3.352	1442	3.61	1	0	3.54716		1090
29	**Average flatfish**								**4.20944**	**6.31416**	
30	**Pacific halibut**	**215**	**0.00314**	**3.24**	**113248**	**3.61**	**1**	**0**	**1.70417**	**2.55626**	
32	**Pacific cod**	**114**	**0.0224**	**2.89**	**19711**	**3.61**	**1**	**0**	**2.28603**	**3.42904**	**4511**
	Lingcod female	113									
	Lingcod male	86.1									
37	**Lingcod average**	**99.55**	**0.0133**	**3**	**13121**	**3.57**	**1**	**0**	**2.79848**	**3.93799**	
38	green sturgeon	190	0.005934	3	40703	3.57			1.67666		
	cabezon	57.7	0.029141	3	5598	3.57			2.33987		
	white sturgeon	350	0.012218	3	523858	3.57			1.09153		
	red irish lord	53	0.028241	3	4204	3.57			2.45515		
	kelp greenling	63.2	0.015583	3	3934	3.57			2.48276		
	rock greenling	63.2	0.012969	3	3274	3.57			2.56055		
	cutthroat trout summer	101.8	0.0138	2.948	11448	3.57			2.0749		3852
	cutthroat trout winter	101.8	0.0234	2.827	11095	3.57			2.08585		3852
38	**Shallowwater benthic feeders**								**2.09591**		
	shortfin mako	321	0.05	2.32	32663	3.57			1.7398		8588
	broadnose sevengill shark	202			0	3.57					
	pacific angelshark female	126			0	3.57					
	pacific angelshark male	126			0	3.57					
	great white shark	653	0.00758	3.085	3661647	3.57			0.78734		27093
	basking shark	1000	0.00494	3	4940000	3.57			0.74871		6032
	tope shark	175	0.0181	2.72	22842	3.57			1.84754		
	blue shark male	295	0.0131	3.2	1048822	3.57			0.97137		776
	blue shark female	242	0.0131	3.2	556520	3.57			1.08049		776
39	**Skates and sharks**								**1.19588**		

APPENDIX C. PARAMETERS USED IN MODELS

***Table C1**. Basic parameters for the 2000, 1950, 1900 and 1750 Ecopath models. Values in bold were calculated by Ecopath.*

	Biomass (t•km^{-2})				Production/Biomass ratio (yr^{-1})				Consumption/Biomass ratio (yr^{-1})			
Groups	**2000**	**1950**	**1900**	**1750**	**2000**	**1950**	**1900**	**1750**	**2000**	**1950**	**1900**	**1750**
Sea otters	0.0001	0.000	0.0001	0.0016	0.130	0.130	0.130	0.130	101.500	101.500	101.500	101.500
Mysticetae	1.3390	1.339	1.5410	2.6720	0.020	0.020	0.020	0.020	9.100	9.100	8.000	8.000
Odontocetae	0.0613	0.061	0.0656	0.0660	0.040	0.020	0.040	0.040	15.500	15.500	15.600	15.600
Seals, sea lions	0.0520	0.057	0.0690	0.0800	0.060	0.060	0.060	0.060	15.100	15.100	15.100	15.100
Seabirds	0.0074	0.011	0.0147	0.0074	0.100	0.100	0.100	0.100	105.200	105.200	105.200	105.200
Transient salmon	0.5880	0.754	0.8400	1.0080	2.480	2.480	0.621	0.517	8.330	8.330	3.718	3.718
Coho salmon	0.0240	0.067	0.0800	0.0960	2.760	2.760	1.069	1.157	13.800	13.800	3.995	3.995
Chinook salmon	0.0180	0.026	0.1200	0.1440	2.160	2.160	0.364	0.366	10.800	10.800	2.823	2.823
Small squid	**0.8446**	**0.955**	**0.7955**	**1.2068**	6.023	6.023	6.023	6.023	34.675	34.675	34.675	34.675
Squid	**0.2833**	**0.316**	**0.2587**	**0.3986**	6.023	6.023	6.023	6.023	34.675	34.675	34.675	34.675
Ratfish	0.5170	0.517	**0.1828**	**0.2618**	0.099	0.099	0.199	0.199	1.400	1.400	1.400	1.400
Dogfish	0.9090	0.800	**0.4761**	1.3635	0.099	0.099	0.140	0.110	2.719	2.719	3.330	3.330
Juvenile pollock	0.1320	0.132	**0.9264**	**1.3177**	1.061	1.060	0.230	0.230	5.305	5.305	5.046	5.046
Pollock	0.3590	0.359	**0.4795**	**0.6218**	0.263	0.263	0.154	0.153	1.168	1.168	3.364	3.364
Forage fish	**8.4847**	**9.554**	**24.603**	**32.501**	1.432	1.432	0.588	0.595	8.395	8.395	6.608	6.608
Eulachon	**1.6613**	**1.893**	**5.0332**	**7.3152**	1.432	1.432	0.600	0.600	8.395	8.395	6.608	6.608
Juvenile herring	2.2650	1.317	**3.7287**	**5.4463**	2.190	2.190	1.173	1.173	10.950	10.950	11.263	11.263
Adult herring	2.2650	0.748	**2.4798**	**7.5033**	0.683	0.683	0.800	0.792	5.840	5.840	7.509	7.509
Juvenile POP	0.0650	0.036	**0.1531**	**0.2132**	0.672	0.672	0.338	0.338	3.210	3.210	6.124	6.124
Adult POP	1.8190	1.019	**1.0111**	**1.4039**	0.144	0.144	0.227	0.227	2.140	2.140	4.083	4.083
Inshore rockfish	0.1000	0.100	**0.0814**	**0.0959**	0.190	0.190	0.182	0.182	5.688	5.688	5.544	3.696
Juvenile piscivorous rockfish	0.0070	0.008	**0.0158**	**0.0198**	0.261	0.261	0.261	0.261	1.890	1.890	1.890	1.890
Adult piscivorous rockfish	0.6540	**0.753**	**0.1186**	**0.1375**	0.037	0.037	0.037	0.037	1.260	1.260	1.260	1.260
Juvenile planktivorous rockfish	0.1360	0.189	**0.1337**	**0.2067**	0.261	0.261	0.261	0.261	3.210	3.210	3.210	3.210
Adult planktivorous rockfish	1.2070	**1.664**	**1.2862**	**2.0859**	0.068	0.068	0.068	0.068	2.140	2.140	2.140	2.140
Juvenile turbot	0.2180	0.218	**0.1697**	**0.2480**	0.330	0.330	0.330	0.330	2.172	2.172	2.172	2.172
Adult turbot	1.5300	1.530	**1.3415**	**2.1965**	0.220	0.220	0.220	0.220	1.983	1.983	1.983	1.983
Juvenile flatfish	0.2590	0.150	**1.6062**	**2.5827**	1.935	1.935	0.382	0.382	6.023	6.023	6.314	6.314
Adult flatfish	0.3920	**0.221**	**1.0143**	**1.7652**	0.949	0.949	0.257	0.257	4.270	4.270	4.209	4.209
Juvenile halibut	0.6080	0.406	**0.2955**	**0.4446**	0.600	0.600	0.116	0.099	1.460	1.460	2.556	2.556
Adult halibut	0.6080	0.429	0.6080	1.0000	0.400	0.400	0.084	0.067	1.095	1.095	1.704	1.704
Juvenile Pacific cod	0.0890	0.047	**0.3073**	**0.4645**	1.980	1.980	0.258	0.258	7.500	7.500	3.429	3.429
Adult Pacific cod	0.1630	0.086	**1.2192**	**2.0392**	1.320	1.320	0.174	0.174	4.000	4.000	2.286	2.286
Juvenile sablefish	0.1190	0.238	**0.1078**	**0.1805**	0.600	0.600	0.273	0.273	7.000	7.000	7.000	7.000
Adult sablefish	0.3010	0.602	**0.1374**	**0.1912**	0.276	0.276	0.184	0.183	3.730	3.730	3.730	3.730
Juvenile lingcod	0.0310	0.078	**0.0045**	**0.0056**	1.200	1.200	0.389	0.389	3.300	3.300	3.938	3.938
Adult lingcod	0.0340	0.085	**0.1191**	**0.1476**	0.800	0.800	0.300	0.262	3.300	3.300	2.798	2.798
Shallow-water benthic fish	0.5090	0.509	**4.4640**	**7.5060**	1.500	1.500	0.266	0.266	5.256	5.256	2.096	2.096
Skates	0.3350	0.335	**0.1669**	**0.2393**	0.310	0.310	0.150	0.150	1.240	1.240	1.196	1.196
Large crabs	**0.4421**	**0.310**	**0.3878**	**0.6525**	1.500	1.500	1.500	1.500	5.000	5.000	5.000	5.000
Small crabs	**0.6495**	**0.574**	**1.4577**	**2.4070**	3.500	3.500	3.500	3.500	14.000	8.750	14.000	14.000
Commercial shrimp	0.0610	**0.039**	**0.0466**	**0.0704**	11.475	11.480	5.700	5.700	45.900	76.533	22.800	22.800
Epifaunal invertebrates	**13.448**	**11.584**	**28.604**	**42.835**	1.448	1.448	1.448	1.448	16.089	4.052	16.089	16.089
Infaunal carnivorous	13.2451	13.245	**4.9530**	**8.2054**	2.000	2.000	2.000	2.000	22.222	22.220	22.222	22.222
Infaunal invertebrate	34.3051	34.305	**23.450**	**39.280**	1.349	1.349	1.300	1.300	14.989	14.990	14.444	14.444
Carnivorous jellyfish	3.0000	3.000	**3.3628**	**4.6258**	18.000	18.000	18.000	18.000	60.000	60.000	60.000	60.000
Euphausiids	8.7000	8.700	**12.606**	**22.662**	6.100	6.000	6.000	6.000	24.820	24.820	24.820	24.820
Copepods	4.6670	4.667	**8.6707**	**13.128**	27.000	27.000	27.000	27.000	90.000	90.000	99.000	99.000
Corals and sponges	1.9286	1.9286	19.286	19.286	0.010	0.010	0.010	0.010	2.000	2.000	2.000	2.000
Macrophytes	5.2800	5.280	5.2800	10.5600	5.256	5.256	5.256	5.256	-		-	-
Phytoplankton	15.4060	15.406	15.4060	15.4060	178.502	178.502	178.502	178.502	-		-	-
Discards	0.0720	0.072	-	-	-	-	-	-	-		-	-

APPENDIX D. DIET MATRICES

***Table D1**: Mysticetae diet.*

	2000	**1950**	**1900**	**1750**
Forage fish	0.014	0.014	0.014	0.014
Adult herring	0.010	0.001	0.010	0.010
Epifaunal invertebrates	0.037	0.037	0.037	0.037
Infaunal carn. invert.	0.037	0.045	0.037	0.037
Infaunal invert. detritivores	0.658	0.658	0.658	0.658
Euphausiids	0.226	0.226	0.226	0.226
Copepods	0.020	0.020	0.020	0.020

***Table D2:** Odontocetae diet.*

	2000	1950	1900	1750
Seals, sea lions	0.001	0.001	0.001	0.001
Transient salmon	0.041	0.041	0.050	0.050
Coho salmon	0.005	0.011	0.005	0.005
Chinook salmon	0.003	0.005	0.005	0.005
Small squid	0.202	0.202	0.202	0.202
Squid	0.224	0.224	0.224	0.224
Ratfish	0.026	0.026	0.026	0.026
Forage fish	0.162	0.162	0.162	0.161
Eulachon	0.032	0.032	0.032	0.032
Juvenile herring	0.026	0.026	0.026	0.026
Adult herring	0.056	0.040	0.056	0.056
Juvenile POP	0.020	0.005	0.020	0.020
Inshore rockfish	0.002	0.003	0.005	0.005
Juv. planktivorous rockfish	0.006	0.010	0.006	0.006
Ad. planktivorous rockfish	0.020	0.011	0.020	0.020
Juvenile turbot	0.027	0.016	0.026	0.026
Large crabs	0.021	0.019	0.019	0.019
Euphausiids	0.115	0.162	0.115	0.115
Discards	0.012	0.005		

***Table D3**: Seal and sea lion diet.*

	2000	**1950**	**1900**	**1750**
Transient salmon	0.080	0.080	0.080	0.080
Coho salmon	0.002	0.002	0.002	0.002
Chinook salmon	0.005	0.005	0.005	0.005
Small squid	0.108	0.108	0.108	0.108
Squid	0.011	0.011	0.011	0.011
Dogfish	0.030	0.030	0.030	0.030
Pollock	0.040	0.040	0.040	0.040
Forage fish	0.070	0.070	0.070	0.070
Juvenile herring	0.280	0.280	0.280	0.280
Adult POP	0.121	0.061	0.121	0.121
Inshore rockfish	0.002	0.003	0.003	0.003
Ad. picivorous rockfish	0.004	0.000	0.004	0.004
Juv. planktivorous rockfish	0.004	0.004	0.004	0.004
Ad. planktivorous rockfish	0.035	0.004	0.035	0.035
Adult turbot	0.063	0.010	0.062	0.062
Adult flatfish	0.060	0.062	0.060	0.060
Juvenile Pacific cod	0.060	0.050	0.030	0.030
Juvenile sablefish	0.006	0.020	0.006	0.006
Adult sablefish	0.020	0.031	0.020	0.020
Adult lingcod		0.130	0.030	0.030

Table D4: *Seabird diet.*

	2000	1950	1900	1750
Transient salmon		0.054	0.052	0.052
Small squid	0.050	0.069	0.069	0.069
Squid	0.050			
Forage fish	0.250	0.263	0.263	0.263
Eulachon	0.050	0.079	0.079	0.079
Juvenile herring	0.100	0.105	0.105	0.105
Adult herring	0.050	0.003	0.079	0.079
Small crabs	0.100	0.041	0.041	0.041
Epifaunal invertebrates		0.041	0.041	0.041
Carnivorous jellyfish		0.036	0.001	0.001
Euphausiids	0.300	0.154	0.115	0.115
Copepods		0.156	0.155	0.156
Discards	0.003			
Detritus	0.047			

Table D5*: Coho diet.*

	2000	1950	1900	1750
Squid	0.300	0.300	0.300	0.300
Forage fish	0.167	0.167	0.167	0.167
Eulachon	0.033	0.033	0.033	0.033
Adult herring	0.250	0.250	0.250	0.250
Euphausiids	0.250	0.250	0.250	0.250

Table D6*: Chinook diet.*

	2000	1950	1900	1750
Forage fish	0.333	0.333	0.333	0.333
Eulachon	0.067	0.067	0.067	0.067
Adult herring	0.400	0.400	0.400	0.400
Euphausiids	0.200	0.200	0.200	0.200

Table D7*: Squid diet.*

	Juvenile				Adult			
	2000	1950	1900	1750	2000	1950	1900	1750
Small squid					0.347	0.347	0.347	0.347
Forage fish	0.167	0.167	0.167	0.100	0.327	0.327	0.327	0.327
Eulachon	0.033	0.033	0.033	0.033	0.065	0.065	0.065	0.065
Juvenile herring	0.100	0.040	0.100	0.100				
Adult herring				0.067				
Carnivorous jellyfish	0.250	0.250	0.250	0.250	0.117	0.117	0.117	0.117
Euphausiids	0.330	0.390	0.330	0.330	0.103	0.103	0.103	0.103
Copepods	0.120	0.120	0.120	0.120	0.041	0.041	0.041	0.041

Table D8*: Ratfish diet.*

	2000	1950	1900	1750
Forage fish	0.278	0.278	0.278	0.278
Eulachon	0.056	0.056	0.056	0.056
Epifaunal invertebrates	0.183	0.183	0.183	0.183
Infaunal carn. invert.	0.070	0.070	0.070	0.070
Infaunal invert. detritivores	0.080	0.080	0.080	0.080
Euphausiids	0.334	0.334	0.334	0.334

***Table D9**: Dogfish diet.*

	2000	1950	1900	1750
Transient salmon	0.009	0.054	0.023	0.023
Coho salmon	0.010	0.015	0.003	0.003
Chinook salmon	0.001	0.010	0.003	0.003
Small squid	0.033	0.033	0.033	0.033
Squid	0.055	0.055	0.055	0.055
Ratfish	0.005	0.006	0.005	0.005
Forage fish	0.077	0.077	0.077	0.077
Eulachon	0.015	0.015	0.015	0.015
Juvenile herring	0.041	0.041	0.041	0.041
Adult herring	0.100	0.010	0.100	0.100
Juvenile POP	0.004	0.004	0.004	0.004
Adult POP	0.003	0.003	0.003	0.003
Juv. planktivorous rockfish	0.003	0.003	0.003	0.003
Ad. planktivorous rockfish	0.015	0.005	0.015	0.015
Juvenile turbot	0.005	0.005	0.005	0.005
Adult turbot	0.013	0.020	0.013	0.013
Juvenile flatfish	0.020	0.010	0.020	0.020
Adult flatfish	0.028	0.020	0.028	0.028
Juvenile Pacific cod	0.008	0.008	0.008	0.008
Adult Pacific cod	0.007	0.005	0.007	0.007
Juvenile sablefish	0.004	0.014	0.004	0.004
Adult sablefish	0.002	0.020	0.002	0.002
Shallowwater benthic fish	0.017	0.017	0.017	0.017
Large crabs	0.046	0.037	0.037	0.037
Small crabs	0.036	0.036	0.036	0.036
Epifaunal invertebrates	0.052	0.052	0.052	0.052
Infaunal carn. invert.	0.017	0.019	0.017	0.017
Infaunal invert. detritivores	0.006	0.008	0.006	0.006
Carnivorous jellyfish	0.039	0.039	0.039	0.039
Euphausiids	0.143	0.149	0.143	0.143
Copepods	0.100	0.130	0.100	0.100
Detritus	0.086	0.080	0.086	0.086

***Table D10**: Pollock diet.*

	2000	1950	1900	1750
Squid	0.031	0.031	0.031	0.031
Juvenile pollock	0.100	0.100	0.100	0.100
Forage fish	0.198	0.198	0.198	0.198
Eulachon	0.028	0.028	0.028	0.028
Epifaunal invertebrates	0.022	0.022	0.022	0.022
Euphausiids	0.461	0.461	0.461	0.461
Copepods	0.160	0.160	0.160	0.160

***Table D11:** Forage fish diet.*

	Forage fish				Eulachon			
	2000	**1950**	**1900**	**1750**	**2000**	**1950**	**1900**	**1750**
Epifaunal invertebrates	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
Carnivorous jellyfish	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
Euphausiids	0.150	0.150	0.150	0.150	0.100	0.100	0.100	0.100
Copepods	0.500	0.500	0.500	0.500	0.600	0.600	0.600	0.600
Detritus	0.050	0.050	0.050	0.050				

***Table D12:** Herring diet.*

	Juvenile				Adult			
	2000	**1950**	**1900**	**1750**	**2000**	**1950**	**1900**	**1750**
Euphausiids	0.100	0.100	0.100	0.100	0.900	0.900	0.900	0.900
Copepods	0.900	0.900	0.900	0.900	0.100	0.100	0.100	0.100

***Table D13**: Inshore rockfish diet.*

	2000	1950	1900	1750
Forage fish	0.060	0.060	0.060	0.060
Eulachon	0.012	0.012	0.012	0.012
Juvenile herring	0.300	0.300	0.300	0.300
Adult herring	0.325	0.050	0.325	0.325
Shallowwater benthic fish	0.045	0.045	0.045	0.045
Large crabs	0.005	0.005	0.005	0.005
Small crabs	0.107	0.107	0.107	0.107
Commercial shrimp	0.040	0.095	0.040	0.040
Epifaunal invertebrates	0.050	0.050	0.050	0.050
Infaunal carn. invert.	0.004	0.124	0.004	0.004
Euphausiids	0.052	0.152	0.052	0.052

***Table D14:** Piscivorous rockfish diet.*

	Juvenile				Adult			
	2000	**1950**	**1900**	**1750**	**2000**	**1950**	**1900**	**1750**
Squid					0.140	0.140	0.140	0.140
Forage fish					0.027	0.027	0.027	0.027
Eulachon					0.005	0.005	0.005	0.005
Skates					0.069	0.069	0.069	0.069
Small crabs	0.100	0.100	0.100	0.100	0.130	0.130	0.130	0.130
Commercial shrimp	0.100	0.100	0.100	0.100				
Epifaunal invertebrates	0.100	0.100	0.100	0.100	0.254	0.254	0.254	0.254
Infaunal invert. detritivores					0.040	0.040	0.040	0.040
Carnivorous jellyfish					0.038	0.038	0.038	0.038
Euphausiids	0.400	0.400	0.400	0.400	0.196	0.196	0.196	0.196
Copepods	0.300	0.300	0.300	0.300				
Detritus					0.101	0.101	0.101	0.101

***Table D15**: Planktivorous rockfish.*

	Juvenile				Adult			
	2000	**1950**	**1900**	**1750**	**2000**	**1950**	**1900**	**1750**
Small squid					0.092	0.092	0.092	0.092
Squid					0.110	0.110	0.110	0.110
Forage fish					0.028	0.028	0.028	0.028
Eulachon					0.006	0.006	0.006	0.006
Juvenile herring					0.109	0.109	0.109	0.109
Carnivorous jellyfish					0.006	0.006	0.006	0.006
Euphausiids	0.500	0.500	0.500	0.500	0.574	0.574	0.574	0.574
Copepods	0.500	0.500	0.500	0.500	0.075	0.075	0.075	0.075

Table D16: *Turbot diet.*

	Juvenile				Adult			
	2000	**1950**	**1900**	**1750**	**2000**	**1950**	**1900**	**1750**
Small squid	0.174	0.174	0.174	0.174	0.207	0.207	0.207	0.207
Squid					0.178	0.178	0.178	0.178
Juvenile pollock	0.030	0.030	0.030	0.030	0.009	0.009	0.009	0.009
Pollock	0.070	0.070	0.070	0.070	0.001	0.001	0.001	0.001
Forage fish	0.111	0.111	0.111	0.111	0.107	0.107	0.107	0.107
Eulachon	0.022	0.022	0.022	0.022	0.021	0.021	0.021	0.021
Juvenile herring	0.150	0.150	0.150	0.150	0.099	0.099	0.099	0.099
Adult herring	0.088	0.048	0.088	0.088	0.010	0.010	0.010	0.010
Juvenile POP					0.001	0.001	0.001	0.001
Adult POP					0.025	0.020	0.025	0.025
Inshore rockfish	0.007	0.007	0.007	0.007				
Juv. picivorous rockfish	0.001	0.001	0.001	0.001				
Juv. planktivorous rockfish	0.017	0.017	0.017	0.017				
Juvenile turbot					0.001	0.001	0.001	0.001
Juvenile flatfish	0.033	0.033	0.033	0.033	0.020	0.020	0.020	0.020
Adult flatfish					0.005	0.005	0.005	0.005
Adult Pacific cod					0.026	0.003	0.026	0.026
Shallowwater benthic fish					0.123	0.128	0.133	0.133
Small crabs	0.100	0.100	0.100	0.100				
Commercial shrimp	0.100	0.100	0.100	0.100	0.021	0.044	0.021	0.021
Epifaunal invertebrates	0.033	0.033	0.035	0.035	0.024	0.024	0.024	0.024
Euphausiids	0.062	0.074	0.062	0.062	0.050	0.050	0.050	0.050
Discards	0.002				0.010			
Detritus		0.030			0.062	0.010	0.062	0.062
Import						0.062		

Table D17: *Flatfish diet.*

	Juvenile				Adult			
	2000	**1950**	**1900**	**1750**	**2000**	**1950**	**1900**	**1750**
Forage fish	0.050	0.050	0.050	0.050	0.154	0.154	0.154	0.154
Eulachon	0.010	0.010	0.010	0.010	0.031	0.031	0.031	0.031
Small crabs	0.068	0.068	0.068	0.068	0.038	0.038	0.038	0.038
Epifaunal invertebrates	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
Infaunal carn. invert.	0.373	0.373	0.373	0.373	0.272	0.272	0.272	0.272
Infaunal invert. detritivores	0.453	0.453	0.453	0.453	0.455	0.455	0.455	0.455
Euphausiids					0.004	0.004	0.004	0.004

Table D18: *Halibut diet.*

	Juvenile				Adult			
	2000	**1950**	**1900**	**1750**	**2000**	**1950**	**1900**	**1750**
Small squid	0.033	0.033	0.033	0.033	0.051	0.051	0.051	0.051
Squid	0.030	0.030	0.030	0.030	0.076	0.076	0.076	0.076
Forage fish	0.055	0.055	0.055	0.055	0.014	0.014	0.014	0.014
Eulachon	0.011	0.011	0.011	0.011	0.003	0.003	0.003	0.003
Juvenile herring	0.050	0.050	0.050	0.050				
Adult herring					0.100	0.020	0.100	0.100
Juvenile POP	0.003	0.003	0.003	0.003				
Adult POP					0.020	0.020	0.020	0.020
Juv. planktivorous rockfish					0.005	0.005	0.005	0.005
Ad. planktivorous rockfish					0.002	0.001	0.002	0.002
Adult turbot					0.043	0.074	0.043	0.043
Juvenile flatfish	0.020	0.020	0.020	0.020				
Adult flatfish					0.123	0.123	0.123	0.123
Juvenile Pacific cod	0.008	0.008	0.008	0.008				
Adult Pacific cod					0.100	0.060	0.100	0.100
Shallowwater benthic fish	0.055	0.055	0.055	0.055				
Skates					0.013	0.053	0.013	0.013
Large crabs	0.300	0.300	0.300	0.300	0.210	0.210	0.210	0.210
Small crabs	0.300	0.300	0.300	0.300	0.140	0.140	0.140	0.140
Commercial shrimp	0.060	0.060	0.060	0.060				
Epifaunal invertebrates					0.060	0.110	0.060	0.060
Discards					0.040			
Detritus	0.075	0.075	0.075	0.075		0.040	0.040	0.040

***Table D19**: Pacific cod diet.*

	Juvenile				Adult			
	2000	**1950**	**1900**	**1750**	**2000**	**1950**	**1900**	**1750**
Forage fish					0.393	0.393	0.393	0.393
Eulachon					0.079	0.079	0.079	0.079
Juvenile herring					0.009	0.009	0.009	0.009
Adult herring					0.253	0.153	0.253	0.253
Adult turbot					0.054	0.154	0.054	0.054
Shallowwater benthic fish					0.212	0.212	0.212	0.212
Small crabs	0.027	0.027	0.027	0.027				
Epifaunal invertebrates	0.310	0.310	0.310	0.310				
Infaunal carn. invert.	0.079	0.079	0.079	0.079				
Infaunal invert. detritivores	0.263	0.263	0.263	0.263				
Euphausiids	0.115	0.115	0.115	0.115				
Copepods	0.057	0.057	0.057	0.057				
Detritus	0.149	0.149	0.149	0.149				

***Table D20**: Sablefish diet.*

	Juvenile				Adult			
	2000	**1950**	**1900**	**1750**	**2000**	**1950**	**1900**	**1750**
Small squid	0.018	0.018	0.018	0.018		0.050		
Juvenile pollock					0.010	0.010	0.010	0.010
Forage fish	0.025	0.025	0.025	0.025	0.333	0.333	0.333	0.333
Eulachon	0.005	0.005	0.005	0.005	0.067	0.067	0.067	0.067
Juvenile herring	0.020	0.020	0.020	0.020				
Adult herring	0.020	0.020	0.020	0.020	0.100	0.010	0.100	0.100
Juvenile POP	0.001		0.001	0.001				
Adult POP		0.001						
Juv. planktivorous rockfish	0.001	0.001	0.001	0.001	0.005	0.005	0.005	0.005
Juvenile turbot	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Juvenile flatfish					0.010	0.010	0.010	0.010
Juvenile halibut					0.045	0.045	0.045	0.045
Juvenile Pacific cod					0.010	0.005	0.010	0.010
Juvenile sablefish					0.030	0.030	0.030	0.030
Small crabs					0.010	0.010	0.010	0.010
Commercial shrimp					0.010	0.015	0.010	0.010
Epifaunal invertebrates	0.020	0.020	0.020	0.020	0.010	0.010	0.010	0.010
Carnivorous jellyfish	0.050	0.050	0.050	0.050	0.350	0.390	0.350	0.350
Euphausiids	0.830	0.830	0.830	0.830				

***Table D21:** Lingcod diet.*

	Juvenile				Adult			
	2000	**1950**	**1900**	**1750**	**2000**	**1950**	**1900**	**1750**
Forage fish	0.167	0.177	0.167	0.167	0.317	0.317	0.317	0.317
Eulachon	0.033	0.033	0.033	0.033	0.063	0.063	0.063	0.063
Juvenile herring	0.100	0.200	0.100	0.100	0.050	0.050	0.050	0.050
Adult herring	0.100		0.100	0.100	0.370	0.159	0.370	0.370
Juvenile POP					0.050	0.020	0.050	0.050
Inshore rockfish					0.010	0.010	0.010	0.010
Juv. picivorous rockfish					0.010	0.005	0.010	0.010
Juv. planktivorous rockfish					0.010	0.020	0.010	0.010
Juvenile turbot					0.010	0.010	0.010	0.010
Juvenile flatfish	0.200	0.180	0.200	0.200	0.005	0.010	0.005	0.005
Juvenile Pacific cod	0.200	0.150	0.200	0.200	0.050	0.010	0.050	0.050
Adult Pacific cod					0.050	0.030	0.050	0.050
Juvenile lingcod					0.005	0.280	0.005	0.005
Small crabs		0.100						
Commercial shrimp	0.100	0.160	0.100	0.100				
Epifaunal invertebrates	0.040		0.040	0.040				
Infaunal carn. invert.	0.030		0.030	0.030				
Infaunal invert. detritivores	0.030		0.030	0.030				
Detritus						0.016		

Table D22: *Shallow water benthic fish diet.*

	2000	1950	1900	1750
Squid	0.001	0.001	0.001	0.001
Forage fish	0.198	0.198	0.198	0.198
Eulachon	0.040	0.040	0.040	0.040
Shallowwater benthic fish	0.010	0.010	0.010	0.010
Small crabs	0.333	0.333	0.333	0.333
Commercial shrimp	0.004	0.004	0.004	0.004
Epifaunal invertebrates	0.037	0.037	0.037	0.037
Infaunal carn. invert.	0.191	0.191	0.191	0.191
Infaunal invert. detritivores	0.096	0.096	0.096	0.096
Euphausiids	0.025	0.025	0.025	0.025
Copepods	0.048	0.048	0.048	0.048
Detritus	0.017	0.017	0.017	0.017

Table D23*: Skate diet.*

	2000	1950	1900	1750
Forage fish	0.238	0.238	0.238	0.238
Eulachon	0.048	0.048	0.048	0.048
Large crabs	0.140	0.140	0.140	0.140
Small crabs	0.250	0.250	0.250	0.250
Commercial shrimp	0.100	0.100	0.100	0.100
Epifaunal invertebrates	0.100	0.100	0.100	0.100
Infaunal carn. invert.	0.050	0.050	0.050	0.050
Infaunal invert. detritivores	0.050	0.050	0.050	0.050
Detritus	0.024	0.024	0.024	0.024

Table D24*: Crab diet.*

	Large				Small			
	2000	**1950**	**1900**	**1750**	**2000**	**1950**	**1900**	**1750**
Juvenile flatfish	0.100	0.060	0.100	0.100				
Small crabs	0.100	0.100	0.100	0.100				
Commercial shrimp	0.015	0.015	0.015	0.015				
Epifaunal invertebrates	0.435	0.435	0.435	0.435	0.800	0.800	0.800	0.800
Infaunal carn. invert.	0.025	0.065	0.025	0.025	0.100	0.100	0.100	0.100
Infaunal invert. detritivores	0.025	0.025	0.025	0.025	0.100	0.100	0.100	0.100
Detritus	0.300	0.300	0.300	0.300				

Table D25: *Commercial shrimp diet.*

	2000	1950	1900	1750
Euphausiids	0.300	0.300	0.300	0.300
Copepods	0.200	0.200	0.200	0.200
Detritus	0.500	0.500	0.500	0.500

Table D26*: Invertebrate diet.*

	Epifaunal	Infaunal carn.	Infaunal detrit.
	All periods	All periods	All periods
Infaunal invert. detritivores		0.100	
Macrophytes	0.001		
Detritus	0.999	0.900	1.000

Table D27*: Carnivorous jellyfish.*

	All Periods
Carnivorous jellyfish	0.050
Copepods	0.050
Detritus	0.900

Table D28*: Euphausiid and copepod diet.*

	Euphausiid	Copepod
	All periods	All periods
Copepods	0.200	
Phytoplankton	0.800	1.000

APPENDIX E. NON-MARKET PRICES

Non-market Prices:

(Beattie 2001) suggested a non-market price for all marine mammals from the money made by wildlife viewing, scuba diving and kayaking in the ecosystem, which brings in $22 million, $8 million and $14 million respectively.

Table E1: *Non-market prices.*

Activity	Functional group	Biomass (t/km^2)	Biomass (tonnes)	Value ($/kg)	Total value ($/kg)
Wildlife viewing	Mysticetae	0.310	22,940	0.719	
	Odontocetae	0.022	1,628	1.351	
	Seals/sea lions	0.052	3,848	0.572	
	Sea birds	0.016	1,184	0.929	
Kayaking	Mysticetae	0.310	22,940	0.076	*0.796
	Odontocetae	0.022	1,628	1.075	*2.426
	Seals/sea lions	0.052	3,848	0.455	*1.027
	Sea birds	0.016	1,184	1.478	*2.407
Scuba diving	Inshore rockfish	0.100	7,400	0.270	0.270
	Shallow water benthic fish	5.280	390,720	0.005	0.005
	Epifaunal invertebrates	5.280	390,720	0.005	0.005
	Kelp	5.280	390,720	0.005	0.005

*Total value includes value from wildlife viewing and kayaking. (Source: Beattie, 2001)

(Beattie 2001) calculates non-market values assuming that all the management costs are spent on marine management and that it is equal on all salmon species.

Table E2*: Management costs in Pacific salmon. (Source: Beattie, 2001)*

Species	Biomass (t/km^2)	Biomass (tonne)	Management cost (tonne)	Management cost ($/tonne)	Management cost ($/kg)
Coho salmon	0.024	1776	17.5	9853.60	9.85
Chinook salmon	0.018	1332	17.5	13138.14	13.14

APPENDIX F. LANDINGS

Table F1: *2000 Landings*

Group Name	Groundfish trawl	Sable	Herring gillnet	Groundfish hook&line	Salmon gillnet	Crab trap	Shrimp / prawn trap	Other Inv.	Halibut hook&line	Salmon troll	Salmon seine	Salmon troll freezer	Herring seine	Shrimp trawl	Eulachon	Longline	Recreational	Total
Transient salmon					0.187					0.007	0.190	0.028					0.002	0.414
Coho salmon					0.001					0.002	<0.001	0.003					0.005	0.011
Chinook salmon	<0.001				<0.001					<0.001	<0.001	0.002					0.027	0.030
Squid	<0.001												<0.001					<0.001
Ratfish	<0.001																	<0.001
Dogfish	<0.001															0.023		0.023
Pollock	0.007																	0.007
Eulachon															0.003			0.003
Adult herring	<0.001		0.121										0.068					0.189
Adult POP	0.065																	0.065
Inshore rockfish	<0.001			0.003					0.004								0.003	0.010
Adult pisc. rockfish	0.023			0.002													0.002	0.027
Adult plank. rockfish	0.076																	0.076
Adult turbot	0.018																	0.018
Adult flatfish	0.053																	0.053
Juvenile halibut	<0.001								0.028								0.001	0.029
Adult halibut	<0.001								0.028								0.014	0.042
Adult Pacific cod	0.018								0.002									0.020
Adult sablefish	<0.001	0.055							0.003									0.059
Juvenile lingcod																	0.002	0.002
Adult lingcod	0.007																0.001	0.008
Shallowwater benthic fish	<0.001																	<0.001
Skates	0.016																	0.016
Large crabs	<0.001					0.053											0.002	0.055
Commercial shrimp	<0.001						0.006							0.052			<0.001	0.058
Epifaunal invertebrates	<0.001							0.078									<0.001	0.078
Sum	0.284	0.055	0.121	0.005	0.189	0.053	0.006	0.078	0.064	0.009	0.190	0.032	0.068	0.052	0.003	0.023	0.060	1.292

Table F2: *1950 Landings.*

Group Name	Groundfish trawl	Sable	Herring gillnet	Ground H+L	Salmon gillnet	Crab trap	Shrimp / prawn trap	Other Inv.	Halibut H+L	Salmon troll	Salmon seine	Salmon troll freezer	Herring seine	Shrimp trawl	Eulachon	Longline	Seine nets	Recreational	Sea lion shooting	Total
Seals, sea lions																			0.001	0.001
Transient salmon					0.181					0.005	0.208	0.005						<0.001		0.398
Coho salmon					0.020					0.014	0.012	0.014						<0.001		0.061
Chinook salmon					0.006					0.006	0.001	0.006						0.002		0.021
Dogfish																0.034				0.034
Pollock	0.006																			0.006
Forage fish																	0.006			0.006
Eulachon															<0.001					<0.001
Adult herring			<0.001										0.232				0.232			0.465
Adult POP	0.002			<0.001												<0.001				0.003
Inshore rockfish				0.002					0.002									<0.001		0.004
Adult pisc. rockfish	0.010			0.001														<0.001		0.011
Adult plank. rockfish	0.036																	<0.001		0.036
Adult turbot	0.003																			0.003
Adult flatfish	0.039																			0.039
Juvenile halibut									<0.001											<0.001
Adult halibut	0.097								<0.001									0.001		0.099
Adult Pacific cod	0.019															<0.001	0.033			0.052
Adult sablefish	0.002	0.004																		0.006
Juvenile lingcod																		0.003		0.003
Adult lingcod	0.031			0.009											0.008			0.002		0.050
Skates	<0.001															<0.001				<0.001
Large crabs	<0.001					0.005												<0.001		0.005
Commercial shrimp							0.001							<0.001				<0.001		0.002
Epifaunal inverts.								0.029										<0.001		0.029
Sum	0.245	0.004	<0.001	0.011	0.207	0.005	0.001	0.029	0.003	0.025	0.221	0.025	0.232	<0.001	0.009	0.035	0.272	0.010	0.001	1.337

***Table F3**: 1900 Landings.*

Group Name	Herring	Hook and Line	Salmon seine	Eulachon	Whaling	Longline (setline)	FN Halibut	FN Inverts.	Total
Mysticetae					0.027				0.027
Odontocetae					0.002				0.002
Transient salmon			0.126						0.126
Coho salmon			0.012						0.012
Chinook salmon			0.019						0.019
Dogfish						0.017			0.017
Eulachon				0.043					0.043
Adult herring	0.002								0.002
Juvenile halibut		0.008					0.002		0.010
Adult halibut		0.008					0.002		0.010
Adult Pacific cod							0.001		0.001
Adult lingcod		0.003							0.003
Epifaunal inverts.								<0.001	<0.001
Infaunal invert. detrit.								<0.001	<0.001
Sum	0.002	0.018	0.156	0.043	0.030	0.017	0.005	<0.001	0.270

***Table F4**: 1750 Landings.*

Group Name	Sea otters	Halibut hook&line	Salmon seine	Eulachon	Herring	Whaling	Cod, etc.	Inverts.	Total
Sea otters	<0.001								<0.001
Mysticetae						<0.001			<0.001
Seals, sea lions						<0.001			<0.001
Transient salmon			0.046						0.046
Coho salmon			0.023						0.023
Chinook salmon			0.023						0.023
Eulachon				0.043					0.043
Adult herring					0.002				0.002
Juvenile halibut		0.010							0.010
Adult halibut		0.010							0.010
Adult Pacific cod							0.001		0.001
Adult lingcod							<0.001		<0.001
Epifaunal invertebrates								<0.001	<0.001
Infaunal invert. detrit.								<0.001	<0.001
Sum	<0.001	0.019	0.091	0.043	0.002	<0.001	0.002	0.001	0.159

APPENDIX G. GROUP DEFINITIONS

Table G1. *Species included in each model group. Name of Ecopath functional group is in bold.*

Common name	Scientific name
Sea Otters	
Sea otter	*Enhydra lutra*
Mysticetae	
blue whale	*Balaenoptera musculus*
fin whale	*Balaenoptera physalus*
sei whale	*Balaenoptera borealis*
humpback whale	*Megaptera novaeangliae*
right whale	*Balaena glacialis*
gray whale	*Eschrichtius robustus*
Odontocetae	
sperm whale	*Physeter macrocephalus*
Baird's beaked whale	*Berardius bairdii*
northern right whale dolphin	*Lissodelphis borealis*
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*
Dall's porpoise	*Phocoenoides dalli*
harbour porpoise	*Phocoena phocoena*
killer whale	*Orcinus orca*
Seals and sea lions	
Steller sea lion	*Eumetopias jubatus*
harbour seal	*Phoca vitulina*
northern fur seal	*Callorhinus ursinus*
northern elephant seal	*Mirounga angustirostris*
California sea lion	*Zalophus californianus*
Seabirds	
gulls	*Laridae*
grebes	*Podicipedidae*
Cassin's auklet	*Ptychoramphus aleuticus*
tufted puffin	*Fratercula corniculata*
common murre	*Uria aalge*
rhinoceros auklet	*Cerorhinca monocerata*
marbled murrelet	*Brachyramphus marmoratus*
pigeon guillemot	*Cepphus columba*
merganser spp.	*Mergus serrator, M. merganser*
pelagic cormorants	*Phalacrocorax pelagicus*
sooty shearwater	*Puffinus griseus*
northern fulmar	*Fulmarus glacialis*
double-crested cormorant	*Phalacrocorax auritus*
common loon	*Gavia immer*
Transient salmon	
sockeye	*Oncorhynchus nerka*
chum	*Oncorhynchus keta*
pink salmon	*Oncorhynchus gorbuscha*
Coho and chinook salmon	
coho salmon	*Oncorhynchus kisutch*
chinook salmon	*Oncorhynchus tshawytscha*
Juvenile and adult squid	
common squid	*Loligo opalescens*
Ratfish	
ratfish	*Hydrolagus collei*
Dogfish	
dogfish	*Squalus acanthias*
Juvenile and adult pollock	
walleye pollock	*Theragra chalcogramma*
Forage fish and eulachon	
sandlance	*Ammodytes hexapterus*
pilchards	*Sardinops sagax*
anchovy	*Engraulis mordax*
capelin	*Mallotus villosus*
chub mackerel	*Scomber japonicus*
shad	*Alosa sapidissima*
smelts	*Osmeridae*
eulachon	*Thaleichthys pacificus*
Juvenile and adult herring	
Pacific herring	*Clupea pallasi*
Juvenile and adult Pacific ocean perch	
Pacific Ocean perch	*Sebastes alutus*
Inshore rockfish	
copper rockfish	*Sebastes caurinus*
quillback rockfish	*Sebastes maliger*
tiger rockfish	*Sebastes nigrocinctus*
China rockfish	*Sebastes nebulosus*
yelloweye rockfish	*Sebastes rubberrimus*
Juvenile and adult piscivorous rockfish	
rougheye rockfish	*Sebastes aleutioanus*
shortraker rockfish	*Sebastes borealis*
shortspine thornyhead	*Sebastolobus altivelis*
longspine thornyhead	*Sebastolobus alascanus*
black rockfish	*Sebastes melanops*
blue rockfish	*Sebastes mystinus*
chillipepper	*Sebastes goodei*
dusky rockfish	*Sebastes ciliatus*
Juvenile and adult planktivorous rockfish	
yellowmouth rockfish	*Sebastes reedi*
red-stripe rockfish	*Sebastes proriger*
widow rockfish	*Sebastes entomelas*
yellowtail rockfish	*Sebastes flavidus*
darkblotch rockfish	*Sebastes cremeri*
canary rockfish	*Sebastes pinniger*

splitnose rockfish	*Sebastes diploproa*
sharpchin rockfish	*Sebastes zacentrus*
Puget sound rockfish	*Sebastes emphaeus*
bocaccio	*Sebastes paucispinis*
shortbelly rockfish	*Sebastes jordani*
Juvenile and adult turbot	
arrowtooth flounder	*Atheresthes stomias*
Juvenile and adult flatfish	
rock sole	*Lepidosetta bilineata*
English sole	*Parophyrys vetulus*
dover sole	*Microstomas pacificus*
Juvenile and adult halibut	
halibut	*Hippoglossus stenolepsis*
Juvenile and adult Pacific cod	
Pacific cod	*Gadus macrocephalus*
Juvenile and adult sablefish	
Sablefish	*Anoplopoma fimbria*
Juvenile and adult lingcod	
lingcod	*Ophiodon elongatus*
Shallow-water benthic fish	
sculpins	*Cottidae*
blennies	*Blennidae*
poachers	*Agonidae*
gobies	*Gobiedae*
greenlings	*Hexagramidae*
rock greenling	*Hexagrammos lagocephalus*
eelpouts	*Zoarcidae*
northern clingfish	*Gobiesox maeandricus*
red irish lords	*Hemilepidotus hemilepidotus*
cabezon	*Scorpaenichthys marmoratus*

cutthroat trout	*Oncorhynchus clarki clarki*
white sturgeon	*Acipenser transmontanus*
Skates	
big skate	*Raja binoculata*
longnose skate	*Raja rhina*
starry skate	*Raja stellulata*
black skate	*Raja kincaidi*
deep-sea skate	*Raja abyssicola*
tope shark	*Galeorhinus galeus*
great white shark	*Carcharodon carcharias*
broadnose sevengill shark	*Notorynchus cepedianus*
bluntnose sixgill shark	*Hexanchus griseus*
blue shark	*Prionace glauca*
basking shark	*Cetorhinus maximus*
diamond stingray	*Dasyatis dipterura*
Pelagic stingray	*Pteroplatytrygon violacea*
Large and small crabs	
Dungeness crab	*Cancer magister*
red rock crab	*Cancer productus*
tanner crab	*Chionecetes sp.*
king crab	*Paralithodes sp.*
kelp crab	*Pugettia producta*
Commercial shrimp	
smooth shrimp	*Pandalus jordani*
spiny shrimp	*Pandalus borealis eous*
pink shrimp	*Pandalus goniurus*
coonstripe shrimp	*Pandalus danae*
humpback shrimp	*Pandalus hypsinotus*
sidestripe shrimp	*Pandalopsis disbar*
prawn	*Pandalus platycterus*
Macrophytes	
bull kelp	*Nereocystis leutkeana*
giant kelp	*Macrocystis integrifolia*