

FINAL REPORT

**HUMPBACK AND BLUE WHALE PHOTO-IDENTIFICATION RESEARCH
OFF CALIFORNIA, OREGON AND WASHINGTON IN 1998**

Prepared for:
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TABLE OF CONTENTS

EXECUTIVE SUMMARY.....	3
INTRODUCTION.....	4
METHODS	5
Surveys off Washington and Oregon	5
Dedicated photographic identification surveys off California	5
Monterey Bay surveys conducted with Oceanic Society	6
Identifications obtained by the Whale Corps in the Santa Barbara Channel	7
Other contributors for photographs off California	7
Photographic identification methods	7
Biopsies and tagging of blue whales	8
Data analyses.....	8
RESULTS AND DISCUSSION	10
Photographic identification samples	10
Regional patterns in sightings and identifications	10
Comparison to previous years.....	10
Movements between areas	10
Status of humpback whales off Oregon and Washington.....	11
Abundance estimates and mortality rates.....	11
Reproductive rates of humpback whales	12
ACKNOWLEDGMENTS	13
REFERENCES	14
TABLES AND FIGURES	17

EXECUTIVE SUMMARY

This report provides an update on the results of humpback and blue whale research based on the field work conducted in 1998. It summarizes the photo-identification results and examines distribution, abundance and population trends, and reproduction and mortality for humpback and blue whales. Surveys were conducted by Cascadia Research and a number of collaborators as a part of several studies. Cascadia personnel conducted 83 vessel days of survey effort between 4 May and 8 Dec 1998 covering most of the California coast and northern Washington. An addition, effort was conducted by collaborators who provided identification photographs to us.

Surveys were primarily conducted using two 5.3m rigid-hull inflatable boats (RHIBs). Individual identification photographs were obtained of humpback and blue whales using methods that have been employed in past research with these species. During survey effort by Cascadia personnel, 433 sightings of 1,027 humpback whales and 322 sightings of 437 blue whales were made off California and 23 sightings of 40 humpback whales were made off Washington. Combined with additional effort by a number of collaborating researchers these sightings resulted in 888 successful identifications of humpback whales representing 423 different individuals and 400 identifications of blue whales representing 228 individuals. This represents the largest sample of humpback whale identifications and one of the largest for blue whales we have obtained since our research began in 1986.

Humpback and blue whale identifications were obtained from a number of different areas and months and these indicated extensive movements among most regions. Humpback whales off northern Washington were an exception and animals from this region show a low matching rate with California and appear to be part of a separate feeding aggregation that begins north of about 47°30'N.

New estimates of humpback whale abundance were obtained using several mark-recapture models. These provide a new estimate of 905 humpback whales for California-Washington. This feeding aggregation has shown a highly significant annual increase since 1988 averaging about 8% per year. The annual survival rate during this period has averaged 95%.

INTRODUCTION

Cascadia Research continued research in 1998 examining the distribution, abundance, movements, and population dynamics of humpback and blue whales off California, Oregon, and Washington. A central method to this research is the use of identification photographs of humpback and blue whales to track individual whales.

Support for this research has come from a number of sources in 1998:

- Primary support for the overall research effort specially aimed at assessing population size and trends and reproductive and mortality rates came from Southwest Fisheries Science Center under Purchase Order #40ABNF801113.
- The Olympic Coast National Marine Sanctuary contributed support for conducting surveys off northern Washington and provided space for a researcher on their survey with the NOAA ship *McArthur* under Purchase Order #40ABNC801428.
- The Marine Mammal Research Program supported fieldwork was conducted around Pioneer Seamount specifically to assess the impact of the ATOC sound source on marine mammals through a subaward from the University of California at Santa Cruz.

This report provides an update on the results of humpback and blue whale research based on the field work conducted in 1998. It summarizes the photo-identification results and examines distribution, abundance and population trends and reproduction and mortality for humpback and blue whales.

METHODS

Surveys were conducted as part of several studies (see Tables 1-7 for summaries of effort). Cascadia personnel conducted 83 vessel days of survey effort between 4 May and 8 Dec 1998 covering most of the California coast and northern Washington. In addition, effort was conducted by collaborators who provided identification photographs to us. Survey effort by project component is given in the following sections.

Surveys off Washington and Oregon

Surveys off Washington and Oregon in 1998 primarily were focused on humpback whales west of Cape Flattery and were in conjunction with surveys for gray whales and involved 33 days of surveys (Table 1). Components of this effort in and around Washington and Oregon included:

1. Photographic identification of humpback and gray whales conducted off northern Washington and British Columbia from 25 June to 29 September using Cascadia boats and the Olympic Coast Sanctuary vessel *Tatoosh*.
2. Survey on 25 August primarily to identify gray whales off Oregon. Additional surveys for humpback, blue, and gray whales near the Oregon/California border in October are covered in the next section.
3. Photographic identification of gray whales conducted in and around Puget Sound primarily from March to May. This included surveys in association with the USGS SHIPS seismic surveys in March.
4. Surveys in October and November to identify late-season gray whales in Puget Sound and the Strait of Juan de Fuca.

Identification photographs of humpback whales were also provided to us from a number of other sources including:

- Humpback whales photographed incidental to gray whale research off Vancouver Island near the Washington/BC border by Brian Gisborne and Volker Deeke.
- Ed Bowlby of the Olympic Coast National Marine Sanctuary obtained identification photographs of five humpback whales on 25 and 25 June 1998 during cruises by the NOAA ship *McArthur* off the northern Washington coast.

Dedicated photographic identification surveys off California

Photographic identification of humpback and blue whales were conducted off California by Cascadia personnel on 81 days between 4 May and 8 December 1998 (Table 2). These were

conducted primarily using Cascadia's 5.3m RHIBs as well as some other larger boats. This survey effort had several components including:

- Early season surveys using Cascadia's RHIB primarily in May in the region off Half Moon Bay to identify humpback whales.
- Surveys from 3 June to 5 July using Cascadia's RHIB in the Southern California Bight to sample large concentrations of blue whales off San Diego and humpback whales in the Santa Barbara Channel.
- Surveys and identifications from the *Pacific Clipper* and Cascadia's RHIB in the Santa Barbara Channel from 20 July through 6 August in association with a collaborative project on acoustics of blue whales with Scripps Institute of Oceanography.
- Surveys aboard the Truth in the Southern California Bight from 27 to 31 July 1998 in association with the Oceanic Society.
- Surveys conducted in association with National Geographic Television using Cascadia's RHIB from 4-11 August and 4-5 September in the Santa Barbara Channel, northern Monterey Bay, and off Bodega Bay.
- A survey of the central and northern California coast with an emphasis on monitoring in the vicinity of Pioneer Seamount using the research vessel *Russamee* and associated inflatable from 31 August to 12 September 1998. The survey extended from Monterey Bay north to Cape Mendocino. Observations in the Pioneer Seamount area were aimed at gathering data related to the Marine Mammal Research Program designed to examine impacts of the ATOC sound source on marine mammals.
- Late season surveys conducted using Cascadia's RHIB off northern California out of Eureka and Crescent City between 31 August and 11 October 1998.
- Several other areas were sampled using Cascadia's RHIB including waters between Pt. Conception and Morro Bay and from Monterey Bay to Bodega Bay on a periodic basis through the season.

Monterey Bay surveys conducted with Oceanic Society

A collaborative research effort with Nancy Black and the Oceanic Society yielded additional dedicated photographic identification surveys in the Monterey Bay area on 27 days between 20 July and 15 October 1998 (Table 3). These surveys were conducted aboard the *Point Sur Clipper* out of Monterey and were directed by Nancy Black. In addition to these dedicated surveys, photographs were also obtained opportunistically on whale watch trips on 54 days conducted between 11 April and 19 November 1998 (Table 4).

Identifications obtained by the Whale Corps in the Santa Barbara Channel

Volunteer naturalists working with the Santa Barbara Museum of Natural History (Whale Corps) obtained identification photographs of humpback and blue whales from the whale-watch vessel *Condor* (Table 5). We trained members of the Whale Corps to take identification photographs and provided camera equipment and film. They obtained identification photographs on 21 days between 4 June and 16 August 1998 (Table 5). These photographs were limited to opportunistic approaches and were concentrated in the eastern and central Santa Barbara Channel where most whale watching was conducted.

Other contributors for photographs off California

A number of other researchers and naturalists provided photographs of humpback or blue whale obtained incidental to other activities. These included:

- Eric Martin of the Marine Mammal Study Center obtained identification photographs of humpback, blue and fin whales in the Southern California Bight (Table 6).
- Sandy Rosenberg provided photographs of several humpback whales seen in Monterey Bay on 1 August 1998
- Ms. Tera Killip provided a humpback photograph from off Point Reyes on 20 September 1998.
- Karen and Brad Balon provided photographs of a humpback whale taken off San Francisco Bay on 25 July 1998.
- Yuki and Michuru Ogino provided photographs of blue and humpback whales taken in the Santa Barbara Channel from 2-6 August 1998.
- Sue Lynn Konopka-Reif provided photographs of a humpback whale in Monterey Bay on 22 August 1998

Photographic identification methods

Identification photographs were taken with *Nikon* 8008s 35mm cameras equipped with a 300mm *Nikkor* telephoto lenses and databacks that recorded date/time on the exposed film. High-speed black-and-white film (*Ilford HP-5+*) was exposed pushed 1½ stops so that exposure times were generally 1/1,000 or 1/2,000 sec.

Identification photographs were taken using standard procedures employed in past research off California and Washington (Calambokidis *et al.* 1990a, 1990b, 1992, 1996, 1998). Both the right and left sides of blue whales in the vicinity of the dorsal fin or hump were photographed as well as the ventral surface of the flukes. For humpback whales, photographs were taken of the ventral surface of the flukes.

Humpback and blue whale identification photographs taken in 1998 were first compared internally and then compared to catalogs of all humpback and blue whales identified along California-Washington. These catalogs consist of 965 different humpback whales and 1,070 different blue whales identified primarily since 1986 and extending through 1997 (Calambokidis *et al.* 1998). Individual whales identified in 1998 that did not match past years and that were of suitable quality were assigned new unique identification numbers and added to the catalogs.

Biopsies and tagging of blue whales

In collaboration with both Scripps Institute of Oceanography and Mark McDonald, we obtained photographic identifications and biopsies of blue whales in the Santa Barbara Channel where Scripps was conducting acoustic monitoring of blue whales. One aspect of this collaboration was to determine the identity and sex of vocalizing whales. In 1998, we had trouble locating and sampling the blue whales that were being heard. Although some samples were obtained from the vicinity of acoustic monitoring, it is unclear whether any of these will be able to be linked to the acoustic localizations.

Nine skin samples were collected in 1998 (Table 8). Seven of these were from blue whales and two from humpback whales. These were obtained under a NMFS permit held by SWFSC. These samples were delivered to SWFSC for analysis. Three of the blue whale samples were obtained incidental to contact made with whales while attempting to attach the ‘critter-cam’ instrument package.

A pilot effort was initiated in 1998 in collaboration with National Geographic Television to evaluate the feasibility of attaching an instrument package to a blue whale. The ‘critter-cam’ instrument package included a digital video camera, hydrophone recording to digital tape, and a depth and temperature sensor. Initial attempts were with a suction-cup attachment on the end of pole. Approaches with Cascadia’s RHIB on five occasions successfully allowed contact with the side of the whale but we were unable to get a firm attachment (Table 9). A floy-tag (using an implanted barb) attachment was also tried three times. On one of these occasions the instrument package was successfully attached for a period of about 10 minutes but the instruments were not operational. Based on these experiences, we concluded that blue whales could be approached closely enough to attach an instrument with a pole. Modifications to the suction-cup design are needed to improve upon this method.

Data analyses

Sighting, effort and identification data were computer coded into databases (*dBase III+*) used in past research (Calambokidis *et al.* 1989a, 1989b, 1990a, 1990b). These consist of three principal data records: a database containing survey effort (date and times of vessel positions, movements, and sighting conditions) and marine mammal sightings based on the field records and archived by year, 2) an identification database (MN-ID) that recorded each sighting of an identified humpback whales made since the beginning of our research effort in 1986, and 3) a similar identification database (BM-ID) for blue whales.

Data analyses were conducted using custom computer programs generated in compiled Basic (*Turbobasic*) programming language. These programs read text files of the databases described above and compile summaries of the number of unique whales seen by region and time period, movements of animals based on resightings of the same individual during a season, interchange rates based on inter-year returns of animals among regions, and mark-recapture abundance estimates.

Annual reproductive rates were made for humpback whales using the number of mothers and calves identified photographically as a percentage of the total number of whales identified (including mothers and calves). We did not use calf identifications because they tended to raise their flukes less often and therefore were identified less often than mothers. These rates include neonatal mortality that occurred prior to the time whales were sampled on the feeding ground. We also examined the sighting histories of whales noted as mothers and calves.

Estimates of abundance and mortality rates were conducted using individually identified humpback whales and several mark-recapture models (Hammond 1986, Seber 1982). For mark-recapture estimates we used inter-year samples from California, Oregon, and Washington (excluding the Washington/British Columbia border area). Petersen mark-recapture estimates were used to estimate abundance based on samples from adjacent years starting in 1988 when samples from multiple regions of California were first obtained. The Chapman modification of the Peterson estimate (Seber 1982) was used because it was appropriate for sampling without replacement (Hammond 1986). Multi-region samples were not collected in 1989 but were available every year starting in 1990. Abundance and mortality rate estimates were also obtained using the Jolly-Seber multi-year models and the annual samples from 1990 to 1990. General assumptions and potential biases for these calculations are discussed in Hammond (1986) and Calambokidis *et al.* (1990a).

RESULTS AND DISCUSSION

Photographic identification samples

During survey effort by Cascadia personnel, 433 sightings of 1,027 humpback whales and 322 sightings of 437 blue whales were made off California, and 23 sightings of 40 humpback whales were made off Washington (Table 7). Additional sightings of each species were also made by a number of collaborating researchers (Table 7). These sightings resulted in 888 successful identifications of humpback whales representing 423 different individuals and 400 identifications of blue whales representing 228 individuals. Results of some of the region-specific studies are reviewed below followed by an overview of each species.

Regional patterns in sightings and identifications

Photographic identifications in 1998 were well distributed seasonally and geographically. We identified humpback whales from May to December with over 100 identifications every month from June to October (Table 10). Geographic coverage was also extensive for humpback whales with more than 40 identifications from the Santa Barbara Channel, Monterey Bay area, Half-Moon Bay region, Gulf of the Farallones and Point St. George (Table 10).

Blue whale photographic identification was also well distributed (Table 10). Identifications by Cascadia personnel were made from May to October with samples of more than 50 identifications from June to September. Large samples were obtained from the southern portion of the Southern California Bight, the Santa Barbara Channel, Monterey Bay area, and the Gulf of the Farallones. Smaller samples were obtained from six other areas.

Comparison to previous years

The 423 humpback whales identified in 1998 represent the largest number of individuals we have identified in any single year since the research began in 1986 (Table 11). Of these 423, 327 had been seen previously in our research and 96 (23%) were new. The addition of these new whales identified in 1998 brings to 1,071 the total individuals identified off California, Oregon, and Washington since the 1980s (Table 11).

Of the 228 blue whales identified in 1998 is close to the annual maximum of 280 for different individuals seen in a year off California (Table 12). Of these 228, 137 had been seen previously off California and 91 (40%) were new. This brings the total number of blue whales identified off California to 1,166, although this could contain duplicates due to unmatched photographs.

Movements between areas

Extensive movements of humpback whales were seen among most regions (Table 13). Out of 102 humpback whales identified in the Santa Barbara Channel in June and July, 22 were

seen in the Monterey Bay region and 19 in the Gulf of the Farallones also during 1998 (Table 13). Frequent interchange was also seen among humpback whales from Monterey Bay to Pt St. George at the Oregon border. The primary exception to the inter-regional movements were for the humpback whales seen near the Washington/British Columbia border (Table 13).

Status of humpback whales off Oregon and Washington

None of the 29 humpback whales identified near the Washington/British Columbia border were seen in any area to the south in 1998. Of these 29 whales only three (10%) had been off California-Washington in any previous year of our research. Twenty of these 29 (69%) whales had been seen in the Washington-British Columbia border area in a previous year. A rate of discovery graph for the identified whales in this one region shows that an increasing proportion of the whales identified in this area had been seen previously there (Figure 1). This rate shows a high degree of site fidelity and suggests that this region is inhabited by a small number of whales.

With the data from 1998, a clearer picture is emerging of the population structure of whales along the west coast and specifically off Oregon and Washington. Between 1988 and 1998, 293 whales have been identified off Oregon and Washington. Comparing these whales with the 921 humpback whales that have been photographed off California reveals a high degree of interchange between subregions that extend from California to central Washington; 59-82% of whales seen in these in Oregon through central Washington were also photographed off California. A sharp decrease in interchange rate occurred with the whales that were identified near the Washington/British Columbia border ($n=96$), of which only 7% were seen off California. We suggest that the northern limit of the California-Washington feeding range should be defined as central Washington or at about $47^{\circ}30'N$.

Abundance estimates and mortality rates

Mark-recapture estimates were made for humpback whales using several models. We excluded identifications from the Washington-British Columbia border area because this area appears to represent a distinct feeding only rarely used by the whales that typically feed off California, Oregon, and Washington (S of $47^{\circ}30'N$). Two-sample Petersen mark-recapture calculations yielded an estimate of 905 humpback whales for 1997-98 (Table 14).

The mark recapture estimates from consecutive years of data from 1988 to 1998 indicate a steady increase in the number of humpback whales (Table 14, Figure 2). Our earliest estimates using data from multiple regions are for 1988-90 (data from broad regions was not available for 1989) and indicated an abundance of 498 animals. Regression of the log abundance values indicates a highly significant trend ($r^2=0.91$, $p<0.001$) and an annual increase of about 8% per year.

Jolly-Seber mark-recapture models for an open population also indicate an increasing population (Table 15). Abundance increases from 479 in 1991 to 782 in 1997 (estimates are not calculated for the first and last years) and generally correspond but are slightly lower than the

Petersen estimates. The Petersen estimates may be biased upward slightly by the violation of population closure. The Jolly-Seber model also estimates an average annual survival rate of 95% and an average of 79 births annually (Table 15).

Reproductive rates of humpback whales

A total of 19 humpback whale mothers and eight calves were identified off California in 1998. This is 4.8% of the 394 humpback whales identified in 1998 (Table 16). Most of the mothers were seen with calves for the first time, only 5 of 19 (26%) were observed with calves previously. Additionally, 1 of 29 humpback whales identified off northern Washington was a mother with a calf.

Although the reproductive rate based on photo-identification in 1998 was the lowest seen since 1994, it was still slightly above the mean determined for this feeding aggregation between 1986 and 1997 (4.2%, s.d.=1.8). Overall, these past estimates have been low compared to those calculated for other humpback whale populations, rates determined in the Gulf of Maine using similar methods averaged 7.9% (range=4.5%-10.3%, Clapham and Mayo 1990). This has been puzzling because of the observed increase in abundance over the same time period.

Our current method of using the number of reproductive females identified as a percentage of all whales identified may be biased somewhat by geographic segregation of mothers with calves in the large study area covered (Steiger and Calambokidis, *In press*). The alternate method of examining calving rates such as those used by Clapham and Mayo (1997, 1990) do not fit our data because of sparse sighting histories of reproductive females (Steiger and Calambokidis, *In press*). We expect an improvement in our methods to examine reproduction when our sample of sighting histories of mature females is large enough to use the birth interval model by Barlow and Clapham (1997).

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Numerous collaborating researchers provided photographs of humpback and blue whales from California that were obtained incidental to their research activities:

- Nancy Black, Richard Ternullo, Inger Marie Larsen, and Peggy Stapp provided photographs from Monterey Bay conducted primarily as part of Oceanic Society Expeditions trips and whale watching trips,
- Eric Martin provided identification photographs from off southern California,
- the crew of the *Condor* (Fred Benko, captain) and participants in the Santa Barbara Museum's Whale Corps, especially Charles Woodhouse and Shauna Bingham, provided photographs from the Santa Barbara Channel (Carolyn McClesky, George Handler, Jan Dybdal, Janet Klimowich, Lucky Coil, Peter Cante, Marian Jean, Teri Knight, Loyd Simms, Inge Rose)
- Diane Gendron (CICIMAR) and Michuru and Yuki Ogino provided blue whale identification photographs from the Santa Barbara Channel,
- UCSC personnel provided identification photographs from their tagging efforts off California and Mexico,
- Katy Penland and Bernardo Alps provided additional photographs from southern California.
- Brian Gisborne and Volker Deeke provided humpback whales photographs taken incidental to gray whale research off Vancouver Island near the Washington/BC border.
- Ed Bowlby of the Olympic Coast National Marine Sanctuary provided identification photographs of five humpback whales on 25 and 25 June 1998 during cruises by the NOAA ship *McArthur* off the northern Washington coast,
- Yuki and Michuru Ogino provided photographs of blue and humpback whales taken in the Santa Barbara Channel from 2-6 August 1998.
- Tom Norris conducted surveys and obtained blue whale identifications off San Diego on 21 and 26 June 1998.
- Additional opportunistic photographs were obtained by Sandy Rosenberg, Tera Killip, Karen and Brad Balon, Mark McDonald, Mary-Jane Schramm, Tom Kieckhefer, and Sue Lynn Konopka-Reif

Dave Ellifrit, Jen Quan, Annie Douglas, Hillary Dorinson, Heather Harding, Renee Mensing, Hannah Smith, Megan Hess, and Tamara Gunther assisted in field work from Cascadia boats and NOAA ships. Sheryl Lapp, Lindsey Fauss, Hannah Smith, Heather Medic, Natasha Bodorf, and Megan Hess printed and matched identification photographs and assisted in data compilation and analysis. Jay Barlow provided helpful comments on an earlier draft of this report.

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TABLES AND FIGURES

Table 1. Photo-ID survey effort by Cascadia Research personnel in Oregon and Washington waters in 1998.

Date	Vessel	Time		Latitude		Gray whale			Humpback whale		
		Begin	End	South	North	Sit	Num	ID	Sit	Num	ID
03/12/98	<i>Thom.</i> Launch	14:27:00	17:45:00	47 53.0	48 05.0	1	2	2			
03/14/98	<i>Tully</i> Launch	10:29:00	14:20:00	48 07.9	48 13.1	1	1	1			
03/18/98	N1	15:00:00	18:45:00	47 03.5	47 11.2	1	1	1			
03/21/98	<i>Tully</i> Launch	6:49:00	16:30:00	47 38.7	48 13.2	1	1	1			
03/22/98	<i>Tully</i> Launch	10:25:00	16:05:00	47 53.4	48 31.9	2	3	3			
03/26/98	N1	16:00:00	17:42:00	47 03.4	47 05.3	1	1	1			
03/27/98	N1	8:40:00	18:23:00	47 49.3	48 10.2	3	5	5			
04/07/98	HH	10:15:00	16:48:00	47 37.0	48 08.3						
04/12/98	HH	11:20:00	19:00:00	48 06.0	48 20.2						
04/15/98	HH	10:57:00	18:12:00	47 48.7	48 05.9	2	4	3			
04/16/98	N1	11:10:00	19:45:00	47 51.4	48 25.4	3	7	7			
04/19/98	N1	9:17:00	17:08:00	47 53.4	48 25.3	1	2	2			
04/23/98	HH	8:47:00	12:20:00	47 53.7	48 00.0	1	1	1			
05/08/98	HH	10:03:00	16:20:00	47 50.0	48 07.0						
05/20/98	HH	13:00:00	14:59:00	47 56.3	47 57.1	1	1	1			
06/25/98	TAT	6:41:00	18:01:00	48 22.0	48 39.0				1	1	1
06/26/98	TAT	6:55:00	18:32:00	48 19.5	48 35.1				2	4	2
06/27/98	TAT	12:59:00	18:51:00	48 11.1	48 29.4						
06/28/98	TAT	7:32:00	20:12:00	48 06.4	48 26.5				4	9	8
06/29/98	TAT	9:20:00	15:55:00	48 07.7	48 22.5						
07/14/98	DIS	6:57:00	15:38:00	48 19.6	48 26.9	1	3	3			
07/21/98	TAT	8:56:00	20:02:00	48 10.0	48 23.8				6	10	8
07/22/98	TAT	8:34:00	18:13:00	48 09.9	48 28.2						
08/25/98	N2	6:30:00	18:30:00	44 27.1	44 56.8	24	35	35			
08/26/98	N2	7:40:00	19:20:00	46 54.3	48 23.4						
08/27/98	N2	7:05:00	20:48:00	48 14.2	48 42.2	8	14	14	9	14	13
09/29/98	N1	9:35:00	19:30:00	48 16.5	48 51.8	3	3	3	1	2	2
10/15/98	N1	14:30:00	16:19:00	47 06.1	47 08.0	1	1	1			
10/21/98	HH	13:23:00	18:00:00	48 07.1	48 08.7	2	3	3			
10/28/98	HH	12:25:00	16:00:00	48 07.0	48 07.5	1	1	1			
11/11/98	HH	11:25:00	15:07:00	48 07.0	48 17.7	2	3	3			
11/12/98	N1	16:00:00	16:50:00	47 06.1	47 08.3	1	1	1			
11/17/98	DEB	14:16:00	15:42:00	47 01.1	47 01.5	2	2	2			
Total		33 days				63	95	94	23	40	34

Table 2. Photo-ID survey effort by Cascadia Research personnel off California in 1998. For each day the number of sightings (Sit), total number of animals seen (Num), and estimated number photographed (Photo) by species are shown.

Date	Vessel	Time		hours	Latitude		Blue whale			Fin whale			Gray whale			Humpback whale			
		Begin	End		South	North	Sit	Num	Photo	Sit	Num	Photo	Sit	Num	Photo	Sit	Num	Photo	
5/4/98	N1	10:20:00	18:19:00	7.98	36 51.8	37 30.0									11	24	15		
5/14/98	N2	7:00:00	18:38:00	11.63	36 51.9	37 34.1									6	12	9		
5/17/98	N2	7:30:00	8:50:00	1.33	37 28.8	37 30.1													
5/24/98	N2	7:45:00	19:55:00	12.17	37 18.5	37 55.3									16	32	24		
5/27/98	N2	10:44:00	18:00:00	7.27	37 28.3	37 41.4									1	1	1		
5/30/98	N2	9:39:00	16:08:00	6.48	37 21.6	37 51.1	1	1	1						4	5	4		
6/3/98	N2	6:20:00	8:55:00	2.58	34 10.2	34 24.5													
6/4/98	N2	6:16:00	17:17:00	11.02	34 05.0	34 24.5									16	32	29		
6/5/98	N2	5:51:00	15:26:00	9.58	32 42.5	33 00.0	25	29	29										
6/6/98	N2	5:47:00	15:41:00	9.90	32 25.7	32 50.7	15	23	21										
6/7/98	N2	11:08:00	18:20:00	7.20	32 40.6	33 00.8	19	21	21										
6/8/98	N2	6:45:00	8:30:00	1.75	34 14.2	34 24.5									1	1	1		
6/9/98	N2	6:50:00	18:51:00	12.02	34 06.0	34 24.5									28	48	43		
6/10/98	N2	7:45:00	16:20:00	8.58	35 03.5	35 26.5									16	40	36		
6/21/98	RD	7:26:00	14:40:00	7.23	32 37.5	32 40.2	9	11	11										
6/26/98	RD	7:15:00	12:45:00	5.50	32 39.8	32 40.7	3	3	1										
7/5/98	N2	7:45:00	17:16:00	9.52	33 18.7	33 52.4	6	6	6										
7/6/98	N2	6:52:00	19:48:00	12.93	33 24.5	34 24.5	21	24	23	2	3	3			30	58	55		
7/7/98	N2	6:48:00	17:15:00	10.45	34 04.3	34 24.5	13	14	14						16	55	45		
7/8/98	N2	8:18:00	16:00:00	7.70	34 05.5	34 24.5	7	8	8						8	16	15		
7/20/98	PC	6:30:00	17:33:00	11.05	34 03.3	34 09.7	3	5	5										
7/21/98	PC	6:23:00	17:34:00	11.18	34 03.3	34 10.0	19	30	26						1	1	1		
7/22/98	PC	6:37:00	18:11:00	11.57	34 03.3	34 10.9	1	1	1										
7/23/98	N2	7:53:00	19:30:00	11.62	36 30.5	36 46.2	16	20	19	5	8	7			12	32	23		
7/23/98	PC	6:05:00	16:53:00	10.80	34 03.3	34 09.4	1	1	1										
7/24/98	N2	7:05:00	18:21:00	11.27	36 33.5	37 00.2	7	8	8	1	1	1			33	51	47		
7/26/98	N2	12:58:00	14:52:00	1.90	36 29.3	36 32.1	5	5	5	2	3	2			1	2	2		
7/27/98	N2	8:50:00	14:50:00	6.00	34 08.4	34 24.4													
7/27/98	PC	7:08:00	9:19:00	2.18	33 57.1	34 58.1													
7/27/98	TRU	8:05:00	17:30:00	9.42	34 02.6	34 24.3													
7/28/98	N2	12:28:00	17:22:00	4.90	34 00.5	34 57.7									1	1	1		
7/28/98	PC	7:30:00	16:47:00	9.28	33 51.1	34 00.5													
7/28/98	TRU	7:11:00	18:06:00	10.92	33 00.1	34 23.5													
7/29/98	N2	7:14:00	12:45:00	5.52	33 54.3	34 24.4													
7/29/98	PC	7:05:00	15:56:00	8.85	33 52.2	34 09.2													
7/29/98	TRU	7:19:00	11:12:00	3.88	33 54.3	33 59.6													
7/30/98	N2	7:15:00	18:10:00	10.92	34 06.7	34 26.0	24	29	29										
7/30/98	TRU	7:50:00	15:53:00	8.05	33 53.2	34 21.9	1	7	2										
7/31/98	CRU	7:09:00	16:20:00	9.18	34 12.6	34 23.2	1	8	0										
8/3/98	N2	8:27:00	17:55:00	9.47	34 06.9	34 24.5	5	6	5										
8/3/98	PC	7:09:00	17:10:00	10.02	34 03.4	34 08.4													
8/4/98	N2	8:20:00	17:55:00	9.58	34 06.1	34 24.4	15	20	19										
8/4/98	PC	6:37:00	17:39:00	11.03	34 00.0	34 08.4													
8/5/98	N2	7:30:00	17:30:00	10.00	34 06.0	34 24.4	1	1	0										
8/5/98	PC	6:54:00	17:18:00	10.40	34 00.1	34 08.5													
8/6/98	N2	7:30:00	17:45:00	10.25	34 06.0	34 24.4	1	2	2										
8/6/98	PC	6:33:00	15:08:00	8.58	34 03.5	34 09.7													
8/7/98	N2	13:00:00	18:00:00	5.00	34 06.8	34 24.5													
8/8/98	N2	8:00:00	17:30:00	9.50	33 34.2	34 24.5	1	2	1										
8/9/98	N2	8:08:00	15:15:00	7.12	34 47.2	35 10.4													
8/10/98	N2	7:30:00	18:50:00	11.33	36 55.3	37 00.4	24	24	14						6	10	10		
8/11/98	N2	8:15:00	18:00:00	9.75	36 55.2	37 03.1	6	9	5						6	17	12		
8/12/98	N2	12:05:00	20:53:00	8.80	37 26.2	37 35.4	10	11	10						15	34	31		
8/13/98	N2	9:30:00	20:00:00	10.50	37 28.1	38 18.6	7	8	5						22	72	56		
8/31/98	N1	10:49:00	18:45:00	7.93	41 44.1	41 56.3									8	22	14		
8/31/98	RUS	10:32:00	19:22:00	8.83	37 19.2	37 27.6									6	11	7		
9/1/98	N1	12:15:00	16:05:00	3.83	38 12.9	38 19.4	1	1	1						1	2	0		
9/1/98	RUS	7:34:00	19:02:00	11.47	37 16.9	37 29.0				1	3	3							
9/2/98	ACH	8:00:00	12:20:00	4.33	37 41.0	37 44.3									10	44	30		
9/2/98	RUS	7:13:00	19:32:00	12.32	37 40.2	37 56.0									8	25	13		
9/3/98	ACH	14:28:00	15:19:00	0.85	38 10.3	38 13.2									2	2	2		
9/3/98	N1	11:20:00	20:45:00	9.42	37 55.1	38 21.5	7	13	7										
9/3/98	RUS	7:02:00	19:02:00	12.00	37 58.6	38 22.2									1	1	0		
9/4/98	N1	10:50:00	18:19:00	7.48	38 11.0	38 19.9	2	4	3						5	9	9		
9/4/98	RUS	7:00:00	19:02:00	12.03	38 26.2	39 05.8													
9/5/98	ACH	12:34:00	17:03:00	4.48	39 09.0	39 25.8	3	5	5						2	9	8		
9/5/98	N1	8:35:00	20:39:00	12.07	38 17.7	38 29.0	19	32	23	2	3	3			19	57	43		
9/5/98	RUS	6:48:00	19:35:00	12.78	39 01.7	39 33.2	2	3	1						2	2	2		
9/6/98	N1	12:40:00	20:45:00	8.08	38 17.7	38 33.5	3	4	4						27	81	51		
9/6/98	RUS	7:00:00	19:46:00	12.77	39 46.3	40 59.7									16	30	25		
9/7/98	RUS	6:58:00	19:50:00	12.87	39 15.4	39 33.2	2	4	3						3	6	4		
9/8/98	RUS	7:04:00	18:30:00	11.43	38 25.1	39 14.2	2	4	2						1	2	1		
9/10/98	RUS	17:40:00	19:28:00	1.80	37 16.6	37 27.6													
9/11/98	ACH	15:40:00	19:28:00	3.80	36 41.1	36 43.8	2	3	3										
9/11/98	RUS	7:00:00	19:21:00	12.35	36 23.0	36 43.5	3	4	3										
9/12/98	ACH	8:23:00	17:28:00	9.08	36 48.0	37 05.7	3	5	5										
9/12/98	RUS	7:00:00	19:27:00	12.45	36 45.2	37 14.6	2	4	4						7	7	5		
10/6/98	N1	8:00:00	19:08:00	11.13	41 41.7	41 55.0	4	7	7				2	7	7	7	37	103	81
10/7/98	N1	8:58:00	15:10:00	6.20	40 41.2	40 47.1	7	12	9						2	4	4		
10/10/98	N1	9:20:00	19:00:00	9.67	41 43.2	41 57.7	5	9	8				12	12	12	12	17	48	34
10/11/98	N1	8:35:00	12:15:00	3.67	41 30.3	41 44.5													
12/5/98	RUS	At sea			36 53.4	36 55									4	9	6		
12/8/98	RUS	At sea			36 03.1	36 23									3	7	5		
Total	83 days			698			334	451	380	13	21	19	14	19	19	433	1027	806	

Table 3. Surveys conducted in Monterey Bay in 1998 by Oceanic Society Expeditions (Nancy Black and Peggy Stap). For each day the number of sightings (Sit) and total number of animals seen (Num) is shown.

Date	Time		Latitude		Blue whale		Fin whale		Humpback	
	Begin	End	South	North	Sit	Num	Sit	Num	Sit	Num
7/20/98	8:15:00	15:00:00	36 36.3	36 44.8	1	2			10	17
7/21/98	7:50:00	15:00:00	36 36.3	36 45.4					18	45
7/22/98	7:40:00	15:00:00	36 36.3	36 44.4	2	3			4	12
7/23/98	7:40:00	15:20:00	36 36.3	36 47.0	7	13	1	2	4	10
7/24/98	7:45:00	15:00:00	36 36.3	36 38.7	3	4			5	20
9/14/98	8:05:00	16:00:00	36 34.8	36 45.1						
9/15/98	7:50:00	15:00:00	36 33.4	36 39.9					7	10
9/16/98	7:52:00	15:00:00	36 36.3	36 48.1	1	2			1	1
9/17/98	7:55:00	15:15:00	36 36.3	36 49.5	3	4			3	5
9/18/98	7:55:00	15:10:00	36 36.3	36 50.1						
9/21/98	8:00:00	15:00:00	36 36.3	36 40.6	3	6			8	19
9/22/98	7:48:00	15:00:00	36 30.3	36 46.0	1	1			4	10
9/23/98	7:45:00	15:00:00	36 36.6	36 49.5	1	1			7	14
9/24/98	7:45:00	15:10:00	36 35.6	36 48.0	4	7			2	4
9/27/98	9:08:00	14:45:00	36 32.2	36 39.7					4	9
9/28/98	8:00:00	15:00:00	36 33.1	36 45.7					3	6
9/29/98	7:50:00	16:25:00	36 36.6	36 47.7					7	9
10/1/98	7:50:00	15:00:00	36 22.2	36 37.3					6	9
10/2/98	7:30:00	15:00:00	36 33.4	36 49.9	1	2	1	5	5	8
10/4/98	9:05:00	15:30:00	36 36.6	36 44.9					2	4
10/5/98	7:59:00	15:10:00	36 32.5	36 41.1					3	5
10/6/98	7:57:00	15:00:00	36 36.6	36 48.3	1	1			1	1
10/7/98	7:45:00	15:10:00	36 31.8	36 38.6			5	13	1	2
10/8/98	7:50:00	15:00:00	36 31.4	36 41.1					1	2
10/12/98	8:00:00	15:30:00	36 28.0	36 44.9					2	3
10/13/98	8:00:00	15:15:00	36 36.6	36 51.9					1	6
10/15/98	7:50:00	15:00:00	36 36.6	36 49.5					1	2
Total	27 days				28	46	7	20	110	233

Table 4. Dates and number of photographic identifications obtained from whale watching trips in Monterey Bay in 1998.

Date	Photographer	Number of IDs	
		Blue Whales	Humpback Whales
4/11/98	N. Black		4
4/15/98	N. Black		2
4/26/98	N. Black		2
4/29/98	N. Black		4
4/30/98	N. Black		2
5/6/98	N. Black		2
5/7/98	N. Black		2
5/9/98	N. Black		1
5/14/98	N. Black		1
5/15/98	N. Black		2
5/17/98	N. Black		4
7/3/98	I.M. Laursen		1
7/18/98	N. Black		2
7/19/98	N. Black		2
7/25/98	N. Black		4
7/28/98	N. Black/I.M. Laurs	1	8
8/4/98	I.M. Laursen		4
8/11/98	I.M. Laursen		1
8/20/98	I.M. Laursen		1
8/25/98	I.M. Laursen		1
9/7/98	I.M. Laursen	1	1
9/10/98	I.M. Laursen		12
9/15/98	I.M. Laursen		7
9/22/98	I.M. Laursen	1	3
10/17/98	N. Black	2	1
10/20/98	N. Black	1	2
10/22/98	N. Black	2	4
10/23/98	N. Black		2
10/27/98	N. Black	2	3
10/31/98	N. Black		1
11/1/98	N. Black		1
11/3/98	N. Black	1	
11/12/98	N. Black	1	1
11/13/98	N. Black	2	
11/15/98	N. Black	4	4
11/19/98	N. Black	4	
Total	days 36	22	92

Table 5. Survey effort in the Santa Barbara Channel in 1998 by members of the Whale Corps aboard the Condor. For each day the number of sightings (Sit) and total number of animals seen (Num) is shown.

Date	Blue whale		Fin whale		Humpback		Roll	Frame	Photographer
	Sit	Num	Sit	Num	Sit	Num			
6/4/98					4	9	1	2-12	Shauna Bingham
6/7/98					1	1	1	13-15	Loyd Simms
6/11/98					3	11	1	16-27	Marian Jean
6/18/98					11	23	1,2	28-36.1-15	Teri Knight
6/20/98					2	9	2	16-18	Carolyn McClesky
6/21/98					4	8	2	19-28	Janet Klimowich
6/25/98	1	1			2	11	2,3	29-36,1-4	Carolyn McClesky
7/3/98	2	3			2	3	3	6-22	Teri Knight
7/4/98	1	5			4	14	3	23-36	Lucky Coil
7/6/98	1	1			5	11	4	2-17	George Handler
7/8/98	1	2			3	9	4,5	19-36.1-4	Lucky Coil
7/12/98	1	2					5	6	Inge Rose
7/15/98	1	2	1	1			5	7-15	Lucky Coil
7/17/98	6	9					5,6	16-36,1-3	Teri Knight
7/22/98					1	2	6	4	Carolyn McClesky
7/23/98	2	3			1	1	6	5-7	Shauna Bingham
7/25/98	2	3			1	4	6	9-29	Jan Dybdal
7/29/98	3	5					6	30-34	Teri Knight
8/3/98	4	13			1	1	7	2-29	Marian Jean
8/6/98	1	2					7	31	Shauna Bingham
8/16/98					1	1	7	32-34	Peter Cattle
Total	26	51	1	1	46	118			

Table 6. Number of animals photographed and provided by Eric Martin take off Southern California in 1998.

Date	Roll	Region	Animals photographed		
			Blue	Fin	Humpback
05/30/98	C6	Southern California Bught		4	
06/14/98	C1-3	Santa Barbara Channel			19
07/04/98	C4	33:20-24 118:42-44	3		
07/09/98	C5	Santa Barbara Channel	2		3
07/19/98		Santa Barbara Channel	8		2
Total			13	4	24

Table 7. Summary of photographic identifications from principal sources in 1998. For each type the number of sightings (Sit), total number of animals seen (Num), and either identifications (Ident) or number photographed by species are shown.

Effort type	Region	Date		Days	Humpback whale			Blue whale			Fin whale			Gray whale			
		Start	End		Sit	Num	Ident	Sit	Num	Ident	Sit	Num	Photo	Sit	Num	Photo	
Cascadia	Oregon-Washington	3/12/98	11/7/98	33	23	40	32								63	95	94
Cascadia	California	5/4/98	12/8/98	83	433	1027	570	322	437	308	13	21	19	14	19	19	
Oceanic Society-MB	Monterey Bay	7/20/98	10/15/98	27	110	233	124	28	46	34	7	20					
N. Black whale watch	Monterey Bay	4/21/98	11/19/98	36			92						22				
Whale Corps	Santa Barbara Channel	6/4/98	8/16/98	21	46	118	41	26	51	14	1	1					
Eric Martin	Southern California	5/30/98	7/19/98	5			24						9				4

Table 8. Skin samples obtained from humpback and blue whales in 1998 under permit # 1437 to SWFSC.

Date	Time	Snum	Species	Grp size	Region	Latitude	Longitude	Type of sampling	Reaction	Sample #	Photo
Biopsy samples											
3-Aug	1309	N2-6	BM	1	Santa Barbara Channel	34 07.0	120 07.9	Dart hit, sample obtained	None	CRC-BM-98-1	JAC-14/9-13
3-Aug	1540	N2-16	BM	1	Santa Barbara Channel	34 06.9	120 05.8	Dart hit, sample obtained	None	CRC-BM-98-2	JAC-16/23
12-Aug	1610	N2-13	BM	2	Off Half-Moon Bay	37 33.86	122 58.02	Dart hit, sample obtained	Quick dive, fluke splash	CRC-BM-98-3	JAC-21/18-19
12-Aug	1622	N2-16	BM	1	Off Half-Moon Bay	37 33.63	122 58.1	Biopsy miss	None		JAC-21/20
29-Sep	1421	N1-3	MN	2	Off N. Washington	48 26.64	125 30.27	Dart hit, sample obtained	None	CRC-MN-98-1	JAC-50/7
29-Sep	1421	N1-3	MN	2	Off N. Washington	48 26.64	125 30.27	Dart hit, sample obtained	High fluke-up dive	CRC-MN-98-2	JAC-50/6
Additional skin sample obtained during Critter-cam deployments under permit 937											
5-Sep	1150	N1-8	BM	2	Off Bodega Bay	38 26.4	123 20.4	Floy-tag contact, no attachment	Increases speed	CRC-BM-98-4	JAC-43/4
5-Sep	1401	N1-15	BM	1	Off Bodega Bay	38 26.54	123 19.87	Floy-tag contact & attach for 10 min	Incr. Speed, leaves area	CRC-BM-98-5	JAC-43/20
5-Sep	1457	N1-16	BM	2	Off Bodega Bay	38 27.64	123 20.23	Floy-tag contact, no attachment	None	CRC-BM-98-6	JAC-43/24-27

Table 9. Summary of approaches and attempts to attach instrument package to blue whales.

Date	Time	Snum	Species	Num	Region	Latitude	Longitude	Type of sampling	Reaction	Sample #	Photo	Comments
4-Aug	1430	N2-11	BM	2	Santa Barbara Channel	34 06.9	120 07.6	Suction-cup contact, no atchmt.	None		JAC-16/1-3	
10-Aug	925	N2-4	BM	1	Off Santa Cruz	36 59.7	122 23.5	Suction-cup contact, no atchmt.	Boat avoidance		JAC-17/19-21	
10-Aug	1025	N2-6	BM	1	Off Santa Cruz	37 00.2	122 23.7	Suction-cup contact, no atchmt.	Avoids boat, increases speed			Contact with boat
10-Aug	1130	N2-11	BM	1	Off Santa Cruz	37 00.3	122 23.9	Suction-cup contact, no atchmt.	None			Vertebrae visible
10-Aug	1335	N2-22	BM	1	Off Santa Cruz	37 00.3	122 23.93	Suction-cup contact, no atchmt.	Boat avoidance		JF/15-16	Vertebrae visible
5-Sep	1150	N1-8	BM	2	Off Bodega Bay	38 26.4	123 20.4	Floy-tag contact, no attachment	Increases speed	CRC-BM-98-4	JAC-43/4	Obtain skin sample
5-Sep	1401	N1-15	BM	1	Off Bodega Bay	38 26.54	123 19.87	Floy-tag contact & attach for 10 min	Incr. Speed, leaves area	CRC-BM-98-5	JAC-43/20	Camera malfunctions, obtain skin sample
5-Sep	1457	N1-16	BM	2	Off Bodega Bay	38 27.64	123 20.23	Floy-tag contact, no attachment	None	CRC-BM-98-6	JAC-43/24-27	Obtain skin sample

Table 10. Identifications of humpback and blue whales by region and month in 1998

Region	Code	Month										Total
		4	5	6	7	8	9	10	11	12		
Humpback whales												
S California Bight (outside SBC 32					5							5
Santa Barbara Channel	33			78	89	2						169
Off San Luis	41			2				1				3
Pt. Buchon to Sur	42			12							4	16
Monterey Bay area	51	14	25		110	17	71	35	10	1		283
Ano Nuevo to HMB	52		11			30	2					43
G. Farallones to Bodega	53		9		1	65	75					150
Pt Arena area	54						39					39
Fort Bragg area	61						27					27
Off Eureka	62						3	3				6
Pt. St. George	63					12		100				112
WA/BC	76			15	7	11	2					35
Total all areas		14	45	107	212	137	220	138	10	5		888
Blue whales												
S California Bight (outside SBC 31				80	6							86
Santa Barbara Channel	33			4	84	39						127
Monterey Bay area	51				45	17	29	10	14			115
Ano Nuevo to HMB	52		1									1
G. Farallones to Bodega	53					10	31					41
Fort Bragg area	61						9					9
Off Eureka	62							7				7
Pt. St. George	63							14				14
Total all areas			1	84	135	66	69	31	14			400

Table 11. Number of unique humpback whales identified by Cascadia and collaborators by year and region for California, Oregon and Washington through 1998.

REGION	Code	Number of individuals identified														All
		>86	86	87	88	89	90	91	92	93	94	95	96	97	98	
S Ca. Bight (south)	31	0	0	0	0	0	0	1	0	5	3	0	0	4	0	12
S. Ca. Bight (north outside SBC)	32	0	0	0	1	0	1	0	3	1	6	18	0	0	5	33
Santa Barbara Channel	33	0	0	0	4	0	6	15	97	9	13	136	22	27	102	251
S. Califonia (offshore)	39	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4
Pt Concpetion to Buchon	41	0	0	8	58	0	0	78	4	1	14	20	0	23	3	158
Pt Buchon to Pt. Sur	42	0	0	0	2	0	2	12	0	0	0	0	8	13	16	52
S Monterey Bay Sanc.	51	3	0	4	15	2	13	13	65	45	59	33	89	91	147	384
N Monterey Bay Sanc.	52	0	0	0	2	0	20	0	0	26	4	42	81	47	31	215
Farallones/Cordell	53	16	90	140	134	110	161	89	172	181	164	127	168	32	89	650
Bodega Bay to Pt. Arena	54	0	1	0	5	0	0	0	63	6	0	0	4	5	22	102
C. California offshore	59	0	0	0	0	0	0	0	0	3	1	0	0	0	0	4
Pt. Arena to C. Mendocino	61	0	0	0	0	0	0	4	73	2	0	0	0	23	22	119
C Mend. to Klamath Riv.	62	1	0	0	8	0	0	4	0	4	0	12	8	26	6	61
N California to Oregon	63	0	0	0	3	0	0	85	50	16	0	1	0	14	69	182
S Oregon	71	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2
C. Oregon	72	0	0	0	0	0	22	0	0	0	0	0	7	0	0	29
N Oregon	73	0	0	0	0	0	0	0	6	0	0	0	0	0	0	6
Washington	75	0	0	0	0	0	5	0	0	0	0	0	0	0	0	5
Wash/BC border	76	0	0	0	1	1	10	13	0	3	16	34	34	22	29	94
Puget Sound	79	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2
All		20	91	150	214	111	218	282	398	257	260	364	365	287	423	1071

Table 12. Number of unique blue whales identified by Cascadia and collaborators by year and region for California through 1998.

REGION	Code	Number of individuals identified														All
		>86	86	87	88	89	90	91	92	93	94	95	96	97	98	
S Ca. Bight (south)	31	1	0	0	0	0	5	17	0	7	0	33	16	11	43	128
S. Ca. Bight (north outside SBC)	32	2	2	0	0	0	0	1	19	5	34	91	9	22	0	177
Santa Barbara Channel	33	0	0	0	0	0	0	0	106	0	145	102	77	102	77	474
S. California (offshore)	39	3	1	0	0	0	0	20	0	32	0	0	8	0	0	64
Pt Concpetion to Buchon	41	0	0	0	0	0	0	4	0	2	6	5	2	8	0	27
Pt Buchon to Pt. Sur	42	0	0	0	0	0	0	0	0	2	0	0	7	0	0	9
S Monterey Bay Sanc.	51	9	42	62	25	15	0	0	6	18	18	8	22	10	85	268
N Monterey Bay Sanc.	52	0	0	0	0	0	2	0	1	45	0	3	4	4	1	60
Farallones/Cordell	53	9	36	74	95	64	102	27	109	25	29	7	26	40	22	379
Bodega Bay to Pt. Arena	54	0	0	0	17	1	0	0	20	0	1	0	4	5	0	45
C. California offshore	59	0	0	0	0	0	0	3	0	9	0	0	2	0	0	14
Pt. Arena to C. Mendocino	61	0	0	0	0	0	0	2	93	0	0	0	0	4	7	103
C Mend. to Klamath Riv.	62	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4
N California to Oregon	63	0	0	0	0	0	0	4	4	0	0	0	0	0	7	15
All		24	79	129	122	77	109	76	280	126	208	231	169	182	228	1166

Table 14. Humpback whale abundance using Peterson mark-recapture estimates with samples Mark-recapture estimates of humpback whale abundance off California.

Period	Sample 1			Sample 2				Est.	CV
	Year	Ident.	n	Year	Ident.	n Match			
1988-90	1988	565	213	1990	395	204	87	498	0.06
1990-91	1990	395	204	1991	668	269	101	542	0.06
1991-92	1991	668	269	1992	1023	398	188	569	0.03
1992-93	1992	1023	398	1993	512	254	172	587	0.03
1993-94	1993	512	254	1994	402	244	108	572	0.05
1994-95	1994	402	244	1995	659	330	100	802	0.06
1995-96	1995	659	330	1996	567	331	144	757	0.05
1996-97	1996	567	331	1997	377	266	104	843	0.06
1997-98	1997	381	265	1998	853	394	115	905	0.06

Ident.-Number of identifications during period

n-Number of unique individuals in sample used in mark-recapture estimate

Est.-Estimated abundance

Table 15. Model parameters and population estimates from Jolly-Seber mark-recapture method using California, Oregon, and Washington (not incl. WA/BC border) for 1990-98.

Year	IDs	Prev IDs	r	z	Surv	Births	Marked available	Popul. estimate	SE
1990	208	0	183	0	0.91				
1991	269	105	252	78	0.98	90	188	479	25
1992	398	245	338	85	0.92	58	345	560	14
1993	254	203	218	220	0.97	75	459	574	18
1994	244	191	199	247	0.96	149	494	630	23
1995	331	230	244	216	0.97	56	523	751	29
1996	331	255	195	205	0.94	47	602	781	34
1997	265	216	115	184			638	782	50
1998	394	299	0	0					
Mean	299	194	194	137	0.95	79	464	651	
SD	67	90	94	97	0.03	37	155	121	

Table 16. Reproductive rates of humpback whales off California based on photo-identification. Total m/c (mothers or calves) identified used whichever was higher (including tentative identifications). The total number of whales identified includes mothers and calves identified by Cascadia personnel only.

Year	<u># of mothers IDed</u>		<u># of calves IDed</u>		<u>Total IDed</u>		Rate
	definite	tentative	definite	tentative	m/c	all	
86	1	0	1	0	1	88	1.1
87	3	1	3	1	4	143	2.8
88	7	1	3	1	8	170	4.7
89	1	0	3	0	3	62	4.8
90	3	1	2	0	4	126	3.2
91	8	3	5	3	11	225	4.9
92	8	3	2	2	11	350	3.1
93	10	1	9	2	11	214	5.1
94	5	0	5	0	5	205	2.4
95	17	8	15	4	25	314	8.0
96	10	6	7	3	16	306	5.2
97	15	1	4	2	16	265	6.0
98	17	2	6	2	19	394	4.8

Rate of Discovery of humpback whales at the WA/BC border

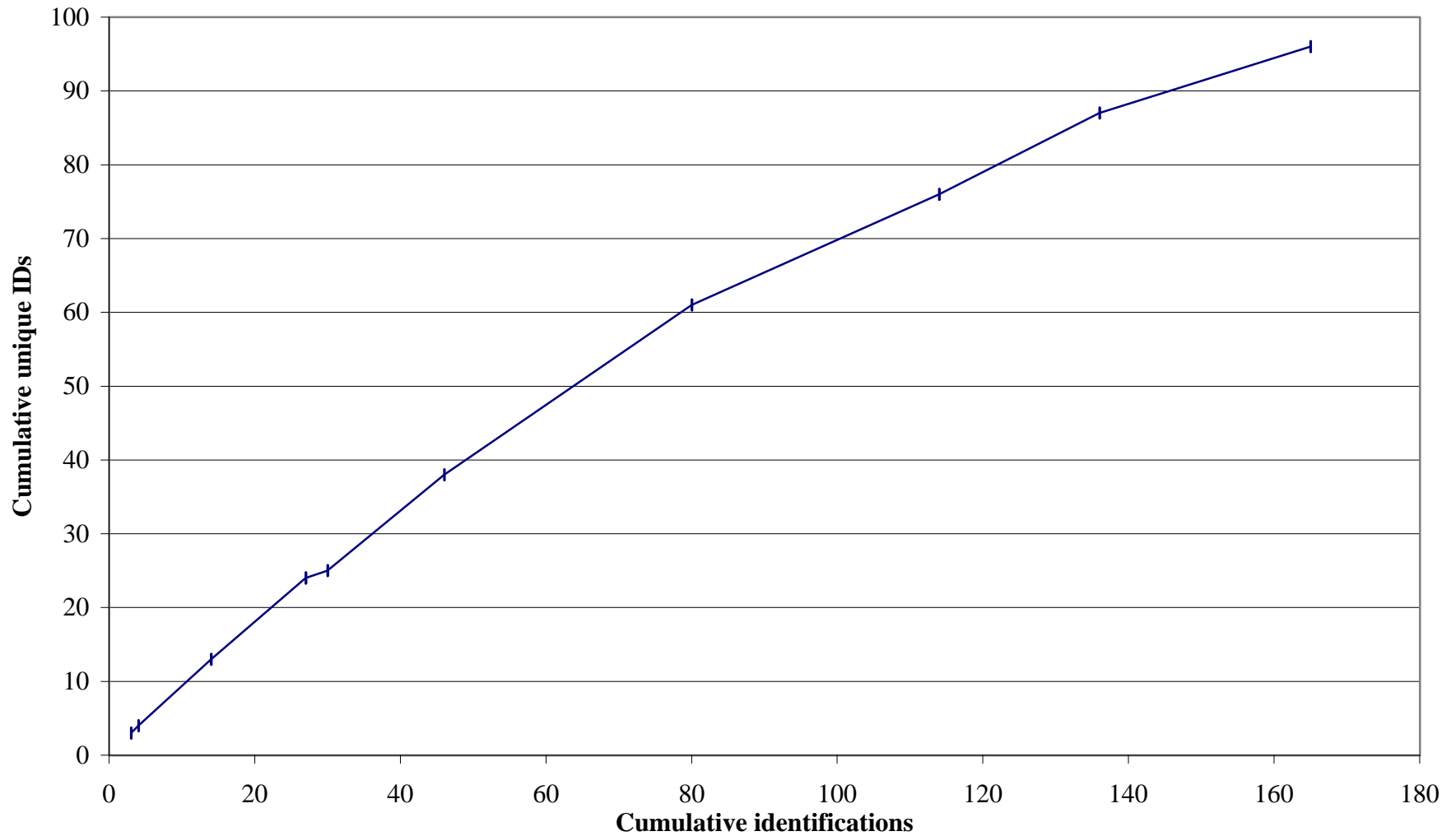


Figure 1. Rate of discovery of new humpback whales in the Washington/BC border area by year from 1990 to 1998,

Trends in abundance of humpback whales

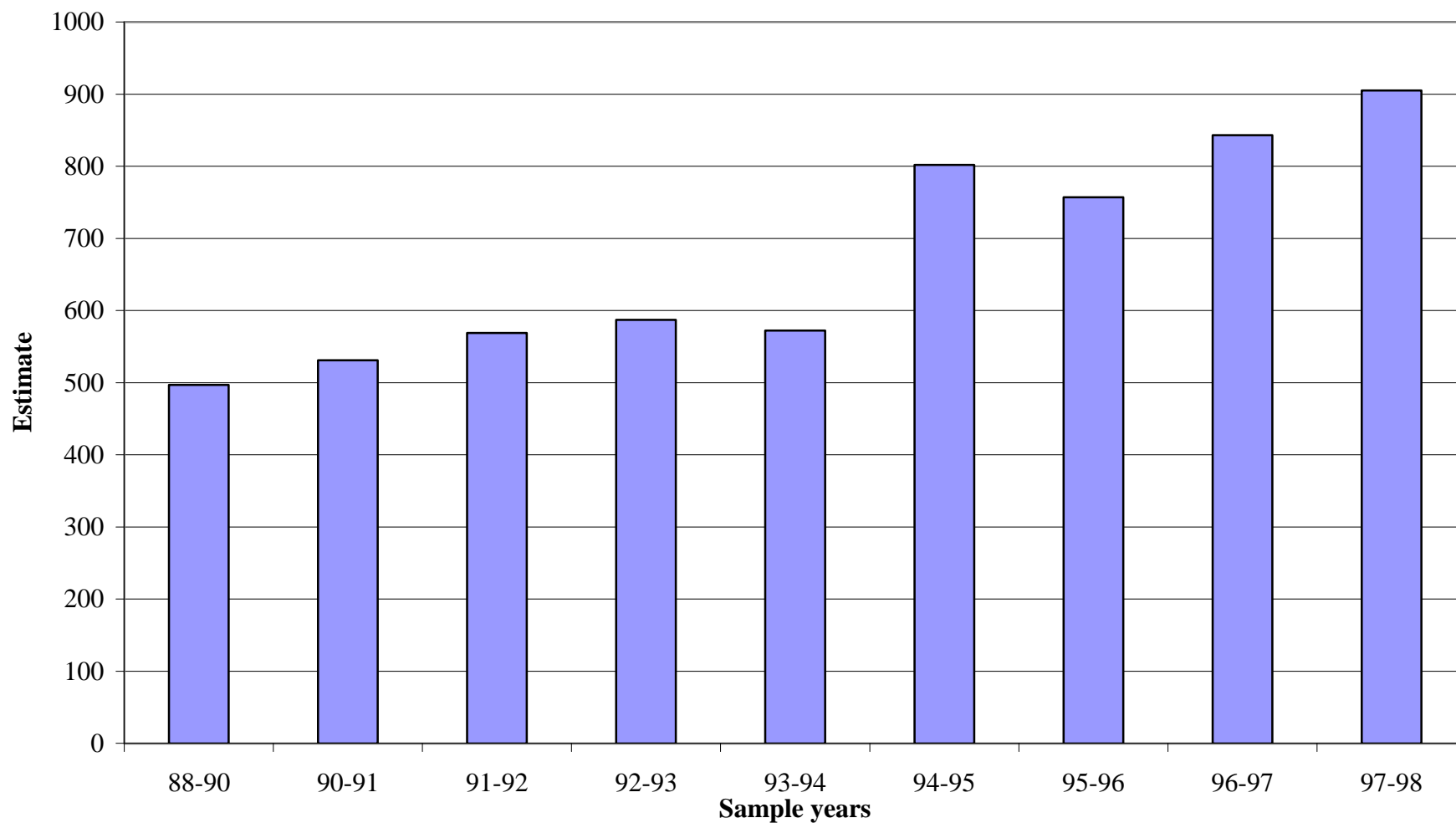


Figure 2. Trends in abundance of humpback whales based on inter-year Petersen mark-recapture estimates. Samples are based on identified individuals off California, Oregon, and Washington (S of WA/BC border area).

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