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INTERNATIONAL
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ABSTRACT

We report on the abundance and trends of humpback whales along the US West Coast where photo-identification has been conducted since 1986. Abundance was estimated for two feeding areas: California-Oregon and Washington-S British Columbia. Abundance off California - Oregon increased steadily at about 7% per year from 1990 through the 2000s when it appeared to plateau based on three different mark-recapture models. Since the late 2000s, humpback whales have expanded their occurrence on feeding grounds in a number of areas. Most dramatically, humpback whales have returned to the Salish Sea, an area they occurred prior to whaling but had been large absent until recent years. We update the migration rates of humpback whales and show that the proportion of whales migrating to different winter breeding areas changes with latitude along the US West Coast, not just between the two recognized feeding areas but also within them. The proportion of whales from the endangered Central America DPS is highest in S California and decreases to very low rates in Washington and S British Columbia. There are some indications that areas of mainland Mexico south of the main wintering areas may be more close associated with the Central America DPS. The dramatic increases in entanglements of humpback whales in 2015 and 2016 may be partly associated with changes in humpback whale occurrence. We also report on recent successes in collaborations with two efforts: 1) Wildbook, including a test of two new automated matching algorithms that are achieving 90% success rate in identifying matches within their top two choices and 2) Happywhale, a project that has created a more effective means for soliciting and receiving opportunistic photo-IDs and providing real-time feedback and information on individuals.

INTRODUCTION

Humpback whales occur widely in the North Pacific and migrate between feeding areas in the spring to fall that range from the US West Coast in the east to Russia in the west to low latitude winter breeding areas that extend from Central America in the east to the Philippines in the west. Humpback whales feed along the US West Coast from S California north to the Canada border (Calambokidis et al. 2015). Two feeding areas are recognized in this region based on photo-ID and genetics (Calambokidis et al. 2009, Baker et al. 2013) consisting of California-Oregon and Washington-S British Columbia. Fourteen humpback whale Distinct Population Segments (DPS) under the US Endangered Species Act were recently recognized worldwide based on winter breeding areas (Jackson et al. 2014, Bettridge et al. 2015); four of these inhabit the North Pacific including those that remain endangered off Central America and W North Pacific. Humpback whales off Mexico are now considered Threatened and those off Hawaii are no longer listed.

Recently, increased numbers of humpback whale entanglements have been seen along the US West Coast; 35 were reported in 2015 and 54 in 2016 (NOAA 2017) which is well above what has been see in past years (Saez et al. 2013). While there have been a variety of species, gear types, and regions where this has been documented, humpback whales have been the dominant species and Dungeness crab gear has been the primary fishing gear involved. Most reports has been from the Monterey Bay area but it is unclear to what degree this is the result of increased reporting in this area due to the more protected waters, high number of whales feeding close to shore, more extensive whale watching activity compared with other regions, and a high level of awareness. Regardless, reported cases certainly underestimate true occurrence especially in areas where there is less whale watching and accessibility. In many areas, like off Washington, where whales are often farther offshore and weather is poorer, whales reported to be entangled are difficult to follow up and are usually never seen again.

Cascadia Research has conducted photographic identification efforts for humpback and blue whales off the US West Coast since 1986. While this effort was initially focused on the Gulf of the Farallones from 1986 to 1990, it more broadly covered the entire West Coast starting in 1991. Annual identifications of typically 200-400 individuals have been obtained from multiple locations along the coast. These have provided both abundance estimates and trends spanning more than 25 years. We have examined movement, population structure, abundance, and trends of these populations (Calambokidis et al. 1990, 2001, 2008, 2009, Calambokidis and Barlow 2004). Here we report updated abundance estimates and trends of humpback whales from past data incorporating field effort through 2014 for all areas and for some key regions through 2016.

METHODS

Photographic identification was conducted as described in previous reports and publications (Calambokidis and Barlow 2004, Calambokidis 2009). Photographic identifications were obtained from the following primary sources:

- Dedicated photo-ID surveys conducted using day trips from shore in 5.9-7.3 m RHIBs along the US West Coast.
- Incidental to other Cascadia survey effort including for SOCAL-Behavioral Response Study (Southern California Bight) and ship-strike related work in southern and Central California.
- Opportunistic photo-ID provided from programs working from whale watch operations, primarily the Channel Islands Naturalist Corps (trips out of Santa Barbara and Ventura) and the Aquarium of the Pacific (out of Long Beach) but also from other whale watch operations out of San Francisco, Monterey Bay, Dana Point, and San Diego.
- Collaborating researchers/naturalists who provided identification photographs obtained as a part of their research including for 2010-11 Jeff Jacobsen, Dawn Goley, SWFSC researchers, Casey Clark (as part of his thesis work for MLML), Izzy Szczepaniak, Brian Gisborne, Peggy Stapp, Michael Fishback and others.
- Occasional opportunistic photographs from members of the public and boaters.
- Collaboration with the Happywhale effort in recent years that provides a platform for submission of identification photographs by the public and whale watch naturalists and ability to get real time information on some of the whales identified (Cascadia has supported and made our photographic catalog and sighting history of identified humpback whales available to this endeavor).

Over the course of the study along the West Coast 23,277 identifications of 3,484 humpback whales were made (Table 1). This encompassed primary effort starting in 1986 through 2014 (with some 2015 effort included for Salish Sea). Each year since 1991, this effort has provided fairly broad coverage along the US West Coast from at least 400 identifications of at least 250 different humpback whales have been made along the US West Coast (Table 1). Effort in different regions have shifted during different periods with effort in early years more concentrated in the Gulf of the Farallones/Cordell Bank area and in more recent years in the Santa Barbara Channel and Monterey Bay. While this has partially reflected occurrence of whales, it is more the result of shifting levels of effort. The long-term photo-ID of humpback whales has not received dedicated funding support since 2010, so most effort in recent years has come largely as a part of the more opportunistic efforts listed above. Nevertheless, 2013 and 2014 saw the largest number of identifications (1,612 and 2,407) and unique whales (710 and 697) compared to all previous years (Table 1).

Calculations of abundance estimates conducted as described in previous publications and reports (Calambokidis and Barlow 2004, 2013) and used annual samples with individuals treated as captured only a single time each period. Annual estimates generated using the Petersen-Chapman estimate using each pair of adjacent years as the two samples. We also use independent 4-year periods to apply two multi-year closed mark-recapture models: 1) Darroch's model M_t in Mark with time varying capture probability and 2) Chao's M_{th} model with time heterogeneity and time varying capture probability. We made estimates using 4-year periods (4 samples) from 1991 to 2014 providing six non-overlapping estimates spanning the period. While using these 4-year periods do involve a greater violation of population closure compared to using 3-year periods (the minimum), they did provide more stable and reliable estimates.

RESULTS AND DISCUSSION

Humpback whale abundance and trends

Estimates of humpback whale abundance for California-Oregon varied by model but all showed a similar trend (Table 1 and 2, Figure 1). Inter-year Petersen estimates peaked with the estimate using 2007-08 data at 2,057 (CV=0.10) and since then have varied widely since then but suggesting either a stable or even decline in estimate (Table 2). The most recent estimate for 2013-14 based on our largest sample to date was 1,399 (CV=0.03).

Estimates based on the 4-year samples and the Darroch and Chao models tracked well with the Petersen estimates though yielding a much smoother trend (Table 3). Similar to the Petersen estimate, the Darroch estimate leveled off in the last two periods with the 2007-10 estimates of 1,828 (CV=.0.03) very similar to that for the last period of 2011-14 of 1,872 (CV=0.01). The Chao model accounting for individual heterogeneity yielded consistently higher estimates than the other models as would be expected (Figure 1, Table 3). Those estimates peaked in 2007-10 at 2,409 (CV=0.06) before declining slightly in the last period to 2,374 (CV=0.03).

Estimates of humpback whale abundance off Washington and S British Columbia (S of 50 N) based on Petersen estimates with adjacent years and including data from Cascadia and DFO as well as collaborators also showed an increase from 1993 through 2014 (Table 4, Figure 2). Estimates were far more variable with higher CVs since sample size was more limited especially in some years.

Expanded areas of occurrence along the US West Coast

There have been changes in humpback whale distribution in a number of areas along the US West Coast in recent years (Figure 3). Most dramatic has been the return of humpback whales into the Salish Sea (includes Strait of Juan de Fuca, Strait of Georgia, and Puget Sound) an area they used to be formerly present until whaling in the early 1990s largely appeared to eliminate these animals. Most of the sightings of humpback whales during the 1990s and early 2000s were from waters outside the Salish Sea (Calambokidis et al. 2015). Sighting reports of whales in inside waters of the Salish Sea have increased dramatically starting in the late 2000s and most dramatically in 2014 (Figure 4) with many of these sightings concentrated in the central Strait of Juan de Fuca but also extending far into Puget Sound (Figure 4). These changes have resulted in a new focus of whale watching efforts in the region to humpback whales especially in periods when killer whales are not around.

The recent return of humpback whales to the Salish Sea is consistent with their occurrence in these waters prior to whaling. Between 1905 and 1925, over 5,500 humpback whales were killed during commercial whaling off Washington and southern British Columbia (Nichol et al. 2002, Scheffer and Slipp 1948). By 1925, humpback whales were so scarce in this region that whaling stations shut down operations and catcher boats moved on to Alaska and California. A whaling station operated in Paige's Lagoon targeted humpback whales in the Salish Sea primarily in winter months in the early 1900s (Trites 2014) and appeared to result in the elimination of animals from inside waters.

Changes in distribution in other regions have involved smaller numbers of whales but have sometimes attracted considerable attention. Off S California, humpback whale feeding has generally occurred from the N Channel Islands north and animals sighted farther south were generally present for only shorter periods. In 2014-16, humpback whales were more common than had been seen in previous years in coastal waters of Santa Monica Bay, and from Long Beach south to off Dana Point. While this primarily involved juvenile animals, it resulted in whale watch effort in this region often getting more sightings of humpback whales than species like blue and fin whales that had been normal for summer and fall months. Similarly, humpback whales were reported inside the Golden Gate Bridge in San Francisco Bay commonly in summer of 2016, something that had been rarer in past years (except where it involved a few individuals like Humphrey, the whale that swam into San Francisco Bay and up the Sacramento River in 1985 and again in 1990). Similarly, part way up the Columbia River and around the town of Chinook, humpback whales were sighted regularly in 2015 and 2016, an area locals did not recall previously seeing humpback whales.

Winter migratory destinations

Known migratory winter area destinations for humpback whales differed dramatically between Washington – S British Columbia and California - Oregon (Table 5). Overall known migratory destinations for California-Oregon feeding areas consisted primarily of Central America and some of the Mexican wintering areas with only smaller numbers of whales documented going to the Mexican Revillagigedos and Hawaii (Table 5). For both Central America and S Mexico, over 70% of identified whales from those areas have been matched to California-Oregon, Whales from Washington – S British Columbia including those identified in the Salish Sea show a more diverse mix of wintering areas.

While clear differences exist in winter migratory destinations among feeding areas, subtler differences also exist within feeding areas (Figure 5). Along the US West Coast, the proportion of whales going to Central America versus mainland Mexico and other winter destinations follows a gradient through the feeding area with whales feeding off S California more likely to go to Central America than those farther north along the coast (Figure 5). The opposite trend exists for mainland Mexico (Figure 5).

Photo-identifications from areas of S Mexico obtained in recent years have been more similar in several ways to Central America than to the main breeding areas in Mexico (Dobson et al. 2015) raising a question on where to consider the border between the Central America and Mexico DPS. More than 70% of the whales identified in S Mexico match whales from the California – Oregon feeding areas suggesting that like Central America whales, the vast majority of these whales migrate to this one feeding area. Also similar to Central America, whales identified in S Mexico disproportionally are seen in southern portion of the California – Oregon feeding area (Figure 5).

Improvements in public submissions and automated matching

New developments in both encouraging contributions from opportunistic sources and automated matching have aided work to date and promise to dramatically improve participation and matching time for photo-ID images. These have come as a result of two independent though related efforts Cascadia has helped encourage and supported including through providing access to Cascadia overall photo-ID collection and SPLASH: 1) Wildbook/Wild me/IBEIS/RPI team has developed new automated matching tools for a variety of species but recently has made important new progress on matching humpback whales, and 2) Happywhale, an effort initiated by Ted Cheeseman focused around encouraging and streamlining photo-ID submissions and providing real-time feedback on potential matches. These efforts have developed in recognition of some of the major challenges in management and matching of larger catalogs.

We recently tested two new automated matching algorithms developed by the Wildbook Team (Flynn et al. 2017, In Prep.). These appeared to be a dramatic improvement on the numerous automated and semi-automated systems that have been developed in the past, which while somewhat effective, have not had ideal success rates especially with larger collections. We conducted a systematic test of two new automated matching algorithms. The first, HotSpotter, is driven by the pigmentation and scarring patterns on the flukes. The second, CurvRank, is driven by the digital measures of curvature along the trailing edge of the fluke. The test involved a sample of 2,777 cropped photographs of humpback whale flukes taken along the US West Coast by Cascadia and collaborators (primarily in 2014) as queries, representing the best image from an encounter. These were compared to a reference collection (Cascadia's historical catalog through 2013) of over 4,041 photos of 3,235 individuals (Table 5). Manual comparison required over 2,500 volunteer and 900 staff hours of matching effort. Both automated programs were very effective in finding the correct match as their top choice (74% for CurvRank and 69% for HotSpotter). The correct match was in the top two choices of one or both programs 90% of the time. This included at least 21 verified matches chosen as the top two results that were missed in the manual comparison (Figure 6-7). These were primarily found by CurvRank (20 of 21 were first rank) and mostly consisted of black flukes especially where there had been a change in fluke coloration or marks. The most common reasons for algorithm missed matches were a lack of distinct patterns (HotSpotter) or partially obscured or poorly visible trailing edge (CurvRank). These results promise to revolutionize the ability to maintain and compare large collections.

Another effort, Happywhale, has helped encourage submission of photographs and participation along the US West Coast, though the system is also being applied to other regions (Cheeseman et al. 2017). This system currently makes use of some of the earlier versions of the open source matching software mentioned previously. Citizen scientist engagement benefits the science by generating otherwise unavailable data while creating environmental education; collectively, as of March 2017, Happywhale had received submissions of 36,000 images from over 900 contributors, involving more than 9,500 encounters of over 4,500 identified individual humpbacks. The platform has been collecting worldwide data, with 87% of individually identified humpback whales coming from our focal region of the North Pacific. Happywhale aims to enable near-real-time catalog comparison and integration, together with new data generation to create an ocean-basin-wide ongoing linkage study building upon exiting datasets like the SPLASH study and the long-term study of humpback whales along the US West Coast. For the US West Coast, the Happywhale effort has been tightly integrated with Cascadia's ongoing scientific studies.

Increased entanglements along the US West Coast

The dramatic increase in entanglements of humpback whales along the US West Coast is emerging as an important issue. In 2015, 35 humpback whale entanglements were reported with 54 in 2016 (NOAA 2017). These cases represent minimums because additional cases go undocumented especially from areas with less whale watch activity. Even though there are some changes to fishing activity especially for Dungeness Crab (a major source of the entanglements) which may explain a portion of this increase, it also appears changes in whale occurrence plays a key role.

Humpback whales are known to shift prey between krill and fish along the US West Coast and these shifts seem to match the relative abundance of prey and are reflected in changes in stable isotope concentrations from skin samples taken in biopsies of whales (Fleming et al. 2015). Some of these shifts in prey, especially when targeting nearshore concentrations of fish like anchovies, has sometimes brought whales closer to shore and into new areas. Humpback whales documented feeding inside San Francisco Bay and in the Columbia River appeared to be feeding on anchovies.

Some of the changes in whale occurrence contributing to greater entanglement may also be related to humpback whales reaching carrying capacity including:

- Expansion into more peripheral habitats
- Greater time on feeding grounds to meet nutritional needs
- More animals overwintering or arriving early in the season causing greater overlap with Dungeness crab fishery which is most intense in winter and early spring.

Table 1. Humpback whale identifications by year and region along the US West Coast extending into S British Columbia. IDs reflect number of times a whale was identified and Unique reflects number of different individuals for each period and region.

Region	<1986	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	IDs	Unique
S Ca. Bight (south)							1		5	3			4					3		5				2	2	2		1		8		36	34
S. Ca. Bight (north, not SBC)				1		1		3	1	7	29			5			9	1				8			16	8	3	11	4	31		138	88
Santa Barbara Channel				5		14	28	222	11	21	259	33	42	169	22	1	3	104	83	37	210	131	189	187	504	362	398	312	145	127		3619	715
S. California (offshore)							4																5	1		35		2	2	2		51	44
Pt Conception to Buchon			8	115			169	4	1	23	32		29	3	2	133	25	44	14	49	51			13		2	8					725	292
Pt Buchon to Pt. Sur				2		2	26					8	18	16	9	5	4			23	123	13		87		98		3	30			467	267
C. California offshore																								4								4	4
S Monterey Bay Sanc.	3		6	18	2	13	38	101	86	83	58	158	133	283	358	424	137	70	171	147	221	255	18	263	179	212	88	439	977	1986		6927	1438
N Monterey Bay Sanc.				2		30			33	4	55	97	53	43	14		192	43	84	103	30	12	9	18	91				3	3		919	531
Farallones/Cordell	19	466	794	399	265	316	181	372	336	261	215	250	37	150	148	43	101	156	141	105	46	46	170	157	72	95	92	47	267	140		5887	1397
Bodega Bay to Pt. Arena		1		5				119	8			5	5	41	2		1		5			2										194	113
Pt. Arena to C. Mendocino							5	116	2				25	27				22	10		5					2	4		3			221	161
C Mend. to Klamath Riv.	1			11			4		4		13	8	28	6						8	34	35	11	1	4	2	31	190	9	32		432	319
N California to Oregon				3			212	68	25		1		16	112	9		3	9	24	8	39	2	15			5	76	7	5			639	289
S Oregon								2									5	2								1	18			2		30	28
C. Oregon						23						7			49	9	2	35	1		8			2						1		137	100
N Oregon								14									1		1				1	3					1	2		23	15
S Washington						5								1			6			7	40	9	15	11	12	3	10	11			1	131	115
N Washington					1	2	4		2	17	49	45	17	46	58	30	41	42	7	32	46		29	60	2	7	17	95	115	18	1	783	385
WA/BC inside waters				4						3	1	1	2	4	1	1		1	8	36	53	37	77	11	41	21	4	9	16	28	240	599	154
S British Columbia						8	10	2	1	3		12	7	48	76	34	27	39	11	92	407	34	79	31	186	57	49	40	35	27		1315	340
IDs	23	467	808	565	268	414	682	1023	515	425	712	624	416	954	748	680	557	571	560	652	1313	584	618	851	1109	912	798	1167	1612	2407	242	23277	
Unique	20	91	150	212	110	216	282	399	256	261	362	367	291	435	382	268	311	361	409	379	556	337	387	526	578	492	452	652	710	697	63		3484

Table 2. Estimates of abundance of humpback whales for California-Oregon using Petersen estimates based on annual samples of photographic identifications.

Year	n1	n2	m	Pop	CV	SE
1990-91	205	269	105	524	0.05	28
1991-92	269	397	188	568	0.03	16
1992-93	397	253	173	580	0.03	18
1993-94	253	244	108	570	0.05	31
1994-95	244	328	101	789	0.06	49
1995-96	328	331	146	742	0.05	34
1996-97	331	268	106	834	0.06	51
1997-98	268	385	120	857	0.06	48
1998-99	385	328	129	976	0.06	54
1999-2000	328	227	109	681	0.06	38
2000-01	227	266	82	732	0.07	53
2001-02	266	313	86	963	0.07	72
2002-03	313	386	92	1306	0.08	99
2003-04	386	302	87	1332	0.08	105
2004-05	302	369	71	1556	0.09	143
2005-06	369	293	92	1169	0.07	86
2006-07	293	297	56	1536	0.11	163
2007-08	297	441	63	2057	0.10	209
2008-09	441	476	142	1473	0.06	85
2009-10	476	432	150	1367	0.05	74
2010-11	432	389	146	1148	0.05	61
2011-12	389	520	135	1493	0.06	89
2012-13	520	589	172	1776	0.05	93
2013-14	589	647	272	1399	0.03	47

Table 3. Estimates of abundance of humpback whales off California-Oregon based on 4-year closed models.

	Darroch M_t			Chao M_{th}		
4-Year Period	N	SE	CV(N)	N	SE	CV(N)
1991-1994	639	9.1	0.01	797	33.1	0.04
1995-1998	895	17.4	0.02	1099	50.3	0.05
1999-2002	967	26.6	0.03	1324	81.4	0.06
2003-2006	1554	54.4	0.04	2045	136.0	0.07
2007-2010	1828	54.7	0.03	2409	139.7	0.06
2011-2014	1872	38.0	0.01	2374	102.0	0.03

Table 4. Estimates of abundance of humpback whales for Washington-S British Columbia using Petersen estimates based on annual samples of photographic identifications.

Year	n1	n2	m	Pop	CV	SE
1994-95	17	35	6	92	0.25	23
1995-96	35	36	11	110	0.19	21
1996-97	36	23	8	98	0.22	21
1997-98	23	50	7	152	0.25	38
1998-99	50	57	14	196	0.18	36
1999-2000	57	41	15	151	0.16	25
2000-01	41	44	5	314	0.33	103
2001-02	44	48	13	157	0.18	29
2002-03	48	23	10	106	0.19	20
2003-04	23	77	10	169	0.20	34
2004-05	77	187	27	523	0.14	72
2005-06	187	43	25	317	0.11	36
2006-07	43	90	15	249	0.18	44
2007-08	90	85	17	434	0.18	79
2008-09	85	102	14	590	0.21	124
2009-10	102	61	23	265	0.14	36
2010-11	61	63	10	360	0.24	86
2011-12	63	132	16	500	0.19	94
2012-13	132	123	22	716	0.17	120
2013-14	123	50	11	526	0.23	121

Table 5. Currently known matches between West Coast feeding areas and wintering areas. Not all comparisons have been made among areas so all numbers reflect minimums and may vary due to comparisons completed.

Region		**Ogas.**	**HI**	**Rev Mx**	**B Mx**	**M Mx**	**S Mx**	**C Am**
	n	NA	NA	NA	NA	NA	95	267
WA-SBC out	672	1	22	12	20	46	5	9
Salish Sea	139		6	2	1	8	0	1
CA-OR	2812		5	8	96	317	66	226

Table 6. Summary from test of two new automated matching algorithms developed by Wildbook Team (Flynn et al. 2017) of 2,777 humpback fluke photographs (mostly from 2014 US West Coast) against a reference catalog of 4,041photos of 3,235 whales (from 1986-2013). The 2,169 verified matches include those identified by Cascadia manual matching and 21 matches found in top to choices of algorithm verified as missed.

	Edge matcher		Hot Spotter-Pattern	
Category	**n**	**%**	**n**	**%**
Total verified matches present	2,169			
Match in top 1	1,615	74%	1,489	69%
Match in top 2	1,673	77%	1,536	71%
Match in top 5	1,730	80%	1,576	73%
Match in top 10	1,752	81%	1,604	74%
Proportion of 2,169 verified matches found				
Total matches found by CRC manual	2,147	99%		
Top Match in both	1,190	55%		
Top Match in at least one	1,914	88%		
Top 1 or 2 match in at leat one algorithm	1,951	90%		

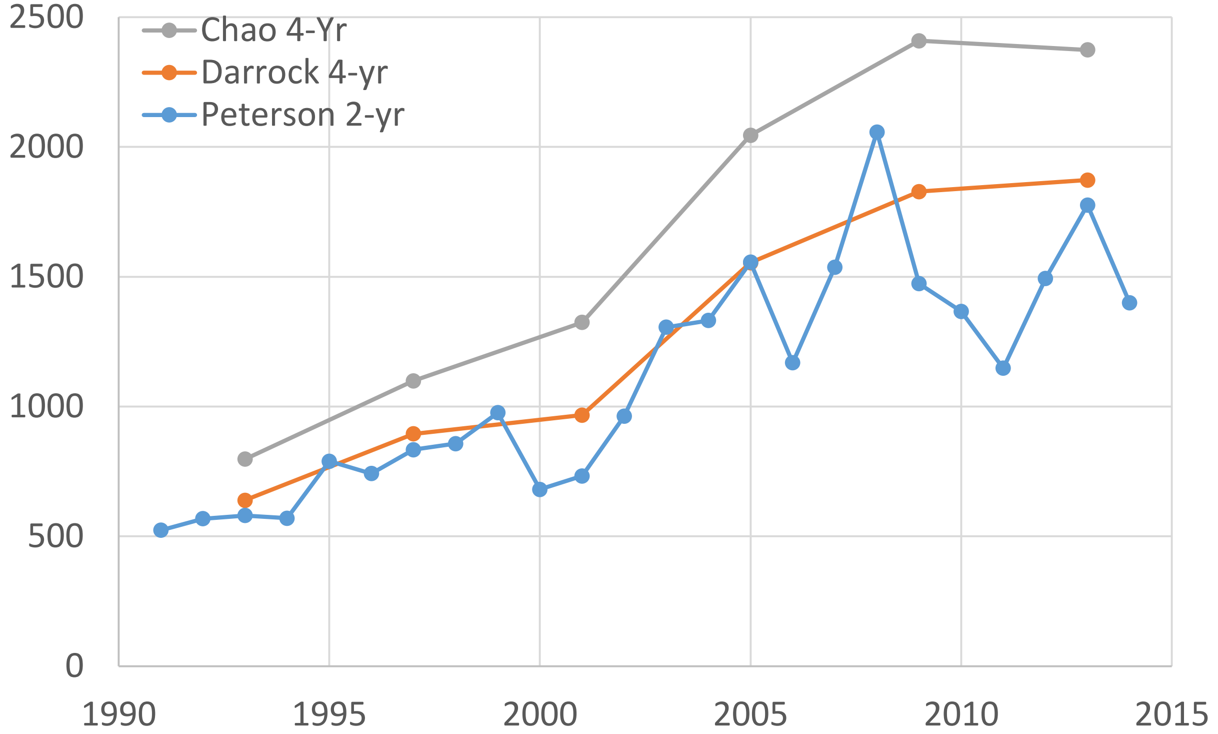

Figure 1. Estimates of abundance of humpback whales off California-Oregon based on different mark-recapture models (see text and Table 3 for details).

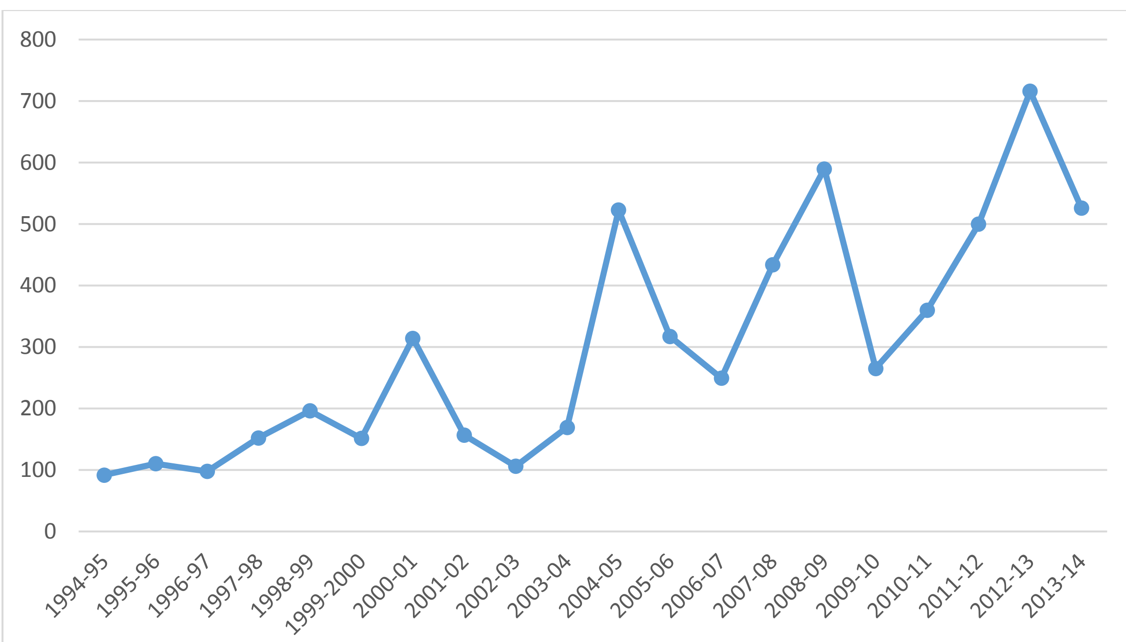

Figure 2. Estimates of abundance of humpback whales off Washington and S British Columbia using Petersen estimate with adjacent years. See Table 4 for details.

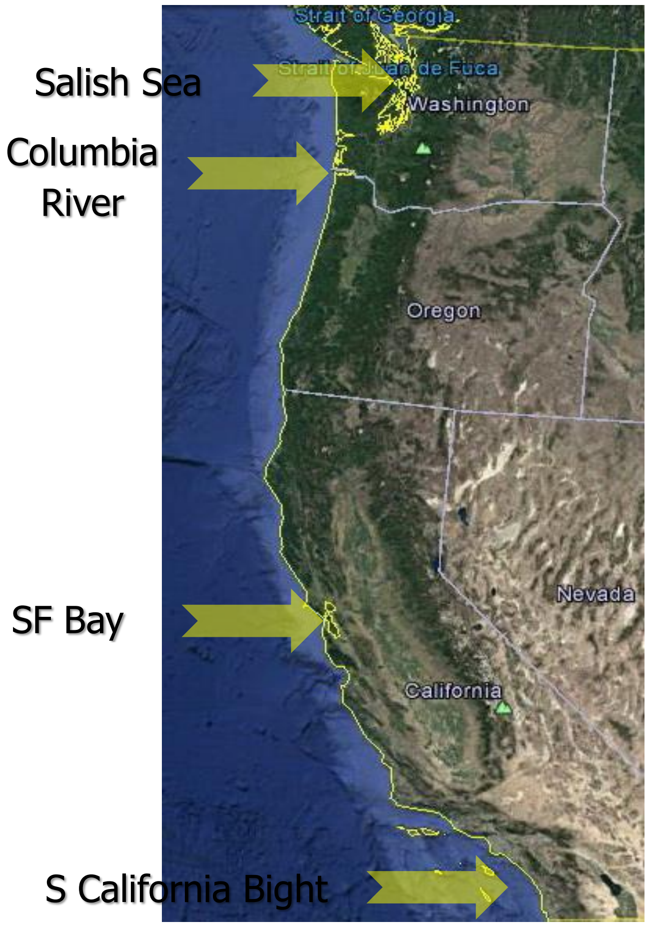

Figure 3. Locations of humpback whale sightings in the feeding season along the US West Coast in recent years where they previously were uncommon.

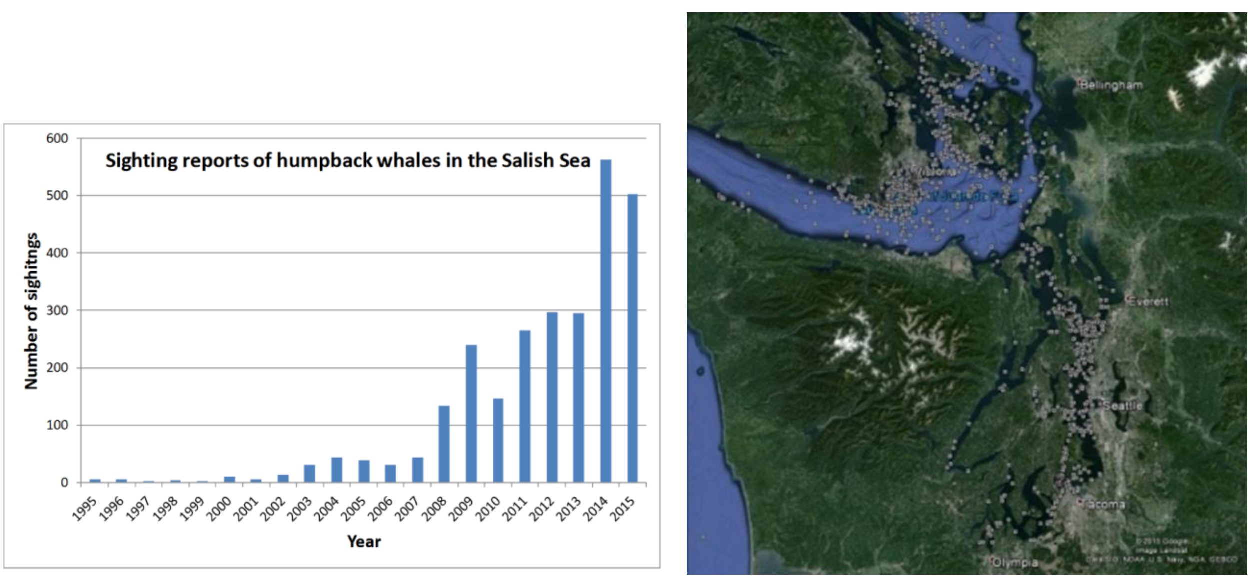

Figure 4. Increase in humpback whale sightings reports to Cascadia Research and Orca Network (left) and distribution of sighting locations in the Salish Sea (right).

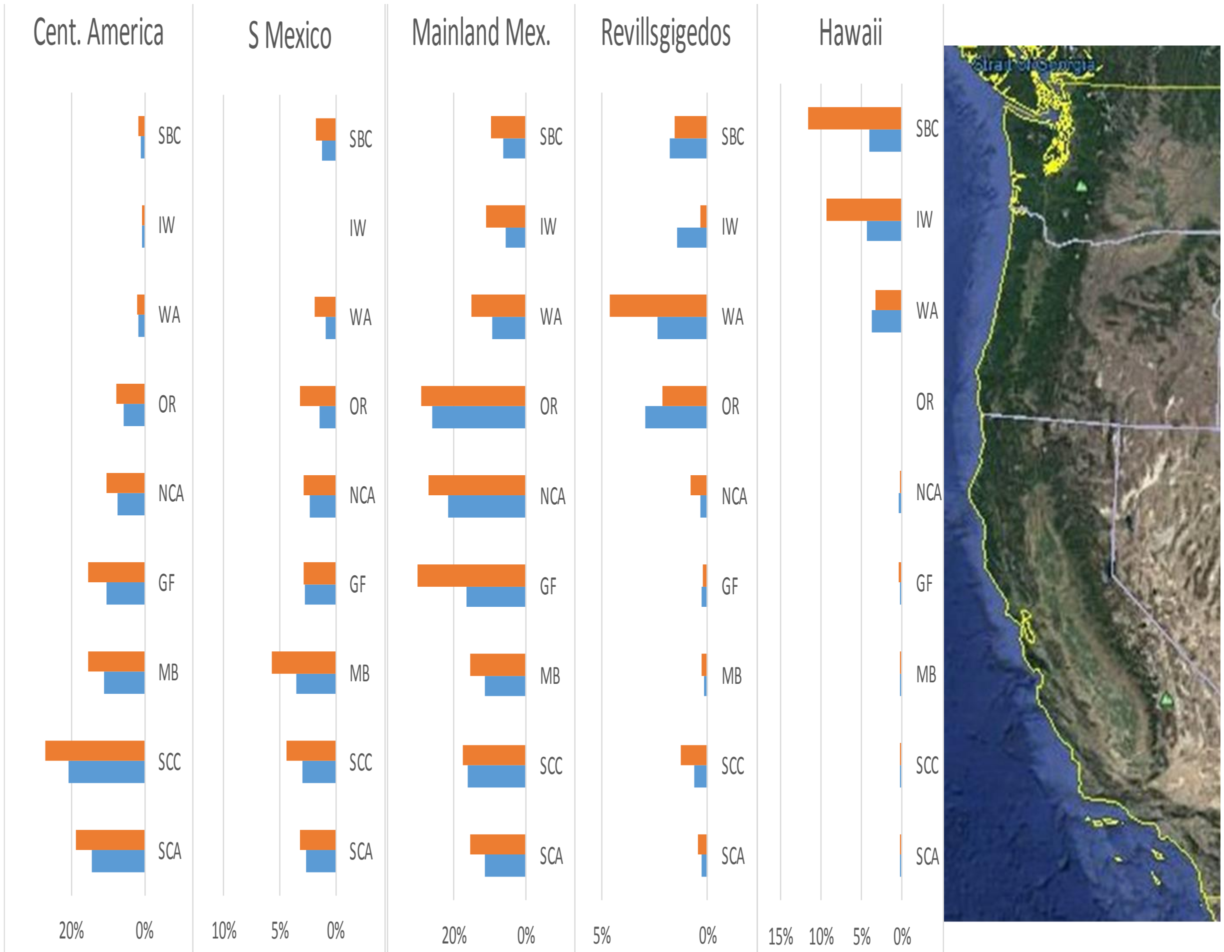

Figure 5. Proportions of humpback whales in different feeding areas that match different wintering areas. Blue bars show percent of unique individuals and red show percent of encounters in each area known to match each wintering area.

Figure 6. Example of a match (CRC 10442) found by edge detector as top choice that had been missed (match to bottom photograph) in manual matching. Top photo from 26 Aug 2009 (Calambokidis) and bottom from 4 March 2015 (Whales of Guerrero). Despite lack of distinctive color pattern and changes to trailing edge, the match was the top choice in the edge detection.

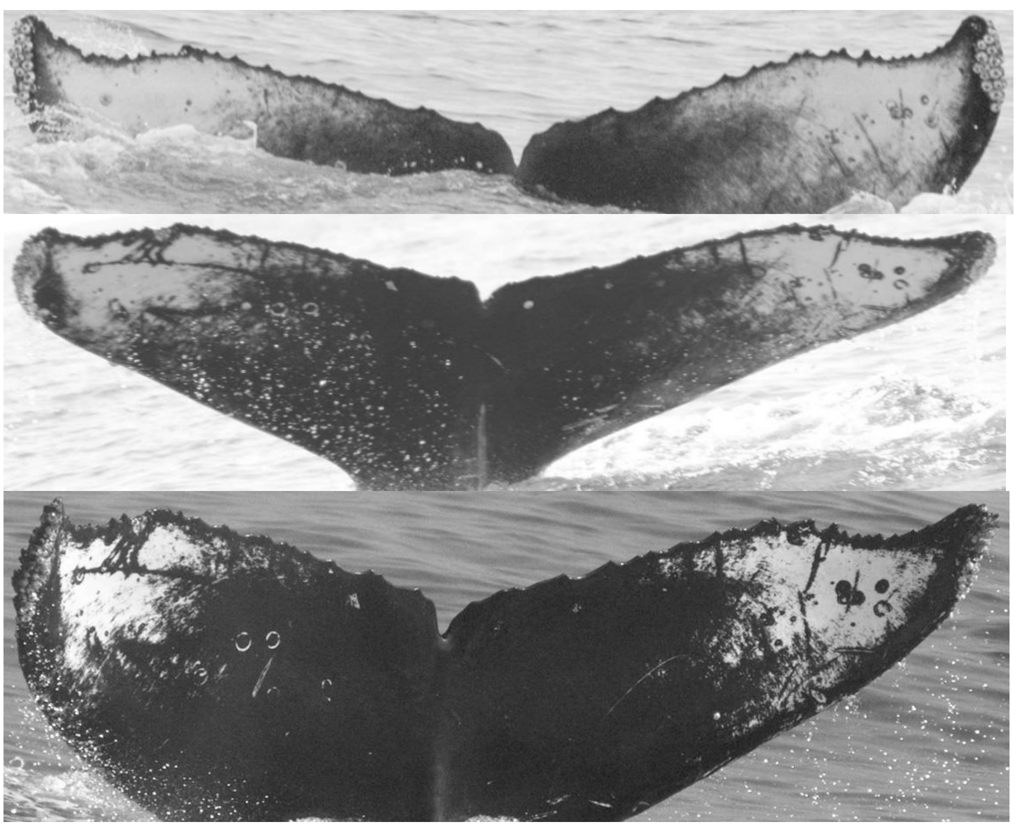

Figure 7. Matches (CRC-12064) found by edge detector and pattern recognition with one of the matches of above photographs missed by manual matching. Photos from top: 1) Photo by OSU on 4 August 2005, 2) photo by Cascadia on 6 August 2006, 3) photo from Monterey Bay Whale Watch on 31 May 2012.

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