Estimated humpback whale bycatch in the U.S. West Coast Groundfish Fisheries 2002-2017

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Executive Summary

In accordance with the National Marine Fisheries Service (NMFS) Biological Opinion (BiOp) on Continuing Operation of the Pacific Coast Groundfish Fishery, this document provides a summary of observed bycatch of U.S. Endangered Species Act (ESA)-listed humpback whales (*Megaptera novaeangliae*) in sectors of the west coast groundfish fishery from 2016–2017.

There have been two documented takes of a humpback whale in the Pacific Coast groundfish fisheries—one in the Limited Entry (LE) sablefish pot fishery sector in 2014 and one in the Open Access Fixed Gear pot fishery sector in 2016. Although there have been no other observed takes in Pacific coast groundfish fisheries since data collection began in 2002, pot and trap fisheries generally represent the majority of documented fishery interactions with humpbacks along the U.S. west coast. We used Bayesian procedures to estimate annual mean fleet-wide bycatch and a running 5-year fleet-wide average in two West Coast groundfish pot sectors. The estimated fleet-wide entanglements/takes in the combined LE Sablefish and Open Access Fixed Gear pot sectors were consistently above the 5-year running average threshold over the time period examined (2002-2017). While the estimated fleet-wide entanglements/takes in the LE Sablefish pot sector were consistently below the 5-year running average threshold, the estimated fleet-wide entanglements/takes in the Open Access Fixed Gear pot sector was consistently above the 5-year running average threshold.

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Introduction and Background

In accordance with the National Marine Fisheries Service (NMFS) Biological Opinion (BiOp) Regarding the Effects of the Continued Operation of the Pacific Coast Groundfish Fishery (NMFS 2012a) as governed by Pacific Coast Groundfish Fishery Management Plan, this document provides a reporting of observed takes of U.S. Endangered Species Act-listed humpback whales (*Megaptera novaeangliae*) in U.S. west coast groundfish fishery sectors. This report updates assessments submitted in accordance with the Biological Opinion requirement, which reported on bycatch in the fisheries for 2010-2013 (Hanson et al. 2015) and 2014-2015 (Hanson et al. 2017).

Humpback Whale Status, Life History and Ecology

Humpback whales (*Megaptera novaeangliae*; Borowski, 1781) are baleen whales of the family Balaenopteridae. This section is adapted from the recent NOAA Fisheries Humpback Whale Status Review; for details, see Bettridge et al. (2015). Humpback whales are found in all oceans of the world with a broad geographical range from tropical to temperate waters in the northern hemisphere and tropical to arctic waters in the southern hemisphere. All populations migrate seasonally between winter calving and breeding grounds and summer feeding grounds within ocean basins. Despite this potential for dispersal, interbreeding of individuals from different major ocean basins is extremely rare. Whales from the major ocean basins are differentiated by reproductive seasonality, behavior, color patterns, and genetics.

Humpback whales were listed worldwide as endangered under the ESA in 1970, and a Recovery Plan was finalized for this species in 1991 (NMFS 1991). Under the MMPA, humpback whales are classified as a strategic stock and considered depleted. On August 12, 2009, NMFS initiated an ESA status review of humpback whales (74 Fed. Reg. 40568) and produced a status review (Bettridge et al. 2015) that identified distinct population segments (DPS) of humpback whale and evaluated their risk of extinction. In September 2016, NMFS issued a final rule revising the listing status of the species (81 FR 62259), in which 14 distinct population segments were identified. Of these, nine did not warrant listing under the ESA, four were listed as endangered, and one was listed as threatened. In the North Pacific, there are four discrete and significant DPS, identified by breeding location: *Hawaii, Central America, Mexico*, and *Western North Pacific*. Humpback whales found off the Oregon, Washington, and California coast are from the Central America, Mexico and Hawaii DPS (Barlow et al. 2011). Only the Mexico DPS and Central America DPS are listed, as threatened and endangered, respectively.

Breeding locations in the North Pacific are more geographically separated than feeding areas and include regions offshore of Hawaii, Central America; the west coast of Mexico, and the Ogasawara and Okinawa Islands and the Philippines. Feeding areas in the North Pacific range from California, USA to Hokkaido, Japan, with most feeding occurring in coastal waters. Humpback whales in the North Pacific rarely move between these breeding regions. Strong fidelity to both feeding and breeding sites has been observed but movements are complex (Calambokidis *et al.* 2008; Barlow *et al.* 2011). In general, Asia and Mexico/Central America are the dominant breeding areas for humpback whales that migrate to feeding areas in lower latitudes and coastal California and Russia. The Revillagigedo Islands and Hawaiian Islands

serve as wintering areas for humpback whales that feed in the more central and higher latitude areas (Calambokidis *et al.* 2008). Exceptions to this pattern exist, and complex population structure and strong site fidelity appear to coexist with lesser known, but potentially high, levels of plasticity in the movements of humpback whales (Salden *et al.* 1999).

The Hawaii DPS is composed of humpback whales that breed within the main Hawaiian Islands. Whales from this DPS use most known feeding grounds in the North Pacific; half migrate to feeding grounds in southeast Alaska and northern British Columbia, with many also using northern Gulf of Alaska and Bering Sea feeding grounds. The Central America DPS is composed of humpback whales that breed along the Pacific coast of countries in Central America. Whales from this DPS feed almost exclusively offshore of California and Oregon in the eastern Pacific, with a few individuals in the northern Washington-southern British Columbia feeding grounds. The Mexican DPS is composed of humpback whales that breed along the Pacific coast of mainland Mexico, Baja California, and the Revillagigedo Islands. Whales from this DPS feed across a broad geographic range from California to the Aleutian Islands, with concentrations in California-Oregon, northern Washington-southern British Columbia, northern and western Gulf of Alaska and Bering Sea feeding grounds. The Western North Pacific DPS is a combined DPS composed of humpback whales that breed/winter around Okinawa and the Philippines (Okinawa/Philippines DPS) and a second population that transit the Ogasawara area but breed in an unknown location (Second West Pacific DPS). Whales from the Okinawa/Philippines portion of the DPS migrate to feeding grounds in the northern Pacific, primarily off the Russian coast, while whales from the Second West Pacific DPS are linked to the Aleutian Islands feeding grounds.

A recent analysis of genetic variation in >2000 humpback whales found support for DPS designation in substantial level of genetic divergence among breeding areas at the mtDNA control region (Baker *et al.* 2013). For example, humpback whales in Central America have a unique mtDNA signature (Baker *et al.* 2008a; Baker *et al.* 2008b). The Hawaii population is separated from distant but neighboring populations in both frequencies of mtDNA haplotypes and nDNA (microsatellite) alleles (Baker et al. 2013). In Mexico, mtDNA haplotype frequencies in mainland and the Revillagigedo Islands humpback populations were not significantly different (Baker *et al.* 2013) and were thus considered a single population.

Recent population and abundance estimates for the west coast are summarized in Carretta et al. (2018). Recent humpback whale abundance estimates for the entire North Pacific and have ranged from 18,302 (Calambokidis *et al.* 2008) to 21,808 individuals (Barlow *et al.* 2011); the latter estimate may still be an underestimate of actual humpback whale abundance. For the lower estimate, whale populations in breeding areas have been estimated at 10,000 individuals in Hawaii, 500 for Central America, 6,000-7,000 animals in Mexico, and 1,000 for the Western Pacific, for a total of 17,500-18,500. Barlow *et al.* (2011) did not apportion the 21,808 individuals to breeding areas, but the proportions are likely to be similar to those estimated by Calambokidis *et al.* (2008). Barlow (2016) recently estimated 3,064 (CV= 0.82) humpback whales from a 2014 summer/fall ship line-transect survey of California, Oregon, and Washington waters.

Growth rates have been calculated on regional scales and include ~8%/year for the U.S. West Coast (1991-2008; Calambokidis 2009), 6.6%/year for the Alaskan Peninsula and Aleutian Islands (2001-2003; Zerbini *et al.* 2010), and 10.6%/year in southeast Alaska (1991-2007; Dahlheim *et al.* 2009), 5.5-6.0%/year for Hawaii and 6.7%/year in the western Pacific (1990-1993, NPAC and 2004-2006, SPLASH; Calambokidis *et al*. 2008). More recent estimates show a

possible leveling-off of the population, depending on the choice of model and time frame used (Calambokidis et al. 2017).

Humpback whales face a variety of threats, depending on the region in which they occur. Threats listed in the Recovery Plan include entrapment and entanglement in fishing gear, collisions with ships, acoustic disturbance, habitat degradation, and competition for resources with humans (NMFS 1991). Climate change and ocean acidification are also global threats to marine ecosystems that could indirectly affect humpback whales via trophic dynamics and available prey. Globally, entrapment and entanglement in fishing gear and collisions with ships represent most of the reported and observed serious injuries and mortalities for the species (review in Carretta et al. 2014b). The number of human-related deaths and injuries for each humpback whale feeding group are unknown, but based on the proportion of the overall abundance (2,900 whales) belonging to the California-Oregon (82%) and Washington and southern British Columbia (18%) feeding groups, a majority of cases likely involve whales from the California-Oregon feeding group that includes nearly all of the Central American DPS (Carretta et al. 2018b). Entanglement data are available for most stocks of humpback whales worldwide. These entanglements result from humpback whale interactions with a variety of fisheries and gear types and generally result in some level of serious injury and mortality. The absolute number of humpback whale entanglements is likely under-represented by these data, in part because observer programs and stranding networks do not exist in many parts of the world.

Threats from Fishing Gear Entanglements

Humpback whales may break through, carry away, or become entangled in fishing gear. Whales carrying gear may later die, become debilitated or seriously injured, or have normal functions impaired, all without having been recorded. Of nations reporting to the IWC, 64.7% (n=11) reported humpback whale bycatch from 2003-2008 (Mattila and Rowles 2010). Some countries (*e.g.*, U.S., Canada, Australia, South Africa) have well-developed reporting and response networks collecting information on entanglements. Still, <10% of humpback whale entanglements in the Gulf of Maine are reported, despite strong outreach and a response network (Robbins and Mattila 2004). For whales off the U.S. East Coast, 89% of removed gear was pots/traps or gillnet gear, although other gear types were observed (Johnson *et al.* 2005). A wide range of entangling gear has also been reported in the South Pacific (Neilson 2006; Lyman 2009), Newfoundland (Lien *et al.* 1992) and by the IWC (Mattila and Rowles 2010). In the North Pacific, entanglement is pervasive but highest among coastal populations (Robbins *et al.* 2007a; Robbins 2009).

Entanglement may result in only minor injury, or potentially may significantly affect individual health, reproduction or survival. Studies of the fate of entangled whales in the Gulf of Maine suggest that juveniles are less likely than adults to survive (Robbins *et al.* 2008), and observed entanglement deaths and serious injuries in that region are known to exceed what is considered sustainable for the population (Glass *et al.* 2009). Most deaths likely go unobserved and preliminary studies suggest that entanglement may be responsible for 3-4% of total mortality, especially among juveniles (Robbins *et al.* 2009).

Much more is known about fishing gear entanglement in the Northern Hemisphere than is in the Southern Hemisphere. Off Japan, an entangled whale is legally allowed to be killed and sold on the market (Lukoschek *et al.* 2009), so entanglement often leads to death for humpback whales in this region. While the number of reported bycaught animals is not large, the number of reports

has been increasing and may underestimate the actual number caught. The Mexico population has one of highest scar rates from nets and lines in the North Pacific, indicating a high entanglement rate (Bettridge et al. 2015). Based on this information, the severity of the threat of fishing gear entanglements varies among regions and ranges from low to high.

Threat for Hawaii DPS

Studies indicate that the Hawaii DPS experiences a high rate of interaction with fishing gear (20-71%), with the highest rates recorded in southeast Alaska and northern British Columbia (Neilson *et al.* 2009). Fatal entanglements of humpback whales in fishing gear have been reported in all areas, and observed fatalities are almost certainly under-reported. Studies in another humpback whale feeding ground, which has similar levels of scarring, estimate that the actual annual mortality rate may be as high as 3.7% (Angliss and Outlaw 2008). The level of threat from fishing is considered medium and is not expected to significantly diminish population growth.

Threat for Central America DPS

Vessel collisions and entanglement in fishing gear pose the greatest threat to this population, especially off Panama, southern California, and San Francisco. Between 2004 and 2008, there were 18 reports of humpback whale entanglements in commercial fishing gear off California, Oregon, and Washington (Carretta *et al.* 2010), and the actual number of entanglements may be higher. Effective fisheries monitoring and stranding programs exist in California, but are lacking in Central America and much of Mexico. Levels of mortality from entanglement are unknown, but entanglement scarring rates indicate a significant interaction with fishing gear. The Central America DPS is therefore considered to be at moderate risk of extinction over the next three generations.

Threat for Mexico DPS

Of the 17 records of stranded North Pacific humpback whales in the NMFS stranding database, three involved fishery interactions, two were attributed to vessel strikes, and in five cases the cause of death could not be determined (Carretta *et al.* 2011). Specifically, between 2004 and 2008, 14 humpback whales were reported seriously injured in commercial fisheries offshore of California and two were reported dead. What proportion of these represent the Mexican breeding population is unknown, but the fishing gear involved included gillnet, pot, and trap gear (Carretta *et al.* 2010). The Mexico DPS is considered to be "not at risk" of extinction, although some voted for "moderate risk" reflect the threat of entanglement among other threats.

Threat for Western North Pacific DPS

Whales along the coast of Japan and Korea are at risk of entanglement related mortality in fisheries gear, although overall rates of net and rope scarring are similar to other regions of the North Pacific (Brownell *et al.* 2000). The threat of mortality from any such entanglement is high given the incentive for commercial sale allowed under Japanese and Korean legislation (Lukoschek *et al.* 2009). The reported number of humpback whale entanglements/deaths has increased for Japan

since 2001 due to improved reporting, although the actual number of entanglements may be underrepresented in both Japan and Korea (Baker *et al.* 2006). The level of confidence in understanding the minimum magnitude of this threat is medium for the Okinawa/Philippines DPS and low for the Second West Pacific DPS, given the unknown wintering grounds and primary migratory corridors.

Fishing gear entanglements are considered likely to moderately reduce the population size or the growth rate of the Hawaii, Central America, and Mexico DPSs and are likely to seriously reduce the population size or the growth rate of the Western North Pacific [Okinawa/Philippines] DPS.

West Coast Groundfish Fisheries

The West Coast Groundfish Fishery (WCGF) is a multi-species fishery that utilizes a variety of gear types. The fishery harvests species designated in the Pacific Coast Groundfish Fishery Management Plan (PFMC 2011) and is managed by the Pacific Fishery Management Council (PFMC). Over 90 species are listed in the groundfish FMP, including a variety of rockfish, flatfish, roundfish, skates, and sharks. These species are found in both federal (> 5.6 km off-shore) and state waters (0-5.6 km). Groundfish are both targeted and caught incidentally by trawl nets, hook-&-line gear, and fish pots.

Under the FMP, the groundfish fishery consists of four management components:

The Limited Entry (LE) component encompasses all commercial fishers who hold a federal limited entry permit. The total number of limited entry permits available is restricted. Vessels with an LE permit are allocated a larger portion of the total allowable catch for commercially desirable species than vessels without an LE permit.

The Open Access (OA) component encompasses commercial fishers who do not hold a federal LE permit. Some states require fishers to carry a state-issued permit for certain OA sectors.

The Recreational component includes recreational anglers who target or incidentally catch groundfish species. Recreational fisheries are not covered by this report.

The Tribal component includes native tribal commercial fishers in Washington State that have treaty rights to fish groundfish. Tribal fisheries are not included in this report, with the exception of the observed tribal at-sea Pacific hake (*Merluccius productus*) (also known as whiting) sector.

These four components are further subdivided into sectors based on gear type, target species, permits and other regulatory factors (see Appendix 1). The analyses in this report focus on data from the Limited Entry (LE) sablefish pot fisheries and the open access pot fisheries sectors. The pot gear targets groundfish species, mainly sablefish, and catch is delivered to shore-based processors.

Northwest Fisheries Science Center Groundfish Observer Programs

The NWFSC Groundfish Observer Program's goal is to improve estimates of total catch and discard by observing commercial sectors of groundfish fisheries along the U.S. west coast that target or take groundfish as bycatch. The observer program has two units: the West Coast

Groundfish Observer Program (WCGOP) and the At-Sea Hake Observer Program (A-SHOP). The WCGOP Program was established in May 2001 by NOAA Fisheries (a.k.a., National Marine Fishery Service, NMFS) in accordance with the Pacific Coast Groundfish Fishery Management Plan (50 CFR Part 660) (50 FR 20609). This regulation requires all vessels that catch groundfish in the US EEZ from 3-200 miles offshore carry an observer when notified to do so by NMFS or its designated agent. Subsequent state rule-making has extended NMFS's ability to require vessels fishing in the 0-3 mile state territorial zone to carry observers.

The WCGOP and A-SHOP observe distinct sectors of the groundfish fishery. The WCGOP observes the following sectors: IFQ shore-based delivery of groundfish and Pacific hake, LE and OA fixed gear, and state-permitted nearshore fixed gear sectors. The WCGOP also observes several state-managed fisheries that incidentally catch groundfish, including the California halibut trawl and ocean shrimp trawl fisheries. The A-SHOP observes the IFQ fishery that delivers Pacific hake at-sea including: catcher-processor, mothership, and tribal vessels. Details on how fisheries observers operate in both the IFQ (Catch Share) and Non-IFQ sectors can be found at: http://www.nwfsc.noaa.gov/research/divisions/fram/observation/index.cfm.

Humpback whale bycatch in West Coast Groundfish Fisheries

The primary objective of this report is to provide estimates of bycatch of humpback whales in observed U.S. West Coast federally-permitted groundfish fisheries since the last report (Hanson et al. 2017), which covered the years 2014–2015. Previous reports on marine mammal bycatch in West Coast groundfish fisheries (Jannot et al. 2011, Jannot et al. 2018.) have provided data on bycatch of humpback whales in U.S. west coast commercial fisheries. Additional reports are available on the NWFSC Protected Species Reports webpage (https://www.nwfsc.noaa.gov/research/divisions/fram/observation/data_products/protected_species.cfm).

Amount and Extent of Humpback Whale Take

The Biological Opinion (BiOp) Regarding the Effects of the Continued Operation of the Pacific Coast Groundfish Fishery (PCGF) (NMFS 2012a) stated that:

> We anticipate that take of humpback whales will occur as a result of the proposed continued operation of the PCGF. Incidental take of humpback whales occurs as a result of entanglement with fishing gear, as a consequence of fishing activity. This take is expected to occur in the sablefish pot/trap fishery. In the effects section, we estimated an average of 1 humpback whale per year entangled by proposed fishing, with a maximum of 3 humpback whales entangled in a single year.
>
> Therefore, the incidental take limit for humpback whales is a 5-year average of 1 humpback whale injury or mortality per year, and up to 3 humpback whale injuries or mortalities in any single year. Available data on takes will be reviewed periodically by a Pacific Coast Groundfish and Endangered Species Workgroup as described under Reasonable and Prudent Measures and Terms and Conditions below. In addition to these take limits, we will evaluate total human-caused serious injury and mortality of humpback whales annually, and if PBR is exceeded, we will determine whether the MMPA 101(a)(5)(E) permit and humpback whale ITS are still valid. Consistent with

> the analysis in this biological opinion, a portion of unidentified whale and gear entanglements would be counted against these take limits and for this PBR evaluation in addition to known humpback whale entanglements in gear of the proposed fishery (pro-rating criteria and methods described in Section 2.3.3 or as adjusted by the Workgroup). Data used to pro-rate unidentified whale and gear entanglements will be updated each year. These criteria and methods are conservative in light of uncertainty about proposed fishery impacts on humpback whales, because of the opportunistic nature of entanglement observation and reporting, potential for unobserved injury or mortality because of entanglements, and difficulty identifying entangled whales to species and entangling gear to specific fisheries.

This biennial report represents the fulfillment of the take estimate requirement and associated reporting requirements.

Methods

Data Sources

Data sources for this analysis include onboard observer data from the WCGOP and A-SHOP and landing receipt data, referred to as fish tickets, and obtained from the Pacific Fisheries Information Network (PacFIN).

Observer Program Data

A list of fisheries, coverage priorities and data collection methods employed by WCGOP in each observed fishery can be found in the WCGOP training manual (NWFSC 2019). A-SHOP information and documentation on data collection methods can be found in the A-SHOP sampling manual (NWFSC 2019).

The sampling protocol employed by the WCGOP is primarily focused on the discarded portion of catch. To ensure that the recorded weights for the retained portion of the observed catch are accurate, haul-level retained catch weights recorded by observers are adjusted based on trip-level fish ticket records. This process is described in detail on the WCGOP Data Processing webpage (http://www.nwfsc.noaa.gov/research/divisions/fram/observation/data_processing.cfm). Data processing was applied prior to the analyses presented in this report. For a list of all of the groundfish species defined in the Pacific Coast Groundfish Fishery Management Plan see PFMC (2011).

Fish Ticket Data

For bycatch estimation, the landed amount of a particular fish species or species group is used as the effort metric. Thus, the retained landing information from sales receipts (known as fish tickets) is crucial for fleet-wide total bycatch estimation for all sectors of the commercial groundfish fishery on the U.S. west coast. Fish ticket landing receipts are completed by fish-

buyers in each port for each delivery of fish by a vessel. Fish tickets are trip-aggregated sales receipts for market categories that may represent single or multiple species. Fish tickets are issued to fish-buyers by a state agency and must be returned to the issuing agency for processing. Fish tickets are designed by the individual states (Washington, Oregon, and California) with slightly different formats by state. In addition, each state conducts species-composition sampling at the ports for numerous market categories that are reported on fish tickets. Fish ticket and species-composition data are submitted by state agencies to the PacFIN regional database.

Annual fish ticket landings data, with state species composition sampling applied, were retrieved from the PacFIN database and subsequently divided into various sectors of the groundfish fishery. Observer and fish ticket data processing steps are described in detail on the WCGOP website under Data Processing Appendix (http://www.nwfsc.noaa.gov/research/divisions/fram/observer/data_processing.cfm/). All data processing steps specific to this report are described in the bycatch estimation methods section below.

Designation of 'take' and 'serious injury' interactions

NMFS has established guidelines for distinguishing serious from non-serious injury of marine mammals pursuant to the Marine Mammal Protection Act through a policy directive (NMFS 2012b).

Bycatch Estimation

Statistical Model

We applied statistical models to observer program data to characterize uncertainty in humpback whale bycatch estimation in the sablefish pot fishery (Table 1) and open access pot fishery (Table 2). Because only one humpback whale was documented as bycatch in each fishery sector, we were restricted to using simple statistical models while estimating variances of total bycatch. The first approach we used was the Poisson process model, where the total number of entanglements or bycatch events were assumed to follow a Poisson distribution, $n_{\text{bycatch}} \sim Poisson\ (\lambda_1 \cdot N_y)$.

In this approach, the Poisson rate or intensity parameter (λ_1, where $0 \leq \lambda_1 \leq 1$) was fixed at the annual bycatch point estimate (*e.g.*, 1 bycatch event out of 1000 sets would lead to $\lambda_1 = 0.001$), and the effort for a particular year (N_y) was used to estimate the total bycatch. A caveat of this first approach was that by fixing λ_1, we were ignoring the uncertainty in the bycatch rate, making the 95% CIs overly narrow. For example, two fishery sectors might have the same bycatch point estimate, but if one sector fished with 10x as much effort, that second estimate would be more precise. To incorporate this uncertainty due to variable sample sizes, our second approach was to treat the rate parameter as a random variable (λ_2, where $0 \leq \lambda_2 \leq 1$)

We did not use a common approach to model uncertainty in the proportion pp of a Binomial distribution using the Normal approximation, $p \sim Normal(\hat{p}, \sqrt{\hat{p}(1-\hat{p})/n})$, where $\hat{p}$ is the estimated proportion and n is the sample size, because the 95% CIs can include negative values due to the small estimated proportion. To keep this parameter (p) positive, we instead simulated the number of bycatch events that would have occurred given a certain level of effort, and divided that result by effort. Using our previous numbers as an example, $\lambda_2 \sim Binomial(p = 0.001, N = 1000)/1000$. Both approaches require at least one bycatch event. For each model, we generated 100,000

random draws from the distributions of potential bycatch and calculated summary statistics (mean, median, and variance) as well as measures of uncertainty (95% CIs).

Table 1. Observer data for a) LE sablefish pot fisheries and b) open access pot fisheries sector used in bycatch estimation for humpback whales.

a)

Year	Gear	# vessels	# trips	# hauls	# pots	Observed Landings (mt)	Total Landings (mt)	% Landings Observed	Takes
2002	Pot	6	23	247	5438	82.5	352.2	23%	0
2003	Pot	6	35	362	9017	148.3	604.0	25%	0
2004	Pot	3	13	139	5378	82.7	619.6	13%	0
2005	Pot	7	39	492	13822	281.2	615.0	46%	0
2006	Pot	7	39	289	10708	200.5	581.8	34%	0
2007	Pot	4	30	154	5816	90.0	428.4	21%	0
2008	Pot	6	24	329	13638	244.9	433.0	57%	0
2009	Pot	3	27	67	3883	66.5	489.1	14%	0
2010	Pot	7	43	314	11294	140.4	503.5	28%	0
2011	Pot	3	22	227	9029	137.4	371.9	37%	0
2012	Pot	5	19	351	14218	101.1	286.0	35%	0
2013	Pot	3	14	47	1934	40.5	283.1	14%	0
2014	Pot	4	16	195	7561	104.0	338.1	31%	1
2015	Pot	9	36	308	11634	223.2	358.2	62%	0
2016	Pot	7	55	596	21219	254.3	359.0	71%	0
2017	Pot	3	14	186	7852	115.5	375.5	31%	0

b)

Year	Gear	# vessels	# trips	# hauls	# pots	Observed Landings (mt)	Total Landings (mt)	% Landings Observed	Takes
2003	Pot	7	16	50	345	2.9	190.3	2%	0
2004	Pot	17	96	185	1950	17.0	186.0	9%	0
2005	Pot	14	43	50	835	10.7	379.3	3%	0
2006	Pot	15	38	39	666	7.9	442.9	2%	0
2007	Pot	21	46	75	624	8.8	257.9	3%	0
2008	Pot	20	55	75	833	10.4	240.8	4%	0
2009	Pot	18	30	45	540	8.8	372.6	2%	0
2010	Pot	26	40	71	648	10.7	318.3	3%	0
2011	Pot	29	61	85	831	18.9	255.8	7%	0
2012	Pot	19	35	70	610	9.1	125.8	7%	0
2013	Pot	17	25	48	590	6.3	72.2	9%	0
2014	Pot	21	41	63	686	11.7	147.7	8%	0
2015	Pot	17	49	64	604	14.6	234.2	6%	0
2016	Pot	27	55	73	687	15.3	206.8	7%	1
2017	Pot	44	87	126	1249	24.9	210.6	12%	0

Results and Discussion

Estimating Humpback Whale Bycatch

Estimation of the fleet-wide bycatch is challenging, as only two humpback whales have been observed entangled in U.S. west coast groundfish fisheries since the observer program began in

2002. Using the statistical model described above, we estimated mean annual fleet-wide bycatch of humpback whales (see Appendix 1). To align with the incidental take statement in the 2012 Biological Opinion, we estimated a running 5-year average of bycatch for the combined LE Sablefish and Open Access Fixed Gear pot sectors (Fig 1a) as well as each of the pot sectors separately (Figs. 1b,c).

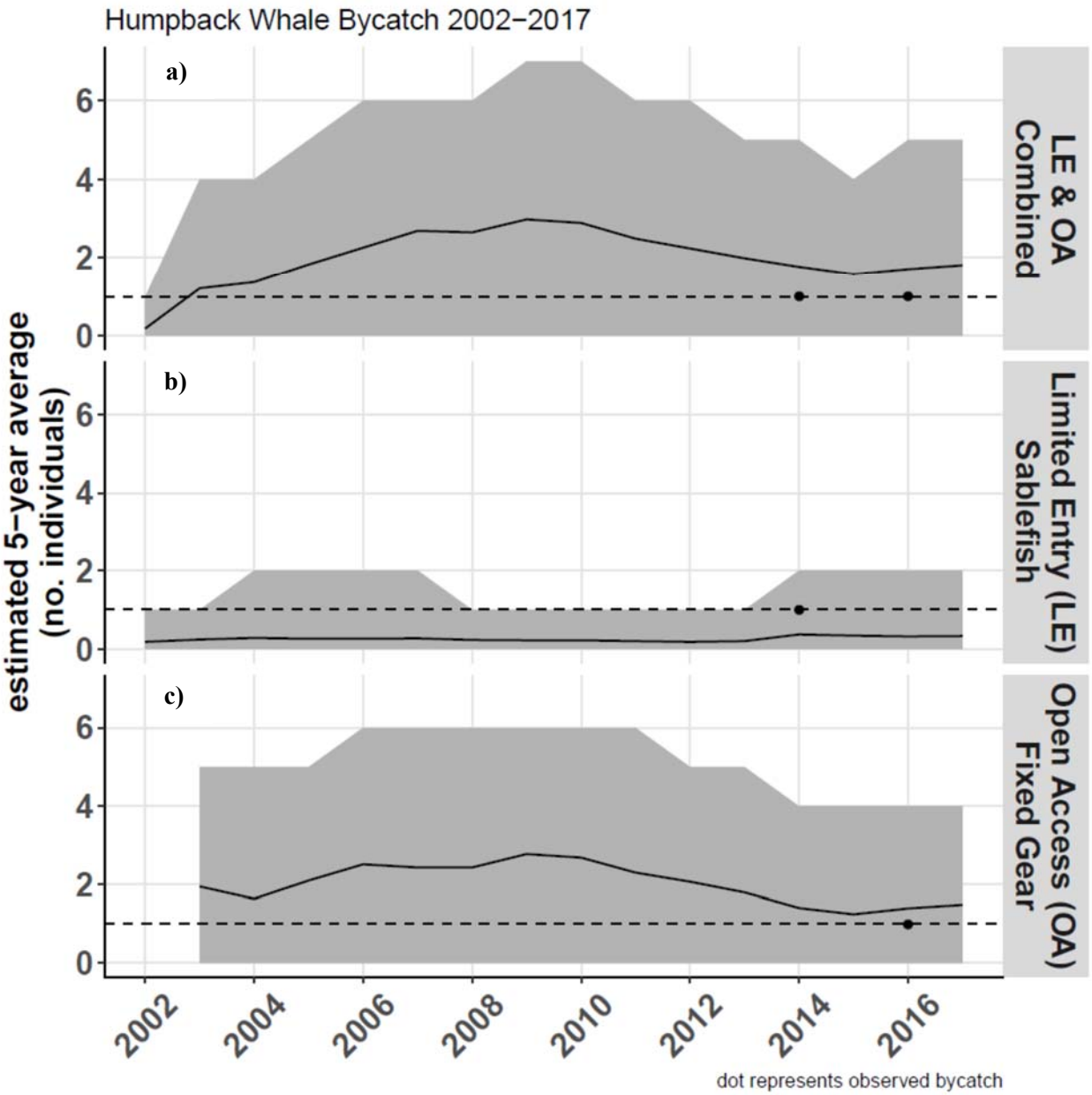

Figure 1. Estimated running 5-year means for the a) combined Limited Entry Sablefish and Open Access Fixed Gear pot sectors, b) the Limited Entry Sablefish pot sector, and the c) Open Access Fixed Gear pot sector. Black lines represent the estimated 5-year running mean of fleet-wide bycatch of humpback whales; gray area represents 95% confidence limits. Dotted lines represent the 5-year incidental take limit as per the 2012 Biological Opinion.

The 2012 Biological Opinion for the continuing operation of West Coast groundfish fisheries set an incidental take limit for humpback whales at three humpback whale injuries or mortalities in

any single year, and an average of one humpback whale injury or mortality per year over a five-year period. While the estimated fleet-wide entanglements/takes in the LE Sablefish pot sector were well below this threshold over the time period examined, the estimated fleet-wide entanglements/takes in the Open Access Fixed Gear pot sector and the two sectors combined consistently exceeded the 5-year mean take limit over the time period examined.

Additional relevant information

Interactions with commercial fisheries likely to take humpback whales

Pot and trap fisheries in general are the most commonly documented source of serious injury and mortality of humpback whales in U.S. west coast waters (Carretta et al. 2013, 2015, 2014a,b, 2017, 2018a), and reports have increased substantially since 2014 (Carretta et al. 2018b). Entanglement reports of humpback whales in 2016 (n=54) was up from 2015 (n=35; NOAA Fisheries 2017); the number of humpback whale entanglement reports declined in 2017 to approximately 2014 levels (NOAA Fisheries 2018).

From 2012 to 2016, Humpback whale injuries and mortality in U.S. West Coast waters were most often reported from entanglements in pot/trap fisheries (n=57), followed by unidentified fishing gear (likely pot/trap gear; n=49), and vessel strikes (n=13) (Appendix 4 in Carretta et al. 2018a). Documented 5-year mortality, serious injury, and prorated injury totals (*i.e*. entangled humpback whales with an injury score < 1) for pot/trap fisheries, in order of frequency are: California Dungeness crab pot (16.75), unidentified pot/trap fishery (7.75), Washington/ Oregon/California sablefish pot fishery (2.5), Washington Dungeness crab pot fishery (0.75), California spot prawn pot fishery (2.5), unknown commercial Dungeness crab pot fishery (0.75), and Oregon Dungeness crab pot fishery (0.75) (Table 1 in Carretta et al. 2018b). Three humpback whale entanglements (all released alive) were observed in the CA swordfish drift gillnet fishery from almost 9,000 sets between 1990 and 2016 (Carretta et al. 2018b).

The increase in entanglements in commercial crab fisheries in recent years has led the California Department of Fish and Wildlife to issue a declaration to close the California Dungeness crab fishery statewide on April 15, 2019 in all commercial fishery management zones. The closure was needed due to a greater risk of whales becoming entangled in commercial Dungeness crab pots, lines, and buoys during the spring and summer months (https://cdfgnews.wordpress.com/2019/04/02/commercial-dungeness-crab-season-to-close-statewide-april-15/).

Changes in Humpback Whale occurrence

In recent years the distribution and duration of time humpback whales stay on the feeding grounds has changed. More humpback whales have been observed in Puget Sound, the mouth of the Columbia River, San Francisco Bay, and closer to shore in general than has been observed since the end of commercial whaling (Calambokidis et al. 2017). Hydrophones and vessel surveys have also reported humpback whale detections later into the winter that has been observed in the past with some evidence that individuals may be over-wintering (Calambokidis et al. 2017). Some of the changes in whale occurrence (expansion into more peripheral habitats, greater time on feeding grounds to meet nutritional needs, and more animals overwintering or arriving early in the season) may signal reaching carrying capacity and be causing greater overlap with Dungeness crab fisheries in winter and early spring and more entanglements (Calambokidis et al. 2017).

Status of Stock

The status of the CA/OR/WA humpback whale stock is summarized in Carretta et al. 2018b). The estimated observed annual mortality and serious injury due to commercial fishery entanglements in 2012-2016 (14.1/yr), non-fishery entanglements (0.2/yr), recreational crab pot fisheries (0.15/yr), serious injuries assigned to unidentified whale entanglements (2.2/yr), observed ship strikes (2.1/yr), represents 18.8 animals, which exceeds the PBR of 16.7 animals. Strandings and at sea observations suggest observed annual humpback whale mortality and serious injury in commercial fisheries is greater than 10% of the PBR, and thus is not approaching zero mortality and serious injury rate. While the CA/OR/WA stock showed a long-term increase in abundance from 1990 to 2008, recent estimates through 2014 have shown variable trends indicate a leveling-off of the population size.

Conservation Recommendations from the Biological Opinion

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02). The following conservation recommendations for humpback whales described in the BiOp provide general guidance for unique, visual marking of sablefish pot/trap gear as identifiable to a specific fishery, as well as guidance to report, track, and retrieve pot/trap gear that becomes lost, and guidance to minimize the loss of pot/trap gear. Implementing these recommendations would improve our knowledge of incidental take of humpback whales in the PCGF and minimize that take. Washington and Oregon commercial Dungeness crab fisheries are example models where regulations for unique, visual marking of gear and programs to report, track, and retrieve lost gear are established.

Citations regarding these regulations and programs are provided below. These measures shall be further discussed and developed by the PCGW, who may recommend adoption as conservation measures.

1) NMFS and the PCGW should work with the PFMC to require or recommend visual marking that can be used to uniquely identify sablefish pot/trap gear (e.g., OAR 635-005-0480 and WAC 220-52-040 for Dungeness Crab Buoy Tag and Gear Marking Requirements). Visual marking can help identify gear entangled on a whale to a specific fishery, while absence of visual markings can also help rule out a fishery that uses unique, visual markers.
2) NMFS and the PCGW should work with the PFMC to create electronic monitoring and logbook reporting requirements for the sablefish pot/trap fishery that require or recommend fishers to document effort and lost gear (see Appendix C for example logbook regulations, instructions, and entry forms that include lost gear reporting).
3) NMFS and the PCGW should work with the PFMC to develop a database to track sablefish pot/trap fishing effort, locations, and lost fixed-gear (see Appendix D for an example database).
4) NMFS and the PCGW should work with the PFMC to summarize data on lost gear from the sablefish pot/trap fishery to evaluate the magnitude of gear loss and factors

that may influence loss (specific areas, times of year, etc.). Also, summarize fixed-gear fishing effort and locations to support overlap analysis with humpback whale (or other large whale) migrations or aggregation. Data summary should follow the reporting cycle developed for the PCGW above.

5) NMFS and the PCGW should work with the PFMC to promote retrieval of lost gear (see Appendix E and Appendix F for information about example programs for gear recovery).
6) NMFS and the PCGW should work with the PFMC to assess available technology to minimize loss of sablefish pot/trap gear (i.e., Gearfinder technology) and promote use of appropriate technology.
7) NMFS and the PCGW should work with the PFMC to investigate the practice of storing sablefish pot/trap gear in the ocean to evaluate the potential for conservation issues and any need for additional regulation.

The NWFSC Observer Program presently collects information on sablefish pot/trap fishing effort, locations, and lost fixed gear on observed vessels, and this information is in the program database. The Fishing Effort Report, submitted as part of the Biological Opinion process, summarizes the Sablefish fishing effort by gear, area, and depth. In addition, that report also summarizes information regarding lost gear. As the Sablefish fleet is currently observed at less than 100% coverage and there is no logbook associated with the fishery, the data available represent the observed portion of the fleet. NMFS has consulted the council's Coast Guard representative about this issue, and the representative felt that the legality of the practice depends on where and how the gear is stored; importantly, the practice likely takes place inside state waters, which complicates matters.

Additional information relevant to the BiOp/RPMs and Conservation Measures

In the incidental take statement in the BiOp, we included reasonable and prudent measures for management planning and take reporting that is applicable to all species considered in the BiOp. "Reasonable and prudent measures" are nondiscretionary measures to minimize the amount or extent of incidental take (50 CFR 402.02). "Terms and conditions" implement the reasonable and prudent measures (50 CFR 402.14). These must be carried out for the exemption in section 7(o)(2) to apply. Here we provide the reasonable and prudent measures, including species specific measures described in the BiOp, followed by additional information on the status of each measure. Included were measures to minimize the amount or extent of incidental take associated with NMFS observer program sampling and handling of protected species where these effects are not otherwise authorized or exempted.

(1) NMFS shall develop a Pacific Coast Groundfish and Endangered Species Workgroup

NMFS has convened a Pacific Coast Groundfish and Endangered Species Workgroup (PCGW), invited PFMC and other entities to provide points of contact, and helped develop terms of reference for the workgroup. The Pacific Coast Groundfish and Endangered Species Workgroup has convened in 2015 and 2017.

(2) NMFS shall characterize changes in fishing effort.

The most recent report summarizing fishing effort in the U. S. Pacific Coast Groundfish Fisheries (2002-2017) by NOAA Fisheries' West Coast Groundfish Observer Program is Somers et al. (2019).

(3) NMFS shall update reporting of take considered in this opinion.

NMFS updates reporting of take on a biennial basis per the BiOp.

(4) NMFS shall update the NWFSC risk assessment, as needed.

If necessary, NMFS will update the BA's risk assessment for humpback whale.

Species-Specific Measures

NMFS included the following reasonable and prudent measure to improve our knowledge of incidental take of humpback whales in the PCGF.

(1) NMFS shall provide all west coast observers with the Fixed Gear Guide (http://swr.nmfs.noaa.gov/psd/Fixed%20Gear%20Guide-FINAL_12.14.11.pdf) and the entangled whale hotline (877-SOS-WHALe) during observer training. The guide will help observers that may opportunistically sight an entangled whale identify the entangling gear to a specific fishery. The hotline provides a resource for reporting and response.

All observers are trained to identify Humpback Whales and are deployed with a marine mammal identification guide. Observers are also provided with the Fixed Gear Guide and the Whale Hotline number and trained to contact the hotline if they observe a whale entanglement. Furthermore, observers are provided with the Marine Mammal Reporting Form, which is given to and submitted by the fisher, when an incidental mortality or injury occurs during commercial fishing activity.

Species-specific Terms and Conditions

The terms and conditions described in the BiOp are non-discretionary, and NMFS must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14). NMFS has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in the incidental take statement (50 CFR 402.14). If the terms and conditions in the BiOp are not complied with, the protective coverage of section 7(o)(2) will likely lapse. Terms and conditions specific to humpback whales are provided below.

1.a. Reporting shall be directed from observers through the observer program.

1.b. Reporting shall be similar to or modeled after the attached form (Appendix B of the BiOp).

The observer program has a data collection form for interactions of marine mammals and other protected species with fishing vessels.

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Appendix 1. Descriptions of fishery sectors in the Pacific Coast Groundfish Fisheries. **Management**

Sector	Sub-Sector	Permits	Gear(s)	Target(s)	Vessel Length (m)	Depths (m)	2002-2010	2011-present
Federally managed Catch Shares fisheries								
Limited Entry (LE) Trawl	Limited Entry (LE) Trawl	Federal LE permit[1] with trawl endorsement	Bottom Trawl, after Jan 1, 2011 also Hook & Line and Pot gear	Groundfish assemblage	11-29	Wide range	Cumulative two-month trip limits; depth-based closures; 14-23% observer coverage	Individual Fishing Quotas (IFQ); 100% observer coverage
	LE California Halibut	CA Halibut permit[2] and LE permit with trawl endorsement[1]	Bottom Trawl	California halibut[5]	9-22	< 55	Cumulative two-month trip-limits; depth-based closures; 3-23% observer coverage	IFQ; 100% observer coverage
At-Sea Hake	Mothership-Catcher Vessel (MSCV)	LE permit with MSCV endorsement[1]	Midwater Trawl	Pacific hake[6]	26-45[4]	53-460[4]	Seasonal quotas for target and bycatch species of concern; 100% observer coverage	IFQ; Seasonal; 100% observer coverage
	Catcher-processors (CP)	LE permit with CP endorsement[1]	Midwater Trawl	Pacific hake	82-115	60-570	Seasonal quotas for target and bycatch species of concern; 100% observer coverage	IFQ; Seasonal; 100% observer coverage
	Tribal	(none)	Midwater Trawl	Pacific hake	< 38	53-460	Tribal; 100% observer coverage	
Shoreside Hake	n/a	LE permit with trawl endorsement[1]	Midwater Trawl	Pacific hake	17-29	Wide range	Seasonal quotas for target and bycatch species of concern; electronic monitoring	IFQ; Seasonal; 100% observer coverage

Sector	Sub-Sector	Permits	Gear(s)	Target(s)	Length (m)	Depths (m)	Management 2002-present
Other Federally managed fisheries							
Non-Nearshore Fixed Gear	Sablefish endorsed	LE permit with fixed gear endorsement[1] and sablefish quota	Longlines, Pots	Sablefish[7]	11-32	> 145	Sablefish tier quotas; seven month season; 9-27% observer coverage
	Sablefish non-endorsed (a.k.a. Zero Tier)	LE permit with fixed gear endorsement[1] w/o sablefish quota	Longlines, Pots	Sablefish, rockfish[8] and flatfish[9]	5-18	> 145	Trip limits; 1-12% observer coverage
	Open Access	(none)	Longlines, Pots	Sablefish and other groundfish	3-30	> 64	Trip limits; 1-6% observer coverage
State managed fisheries							
Open Access (OA) California Halibut		CA Halibut permit[2]	Bottom Trawl	California halibut	9-22	< 55	All fishing occurs within CA waters, most in the California Halibut Trawl Grounds where minimum mesh sizes, seven month season, and minimum size requirements hold; 1-16% observer coverage
Nearshore Fixed Gear[3]		CA or OR state nearshore permits and endorsements	Variety of hand lines, pot gear, stick gear, rod and reel	Rockfish, Cabezon[10], Greenlings[11]	3-15	< 110 (usu. < 55 in OR waters)	Federal and CA or OR state nearshore regulations; area closures; two-month trip limits; minimum size limits; 2- 8% observer coverage
Pink Shrimp		WA, OR, or CA state pink shrimp permit	Shrimp trawl	Pink shrimp[12]	11.5-33	91-256	WA, OR, or CA state pink shrimp regulations; Bycatch Reduction Devices required; trip limits on groundfish landed; 4-14% observer coverage

[1] a.k.a., LE permit; all LE permits are issued by Federal agency (NOAA).
[2] Issued by the state of California.
[3] The state of WA does not conduct a nearshore fishery.
[4] Average values for catcher vessels delivering catch to motherships.
[5] *Paralichthys californicus*
[6] *Merluccius productus*
[7] *Anoplopoma fimbria*
[8] *Sebastes* spp.
[9] Pleuronectiformes
[10] *Scorpaenichthys marmoratus*
[11] Hexagrammidae
[12] *Pandalus jordan*

Appendix 2. Bycatch estimates of humpback whales in a) LE Sablefish pot fishery sector, b) Open Access pot fishery sector, and c) combined sectors.

Year	Annual Mean	Conf. Limit (Lower)	Conf. Limit (Upper)	Running 5-year Mean	5-year Mean CL (Lower)	5-year Mean CL (Upper)
2002	0.18	0.01	0.55	0.18*	0*	1*
2003	0.29	0.02	0.91	0.24*	0*	1*
2004	0.37	0.02	1.20	0.28*	0*	2*
2005	0.20	0.01	0.64	0.26*	0*	2*
2006	0.24	0.01	0.75	0.26	0	2
2007	0.22	0.01	0.68	0.27	0	2
2008	0.11	0.00	0.35	0.23	0	1
2009	0.31	0.01	0.94	0.22	0	1
2010	0.23	0.01	0.74	0.22	0	1
2011	0.15	0.01	0.45	0.20	0	1
2012	0.12	0.00	0.36	0.18	0	1
2013	0.19	0.00	0.58	0.20	0	1
2014	1.15	1.00	1.51	0.37	0	2
2015	0.08	0.00	0.26	0.34	0	2
2016	0.06	0.00	0.19	0.32	0	2
2017	0.17	0.00	0.52	0.33	0	2
2003	1.94	0.10	5.71	1.94*	0*	4*
2004	1.33	0.07	3.93	1.63*	0*	3*
2005	3.00	0.19	9.48	2.09*	0*	3*
2006	3.73	0.20	11.13	2.50*	0*	4*
2007	2.10	0.12	6.09	2.42	0	5
2008	1.92	0.13	5.69	2.42	0	6
2009	3.05	0.18	8.82	2.76	0	6
2010	2.56	0.13	7.40	2.67	0	6
2011	1.81	0.10	4.96	2.29	0	6
2012	0.98	0.05	2.84	2.06	0	6
2013	0.57	0.03	1.73	1.79	0	5
2014	1.11	0.07	3.26	1.40	0	5
2015	1.75	0.11	5.07	1.24	0	4
2016	2.52	1.11	5.59	1.39	0	4
2017	1.43	0.09	4.26	1.48	0	4
2003	2.23	0	6	1.21*	0*	4*
2004	1.70	0	5	1.37*	0*	4*
2005	3.21	0	7	1.83*	0*	5*
2006	3.97	1	8	2.26*	0*	6*
2007	2.33	0	6	2.69	0	6
2008	2.03	0	5	2.65	0	6
2009	3.36	0	7	2.98	0	7
2010	2.79	0	6	2.89	0	7
2011	1.96	0	5	2.49	0	6
2012	1.10	0	4	2.24	0	6
2013	0.77	0	3	1.99	0	5
2014	2.26	0	6	1.77	0	5
2015	1.84	0	5	1.58	0	4
2016	2.58	0	6	1.71	0	5
2017	1.60	0	4	1.81	0	5

* Running average calculated from fewer than 5 years