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Nearshore Migrating Humpback Whales off Metropolitan Lima, Central Peruvian Coast, Underscore Potential Conflict with Fisheries

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Abstract: The notion that 'Stock-G' humpback whales off western South America are primarily deep oceanic migrators is poorly supported. We documented 66 land-based sightings from Pucusana, Lima Sur: 18 incidental (2002–2023) and 48 dedicated sightings during the northbound winter migration (June-July 2023), covering respectively 38 and 105 individual whales, despite a mean daily observer effort of only 58.7 min. Estimated distances from shore ranged 20–7,000 m (mean= 2,729 m) at depths 25–99 m, while 50% migrated at < 2,500 m (median) from shore. Several groups skirted the coastline from headland to headland. Of five southbound migrating groups, four included an adult with neonate; no northbound groups enclosed a neonate. Two cases of single juvenile/subadult whales moving multidirectionally and closely associated with large seabird feeding frenzies, were considered foraging also. In 2023, 94% of all northbound nearshore sightings occurred from 14 June-11 July, signalling the maximum threat period for interactions with coastal fisheries off metropolitan Lima. If migration is temporally and spatially predictable, effective mitigating measures should be feasible.

Keywords: *Megaptera novaeangliae*; land-based observations; anthropogenic interactions; migration; feeding; Southeast Pacific

Introduction

Ramírez (1988) concluded that, off northern Peru, humpback whales *Megaptera novaeangliae* tend to occur close to shore in the spring. In 1965, a large majority of animals were taken from a shore-based whaling station (Paita) at less than 100 nmiles from shore, and many much closer (Ramírez, 1988). Nearshore occurrence was later confirmed for the northern Peruvian breeding/calving ground in Piura and Tumbes (Pacheco et al., 2009; Santillán, 2011; Silva-Buse and Pacheco, 2016). Other authors (Mackintosh, 1942; Clarke, 1957, 1962; Winn and Reichley, 1985) contended that, regionally, off western South America, humpback whales (HW) are deep oceanic migrators, beyond the 200 m depth line, 'which could explain the paucity of inshore sightings, except for the tropical breeding grounds' (Winn and Reichley, 1985). This hypothesis, apparently based on some sightings in Chilean offshore waters, has not been challenged but neither confirmed.

We suggest that the 'paucity of inshore sightings' was due to a lack of dedicated coastal observer effort because we here demonstrate that, at least off the central Peruvian coast, consequential numbers of HW migrate nearshore, within 5 nmiles and many much closer, during the northbound migration in austral winter. Since initial evaluations and calls for increased research (Ramírez, 1988; Van Waerebeek et al., 1996) on the IWC-defined 'Breeding Stock G' off Chile, Peru, Ecuador, Colombia and Panama the species has become the most studied mysticete in the region, partly linked to its value as commercial whale-watching target (*e.g.*, Stevick et al., 2004; Pacheco et al., 2009; Silva-Buse and Pacheco, 2016; Flórez-González, 1991; Flórez et al., 2005; Félix et al., 2011; Avila et al., 2017; Guzman and Félix, 2017 and others). Appreciable knowledge has accumulated recently on the ecology, behaviour, abundance and threats in the breeding/calving grounds off northern Peru

(Pacheco et al., 2009; Santillán, 2011; García-Godos et al., 2013), Ecuador (Félix et al., 2007, 2011; Guzman and Félix, 2017) and Colombia (Flórez-González, 1991; Capella et al. 2007; Avila et al., 2017), to cite a few. A comprehensive review is beyond the scope of this note, but see others (*e.g.* Scheidat et al., 2000; Flórez-González et al., 2005; Hucke-Gaete et al., 2013; Acevedo et al., 2017). Latest, unexpected, insights include evidence of feeding in low-latitude locations in Ecuador and northern Chile (García-Cegarra et al., 2021a).

Several authors (*e.g.*, Stevick et al., 2004; Acevedo et al., 2013; Castro et al., 2013) discussed links between northern and austral final destinations of the annual migration of Stock-G, which covers thousands of km between the Antarctic Peninsula and Fuegian feeding grounds and the tropical breeding/calving grounds. However, very little observational information is available on the actual migratory paths and corridors used by HW outside these major feeding and breeding areas. Here we present evidence of substantial numbers of humpback whales migrating in Lima nearshore waters on the central Peruvian coast, and discuss implications.

Material and Methods

Sightings of humpback whales and other cetaceans were recorded both opportunistically (2002–2023) and in dedicated mode (June-15 July 2023) from the observation platform of the Peruvian Centre for Cetacean Research (CEPEC), Pucusana (12°29.0'S,76°48.1'W), located at the southern limit of Metropolitan Lima (Figure 3-A). One 1997 outlier observation was added. The junior author (E.B.C.), who received prior training, participated in data collection within a 'citizen science' framework (see García-Cegarra et al., 2021b).

The CEPEC platform is positioned on rocky cliffs *ca*. 26.0 m above sea level and overlooks an unnamed inlet (henceforth referred to as 'Whale Inlet') bordered by two rocky headlands, the Punta Grano de Oro at the southern end and Punta Rostro de Cristo in the north (Figure 3-B). The platform offers an unimpeded 150° view (compass: 158°- 308°) of Whale Inlet, of which 110° (compass: 198°-308°) is exposed to the open Pacific Ocean. The Punta Grano de Oro headland is at 1,300 m SSW from the platform and was used as reference to estimate distances to whale groups. Estimated water depth was obtained from online bathymetric charts by Navionics (Garmin ®).[1]

For the period 2002-2022, incidental (opportunistic) observation 'effort' was unquantifiable. The probability to detect passing whales by naked eyes evidently was very low. CEPEC occupation typically amounted to *ca.* 6 months *per annum*. The opportunistic 'effort' was stochastic although a slight bias may exist with higher observation time in summer (when HW are rare) due to favorable weather and visibility.

To improve HW detection, dedicated sighting effort was implemented from 1 June–15 July 2023 (44 effective survey days), when the main northbound migration was estimated to occur. For every hour (08:00–18:00), weather permitting, 5 min were surveyed by naked eye and 10x50 binoculars (Olympus DPS1 6.5°). High-powered 18x50 image-stabilized binoculars (Canon IS UD 3.7°) were used to confirm species ID, group composition and behaviour. With each sighting, the prolonged on-effort time was recorded, as to estimate the relative density of whales (number of whales seen / minute effort).

Data recorded include species, group size (min., max., best estimate), start/stop time of observation, main behaviour, direction, distance from shore (closest and farthest), associated species (especially seabirds), indications of feeding, photos. Main behaviour categories observed included fast travel, slow travel, milling, breaching, lobtailing, flipper-slapping and (rarely) foraging.

Species authentication was based on the distinctive shape of dorsal fin, long flippers, bushy blow, serrated trailing edge of flukes, wheeling surfacing pattern and typical aerial behaviour (Best, 2010; Carwardine, 2020). Two cases of 'like-humpback whale' (*sensu* IWC Scientific Committee), *i.e.* whales at great distance whose behaviour (e.g. full-body leaps) and the few morphological cues observed were consistent with HW, were included.

Results and Discussion

Seasonality

1 https://webapp.navionics.com

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Opportunistic sightings. Prior to June 2023, 18 opportunistic HW sightings (n=32 individuals), the earliest in 1997, were registered from the CEPEC observer platform. All northbound (n=13) and southbound (n= 5) migrating groups were observed, respectively, in the period 18 June – 21 August and 23 Sept– 23 Feb. The latter, rare, summer sighting concerned a juvenile/subadult moving erratically and closely associated with a large group of foraging seabirds, strongly suggesting it was also feeding.

Dedicated (on-effort) sightings. From 1 June to 15 July 2023, effective daily dedicated observer effort (excluding 2 off-days) amounted to a mean of 58.7 min/day (SD=25.67; n=43; range = 0–145 min; median= 50 min). A total of 48 positive humpback whale groups were documented, with two exceptions (see Feeding behaviour) all of these travelling north and assumed to partake in the northbound winter migration. The total number of whales observed in this 6-week period was 105, summing best estimates of group sizes, with 94% of all HW observed in the 4-week period 14 June-11 July 2023 (see Figures 1 and 2). The climax was on 27 June when 6 sightings were recorded and a total of 21 HW. After 11 July whale observations rapidly decreased.

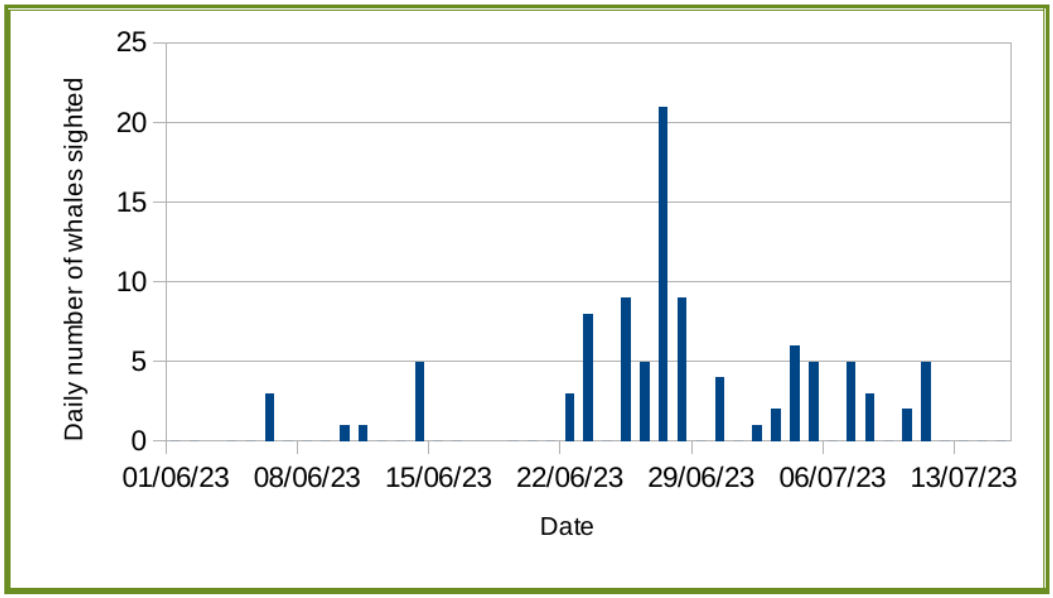

Figure 1. Daily number of northbound migrating humpback whales observed off Pucusana, Lima, in the period 1 June–15 July 2023.

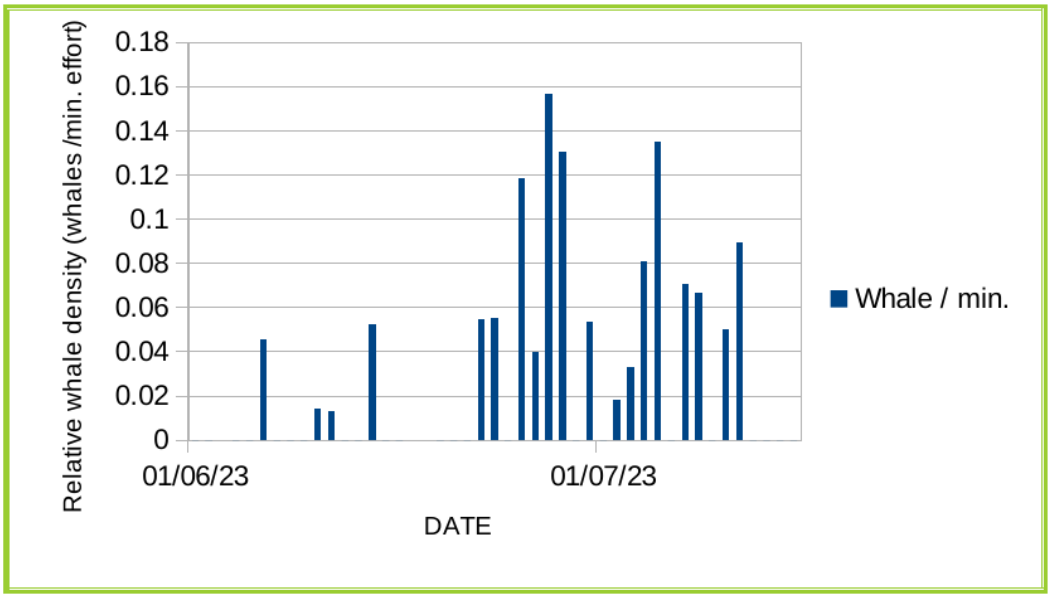

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Figure 2. Daily humpback whale relative density (per minute observation effort) off Pucusana, Lima, for the period 1 June–15 July 2023.

Group Size and Composition

Data on humpback whale group sizes sighted in Pucusana are summarized in Table 1, separated in three samples (Table 1). Median group size was 2 whales (presumably many of these a female and primary male escort); the largest groups consisted of 5 whales. The detected group sizes are considered highly reliable as typically good views were possible, covering multiple surfacings and monitored through image-stabilized binoculars. The latter often permitted to distinguish between individuals, due to differential body size, dorsal fin shape and behaviour. In a 'dedicated' subsample (n= 38), 71.1% consisted of adults or subadults, 26.3% were adult(s) mixed with juvenile(s) and one case (2.6%) was a single juvenile. Many groups synchronized respiration.

Of 5 southbound travelling groups (all opportunistic sightings), 4 included a neonate calf, as determined from its small size (1/3 of adult body), presumably born at one of the known tropical calving grounds in the eastern Pacific (e.g. Scheidat et al., 2000; Flórez-González et al., 2005; Pacheco et al., 2009; Castro et al., 2013).

Table 1. Descriptive statistics for humpback whale group sizes (best estimates) recorded off Pucusana, Lima, Peru. Opportunistic records cover multiple years; dedicated (on-effort) records are from June-July 2013 only.

Subsample	Mean	SD	Range	Median	Mode	Sample size
Opportunistic	1.71	0.85	1–4	2	1	n=18
On Effort	2.19	1.1	1–5	2	2	n=48
Pooled	2.08	1.06	1-5	2	**2**	n=66

Distance from Shore

All migrating humpback whale groups were observed moving in inshore waters, within sight of the shoreline, ranging from barely 20 m from the cliffs (water depth: 25–28 m) up to a maximum of 7,000 m (depth: 99 m). Presumably, offshore, deep-water migrations also occur, however undetected through land-based observations like ours, and/or impossible to positively identify to species.

Estimated distance to shore (in m) for the multiple-year sample of opportunistic sightings ranged 30–3,000 (mean= 601.8; SD= 897.2; median= 100), while for the dedicated sightings in June-July 2023, this range was 20–7,000 (mean= 2729.6; SD= 1665.9; median= 2500). These samples were highly significantly different (Mann-Whitney U= 95.5; z-score= 4.613; $p<0.001$), as expected, considering that for the 2023 sample binoculars were utilized during searches, permitting the spotting of whales at much greater distances. Southbound migrators moved close to shore (range: 50–1,000 m; mean= 330 m; median= 150 m) but the current sample is too small (n= 5) to allow statistical testing.

One group of three whales (one of which was net-entangled, see García-Godos et al., 2013) moved so exceptionally close to the cliffs that the whales were detected (in the office) from the sound of their blows. Another whale breached twice at some 20-25 m from the Punta Rostro de Cristo. Both groups headed north.

Feeding Behaviour

García-Cegarra et al. (2021a) called for further research into the feeding ecology of Stock-G after demonstrating occasional feeding in the Antofagasta area (northern Chile) and in Ecuador. We observed three cases of single individuals of HW moving multi-directionally (unlike migrating whales), in close association with actively feeding seabirds: (i) A juvenile/subadult, in a rare summer sighting (23 February 2023), headed straight into a massive seabird feeding frenzy (mainly Peruvian boobies Sula *variegata)*, locally known as '*pajarada'* and remained directly associated for at least 20 min. Distance from shore was 400-600 m.

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(ii) On 10 June 2023, a single juvenile/subadult, changing course repeatedly continuously (N, S, SW, N again), was thought to be feeding while followed by a foraging *pajarada* of at least 250 seabirds, many diving (Inca terns *Larosterna inca*, Peruvian boobies, cormorants *Phalacrocorax* sp. and band-tailed gulls *Larus belcheri*). Observation 10:00–10:25. The whale performed 12 leaps, after which observation effort was interrupted. The same individual (*cf.* white pectorals) was re-sighted 10:47–10:58 some distance north, still breaching and still directly associated with a feeding frenzy of >120 seabirds, mostly diving boobies and cormorants. (iii) An adult whale (13 July 2009), at 100-500m from shore, milling and changing course also appeared to be feeding near the surface (although with lesser certainty). At least (i) and (ii), interestingly both single juveniles/subadults, are considered positive observations of feeding humpback whales, a first for the central Peruvian coast.

Other Parameters

The effective total duration of observation per group was highly variable, depending on both the azimuth (relative to the observation platform) when first spotted and whale behaviour. Duration ranged from 4–61 min (mean= 20.02; SD= 13.12; median= 17).

Other cetacean species observed in June-July 2023 include a Bryde's whale *Balaenoptera brydei,* an unidentified, fast-swimming, large balaenopterid (either fin *B. physalus* or blue whale *B. musculus*), two other whales (unidentifiable due to great distance), common bottlenose dolphins *Tursiops truncatus*, and dusky dolphins *Lagenorhynchus obscurus*.

Discussion

Contrary to earlier assumptions, new evidence firmly indicates that on Peru's central coast, and more specifically in continental waters off Metropolitan Lima, many 'Stock G' humpback whales migrate nearshore, and can be observed from land. We estimated that for the recorded neritic migrators, 50% (50th percentile) migrate north within 2,500 m from shore, and among these an appreciable number may actually skirt the coastline from headland to headland. Another proportion of HW likely migrate further offshore in continental shelf waters, perhaps including deep oceanic waters, but evidently this cannot be determined through land-based studies. Allen (2013) investigated the roles of geomagnetic and acoustic cues in HW navigation and orientation, but potential visual cues were not studied in any detail. Considering it physically possible, we suggest that nearshore migrating HW may also use visual cues for navigation, such as rocky promontories and other topographic landmarks. Full-body leaps (breaching), which were frequent, perhaps may allow whales to visually locate headlands and thus determine shortest routes. On several occasions, whales closely rounded Pta. Grano de Oro and then crossed Whale Inlet in a straight line north towards Pta. Rostro de Cristo (Figure 3). The proportions of HW that engage in nearshore and offshore migratory paths towards/from the tropical breeding/calving grounds should be determined. To increase the nearshore dataset the present dedicated land-based survey effort should be continued, and in particular also the return spring journey should be monitored.

No neonate calves were seen during northbound migration, consistent with the absence of a calving ground south of Lima. The coasts of Piura, northern Peru, are presently understood to constitute the austral-most breeding/calving grounds for 'Stock G' humpback whales (Pacheco et al., 2009; Santillán, 2011; Silva-Buse and Pacheco, 2016). In contrast, neonate-sized calves were observed in four of five southbound going HW groups, travelling at a mean distance of 312 m. We hypothesize that mother-calf pairs preferentially may choose very nearshore paths, and use the shoreline and shallow water as physical barriers against predators. However, this requires confirmation.

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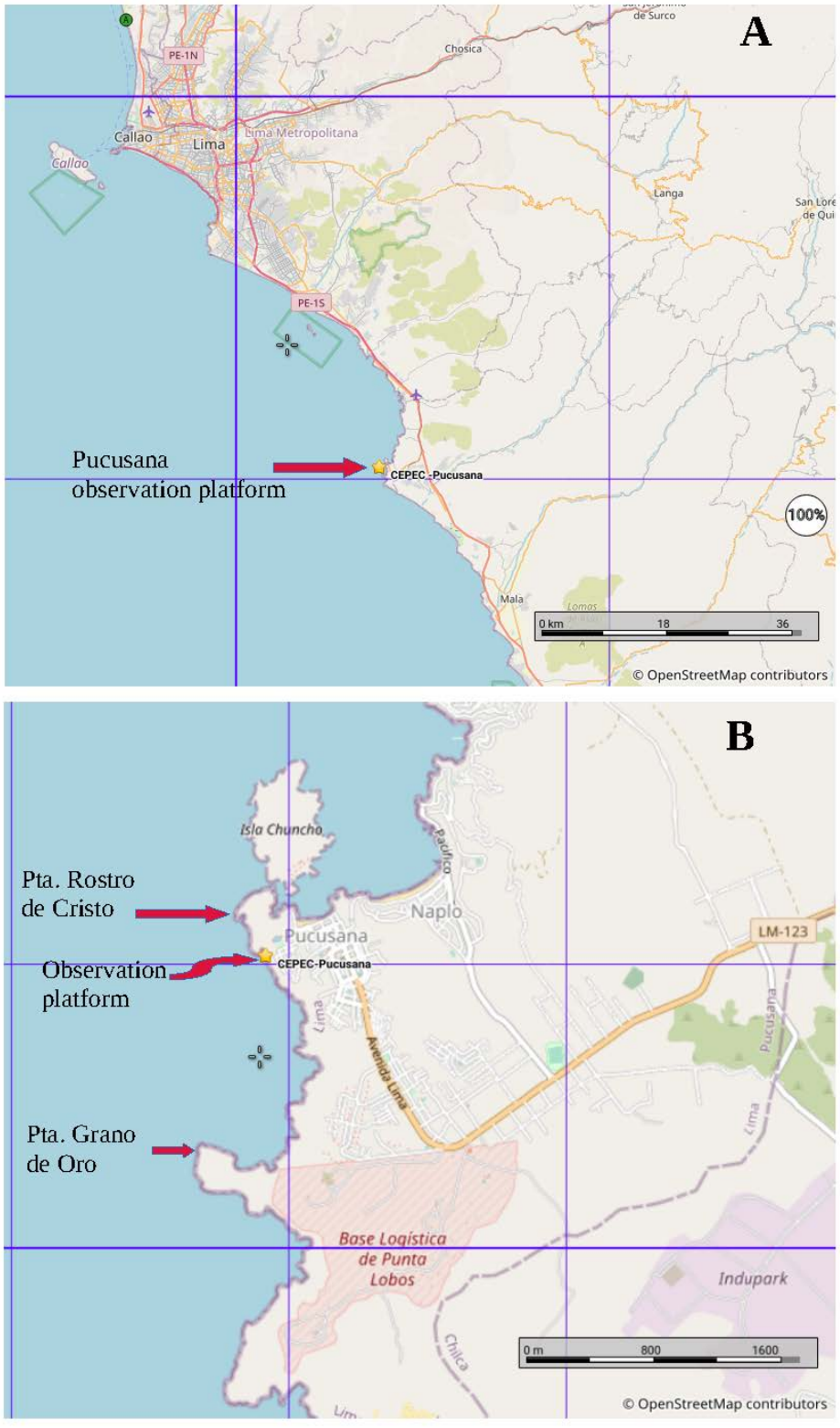

Figure 3. (A) Location of the Pucusana fishing port at the southern limit of Metropolitan Lima. (B) Map of the study area showing topography of the coastline in the vicinity of the CEPEC observation platform. The southern (Punta Grano de Oro) and northern boundaries (Punta Rostro de Cristo) of the monitored waters are indicated. Modified from OpenSeaMap (Marble Virtual Globe, Version 2.2.20).

The nearshore migration occurs despite the dense small-vessel traffic observed, including large numbers of artisanal gillnet fishing craft and industrial purse-seiners. No indications of vessel avoidance behaviour were detected, nor did fishing boats avoid whales. Its nearshore occurrence may

help explain why the HW is the whale species most vulnerable to net entanglements in Peru. Records show that HW accounts for 66.7 % of whales involved in lethal net entanglement cases in Peru. Ten cases were documented up to 2012 (Valdivia and Ramírez, 1981; García-Godos et al., 2013) but unfortunately many new records exist. Lethal entanglement as well as ship collisions have also been recorded from the high-density HW breeding/calving ground around Isla de la Plata, Ecuador (Félix and Van Waerebeek, 2005; Félix et al., 2007; 2011) and Isla Gorgona, Colombia (Capella et al., 2001; Flórez-González et al., 2005; Avila et al., 2017). Generally, G-Stock has been severely affected by fishery interactions, with an estimated rate of 32 net entanglements per year in Ecuador in the period 2004–2006 (Félix et al. 2007; 2011) and a mean of 2.8 entanglements per year in Colombia in 1996–2006 (Capella et al., 2001, 2007), most with lethal outcome. No estimates exist for Peru and Chile but the wide spatial and temporal distribution of entanglements in Peru (García-Godos et al., 2013) suggests that both breeding and migrating whales are affected. The finding that significant numbers of humpback whales migrate so close to shore underscores the obvious threat of severe interactions with inshore operating artisanal fisheries. We strongly recommend that dedicated land-based observations should be continued, including if possible monitor from an additional station such as in Chorrillos or Miraflores. A future migration cycle during a non-El Niño year should also be observed as to compare with the present El Niño year, in an attempt to deduct whether ENSO events have, or not, a significant impact on spatial and temporal distribution of humpback whales in Peruvian waters. Finallly, marine environment managers and conservationists should consider launching an awareness building campaign in coastal Peru, and invite fishermen to duly report all cases of whale net entanglements and vessel-whale collisions and comment on the outcome for both whales and fishers' gear.

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Conflict of interest: The authors declare no conflicting interests related to any aspect of this scientific note.

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