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WHERE HUMPBACK WHALES AND VESSEL TRAFFIC COINCIDE, A COLOMBIAN PACIFIC CASE STUDY

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ABSTRACT

During the austral winter, G-stock humpback whales immigrate and occupy the Bahía Málaga area, Colombian Pacific, to breed and calve. However, due to fishing and whale-watching activities, and proximity to the major Buenaventura seaport, significant vessel traffic transits the Bahía Málaga. We counted the number of whales and boats present h^{-1} in a 14 km^2 area, from a 20 m high shore platform. During 312 daytime hours of observations over 52 days in August-September 2008, we recorded 770 sightings of whale pods (many resampled), 0-15 humpback whales h^{-1} (mean 4.0 whales h^{-1}) and 0-17 vessel trips h^{-1} (mean 4.5 trips h^{-1}). Each additional day in the breeding season showed an 1.0% increase in the mean number of sighted whales, due to still arriving whales and new calves. The majority of trips (96%) consisted of small vessels, the rest were medium vessels. Most (71.1%) transited at fast speed (≥16 knots). To evaluate whether the vessels affected the density of whales per hour in the study area, we fitted a Generalized Linear Model with number of whales as dependent variable and vessel size and speed as factors. Number of vessel trips did not have a significant impact on the number of whales sighted h^{-1}. Over the short term (hours), the whales remained in the same area despite the shipping. The evident risk of vessel-whale collisions and potential long-term impact are discussed. To mitigate risk of ship strikes, several measures are recommended, such as a vessel speed below 10 knots in the vicinity of whales.

KEY WORDS: *Megaptera novaeangliae*, Cetacean, Pacific Ocean, Colombia, Uramba-Bahía Málaga, vessel traffic, collision threat.

RESUMEN

Donde las ballenas jorobadas y el tráfico de embarcaciones coinciden, un caso de estudio en el Pacífico colombiano. Durante el invierno austral, el stock G de ballena jorobada llega a Bahía Málaga, Pacífico colombiano, para reproducirse y criar. Debido a su cercanía con el puerto comercial de Buenaventura y a la pesca y turismo, Bahía Málaga presenta un tráfico frecuente de embarcaciones. Desde una plataforma de observación terrestre a 20msnm registramos el número de ballenas y embarcaciones por hora presentes en un área de 14km^2. Durante 312 horas diurnas, 52 días, agosto-septiembre de 2008, registramos 770 grupos de ballenas (mayormente re-muestreados), 0-15 ballenas h^{-1} (promedio 4.0 ballenas h^{-1}) y 0-17 tránsitos de embarcaciones h^{-1} (promedio 4.5 tránsitos h^{-1}). Cada día adicional en la temporada mostró un incremento de 1.0% en el número de ballenas, debido a que ellas y sus crías aún estaban llegando ó naciendo. El 96% de los tránsitos fueron realizados por embarcaciones pequeñas y el resto por medianas. El 71.1% de las embarcaciones transitaron rápido (≥16 nudos). Para evaluar sí las embarcaciones afectaban la densidad de ballenas en el área, se ajustó un Modelo Lineal Generalizado, con el número de ballenas como variable dependiente y tamaño y velocidad de la embarcación como factores. El tráfico de embarcaciones no tuvo impacto significativo en el número de ballenas h^{-1}. En el corto plazo (horas) las ballenas permanecieron en la misma zona a pesar del tráfico. Se discute el riesgo evidente de colisiones entre embarcaciones y ballenas. Para mitigar este riesgo se recomiendan varias medidas, entre ellas transitar a una velocidad menor de 10 nudos en cercanía de las ballenas.

PALABRAS CLAVE: *Megaptera novaeangliae*, Cetácea, Océano Pacífico, Colombia, Uramba-Bahía. Málaga, tráfico de embarcaciones, riesgo de colisiones.

INTRODUCTION

The Southeast Pacific population (IWC "G-stock") of humpback whale, *Megaptera novaeangliae*, visits the Colombian Pacific coast annually between June and November in order to breed and rear their calves after an 8,500 km migration from feeding grounds near the Antarctic Peninsula and the Strait of Magellan (Stone *et al*. 1990; Stevick *et al*. 2004; Acevedo *et al*. 2007; Capella *et al*. 2008). The Bahía Málaga area is the most important humpback whale breeding site in Colombia with an estimated population of 857 individuals seasonally utilizing this area (Flórez-González *et al*. 2007), and with more than 79 % of the sighted pods containing calves (Ávila *et al*. 2015). Bahía Málaga and surroundings, including the bay's entrance, were designated a national park "Parque Nacional Natural Uramba-Bahía Málaga" in August 2010. The bay has one of the highest marine and coastal biodiversities found on the Pacific South American coast (INVEMAR *et al.* 2006; Ávila *et al.* 2013; de Mesa and Cantera 2015). The economy of the region is based primarily on tourism, fishing, mining, timber extraction and hunting (Cantera *et al*. 2013).

Waters surrounding Bahía Málaga are characterized by intense maritime traffic as vessels arrive and depart from Buenaventura Port, Colombia's largest seaport. From 2004 to 2006 an annual average of monthly traffic ranged between 870.1 and 927.8 vessels moving through the port (DIMAR 2007). The shipping lane connecting Buenaventura port with the north lies some 4 km offshore Negritos rocky reef (03°53'N, 77°24' W) at Bahía Málaga's entrance (DIMAR 1998). Furthermore, in 2008 around 50 fishing vessels regularly transited in Bahía Málaga (Caicedo *et al*. 2008). In addition, the presence of a Navy base inside Bahía Málaga, whose access channel is north of Negritos rocky reef and Palma Island (see Figure 1), might lead to significant navy vessel traffic. Finally, because Bahía Málaga is the most important tourist destination for humpback whale-watching in Colombia, there is also a high aggregation of whale-watching vessels, i.e., an average of six vessel trips per day (range 1- 42, n = 267) from August to September (Ávila *et al*. 2015).

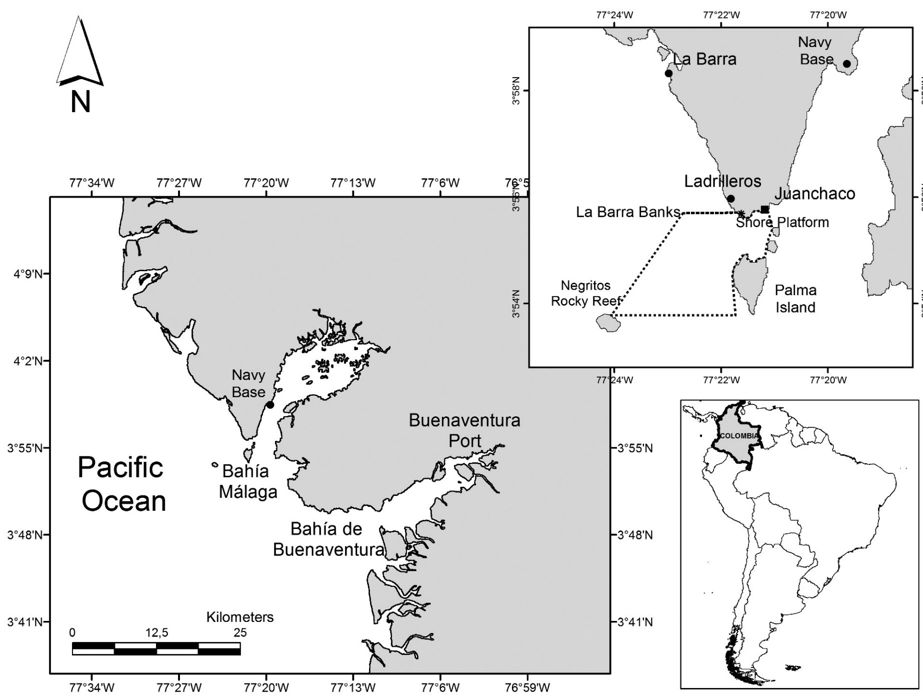

FIGURE 1. Study site at Bahía Málaga in the Colombian Pacific Ocean, South America. Observations were made from a 20 m high shore-based platform between the towns Juanchaco and Ladrilleros

The global increase in maritime traffic, and especially of ocean-going vessels, is thought to be one of the greatest threats to the whales because of the high frequency of vessel-whale collisions (Laist *et al*. 2001; Jensen and Silber 2004; Capella *et al*. 2007; Van Waerebeek *et al*. 2007; Vanderlaan and Taggart 2007; Carrillo and Ritter 2010; IWC 2014). This adds to the pressure on health and communication due to chemical and noise pollution (Baker and Herman 1989; Corkeron 1995; Au and Green 2000; Van Bressem *et al*. 2009). Shipping traffic also generates behavioural changes (Bauer 1986; Watkins 1986; Corkeron 1995; Scheidat *et al*. 2004; Ávila *et al*. 2015). After the fin whale *Balaenoptera physalus*, the humpback whale is the second most often vessel-struck whale species globally (Van Waerebeek and Leaper 2008). Collisions with whales have occurred with all types of vessels, but were more frequent with larger (> 80 m), mainly naval ships and container/cargo vessels, and with ships travelling at speeds of 15 knots or faster (Laist *et al*. 2001; Jensen and Silber 2004; Vanderlaan and Taggart 2007). With regard to the distance kept between whales and vessels, the behaviour of humpback whales was found to be affected when vessels came within 100 m (Corkeron 1995; Stamation *et al*. 2010), or when vessels were between 500 m and 1 km away (Bauer 1986; Bauer and Herman 1986). Behavioural changes were found to be caused mainly by engine noise (Bauer and Herman 1986; Richardson *et al*. 1995). All vessels produce underwater noise (Au and Green 2000) and whales appeared capable to detect and recognize such sounds at distances of up to 8-10 km (Corkeron 1995). In Hawaii, exposure to vessel traffic was found to be stressful to humpback whales. The number and speed of vessels, as well as directional changes were correlated with changes in behaviour including respiration rates, diving intervals, swimming speed and aerial behaviour, and such changes were elicited when vessels were 0.5 - 1.0 km away (Bauer 1986; Bauer and Herman 1986; Bauer *et al*. 1993). Also, the duration of some song elements and the emission of sounds changed in response to approaches by vessels (Watkins 1986; Norris 1994). Off Newfoundland, the number of whales decreased by continuous dredging activity coincident with vessel traffic (Borggaard *et al*. 1999).

Other studies, however, found that humpback whales appeared tolerant of maritime traffic, showing no immediate behavioural changes with frequent vessel traffic and no disruption in their activity (Watkins 1981; Borggaard *et al*. 1999). In the Northwest Atlantic, humpback whales co-occur with vessel traffic and anthropogenic noise (Stimpert *et al*. 2011), as well as in the Gulf of Panama (Guzman *et al*. 2012).

To reduce risk of collision between vessels and whales the International Maritime Organization (IMO), a specialized agency of the United Nations, developed a guidance document, which recommends : 1) to avoid areas with the most whales, if not possible, to slow down speed to 10 knots; 2) to avoid whales which surface directly ahead of the vessels; and 3) to report incidents using the International Whaling Commission (IWC) ship strikes template to contribute with more information to help to understand the problem (FPS Public Health, Food Chain Safety and Environment 2014; IWC 2014). Until 2012 the IMO measures have been successfully adopted along the eastern seaboard of the USA and the Scotia-Fundy region of Canada to protect the Atlantic right whale (*Eubalaena glacialis*), and in the western Mediterranean Sea to protect the fin (*Balaenoptera physalus*), sperm (*Physeter macrocephalus*) and long-finned pilot whales (*Globicephala melas*) (Silber *et al*. 2012).

Because of the collision threat and other potential disturbance that dense vessel traffic may represent to humpback whales in Bahía Málaga, and considering the complete absence of regional information, the objective of this research was to conduct a preliminary study of the short-term effect of vessel traffic on local whale density (whales observed per unit time in the study area) during the breeding season.

MATERIALS AND METHODS

Study area

Bahía Málaga (bordered by 03˚51'N - 3˚57'N, and 77˚19'W - 77˚25'W) is located in the Department of Valle del Cauca, Colombian Pacific, with the bay's entrance situated at 36 km steaming distance northwest of the Buenaventura seaport, itself located inside Bahía Buenaventura (Figure 1). This area is characterized by a high rainfall of around 6,000 mm per year, warm surface waters year-round (25 - 26 °C) and low salinities ranging 20-33 nearshore (Prahl *et al*. 1990; Cantera 1993). The average water depth of the study area is 30 m. The oceanic waters are relatively clear, but transparency of nearshore water is less than 50 cm (Cantera 1993). Observations were made from a shore-based platform, located at 03°55'N, 77°21'W between the towns of Ladrilleros and Juanchaco. The target area covered some 14 km^2 of coastal waters off the northwestern entrance of Bahía Málaga, delimited by Negritos rocky reef (03°53.73' N, 77°24.72' W), La Barra sandbanks (03°55.655' N, 77°23.0478' W) and Palma Island (03°54.480' N, 77°21.48' W) (Figure 1). The bay's entrance hosts the greatest whale concentration in Bahía Málaga and surroundings (Londoño 2002). The effective distance between the observation platform and whales ranged between 0.5 km and 6.0 km.

Data collection and analyses

Surveys were conducted during 52 days in the breeding and calving season of August and September 2008. Observations of whale pods and vessel traffic were made from a shore-based platform (using 7x50 binoculars) at a height of 20 m above the mean lower low tide level. Vessels and whale pods were observed and counted by two marine mammal observers (LMC, ICA) alternating with one hour shifts. Thus, observations were conducted continuously by one researcher throughout the day when conditions were optimal, i.e., no rainfall, good visibility (6 km) and wind force less than 4 Beaufort. We scheduled nine 1-hour day-time observation periods, starting from 08:00 to 08:59, and so forth, until the last hour from 16:00 to 16:59.

In order to test whether the number of transiting vessels altered the density of whales over the short term, we recorded for every hour, by direct count, the number and types of vessels passing through the study area and the number of individual whales in the same area.

A "pod" was defined as a group of whales that were swimming within three body lengths of one another (Scheidat *et al*. 2004). Pod type was defined based on the presence of adults (12 - 18 m length) and/or calves (one-half to one-third of an adult's body length). An adult that accompanied a calf was assumed to be its mother, and any additional adults travelling with the mother-calf pairs were deemed "escorts" (Herman and Antinoja 1977; Whitehead 1981; Baker *et al*. 1987). Whale pods were observed continuously to determine the density of whales per hour unit (number of whales seen h^{-1}). The same pod could be observed in more than one hour unit, *i.e*., individual whales and pods could be re-sampled in subsequent hours.

Similarly, we counted "vessel trips", the number of vessels that transited in the area per hour, considering that a particular vessel could transit, and thus be counted, more than once, even within the same hour in case it briefly left the study area and returned. We distinguished different vessel trip categories according to three criteria. First, according to their activity: fishing vessels, transport vessels (included passenger transport), tourism and leisure vessels (whale-watching, diving, yachts, sport fishing), and vessels of the navy and environmental authorities. Second, according to vessel size: small (3-15 m), medium (15-60 m), and large vessels (> 60 m). Third, in relation to their speed: fast (≥ 16 knots) or slow (< 16 knots), estimated from a known track (ca. 1.5 km) covered in, respectively, less or more than 3 minutes.

To evaluate whether the presence of vessels affected the abundance of whales per hour in the study area, we fitted a Generalized Linear Model (GLM, with Poisson distribution of error for count data) with number of whales as dependent variable and vessel size and speed as factors, including time (days and hours) as predictor (to control for the possible re-sampling between observation days and hours).

RESULTS

During 312 hours of observations we registered between 0 - 17 vessel trips h^{-1}, with an average of 4.5 vessel trips h^{-1} (SD = 3.1) (Table 1). On a total of 1,402 recorded vessel trips, 878 vessel trips occurred in August (mean = 5.3 h^{-1}, SD = 3.3) and 524 vessel trips in September (mean = 3.5 h^{-1}, SD = 2.6). Between 12 - 89 vessel trips per day (median = 25; n = 52 days, sampling 08:00 - 16:59) were recorded.

Of the total number of vessel trips observed, 36.4% were made by fishing vessels, 38.2% by transport vessels, 23.5% by tourism and leisure vessels, and 7% by the navy and environmental authorities. The majority of trips (95.9%) involved small vessels with a modal length of 7 m (beam 2 m, draft 0.5 m) and typically powered by an 80 hp outboard engine (Figure 2). The relatively uncommon medium vessels (4.1%), with a modal length of 30 m (max. 60 m), a 9 m beam and 2.7 m draft, were typically powered

TABLE 1. Effort data and results, including total numbers and mean values (per hour) of vessel trips, whale pods and humpback whales counted for each of nine 1-hour observation periods, in Bahía Málaga, Colombian Pacific, in the period August –September 2008

Observation period	Effort hours	Vessel-trips							Humpback whales					
		Small vessels		Medium vessels		Vessel-trips/h			Pods of whales	Individuals of whales/h				
		Fast	Slow	Fast	Slow	Total	Mean	SD		Adults	Calves	Total	Mean	SD
8:00-8:59	3	4	5	0	0	9	3.0	4.4	7	7	3	10	3.3	1.5
9:00-9:59	39	82	41	1	10	134	3.4	2.9	91	110	38	148	3.8	2.0
10:00-10:59	40	158	66	2	8	234	5.9	2.9	109	141	42	183	4.6	3.0
11:00-11:59	46	143	53	3	10	209	4.5	3.8	105	121	50	171	3.7	1.8
12:00-12:59	49	127	62	0	7	196	4.0	2.7	118	132	53	185	3.8	1.9
13:00-13:59	47	135	65	0	7	207	4.4	2.7	113	133	50	183	3.9	2.0
14:00-14:59	44	170	45	0	4	219	5.0	3.5	101	120	50	170	3.9	1.9
15:00-15:59	41	123	48	1	5	177	4.3	2.8	120	137	60	197	4.8	2.8
16:00-16:59	3	14	3	0	0	17	5.7	3.1	6	10	2	12	4.0	3.5
Total	312	956	388	7	51	1402	4.5	3.1	770	911	348	1259	4.0	2.2

FIGURE 2. Typical small vessels that transit in Bahía Málaga area

FIGURE 3. Typical medium-sized vessels that transit in Bahía Málaga area

by 400 hp engines (Figure 3). We did not record any large vessels within the study area, although they did transit in Bahía de Buenaventura. The majority of small vessels (71.1%) transited at a speed of 16 knots or faster, the rest (28.9%) at a lower speed. Most (87.9%) of the medium vessels transited at a speed less than 16 knots, the remainder (12.1%) at a higher speed. The majority of vessels departed/arrived from/to their home port at Juanchaco, and sailed direction La Barra, Buenaventura port or to seaward (Figure 1).

We recorded between 0 - 15 humpback whales h^{-1} (mean = 4.0 whales h^{-1}, SD = 2.2) (Table 1). A total of 770 sightings of whale pods, many of which re-sampled, comprised 1259 whale individuals, including 911 adults and 348 calves. We sighted a total of 579 whales in August (mean = 3.5 h^{-1}, SD = 1.9), and 680 whales in September (mean = 4.6 h^{-1}, SD = 2.4). Between 2 - 48 whales per day (median = 23; n= 52 days, with sampling 08:00 - 16:59) were sighted. It should be stressed that many whales undoubtedly were re-sampled.

The results of the GLM showed that the number of whales per hour was only impacted by the days along the breeding season. Over the study period we found that with days progressing along the breeding season the number of whales sighted h^{-1} significantly increased (Z= 5.4, P < 0.001) towards the end of the period. Each additional day showed an 1.0 % increase in the mean number of sighted whales. A 95 % confidence interval is given by (1.006, 1.013), which represents a 0.6 – 1.3 % increase (Figure 4). We suggest this is explained by a combination of continuing new arrivals and births (Figure 5). On the other hand, over the course of the day fewer whales seemed to be sighted at noon (Figure 6), albeit the hours along the day did not significantly influence the number of whales sighted h^{-1} (Z= 1.5, P = 0.33). Visibility was normally optimal around noon, considering highest light intensity and minimal glare. The potential for glare increases with low sun angles over the horizon in late afternoon and early morning. Hence, apparent lower whale counts at noon are not explained by visibility, and the cause remained unclear.

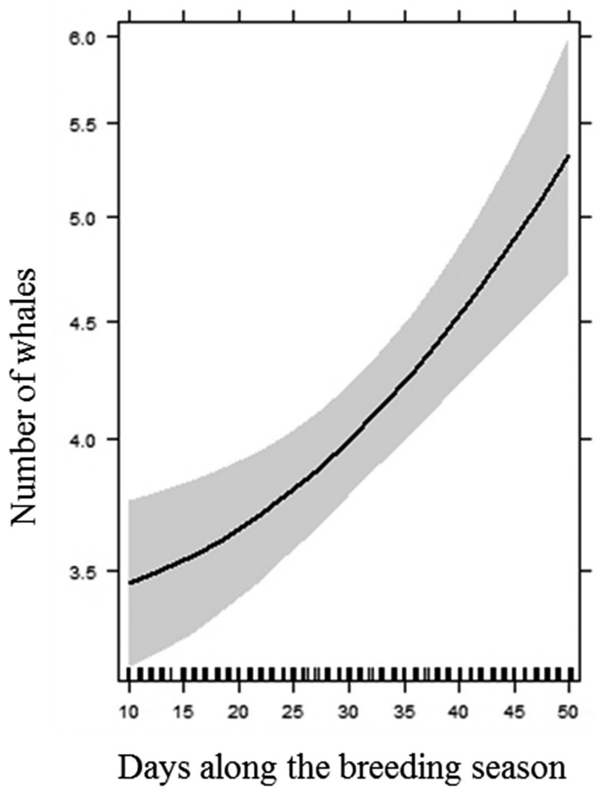

FIGURE 4. Average number of whales sighted per hour along the breeding season (August-September 2008). Shaded area indicates 95% confidence intervals

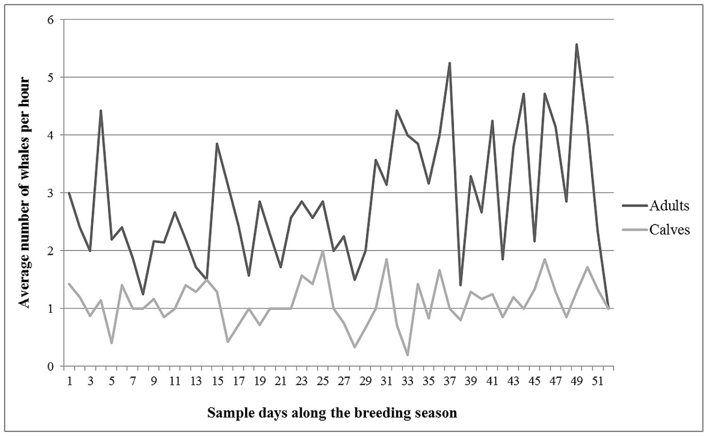

FIGURE 5. Variation along the breeding season of the average number of whales per hour observed in the study area (averaged for each sampled day, n=52, in August-September 2008). Overall average number of adults observed per hour: mean=2.9, SD=1.9, N=312. Overall average number of calves observed per hour: mean=1.1, SD=0.7, N=312

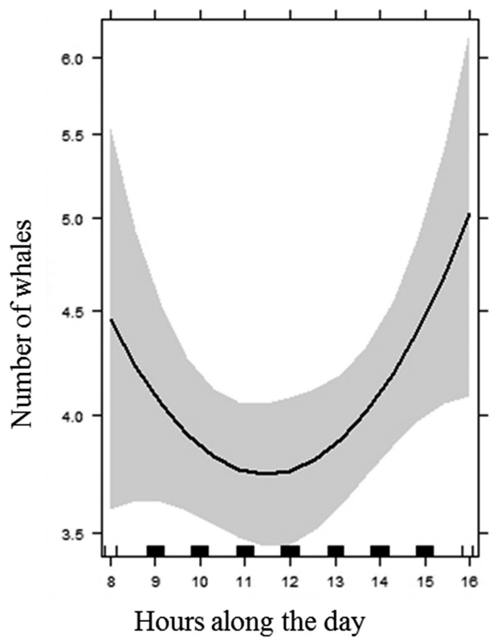

FIGURE 6. Average number of whales sighted per hour along the day (from 8:00 to 16:59). Shaded area indicates 95% confidence intervals

When analyzing whether the frequency of vessel trips altered the short-term density of whales in the study area, we found that the number of vessel trips did not have a significant impact on the number of whales sighted h^{-1} (Z = -0.6, P = 0.561, Figure 7). This was valid also separately for small vessels (Z = 0.6, P = 0.525) and medium vessels (Z = 1.6, P = 0.119). Hence, even though the number of whales sighted h^{-1} seemed to diminish when the number of vessels increased, this was not statistically significant over the short term. The vessels passed by the whales at highly variable estimated distances, from 10 m to 5 km.

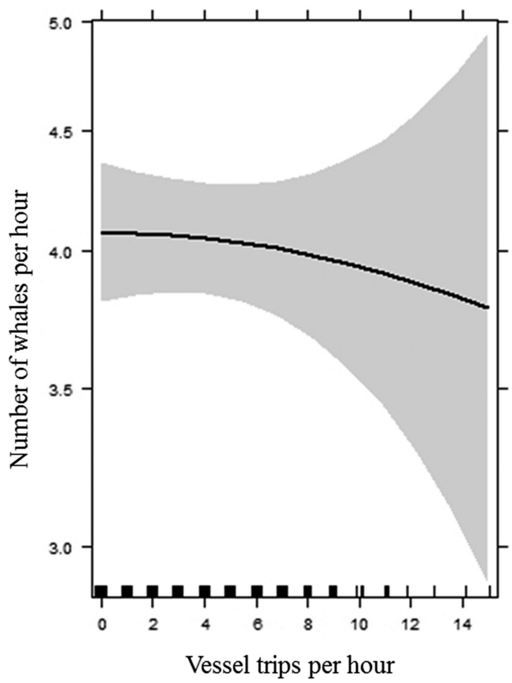

FIGURE 7. Average number of whales present in the study area versus the number of vessel trips per hour. Shaded area indicates 95% confidence intervals

DISCUSSION

Humpback whales arrive in the general study area as early as June and depart in November (Flórez-González *et al*. 2007), and according to our results whales still seemed to be arriving at Bahía Málaga at least until September. In other areas, *e.g*. in Abrolhos, Brazil, and Hawaii, a similar temporal fluctuation in the presence of whales has been reported, where groups with calves increased as the season advanced (Baker and Hermann 1984; Smultea 1994; Morete *et al*. 2007).

We found no statistically significant change in the number of humpback whales in relation to vessel traffic over the short term (hours). Similarly, the breeding ground off Isla de la Plata in southern Ecuador is subjected daily to extensive pressure from small-vessel whale-watching, nonetheless no indications exist of spatial or temporal changes in area utilization (Scheidat *et al*. 2004). Admittedly, no recent information is available. Movements of whales (adults and calves) in the Gulf of Panama coincide with major commercial maritime routes (Guzman *et al*. 2012). On feeding grounds, such as Stellwagen Bank in the NW Atlantic (Stimpert *et al.* 2011) and Glacier Bay, Alaska (Doyle *et al.* 2008) humpback whales have co-occurred with vessel traffic and anthropogenic noise for many years.

However, several studies have shown that, in the long term (years), maritime traffic and other disturbances can lead to changes (*e.g.* Glockner-Ferrari and Ferrari 1990; Borggaard *et al.* 1999; Lien 2001). In parts of the humpback whale breeding area off Hawaii a significant decrease of mothers with calves was reported, due to the increase of vessels and human activities in coastal waters, with whales spreading out towards open sea (Glockner-Ferrari and Ferrari 1990). At Australia's Hervey Bay it was noted that humpback whales changed their main location with the arrival of whale-watching tourism. When the vessels followed them to the new site, the whales moved back to the original location (Todd, pers. comm. in Lien 2001). In Trinity Bay, Newfoundland, when assessing the effects of industrial activity on humpback whales, results were mixed (Borggaard *et al.* 1999). Whales appeared tolerant of transient blasting and frequent vessel traffic, but were more affected by continuous activity from dredging, coupled with vessel traffic. A significant decreased return rate of humpback whales to feeding grounds indicated a possible long-term effect of exposure to blasting (Borggaard *et al.* 1999).

Circumstantial historical information suggests some long-term changes also in our study area. Escobar (1921) reported that between 1918 and 1920 humpback whales entered inside Bahía Málaga (Figure 1) from July to August to give birth to their calves. This apparently continued until the early 1990s when the Navy base in Bahía Málaga became operational. Since then, according to local community members and fishermen (pers. communications to ICA and LMC, 2008), as well as observations by one of us (ICA) in 1998-2013, humpback whales infrequently enter inside the bay. In recent years, studies by Martínez (2000) and Londoño (2002) demonstrated that the highest concentration of humpback whales occurs outside the bay, namely at the bay's northern entrance and between Palm Island and Negritos rocky reef. However, although this apparent change in the spatial distribution of whales at Bahía Málaga could be related to changes in vessel traffic, a major longitudinal study will be required to determine cause-and-effect.

Despite the heavy traffic, often at high speed, registered in Bahía Málaga, we did not record any vessel collisions with whales during the study period. Vanderlaan and Taggart (2007) found that at 15 knots, 80 % of collisions with medium-sized or large vessels were fatal to whales. At speeds of 11.8 and 8.6 knots the fraction of fatal collisions dropped to 50 % and 20 %, respectively. Besides, slow-moving vessels may provide an opportunity for whales to avoid a collision, or for vessel operators to avoid the whales. However, the danger of collisions is not just hypothetical in the Colombian Pacific. On 26 July 2010, some 139 km south of Bahía Málaga, an 8 m vessel powered by a 200 hp outboard engine collided with a calf in waters of Gorgona Island (Ávila *et al.* 2011) when transiting towards Sanquianga National Park at high speed. Although abraded skin was seen, the calf continued swimming and disappeared. The extent of injury could not be assessed and it is unknown whether the calf survived. Non-fatal collisions may cause severe external and internal traumata that may lead to chronic disease and a shortened life-span (Van Waerebeek *et al*. 2007). Reported collisions almost certainly underestimate the real incidence, which may be significantly higher. Many large vessel collisions with whales simply go unnoticed by the crew and thus remain unreported (Félix and Van Waerebeek 2005). Based on stranding records, Capella *et al.* (2001, 2007) found that, between 1986 and 2006, approximately 1.6 % of the humpback whale population in Colombia had been affected by collisions, and at least 5.0 % of these collisions happened in Bahía Málaga.

A humpback whale breeding area near any major port, such as Bahía Malaga, should generate an automatic concern. Significant numbers of collisions occur at humpback whale breeding and feeding grounds where maritime traffic is dense due to the presence of large commercial ports. On the US Atlantic coast, one third of the humpback whales found dead between 1985 and 1992 had ship strike injuries (Wiley *et al*. 1994). Most of the victims were calves (80 %), or mothers with newborn calves (Stevick 1999). On the northern Gulf of Guinea breeding ground, where humpback whale nearshore presence overlaps with shipping lanes to and from the rapidly developing seaports of Sekondi-Takoradi, Tema, Lomé and Cotonou (Félix and Van Waerebeek 2005; Van Waerebeek *et al*. 2007), near-misses were repeatedly observed (KVW, unpublished data).

Two main measures have been proposed to reduce the threat of collision with whales in various locations (*e.g*., Gulf of Maine, Glacier Bay, Hawaii, Great South Channel, Boston, Hauraki Gulf, Bay of Fundy, Roseway Basin, Gulf of Panama, Cabo de Gata and Strait of Gibraltar): 1) the separation of vessels and whales in space and time; and, 2) the reduction in vessel speed (*e.g*., Laist *et al*. 2001; Vanderlaan and Taggart 2007, 2009; Vanderlaan *et al*. 2009; Gende *et al*. 2011; Wiley *et al*. 2011; Guzman *et al*. 2012; Silber *et al*. 2012; Redfern *et al*. 2013; Conn and Silber 2013; Constantine *et al*. 2015). Since 2001, whale-watching regulations were introduced in Bahía Málaga with the aim to minimize negative impacts on whales by the whale-watching vessels. The regulations include a maximum of 15 whale-watching boat trips per day during the season (June–November), keeping a minimum distance of 200 m between the boat and the whales, and a navigation speed, when near whales, no faster than the speed of the slowest whale (DIMAR 2001; Ávila *et al*. 2015).

Our observations at Bahía Málaga clearly demonstrated that during the breeding season, humpback whales and vessel traffic spatially fully overlap. This information urges the application of the precautionary principle as adopted by the Colombian government in 1993. To avoid strikes, in addition to the rules established by DIMAR (2001), we also recommend to reduce vessel speed in the vicinity of whales to 10 knots or less (*cf.* Vanderlaan and Taggart 2007; Guzman *et al*. 2012; FPS Public Health, Food Chain Safety and Environment 2014). Also, as mandated in Spain, if any whales are closing in, or emerge unexpectedly within the vessel's route, whale-watching boat drivers should switch the engine to neutral, disengage and reduce to low revolutions or, if necessary, stop (Heredia 2012). Van Waerebeek *et al*. (2007) suggested that propeller-guards should be made compulsory for all boat-based cetacean tourism, as habituation to boat traffic seems to be a contributing factor in accidents. Finally, as recommended by the IMO, if feasible, alternative shipping routes for larger vessels should be contemplated during the wintering season, avoiding the areas with high whale density. Finally, any collision should be documented and reported to maritime authorities.

CONCLUSIONS

Humpback whales and vessel traffic spatially and temporally overlap in Bahía Málaga during the breeding season. In the 2008 season we registered an average of 4.0 whales per hour and an average of 4.5 vessels per hour at the bay's northern entrance, the highest concentration area of humpback whales in Bahía Málaga. The vessel traffic in this area was relatively high and dedicated to tourism, transport, fishing and navy. The majority were fast, smaller vessels, transiting at speeds of 16 knots or higher. Sightings of whales increased in August-September as the breeding season progressed: each additional day showed an 1.0 % increase in the mean number of sighted whales, both due to still arriving whales and births.

No significant change was found in the number of humpback whales in Bahía Malaga in relation to vessel traffic in the short term. The environmental or biological factors (*e.g*. shelter from heavy weather and predators, low-risk calving) that seem to push whales to hold on to this perhaps exceptionally favorable habitat despite significant anthropogenic disturbance should be determined.

In order to mitigate the risk of collisions, we support the DIMAR whale-watching regulations in place since 2001 (maximum 15 boat-trips per day; maintaining 200 m minimum distance). In line with IMO recommendations we also recommend a reduction in vessel speed when in the vicinity of whales to 10 knots or less, switching the engine to neutral with whales closing, and promote the installation of propeller guards.

Considering the importance of Bahía Málaga as a low-latitude calving and breeding ground for the SE Pacific population of humpback whales, as well as its importance to Colombia's whale-watching tourism, this initial study will serve as a useful starting point for further improvements to preventive measures, demonstrates the need for long-term monitoring, and contributes to present and future whale research in Colombia's Pacific region.

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