Ocean & Coastal Management 148 (2017) 31–39

Contents lists available at ScienceDirect

Ocean & Coastal Management

journal homepage: www.elsevier.com/locate/ocecoaman

The effectiveness of incentivized and non-incentivized vessel speed reduction programs: Case study in the Santa Barbara channel

Ryan Freedman [a, d, *], Sean Herron [a], Mary Byrd [b], Kristi Birney [c], Jessica Morten [a], Brian Shafritz [b], Chris Caldow [a], Sean Hastings [a]

[a] Channel Islands National Marine Sanctuary, University of California, Bldg 514, MC 6155, Santa Barbara, CA 93106, USA
[b] Santa Barbara County Air Pollution Control District (SBCAPCD), 260 N San Antonio Rd # A, Santa Barbara, CA 93110, USA
[c] UCSB Donald Bren School of Environmental Science and Management Santa Barbara, CA 93106, USA
[d] Department of Ecology, Evolution and Marine Biology, University of California Santa Barbara, USA

ARTICLE INFO

Article history:
Received 2 February 2017
Received in revised form
18 May 2017
Accepted 12 July 2017

Keywords:
Shipping
Whales
Conservation
Ship strikes

1. Introduction

Shipping is an important industry to southern California, with the Ports of Los Angeles (POLA) and Long Beach (POLB) experiencing steady, substantial growth over the last 20 years. Currently, these ports facilitate over 470 billion $US in trade annually (Port of Long Beach and Port of Los Angeles websites). However, this lucrative and expanding industry is associated with a number of environmental impacts, including ocean noise pollution, air pollution and whale ship strikes (Redfern et al., 2013; McKenna et al., 2012; National Research Council of the US National Academies, 2003; Andrew et al., 2002). The level at which shipping adversely impacts local ecosystems has often been linked to ship speed, with conventional wisdom being that faster ships lead to increased pollutant emissions (Psaraftis et al., 2009), increased noise pollution and higher whale mortality risk (Wiley et al., 2011; Vanderlaan and Taggart, 2007; Wang et al., 2007; Laist et al., 2001). Ocean noise is important to track as it has been associated with increased stress, reduced feeding, and potentially increasing susceptibility of whales to ship strikes (Redfern et al. Forthcoming; Gedamke et al., 2016; McKenna et al., 2015; Clark et al., 2009).

While the industry is global in scale, some regions of the world have significantly higher concentrations of ship traffic. Via POLA and POLB, the Southern California Bight contains approximately 50% of seaborne cargo into the US (Louttit, pers comms.) but is also home to The Channel Islands National Marine Sanctuary (CINMS) serves as a federal designated marine protected area in an otherwise heavily urbanized Southern California Bight marine ecosystem. In Santa Barbara County alone (one of the counties surrounding the sanctuary), emissions from ships account for over 50% of the total NOx emissions (SBCAPCD, 2016). Ship emissions contribute to worsening air quality and can even increase the prevalence of lung-related disease rates (Bone et al., 2016; Corbett et al., 2007; Bailey and Solomon, 2004). In addition, the Santa Barbara Channel ranks among some of the noisiest ocean regions worldwide, with just 6% of the Sanctuary experiencing noise pollution levels below estimated pre-industrial conditions (Gedamke et al., 2016).

Beyond contributing to ambient noise pollution, ships commonly collide with whales in the SCB; leading to injury or mortality. Whale ship strikes have been in the public spotlight in the SCB after four blue whales (*Balaenoptera musculus*), an ESA-designated endangered species, washed ashore and were ruled as likely to be ship strike mortalities in 2007 (Berman-Kowalewski et al, 2010). While managers can not be sure of the exact numbers of ship strikes per year due to the low chances of discovering an event, this number greatly exceeded recorded confirmed or presumed ship strike fatalities in previous years. This prompted the National Oceanic and Atmospheric Administration (NOAA) to declare an Unusual Mortality Event (UME). Given that the Eastern Tropical Pacific Blue Whale stock has been slower to recover than other large baleen whale populations (Irvine et al., 2014) and that recent research has indicated that blue whales do not exhibit rapid avoidance behavior to avoid ship strikes (McKenna et al., 2015), a number of policy actions taken by NOAA

* Corresponding author. Channel Islands National Marine Sanctuary, University of California, Bldg 514, MC 6155, Santa Barbara, CA 93106, USA.
E-mail address: ryan.m.freedman@noaa.gov (R. Freedman).

http://dx.doi.org/10.1016/j.ocecoaman.2017.07.013

have been focused on their recovery. Ship strikes are known to also affect fin (*Balaenoptera physalus*) and humpback (*Megaptera novaeangliae*) whales as well in southern California at relatively consistent rates annually (Calambokidis, 2011; Vanderlaan and Taggart, 2007). Based on a review of NMFS marine mammal stranding data there has been on average 1–3 large baleen whales likely struck by ships along the California coast. All of these species are afforded the same protections by the Marine Mammal Protection Act (50 C.F.R. Part 218) and when in sanctuary waters the National Marine Sanctuaries Act (Title 16, Chapter 32, Sections 1431 et seq. United States Code).

Local, state and federal agencies are working together to mitigate impacts of the shipping industry on air quality and whale populations in Southern California through a number of spatial exclusion and speed reduction efforts. In 2008, the California Resources Board (CARB) adopted fuel regulations that required the use of cleaner fuels out to 24 nm from the coast to reduce the amount of shipping emissions nearshore. Later, in 2010, the United States Environmental Protection Agency (EPA) enacted the North American Emission Control Area (referred to ECA for the remainder of this manuscript), which limited the sulfur content of shipping fuels within 200 nm of the coastline (Environmental Protection Agency EPA, 2010). Both regulations had unintended consequences of altering the spatial patterns of traffic in SCB, with over 50% of the ships deciding to not use the nearshore shipping lanes in the SBC when the CARB rule went into effect. The establishment of the ECA likely pushed ships to slow down to improve fuel economy as they had to use more expensive cleaner fuels. This created a somewhat scattered pattern of shipping traffic, with a lot of the traffic going south of the Northern Channel Islands; an area with a scarcity of available cetacean habitat data compared to other parts of the SBC. In 2014 and 2015, 34% and 40%, respectively, of arrivals to POLA and POLB used the SBC Traffic Separation Scheme (TSS), a designation used to organize shipping traffic into lanes. Comparatively, 28% (2014) and 21% (2015) of transits approach the ports from a western approach south of the sanctuary, which has no shipping lane (Loutitt, unpublished data). While these efforts have likely reduced air pollution in Santa Barbara and Ventura coastal communities, a high density of traffic and its respective level of impacts remains in the greater SCB.

In response to the highly variable traffic patterns, there have been a number of efforts to understand how re-routing ship traffic and changing placement of shipping lanes in the SCB could reduce risk to whales from ship strikes. Based on recommendations from NOAA, the International Maritime Organization (IMO) shifted the TSS in the SBC in 2013 following a US Coast Guard Port Route Access Study to determine alternate routes for shipping lanes (Segee, 2010; US Coast Guard 33 CFR Part 167). In 2008 and again in 2015, the Channel Islands National Marine Sanctuary Advisory Council (SAC) investigated potential management alternatives to better protect whales in the CINMS region. The SAC's 2015 Marine Shipping Working Group proposed a number of alternatives, including adjustments to the TSS, an extension of the IMO-declared Area To Be Avoided (ATBA) around the islands, a new western route transiting south of the sanctuary into the POLA and POLB, a seasonal VSR zone, and an expanded VSR incentive-based trial (Marine Shipping Working Group Final Report, 2016). With available whale distribution data and increasingly sophisticated population and habitat modeling, managers are considering to what degree the SAC's recommendations would reduce ship strike impact (Marine Shipping Working Group Final Report, 2016).

Given the high density of traffic in the SCB, fuel regulations alone do not directly reduce ship strike risk. Even though the existing TSS had recently been adjusted to reduce the co-occurrence of ships and whales, overlap of shipping activities and critical whale habitat still occurs. Because of the remaining overlap, agencies and conservation groups are still pursuing VSR programs to further reduce risk to large cetaceans and decrease air emissions. Large vessels that travel at slower speeds burn less fuel as long as they remain above a specific speed threshold. Thusly, these slow-going vessels emit fewer pollutants compared to those traveling at greater speeds (Psaraftis et al., 2009). In addition to these air quality benefits, evidence also shows a decrease in cetacean mortality risk in ship collision events with decreases in speed (Wiley et al., 2011; Vanderlaan and Taggart, 2007; Wang et al., 2007; Laist et al., 2001).

VSR programs have been instated in other areas with success. Both POLA and POLB use monetary incentives to slow ships coming into the ports through dockage fee reimbursements (POLA, 2009; POLB, 2009). The program has been widely deemed a success with large reductions in emissions around the port and surrounding areas (POLB, 2013). However, emissions measurements still exceed state and federal standards outside of the program's incentive areas (40 nm) and it is possible that ships will increase speed to make up time lost from participating in a VSR. This speed adjustment could spatially alter where impacts are the greatest and simply pass along increased ship strike risk farther along the coast.

Voluntary VSR (e.g. non-incentivized) programs have never been compared to incentivized VSR approaches in the same spatial area and under identical emissions regulations. Comparing these approaches is important because while voluntary incentivized programs may come at a cost to conservation groups or taxpayers, they may have improved efficacy over voluntary measures without incentives. In response to regional shipping issues in the Santa Barbara Channel, Channel Islands National Marine Sanctuary (CINMS) and Santa Barbara County Air Pollution Control District (SBCAPCD) implemented a trial incentivized VSR Program in the Santa Barbara Channel TSS in the summer of 2014. Since 2008 the National Marine Fisheries Service and CINMS have implemented a voluntary speed reduction program in this same area. This allows CINMS and SBCAPCD to test the efficacy of an incentivized approach to vessel speed reduction along an open coastline and compare that approach to a voluntary measure under similar conditions.

2. Materials and methods

2.1. Study area

The Santa Barbara Channel and the northern Channel Islands are a biological hotspot for cetaceans and are known for high cetacean density during summer months (Gedamke et al., 2016; Calambokidis et. al. 2015; Calambokidis and Barlow, 2004; Bailey et al., 2009). There is an existing Traffic Separation Scheme (i.e. north and south bound shipping lanes) between the mainland coast and the Channel Islands as well as an Area To Be Avoided (ATBA) around the Channel Islands National Marine Sanctuary (Fig. 1). The ATBA effectively keeps large traffic outside of the majority of sanctuary waters and the Sanctuary has additional regulations prohibiting large vessels over 300 gross tons from within 1 nm of the islands. Over the last few years shipping traffic has split around the ATBA with approximately 2400 transits going through the shipping lane and approximately 1400 transits traveling south of the islands annually.

2.2. Incentivized VSR trial (IVSR)

The IVSR area extended from POLA and POLB's incentive area (40 nm from the port entrance) to the end of the shipping lane around Point Conception (Fig. 1) creating a trial area that spans