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Entanglement risk to western gray whales in Russian Far East fisheries

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INTERNATIONAL WHALING COMMISSION

Entanglement Risk to Western Gray Whales in Russian Far East Fisheries

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Cover photo: Western gray whale in Sakhalin © David Weller

Disclaimer: This is a working paper commissioned by IUCN and developed as part of the IUCN's Western Gray Whale Advisory Panel process. It will be submitted to the International Whaling Commission (IWC) Scientific Committee (SC) for its annual meeting in May 2017. This working paper contains preliminary research, analysis, findings, and recommendations and is being circulated to stimulate timely discussion and critical feedback and to inform ongoing discussion on an emerging issue. It will eventually be submitted for journal publication - in another form and with its content revised to some extent. For more information, please contact the WGWAP Secretariat: anete.berzina@iucn.org.

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Acronyms

DCR	Daily Catch Report
FAO	Food and Agriculture Organisation of the United Nations
ISRP	IUCN's Independent Scientific Review Panel (the predecessor of the WGWAP)
IUCN	International Union for Conservation of Nature
IWC	International Whaling Commission
RFE	Russian Far East
SC	Scientific Committee
SEW	Sakhalin Environment Watch
SI/M	Serious Injuries and Mortalities
WGW	Western stock of the gray whales (*Eschrichtius robustus*), also called Western Gray Whales
WGWAP	IUCN's Western Gray Whale Advisory Panel

1 Introduction

1.1 State of knowledge of western gray whales

Gray whales (*Eschrichtius robustus*) occur in the eastern and western North Pacific and adjacent seas. The eastern stock ranges from Baja California to the Arctic Ocean, and is abundant and not assigned any special protective status (Carretta *et al*. 2015). The situation with the western stock (hereafter WGW or WGWs) is much different. Historical evidence indicates that gray whales were fairly numerous in the western Pacific prior to modern commercial whaling. Whaling in that region began in the 1890s and took about 2,000 animals, mainly in Korean and Japanese waters, during the 20th century (Kato and Kasuya 2002, IWC 2015a). At that time they migrated along the Asian coast between eastern Russia and the South China Sea. However, sightings had become very infrequent by the middle of the 20th century, and some considered WGWs to be extinct (Bowen 1974). More recent observations made off the east coast of Sakhalin Island and southern Kamchatka suggested that a population of around 140 WGWs older than calves existed in 2012, with an increasing trend in abundance (Cooke *et al*. 2013). WGWs are listed as endangered in the Russian Red Data Book and as endangered under the U.S. Endangered Species Act, considered depleted and strategic under the U.S. Marine Mammal Protection Act, and listed as critically endangered in the Red List of Threatened Animals maintained by the International Union for Conservation of Nature (IUCN; Reilly *et al*. 2008). Although genetics studies show differences between the eastern and western populations (Lang *et al*. 2011), telemetric tagging studies (Mate *et al*. 2015) and photographic and genetic matching of animals seen in the eastern and western North Pacific (Weller *et al*. 2012) indicate that some WGWs occur in coastal waters of western North America where their distribution overlaps that of the eastern stock (see IWC 2015a, b).

1.2 Concerns about WGW-fishery interactions

Two international bodies – the International Whaling Commission’s (IWC) Scientific Committee (SC) and the IUCN’s Western Gray Whale Advisory Panel (WGWAP) – have been monitoring and commenting regularly over the past decade and a half on recorded instances of WGW entanglement or entrapment in fishing gear.

In October 2002, the SC sponsored a workshop on WGW research and monitoring. The workshop report summarized the sparse evidence of fishery interactions through 2002, consisting of only one instance of apparent entanglement in Japan (IWC 2004). The recommendations and 10-year plan for research and monitoring appended to the workshop report referenced the need to examine WGW photographs for evidence of disease, scars from killer whale (*Orcinus orca*) attacks, and human interactions (e.g., ship strikes and fishing gear entanglements and entrapments).

At its 2005 and 2006 annual meetings, the SC learned of WGW deaths in set nets (i.e., trap nets) in Japan during 2005 (Kato *et al*. 2005, 2007; IWC 2006a, 2007; see section 2.2 below). The SC concluded (IWC 2006b) that an education campaign was needed for fishermen and others throughout the WGW’s potential range, focused on documentation of stranded or bycaught whales and the need for efforts to release incidentally caught whales. Further, it recommended that all range states organize stranding networks and conduct aerial surveys and beach surveys to search for stranded or bycaught gray whales.

The report of IUCN’s Independent Scientific Review Panel (ISRP, the predecessor of the WGWAP) includes a review of the evidence available at the time concerning bycatch (including all forms of entanglement and entrapment) of WGWs in fisheries in east Asia, and fisheries were cited among the factors contributing to cumulative effects on the population (Reeves *et al*. 2005). This and other later efforts by IUCN-convened panels focused on the potential impacts of oil and gas development activities with little attention paid to fisheries. However, the individual- and stage-based population model developed by Justin Cooke (initially presented in Reeves *et al*. 2005) provided an analytical framework for evaluating removal scenarios that could be applied to bycatch mortality.

Fishery issues appeared explicitly on the WGWAP agenda in November 2007 when it was noted that the WGW was not currently listed as a protected species in Japan and that therefore the products of individuals caught in fishing gear (or otherwise killed or found stranded) could be sold in markets (WGWAP-3[1]). A legal listing that would prohibit such use was confirmed by the Japanese delegation at the 2008 SC meeting (IWC 2009). At its 2007 meeting the WGWAP reviewed the four recent deaths of female WGWs in Japan (three deaths in 2005 and one in 2007) and concluded that those cases should be treated as additional mortality in Cooke's population model. The Panel concluded that a range-wide conservation strategy was needed and IUCN therefore organized a range-wide WGW workshop in October 2008. The workshop led to the draft Conservation Management Plan that highlights entrapment and entanglement in fishing gear as the greatest known threat to WGWs (Brownell *et al*. 2010).

A dead gray whale was found in the intertidal zone near Chaivo Lagoon on Sakhalin Island on the morning of 5 September 2009. The cause of death could not be determined, and at its December 2009 meeting (WGWAP-7) the WGWAP made several recommendations to improve stranding response. Also at that meeting, Sakhalin Energy identified several additional issues and described actions that it had taken in response to the stranding. Little progress was subsequently made on this issue, and in fact the Panel was disappointed to learn in 2010 that Sakhalin Energy had decided to discontinue its dedicated aerial surveys of Sakhalin beaches to search for whale carcasses (WGWAP-9). This subject was revisited by the Panel at its February 2012 meeting at which it noted the need to ensure that any future stranded gray whale be examined in detail and that this required a trained necropsy team on call and available to respond to the next stranding (WGWAP-12). The Panel has continued to state its belief that Sakhalin Energy and other energy companies operating at Sakhalin have a useful and appropriate role to play with regard to carcass detection, strandings, and necropsies (WGWAP-12 and 14). Also, the Panel recently expanded this to include disentanglement training and capacity building to be carried out under IWC auspices (e.g., WGWAP-14, WGWAP-16).

At its 2015 meeting the WGWAP learned of a gray whale that had been observed entangled off Sakhalin in 2013 (see section 2.2 below), and of opportunistic observations of salmon fishing activities near Piltun Lagoon in July 2015 made by Grigoriy Tsidulko (WGWAP-16). The Panel made a commitment to analyze the fishery interaction issue further, and a preliminary analysis was published by IUCN in 2016 as an annex to its first Performance Standards Task Force meeting (Lowry 2016).

1.3 Objectives of this study

Objectives of this study were discussed and agreed at a WGWAP meeting in November 2016 (WGWAP-17), as follows:

- Summarize and map all available evidence of WGW entanglements, and review the literature on gear types known to catch gray whales.
- Summarize the legal/regulatory situation in at least Sakhalin Oblast, including salmon fishing as well as other fisheries with potential risk of entangling or entrapping gray whales.
- Describe and map the relevant fisheries and how they operate (for Sakhalin and other Russian Far East fisheries as feasible).
- Identify gaps in knowledge and suggest ways to close them.
- Suggest potential approaches to mitigation and consistent reporting and documentation.

1 All WGWAP meeting reports are available in English and Russian at https://www.iucn.org/western-gray-whale-advisory-panel/panel/meetings/glance-meeting-reports

2 Evidence of gray whale entanglement and entrapment in fishing gear

Because they generally feed near the bottom, often in nearshore areas, and generally use coastal migratory routes where fixed fishing gear is concentrated, gray whales have a particularly high risk of entanglement and entrapment (Brownell *et al*. 2010). There is clear evidence that gray whales can and do become entrapped or entangled in fishing gear, particularly gillnets and vertical lines used for pots or traps. Available information on entrapments and entanglements of WGWs is presented below.

2.1 Russian Far East

Bycatch is not systematically monitored in many Russian Far East (RFE) fisheries and data on whale entanglements and entrapments are therefore very incomplete. Coastal regions are not systematically surveyed for beach-cast animals and therefore carcasses are only detected opportunistically. Those that are detected are rarely examined carefully for possible evidence of entanglement or other causes of death.

Large whales are known to become entangled in salmon driftnets in the RFE (Kornev 1994, Artyukhin *et al*. 2010). In 1995-1999 when a large scale Japanese salmon drift net fishery operating in the RFE was monitored by marine mammal observers every season, there were records of entanglement and drowning of large unidentified whales (Burkanov and Nikulin 2001, Nikulin and Burkanov 2001, Burkanov *et al*. 2007). Many observed entanglements occurred on the Pacific side of the northern Kuril Islands.

As mentioned above, a dead 10m long male WGW was found stranded on northeastern Sakhalin Island near Chaivo Lagoon on 5 September 2009. The carcass was examined over the next few days by personnel from Sakhalin Energy, a local veterinarian, and representatives of relevant authorities (Rosprirodnadzor and Rosselkhoznadzor). Some samples and photographs were taken but there was no obvious evidence of vessel strike or fishing gear entanglement and the cause of death could not be determined. The carcass was buried on 18 September. Photographs showed scarring that indicated the whale had experienced a previous non-lethal entanglement in fishing gear (WGWAP-7 report).

A weathered WGW carcass was found on the southeastern shore of Sakhalin on 10 October 2010. The hunter who found it took photographs and estimated it to be 8m long. The photographs showed rope among the bones, and experts who examined the photographs concluded that entanglement in fishing gear could not be ruled out as a cause of death (WGWAP-16 report). Also in 2010, a whale carcass was observed and photographed in Kronotsky State Reserve in eastern Kamchatka (WGWAP-9). From the photographs it was judged likely to be a gray whale.

A previously photo-identified WGW was seen and photographed off northeastern Sakhalin on 22 August 2013 with rope around its caudal peduncle (Weller *et al*. 2014). A rope-related wound on the peduncle appeared relatively fresh and the rope itself looked similar (i.e., in color and type) to that used in the salmon trap fishery that was operating nearby. The whale was seen the next year without the rope and with no evidence of serious injury apparent in photographs (WGWAP-14 report). This incident represented the first documented entanglement of a free-ranging gray whale off Sakhalin Island and coincided with the first known deployment of salmon traps directly in the feeding area at least since 1995 when annual research on gray whales in the region began (Weller *et al*. 2014).

In 2014, fishermen reported to Sakhalin Environment Watch (SEW, a local non-governmental organization in Yuzhno-Sakhalinsk) that a large whale (reportedly >10 m long but species undetermined) had become entangled in a salmon trap south of Piltun Lagoon and was dead when found (WGWAP-14 report). Gray whales are the only whales of this size that are likely to occur so close to shore in this region.

On 12 September 2016, a WGW in the Piltun area was observed to be entangled by a long rope with numerous floats on it. The line and floats were identified as part of a coastal salmon trap. The whale was seen and photographed in late afternoon and not seen and reported again afterwards (Re 2016). The entangled whale was tentatively identified in one of the WGW photo catalogues (WGWAP-17 report). It is important to note that 2016 was a 'low' year for salmon runs on eastern Sakhalin Island and the nearest salmon traps were set 30 km north and more than 40 km south of Piltun Lagoon (Re 2016).

Bradford *et al*. (2009) examined photographs of WGWs (all taken off Sakhalin) for scars indicating anthropogenic interactions. They found that 28 of 150 individuals (18.7%) showed signs of having interacted with fishing gear at least once. Unfortunately, in this type of analysis the locations where whales encountered the gear and the specific fisheries involved are not known.

2.2 Other Asian waters

During 2005-2007, four gray whales died in trap nets set along the Pacific coast of Honshu, Japan (Weller *et al*. 2008, Kato *et al*. 2013). The first was a young female that was seen repeatedly in Tokyo Bay from mid-April until early May 2005, when it was found dead in a net. Then in mid-July 2005, a mother and her female calf died in a net set off Enoshima Island. In January 2007, a young female was entrapped in a net set in Yokahama Bay. Photographs were taken of all four whales but only those from one whale were suitable for photo-identification. Comparisons with the WGW photo catalogue revealed that the identifiable individual had been photographed and biopsied as a calf off northeastern Sakhalin in July and August 2006 where it accompanied an adult female (Weller *et al*. 2008). It would have been approximately one year old when it was entrapped in the set net in January 2007.

On 5 November 2011, a 13.1m female gray whale died from entanglement in a set gillnet in the Taiwan Strait near the mainland coast of China (Wang *et al*. 2015). Comparisons of photographs of that whale with the eastern and western North Pacific catalogues revealed no matches.

2.3 U.S. waters

IWC (2015b) tabulated known entanglements of gray whales in the eastern North Pacific (not including Alaska) for the period 1978-2012. In this 35-year period there were 79 recorded deaths caused by entanglement in fishing gear and 202 injuries (degree of injury not specified). The documented bycatch rate (including deaths and injuries) was about 8 whales per year for that region.

Carretta *et al*. (2015) reported on documented bycatch of gray whales, including serious injuries and mortalities (SI/M), along the west coast of the U.S., including Alaska, during 2008-2012. The average annual known fishery-caused SI/M was 4.4 whales per year. Incidents were reported from January to October, in nets (8), pot gear (7), lines/buoys only (9), and trawls (1).

During 2012-2016, a total of 52 entangled gray whales were reported along the U.S. west coast. In the 21 cases where the type of fishing gear was confirmed or suspected, 8 involved nets and 13 involved pot gear. In 11 cases the gear was identified as originating from the Dungeness crab (*Cancer magister*) fishery (Lauren Saez, personal communication).

3 Distribution and movements of gray whales in the Russian Far East

Groups of Koryak natives (Kamentsy, Parentsy and Itkantsy) living along the northeastern shores of the Okhotsk Sea hunted whales, although the particular species killed by these aboriginal whalers were not well documented (Krupnik, 1984); the author, however, believed that gray whales were hunted in this region until the early 20th century. European and American whalers operating in the western North Pacific (mainly in the Okhotsk Sea) took gray whales from the late 1840s to at least the mid-1880s (Henderson, 1984, 1990).

The historical distribution and abundance of gray whales in the Okhotsk Sea once greatly exceeded what is presently observed (Yablokov and Bogoslovskaya 1984). Reeves *et al*. (2008) plotted the approximate positions and dates (i.e., months) of 160 kills and sightings of gray whales by American whalers in the Okhotsk Sea in the latter half of the 19th century. Gray whales were observed consistently in Shelikhov Bay and Penzhinskaya Gulf from early May to the end of August. They were also seen in Gizhiginskaya Bay (Northeast Gulf) between mid-May and late August and near Magadan along the northcentral Okhotsk Sea coast from at least early June to early July and from mid-August to mid- or late September. American whalers apparently did not visit the coastal waters off northeastern Sakhalin Island where, since at least the 1980s, WGWs have assembled to feed throughout the summer and autumn.

Today, the northeastern Sakhalin shelf is the main feeding ground for WGWs in the RFE (Weller *et al*. 1999). This feeding ground is centered near the mouth of Piltun Lagoon and includes a nearshore and an offshore feeding area (Demchenko *et al*. 2016). In a given year, approximately 150 whales use these areas, with numerous individuals moving between them during the feeding season. Mothers and calves use only the nearshore feeding area, especially the shallow waters very close to shore. In addition to the Piltun region, occasional sightings have been reported during the summer and fall in nearshore waters between Cape Elizabeth in northern Sakhalin and Vostochny Nature Reserve in central Sakhalin. Additionally, in the past decade a summer sighting was reported of several gray whales in Severny Bay in northwestern Sakhalin (SEIC 2011).

Numerous photo-identified whales, including several reproductive females and calves, have been documented feeding both in coastal waters off Sakhalin and off the southern and eastern coasts of Kamchatka (Vertyankin *et al*. 2004, Tyurneva *et al*. 2010). Waters off southeastern Kamchatka, particularly Olga Bay, are apparently used at least occasionally for feeding by small numbers of gray whales. A high proportion of whales observed off Kamchatka in a given year are later (within the same season) observed off Sakhalin. In addition to southeastern Kamchatka, occasional summer sightings of gray whales have been reported along the east coast as far north as Karaginsky Island (Tyurneva *et al*. 2010). Gray whales have also been reported off southwestern to northwestern Kamchatka in the summer and autumn (Bradford *et al*. 2010).

There have been sporadic reports of gray whales off Kekurny Bay, Babushkin Bay and Gizhiginskaya Gulf in the northern Okhotsk Sea (SEIC 2011, Filatova *et al*. 2016) as well as off the Shantar Islands in the far western Okhotsk during the summer (Weller *et al*. 2003). A few of those sightings have been of whales matched to Sakhalin. In the past several decades, gray whales have been sighted occasionally off the northern Kuril Islands (Paramushir and Shiashkotan) in the eastern Okhotsk Sea, and near the Commander Islands (Medny and Bering) in the western Bering Sea (Weller *et al*. 2003).

The majority of gray whale sightings in the RFE occur in coastal waters, often within 5 km of the shore, but they are also seen at some locations such as the offshore feeding area near Piltun which is 35-45 km from the coast. This distribution in sightings is in part due to the extensive research effort focused on the feeding areas off Sakhalin. Results from a recent satellite-tracking study showed three whales departing the Piltun feeding area in late November or early December and crossing open pelagic waters of the Okhotsk Sea as they moved eastbound to the coast of southwestern Kamchatka (Mate *et al*. 2015). All three whales then made long migrations eastward after leaving the RFE (see section 5 below).

When assessing the risk of fisheries in the RFE to gray whales, it is important to consider that both coastal and offshore fishing operations are of concern. Locations where the threat of interactions with fishing gear are likely to be most pronounced include the areas off northeastern Sakhalin and southeastern Kamchatka, where whales assemble in relatively large numbers to feed during the summer and fall.

4 Description of fisheries that may entangle or entrap WGWs in the RFE

4.1 Materials and methods

Commercial fisheries in the RFE use various types of fishing gear and vessels, some of which can be dangerous to gray whales. Because very little information exists on WGW bycatch and interactions with fishing gear in the RFE (see section 2.1 above), we also used published information on large whale entanglements and entrapments elsewhere (Heyning and Lewis 1990, Baird *et al*. 2002, Gilman *et al*. 2006, Artukhin *et al*. 2010, Reeves *et al*. 2013, Werner *et al*. 2015) to identify potentially dangerous gear types. These included fisheries that use long and loose ropes or cables for deployment of gear such as hooks, nets, or traps. We excluded trawl fisheries and most seine fisheries from our analysis because we considered them of lower concern in regard to WGW bycatch. Among seine gear types, we included only the snurrewad (or Danish seine) which is a common gear type in the RFE and is used to catch demersal fishes on the shelf. Other fisheries preliminarily identified as being of primary concern are coastal salmon traps; drift gillnets set for salmon; bottom-set gillnets for demersal fish; all types of crab pots and traps, octopus pots, and whelk pots; and vertical longlines set for squid and bottom-set longlines for demersal fishes.

We organized our analysis by Food and Agricultural Organization (FAO) areas in the RFE where gray whales regularly occur or where individual gray whales have been sighted (Fig. 1 below). We used a depersonalized daily catch report (DCR) dataset obtained from the Russian government-financed institution “Centre of Fishery Monitoring and Communications” for 2010-2014. The Russian Federation requires that each fishing boat capable of fishing trips lasting over 24 hours submit results of fishing activity electronically at the end of each day (i.e., a DCR). The DCR contains a unique boat identification code, the vessel’s position (latitude and longitude) at the time the report is submitted, fishing gear code, number and total length of time of fishing operations that day, fish caught by species in metric tons including target and non-target species, and the code for the zone where fishing occurred. A total of 445,431 DCRs exist in the 5-year dataset for all types of marine fisheries; this includes 312 types and modifications of fishing gear. In total we selected and analyzed 238,735 DCR records (Table 1 below) pertaining to the fisheries listed above. The coastal salmon trap fishery does not submit DCRs, so for it we used publicly available information on salmon fishing permits and rights, commercial salmon fishing regulations, quotas, and catches to assess potential effort. We also used information provided by Dmitry Lisitsyn and Nikolay Vorobiev (from SEW) on actual locations where salmon traps were set, derived from high-resolution satellite imagery.

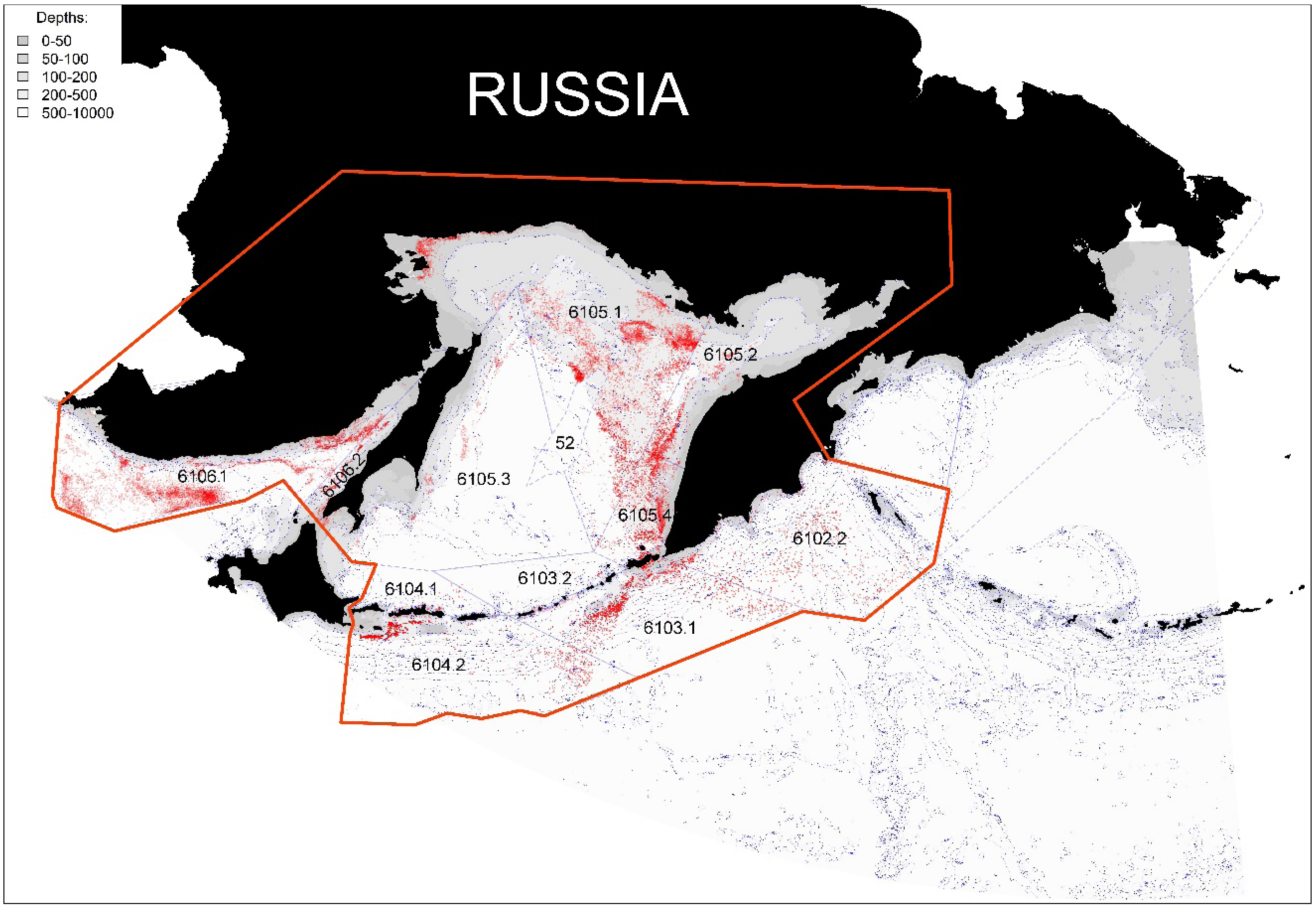

Figure 1. FAO fishing zones and vessel daily catch report locations for selected fisheries that were used in analysis of interactions between western gray whales and Russian Far East fisheries

Fishing gear types	Number of vessel-days with catch, per year					5-year total
	2010	2011	2012	2013	2014	
Gill nets:						
Bottom-set gillnet	1,035	1,025	1,086	1,112	916	5,174
Drift gill net	2,544	2,497	2,797	2,213	2,335	12,386
Longlines:						
Demersal longline	5,862	6,627	6,730	6,389	5,648	31,256
Pelagic longline	455	-	-	-	-	455
Vertical longline	3,669	4,946	5,305	8,356	7,458	29,734
Snurrewad:						
Snurrewad	20,656	18,484	18,034	15,984	16,477	89,635
Demersal traps:						
Crab cone traps	10,840	12,657	11,828	11,095	9,615	56,035
Crab trap large	712	725	658	763	722	3,580
Demersal fish trap	5	62	152	2	-	221
Octopus trap	583	433	554	317	332	2,219
Shrimp trap	729	683	621	738	744	3,515
Whelk trap	1,328	968	825	839	565	4,525
Grand Total	**48,418**	**49,107**	**48,590**	**47,808**	**44,812**	**238,735**

Table 1. Fishing effort for selected marine fisheries in western gray whale habitats in the Russian Far East, 2010-2014

4.2 Coastal salmon trap fishery at Sakhalin Island

Pacific salmon (*Oncorhynchus* spp.) is a highly valued fisheries resource of the Sakhalin region. All six species of Pacific salmon inhabit Sakhalin rivers and surrounding seas, but only two have commercial value, pink (*O. gorbuscha*) and chum (*O. keta*) salmon. The annual commercial catch varies greatly depending on the size of the annual salmon runs. During 2011-2015, the commercial catch fluctuated between 75,000 and 220,000 mt. See MRAG (2012) for a detailed description and analysis of the pink salmon fishery in northeastern Sakhalin Island.

The entire Sakhalin coast is a potential salmon fishing ground and it is divided into small sections that are assigned by the Sakhalin Government to local private fishing companies for a 20-year period (Fig. 2 below). The fishing area extends offshore for 2-3 km. There are two small fishing-free zones along the Sakhalin coast. One located in the middle of the east coast is Vostochny Nature Reserve and the second along the Terpeniya Peninsula is another State nature preserve (zapovednik) “Poronaysky”. Once salmon fishing rights for an area are assigned to a company, only that company has the right to fish salmon there, and it is responsible for all fishing operations. Several sections can be assigned to one fishing company.

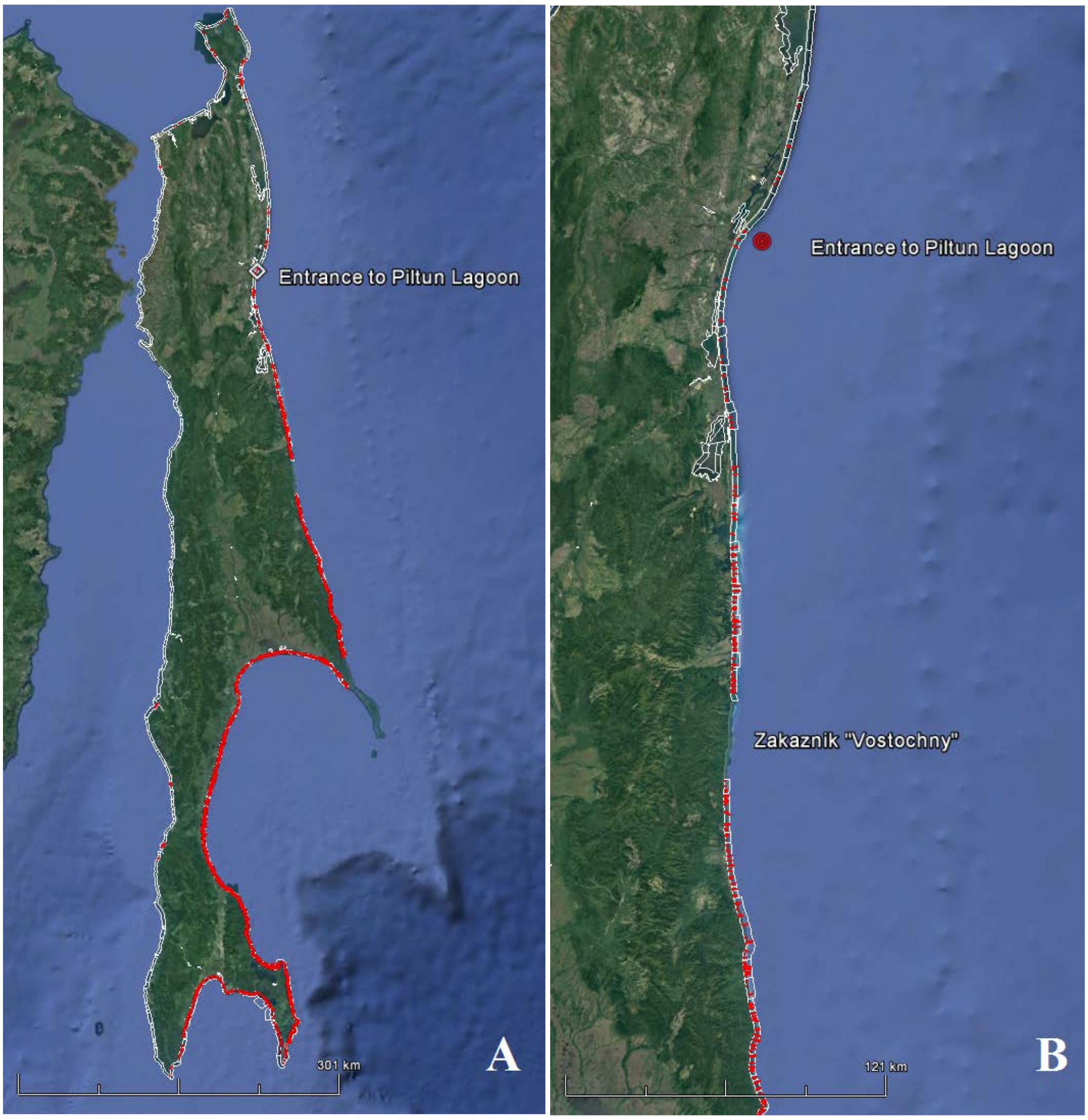

Figure 2. Locations of salmon coastal trap fisheries activity around Sakhalin Island, 2011-2015

Panel A shows all of Sakhalin, panel B shows more detail of the western gray whale summer feeding grounds. White lines along the coast are salmon fishing parcels allotted to private companies and local communities. Red lines show actual coastal salmon trap locations along the Sakhalin coast in 2001-2015. Salmon fishing-free zones on east coast are Zakaznik “Vostochny” and “Poronaysky” State nature preserve.

The coastal salmon trap is a large structure attached to the beach with up to 3 km of 10 m high meshed fence-line set perpendicular to the coast (Fig. 3 below). This fence guides salmon schools into one or more floating traps attached to it. Many ropes and cables are used to anchor the trap to the seafloor and those lines extend for up to several hundred meters from the trap.

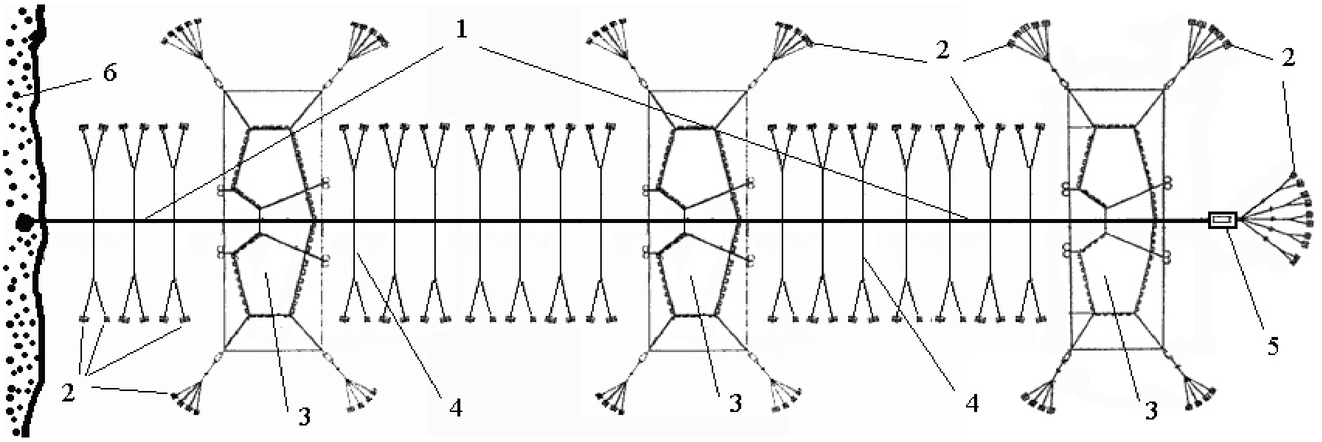

Figure 3. Figure showing the general layout of a coastal salmon trap like those used on Sakhalin Island

1 – main meshed line that serves as a 2-3 km long fence; 2 – anchors or sand bags; 3 – salmon traps; 4 – anchor ropes; 5 – central buoy; 6 – coastline.

The commercial salmon fishing season usually starts in early July and lasts about two months until early or mid-September. Exact dates vary slightly depending on the region and are established annually by special Act of the Sakhalin Government. This Act allows fishing companies to set up coastal salmon traps not more than 30 days before the fishing season starts. So the actual fishing activity period on the coast and in coastal waters may start in early June and last until mid- or late September. Installation of the trap is labour intensive, requiring 20-30+ people depending on how large a fishing company is and how many fishing parcels it has. Small wooden, plastic, or metal fishing boats with outboard gasoline or inboard diesel engines are used, and barges 6-20 m long serve as an auxiliary fleet to move gear from shore into the water and set it up. Catch is usually transferred to processing factories on shore, but during years with high salmon runs large processing vessels anchor near the salmon traps to process and freeze the catch that is brought to them on barges towed by tugs. After the salmon fishing season is closed, fishermen remove the traps. Some ropes or cables that break during the fishing season or in the trap removal process may be left at the trap location with buoys or a few floats attached until the next fishing season.

The Sakhalin Government permits companies to install 550-650 coastal salmon fishing traps annually, of which about 500 are along the east coast of the island and about 100 along the west coast (Fig. 2 above). The actual number of trap installations within permitted parcels is determined by the fishermen. Especially if the company owns several parcels, the number of traps on a parcel may be less than permitted so the total number of traps set annually is lower than the total permitted. In recent years, more than 400 traps have usually been set off Sakhalin. During 2011-2015, the majority of traps were located along the central and southeastern coasts (Fig. 2a above), and effort was much lower along the northeastern coast where the WGW summer feeding grounds are located (Fig. 2b above). Nevertheless, in 2015 several traps were set very near the entrance of Piltun Lagoon. They were installed in accordance with all salmon fishery regulations and permits.

SEW monitored the coastal salmon fishery on all of Sakhalin Island in 2011-2015 using high-resolution satellite imagery to verify compliance of the fishery with the regulations, such as distance between traps and from mouths of nearest rivers, length of the meshed fence-line attached to the shore, the fence-line configuration, etc. The SEW study also provided the information on actual salmon trap locations that is presented in Figure 2 (Dmitry Lisitsyn and Nikolay Vorobiev, pers. comm.). The study found that, in violation of fishery regulations, the main fence-lines of some traps extended up to 5.7 km offshore.

Besides the legally permitted salmon fishery, illegal fishing occurs inside Piltun Lagoon and in the narrow channel that connects the lagoon with the ocean. Poachers use set gillnets and seines.

In addition to the Sakhalin region, a very large-scale coastal salmon trap fishery operates along the southern half of the western coast of Kamchatka (FAO areas 6105.2 and 6105.4; Fig. 1 above) and also in Kronotsky and Kamchatsky gulfs in eastern Kamchatka (area 6102.2).

4.3 Gillnet fisheries

Two types of marine gillnet fisheries operated in the RFE in 2010-2014, the drift gillnet fishery for salmon and the bottom-set gillnet fishery that principally targets Pacific halibut, *Hippoglossus stenolepis* (Table 1 above).

During 2010-2014, the Russian salmon drift gillnet fishery operated over a vast area along the east and southwest coasts of Kamchatka and along the Kuril Islands (FAO areas 6102, 6103, 6104, and 6105; Fig. 4a below). Fishermen used synthetic monofilament nets 30-60 m long and 6-10 m deep with mesh 60-80 mm. As many as 100-150 nets were connected in one line and boats sometimes set several lines a day. Soak time varied between 6 to 15 hours. Total annual effort when catch was reported ranged from 2,213 vessel-days in 2013 to 2,797 in 2012 (Table 1 above). A total of 88 Russian vessels participated in the fishery with 46-59 vessels fishing annually (Table 2 below).

Fishing vessel activity	2010	2011	2012	2013	2014	5-year total
Total number of vessels	58	46	54	54	59	88
Days with catch, total	2,544	2,497	2,797	2,213	2,335	12,386
Days with catch, per vessel	44±4.4	54±4.3	52±4.4	41±3.5	40±2.3	141±14.2
Minimum days, per vessel	1	1	1	1	9	1
Maximum days, per vessel	107	123	122	112	82	469

Table 2. Commercial salmon drift gillnet effort in western gray whale habitats in in the Russian Far East, 2010-2014

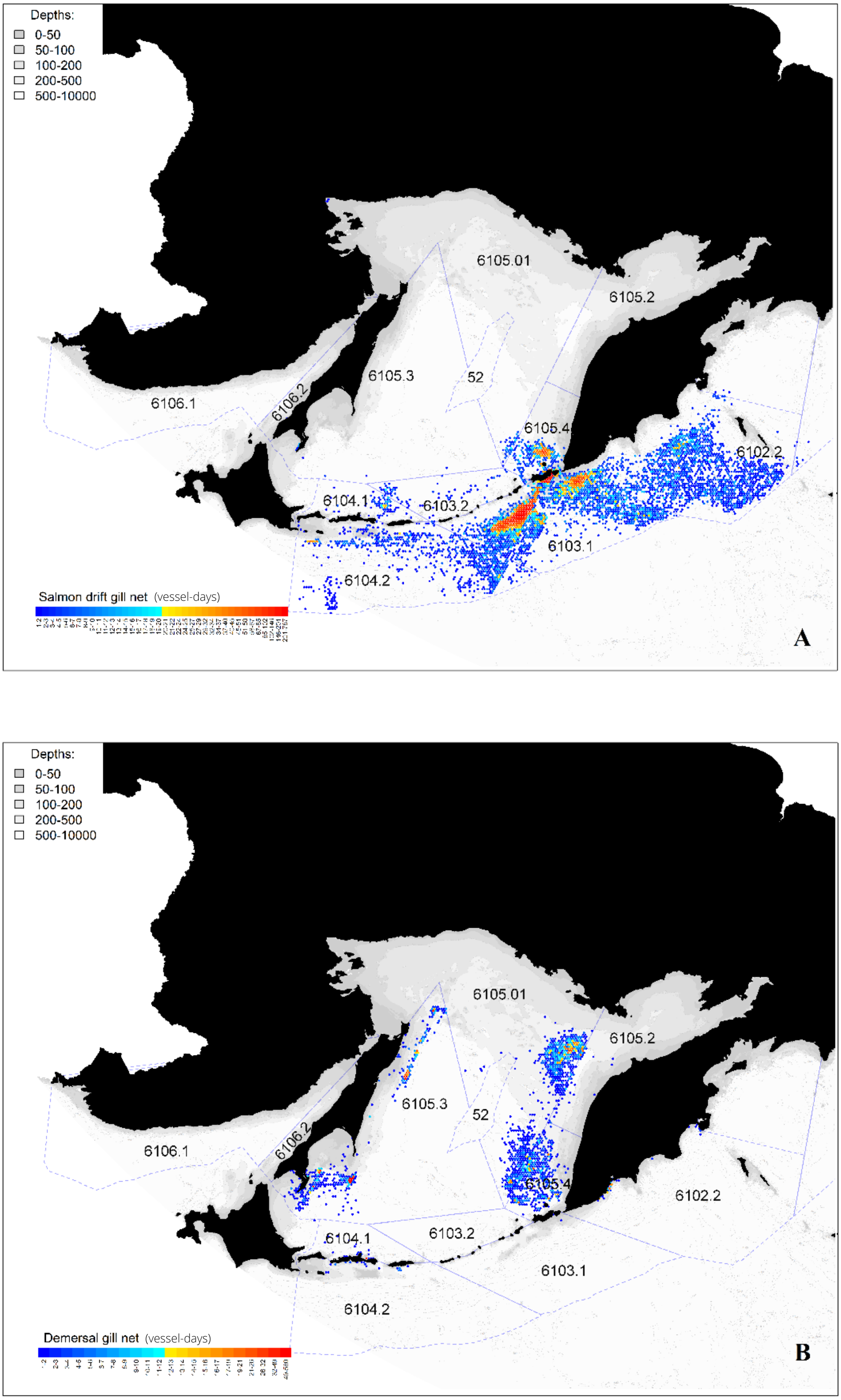

Figure 4. Locations of drift (A) and demersal (B) gillnet fisheries in the Russian Far East in 2010-2014 (vessel-days)

The average individual vessel fishing effort ranged from 40 days in 2014 to 54 in 2011 with a maximum of 123 days. The fishing season started in early or mid-May and continued until late August or early to mid-September (Figure 5 below). Fishing activity increased from May to July then dropped sharply in August. Essentially no fishing occurred during October-April. The commercial salmon driftnet fishery has been banned in Russia since 1 January 2016 (FZ, 2015).

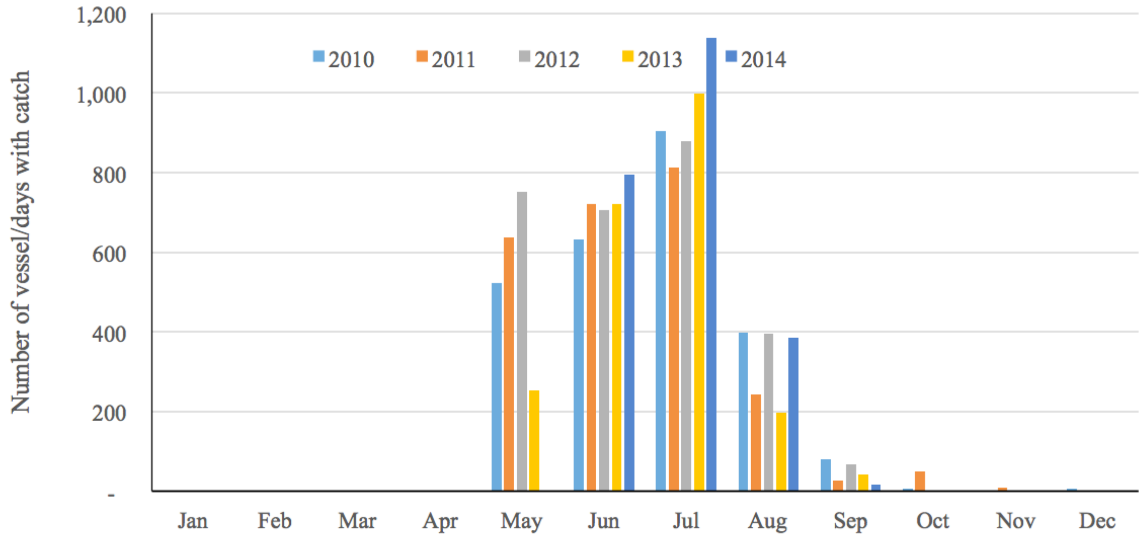

Figure 5. Seasonal changes in the salmon drift gillnet fishery in the Russian Far East, 2010-2014

The bottom-set gillnet fishery for demersal fishes operated mostly in the Okhotsk Sea off the western Kamchatka coast (FAO areas 6105.4 and 6105.1) and offshore from eastern Sakhalin Island (FAO area 6105.3; Fig. 4b above). Bottom-set nets are quite similar to driftnets but have heavier lead lines and are held on the bottom with anchors. One anchor has a buoy and line going to the surface. Bottom-set gillnets are used to catch halibut, Atka mackerel (*Pleurogrammus monopterygius*), and thornyheads (*Sebastolobus* spp.). Annual fishing effort in the entire RFE ranged between 916 and 1,112 vessel-days in 2010-2014 (Table 1 above). A total of 48 vessels were involved in the fishery, but the number fishing fluctuated between 15 and 28 annually. The median annual fishing effort of each vessel ranged between 12.5 and 29 vessel-days. Over 70% of fishing effort occurred in areas with depths of 500 m or more with those vessels targeting halibut and thornyheads. About 20% of the effort occurred on the shelf at 20-100 m depth and targeted Atka mackerel. There were distinct seasonal patterns in the bottom-set gillnet fishery (Fig. 6 below). Fishing effort steadily increased from January to June and decreased from July to December. In total 88% of the fishing effort occurred in April-December.

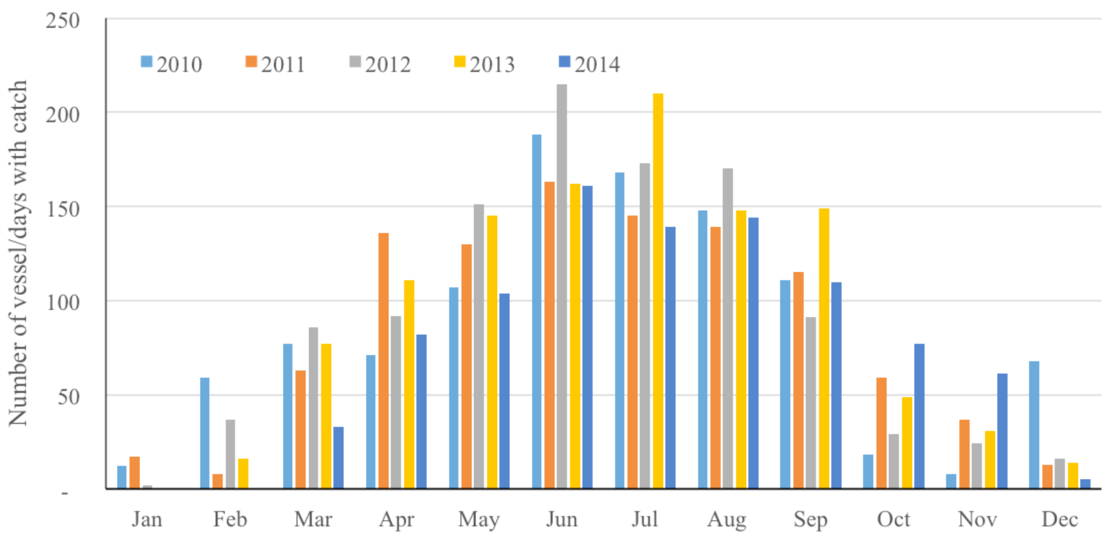

Figure 6. Seasonal changes in the demersal set gillnet fishery in the Russian Far East, 2010-2014

4.4 Longline fisheries

Two types of longline fisheries in the RFE are common in WGW habitat: these include the demersal groundfish longline fishery and the squid vertical longline fishery. The pelagic longline fishery was not included in this analysis because the RFE fishing grounds were restricted to a small area in the western Sea of Japan and fishing effort was small. The groundfish and squid fisheries are about equal in fishing effort. Annual fishing effort for both fisheries combined has been quite steady at 10,000-13,000 vessel-days (Table 3 below). A total of 345 vessels participated in the fishery during 2010-2014, with 163-242 vessels fishing annually. The median of single vessel annual effort ranged from 40 vessel-days in 2014 to 52 in 2010. The maximum annual single vessel fishing effort was the highest among all types of fisheries in the RFE; it ranged from 277 days in 2010 to 324 days in 2012. The vessels fished year-round for demersal fish species.

Fishing vessel activity	2010	2011	2012	2013	2014	5-year total
Total number of vessels	163	190	190	236	242	345
Vessel-days with catch, total	9,986	11,573	12,035	14,745	13,106	61,445
Vessel-days with catch per vessel, median	52.0	49.5	50.0	51.5	40.0	134.0
25th percentile	31.0	38.3	40.0	44.0	31.0	46.0
75th percentile	59.0	57.0	60.0	59.0	54.0	234.0
Minimum days, per vessel	1	1	1	1	5	1
Maximum days, per vessel	277	290	324	293	317	1359

Table 3. Commercial longline fishery effort in western gray whale habitats in in the Russian Far East, 2010-2014

Target species in the groundfish longline fishery are Pacific cod (*Gadus macrocephalus*), Pacific halibut, Greenland turbot (*Reinhardtius hippoglossoides)*, Kamchatka flounder (*Atheresthes evermanni*), thornyheads, *Macrourus* sp., rockfish (*Sebastes* spp.), Atka mackerel, and eelpouts (Zoarcidae). Many other demersal fish species such as sablefish (*Anoplopoma fimbria)*, batoids or rays, gobies (Gobiidae), flatfishes (Pleuronectidae), crabs, and cephalopods are caught as bycatch, but their volume is very small compared to that of the target species. Six different types of longline gear were used in the RFE in 2010-2014. In general, they use a synthetic main line 1-2 km long with shorter lines with hooks attached via swivels. One longline set has 1,000-2,000 hooks. Both ends of the set have lines that go from an anchor to a buoy at the surface. One boat usually sets 3 or more longlines. Soak time is 6-24 hours. Along the east coast of Kamchatka the fishery uses a large portion of the shelf (Fig. 7a below) at depths from 100-300 m. Of 2,856 DCRs for 2010-2014, over 92% were within this depth range, and 54% were within 100-200 m. Only 5% of the fishing effort was reported in depths of 20-100 m. Similar fishing effort was reported in the northern Kuril Islands area (FAO area 6103); there was a total of 2,670 DCRs in the 5-year period with 81% of the effort in the shelf break zone (100-300 m) and half of that effort in the 100-200 m zone. Only 4% of the effort occurred in 20-100 m and 15% was in areas deeper than 300 m. Most of the RFE groundfish longline effort in WGW habitat occurs in the Sea of Okhotsk along the western Kamchatka coast. In that region, there was a total of 20,887 DCRs in 2010-2014 of which half occurred in 2011. Only 28% of the fishing effort was in 100-300 m depths and only 5% of that was in 100-200 m and less than 1% was in less than 100 m. The majority of the effort was in waters over 300 m deep (71%). The highest fishing effort occurred in January and February (~800 vessel-days) and the lowest in September and October (~200 vessel-days) (Fig. 8 below).

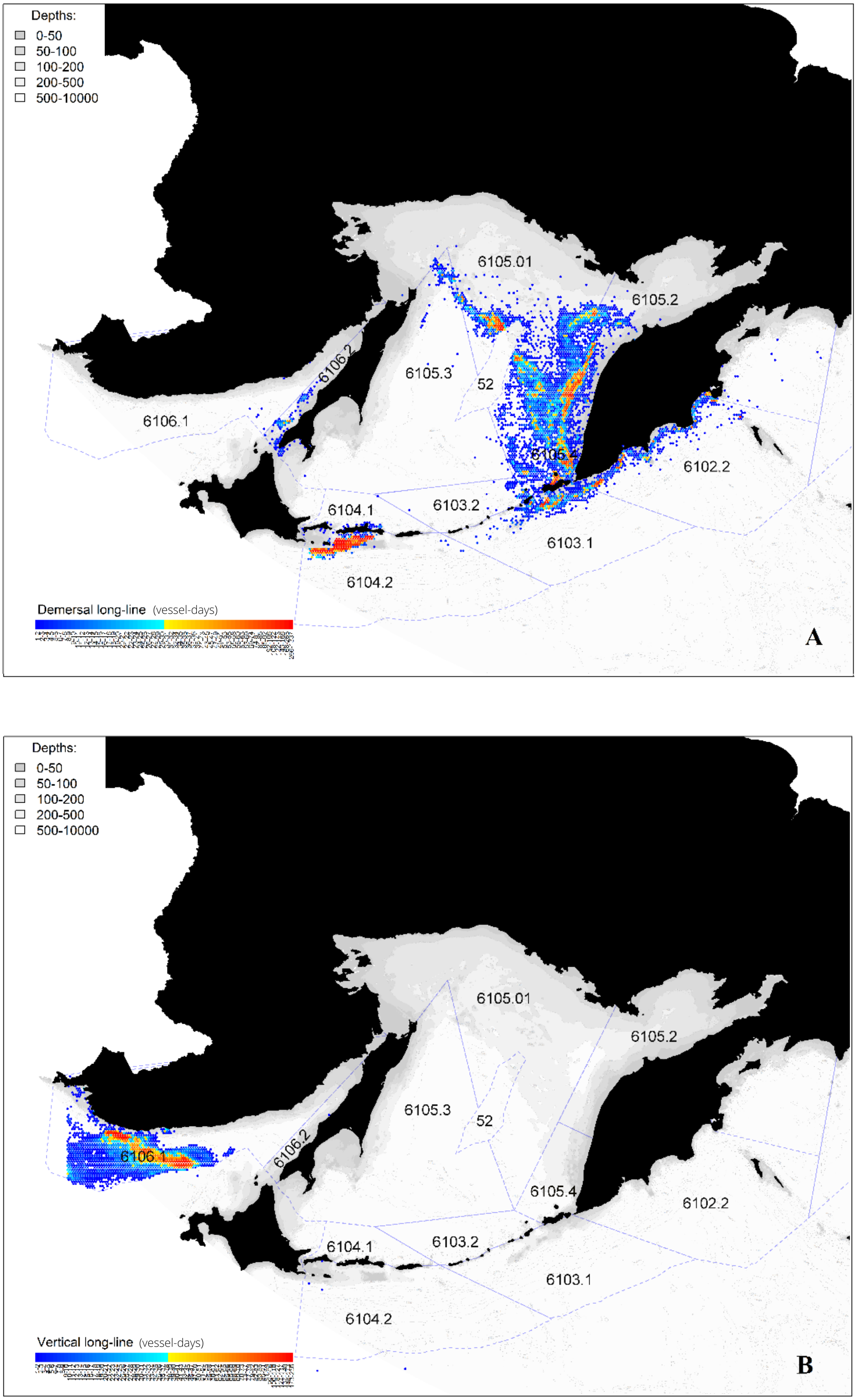

Figure 7. Locations of demersal (A) and vertical (B) longline fishing grounds in the Russian Far East, 2010-2014 (vessel-days)

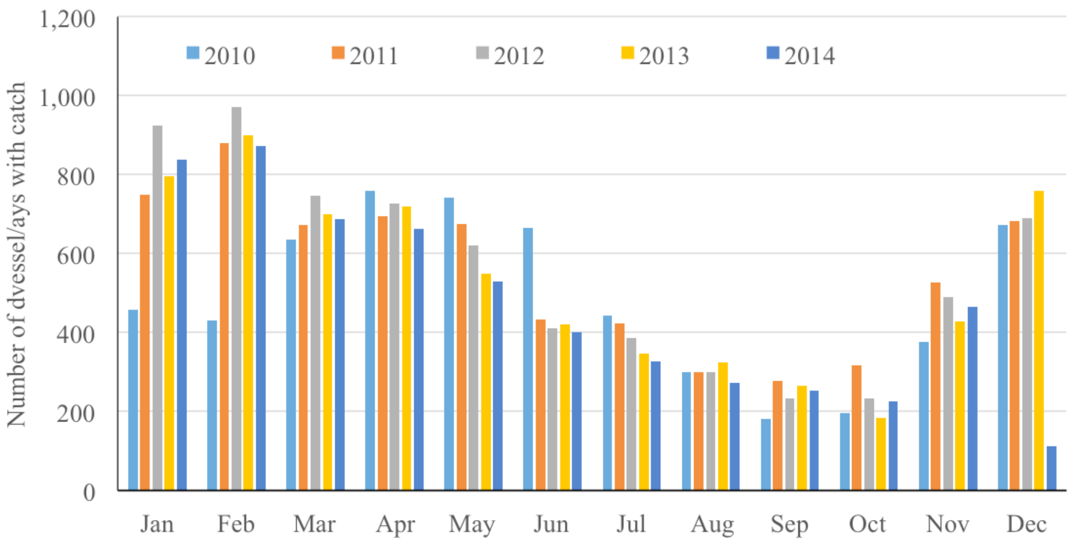

Figure 8. Seasonal changes in the demersal species longline fishery in the Russian Far East, 2010-2014 (vessel-days)

The vertical longline fishery targets Pacific flying squid (*Todarodes pacificus*), and to a much lesser extent other squids such as neon flying squid (*Ommastrephes bartramii*). Most of the fishing grounds are located in the Sea of Japan (FAO area 6106; Fig. 7b above). Operational depth is 10-100 m. This is a seasonal fishery that occurs in late summer and early fall (Fig. 9 below).

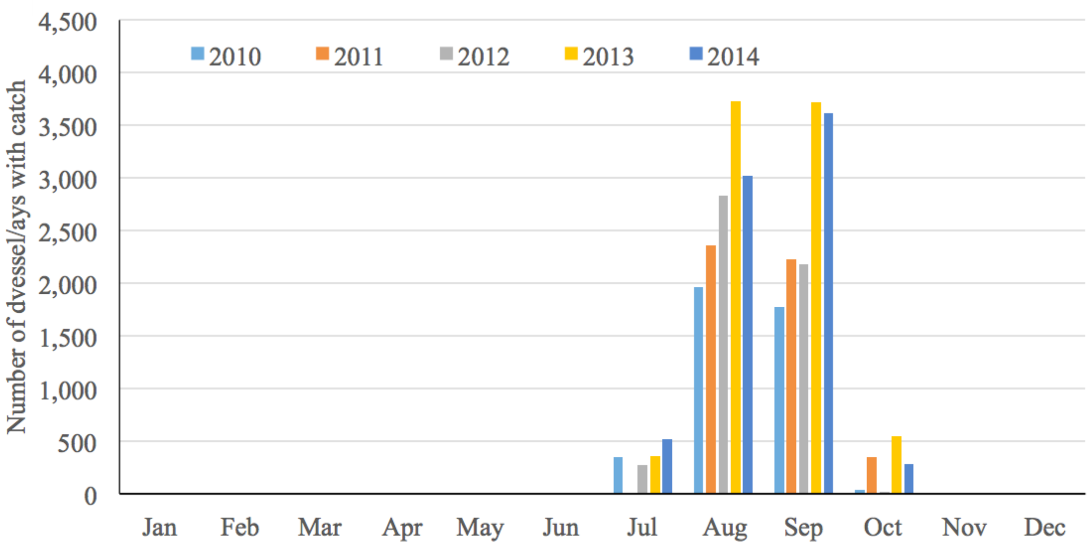

Figure 9. Seasonal changes in the squid vertical longline fishery in the Russian Far East, 2010-2014 (vessel-days)

4.5 Snurrewad fishery

The snurrewad fishery is one of the most common types of coastal groundfish fisheries in the RFE, especially in the Kamchatka (FAO areas 6102.2, 6105.2, and 6105.4), northern Kuril Islands (6103), and Primorie (6106.1) regions (Fig. 10 below). The snurrewad is a type of seine gear that is deployed while the boat moves in a circle. Deployment starts by putting a buoy with 500-800 m of cable attached in the water as the boat moves forward. After this cable is out the seine goes in the water and after the seine a second cable of the same length as the first. The boat continues making a circle to the buoy where the operation started. Then the boat pulls both cables and the cables slip along the bottom pushing fish to the middle of the circle and then into the seine.

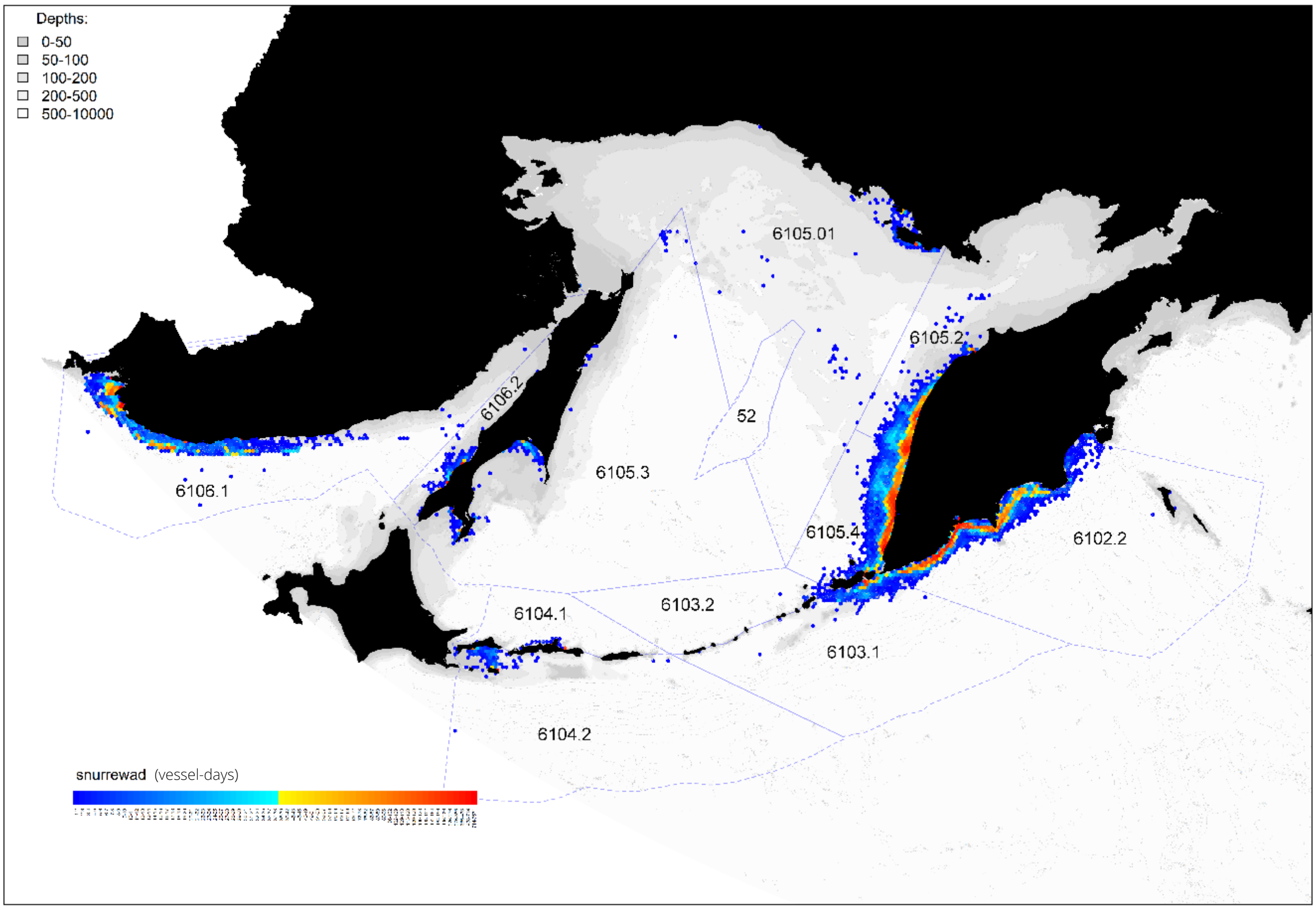

Figure 10. Locations of snurrewad fishing grounds in the Russian Far East, 2010-2014 (vessel-days)

The snurrewad fishery operates mostly on the shelf at 20-200 m depths where 84% of the effort occurs (Fig. 10). Target species are walleye pollock (*Gadus chalcogrammus*), Pacific cod, and flatfishes. A large variety of other demersal species such as sculpins (Cottidae), Pacific halibut, saffron cod (*Eleginus gracilis*), and herring (*Clupea harengus*) are caught as bycatch. The fishery operates year-round, but in summer months the effort is about 2-2.5 times higher than in late fall and winter (Fig. 11 below).

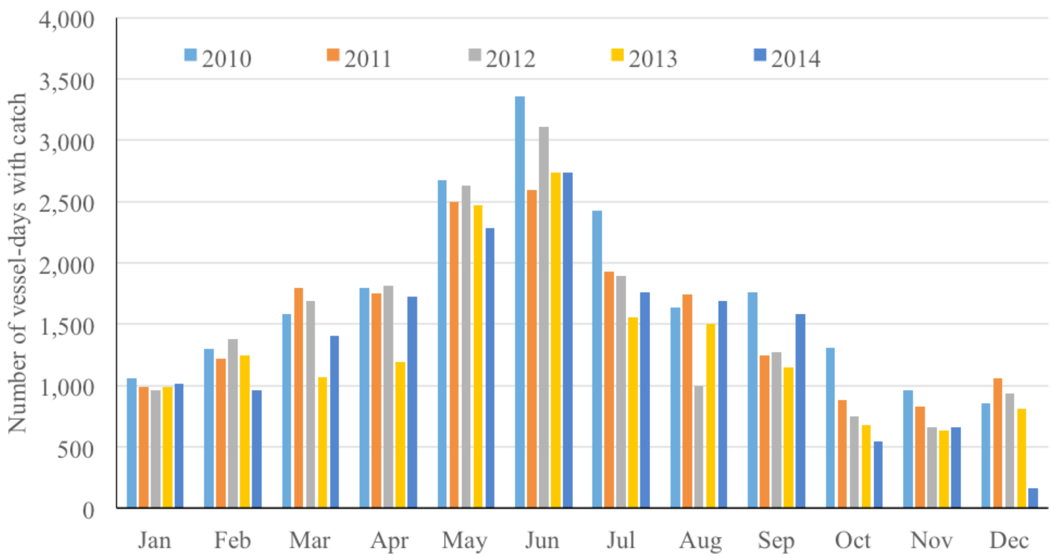

Figure 11. Seasonal changes in snurrewad fishery effort in the Russian Far East, 2010-2014 (vessel-days)

A total of 392 vessels from 20 to 50 m in length participated in the fishery in 2010-2014, with 260-316 vessels fishing per year (Table 4 below). Catch was reported on over 89,000 vessel-days and annual effort ranged from 16,477 and 20,656 vessel-days. On average one vessel reported 52-62 days with catch during a year with a maximum of up to 229 days.

Fishing vessel activity	2010	2011	2012	2013	2014	5-year total
Total number of vessels	316	308	288	261	260	392
Vessel-days with catch, total	20,656	18,484	18,034	15,984	16,477	89,635
Vessel-days with catch per vessel, median	55	53	52	54	62	185
25th percentile	*32.8*	*25.0*	*29.0*	*26.0*	*34.8*	*83.8*
75th percentile	*91.3*	*81.0*	*87.0*	*82.0*	*79.5*	*307.8*
Minimum days, per vessel	1	1	1	1	1	1
Maximum days, per vessel	226	225	229	220	178	971

Table 4. Commercial snurrewad fishery effort in western gray whale habitats in the Russian Far East, 2010-2014

4.6 Demersal trap and pot fisheries

A large-scale fishery using demersal traps and pots exists in the RFE (Table 5 below). These types of gear are deployed on the bottom by two methods. One method is to set several dozen traps or pots that are connected to one another with a line 1,000 m or more long that is anchored at each end. Each end of the set has a long rope connected to a surface buoy which fishermen use to retrieve the gear. The other method is to set single traps or large pots on the bottom, each of which has a long line that goes to a surface buoy. These types of gear are used to catch crabs, demersal fishes, octopus, shrimp, and whelk (Table 6 below).

Fishing vessel activity	2010	2011	2012	2013	2014	5-year total
Total number of vessels	145	140	148	141	120	216
Vessel-days with catch, total	14,197	15,528	14,638	13,754	11,978	70,095
Vessel-days with catch per vessel, median	97	110	88	93	95	231
25th percentile	*36.0*	*54.0*	*43.0*	*37.0*	*39.0*	*57.3*
75th percentile	*153.0*	*162.0*	*138.3*	*139.0*	*146.5*	*545.0*
Minimum days, per vessel	1	1	1	1	1	1
Maximum days, per vessel	324	318	323	318	323	1,447

Table 5. Commercial demersal trap and pot fishery effort in western gray whale habitats in the Russian Far East, 2010-2014

Type of demersal trap fishery	2010	2011	2012	2013	2014	5-year total	%
crab cone trap	10,840	12,657	11,828	11,095	9,615	56,035	79.9
crab trap large	712	725	658	763	722	3,580	5.1
demersal fish trap	5	62	152	2		221	0.3
octopus trap	583	433	554	317	332	2,219	3.2
shrimp trap	729	683	621	738	744	3,515	5.0
whelk trap	1,328	968	825	839	565	4,525	6.5
TOTAL	**14,197**	**15,528**	**14,638**	**13,754**	**11,978**	**70,095**	**100.0**

Table 6. Structure of demersal trap fishery effort in western gray whale habitats in the Russian Far East, 2010-2014 (vessel-days)

Over 85% of the fishing effort in the trap and pot fishery is for crabs. The major target species are Alaskan king crab (*Paralithodes camtschaticus*), spiny king crab (*Paralithodes brevipes*), golden king crab (*Lithodes aequispinus*), blue king crab (*Paralithodes platypus*), triangle tanner crab (*Chionoecetes angulatus*), tanner or bairdi crab (*Chionoecetes bairdi*), beni-zuwai crab (*Chionoecetes japonicus*), and snow or opilio crab (*Chionoecetes opilio*).

A total of 216 fishing boats were involved in the trap and pot fishery in 2010-2014 of which 120-148 boats fished annually. The vessels reported 70,095 total DCRs, with about 15,500-20,000 annually (Table 5 above). On average one boat reported 88 to 110 fishing days per year. The maximum annual single-boat effort was over 318 days.

Trap and pot fishing effort was spread widely in the Okhotsk Sea and Sea of Japan (Figs.12-14 below). Major fishing areas are located on the shelf along the western coast of Kamchatka (FAO areas 6105.2 and 6105.4), in the northern Okhotsk Sea (area 6105.1), along the shelf off the east coast of Sakhalin (area 6105.3), and along the Asian mainland shelf in the Sea of Japan (area 6106.1). The fishery uses the shelf (0-200 m) and shelf break (201-500 m), for 47% and 38% of total effort. The fishery operates year-round but is most active in May-June and September-November, when effort is 3-4 times higher than in the other months (Fig. 15 below).

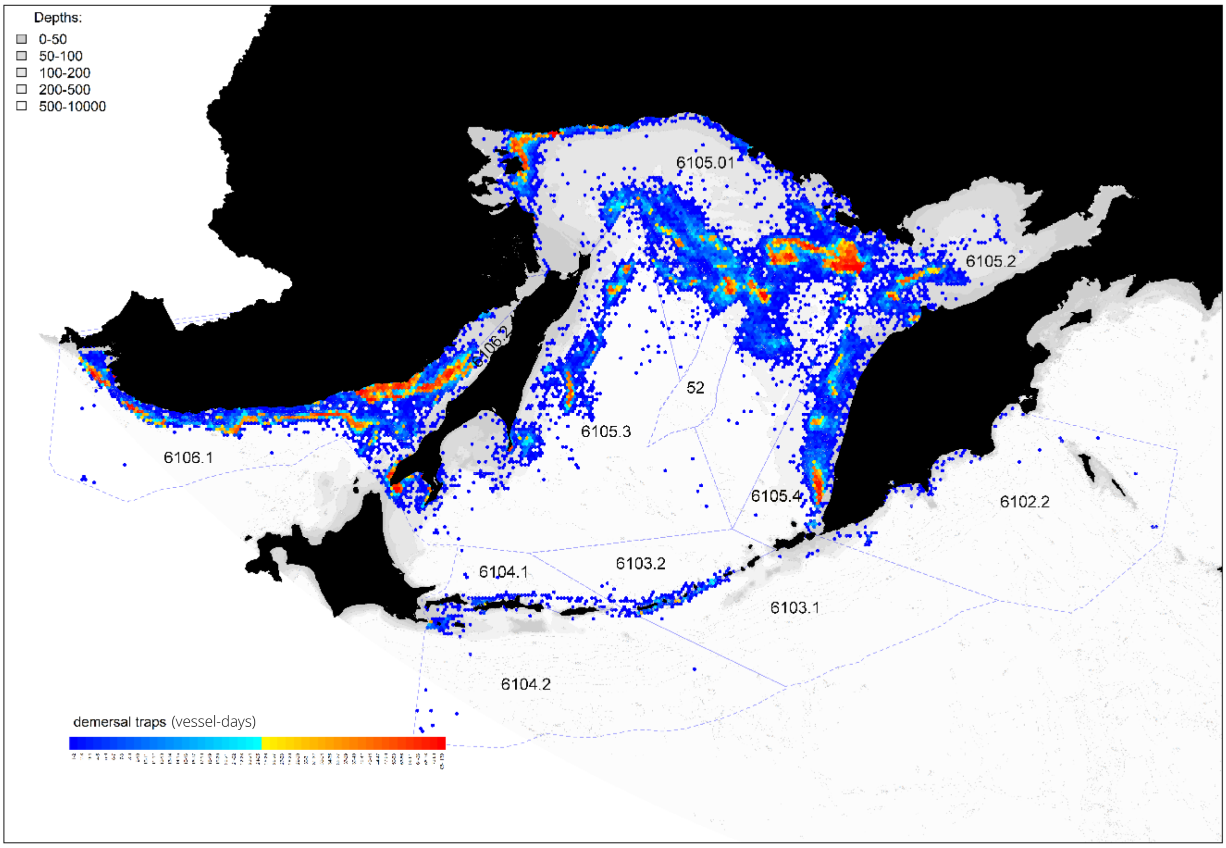

Figure 12. Locations of demersal trap fishing grounds (all fisheries) in the Russian Far East, 2010-2014. (vessel-days)

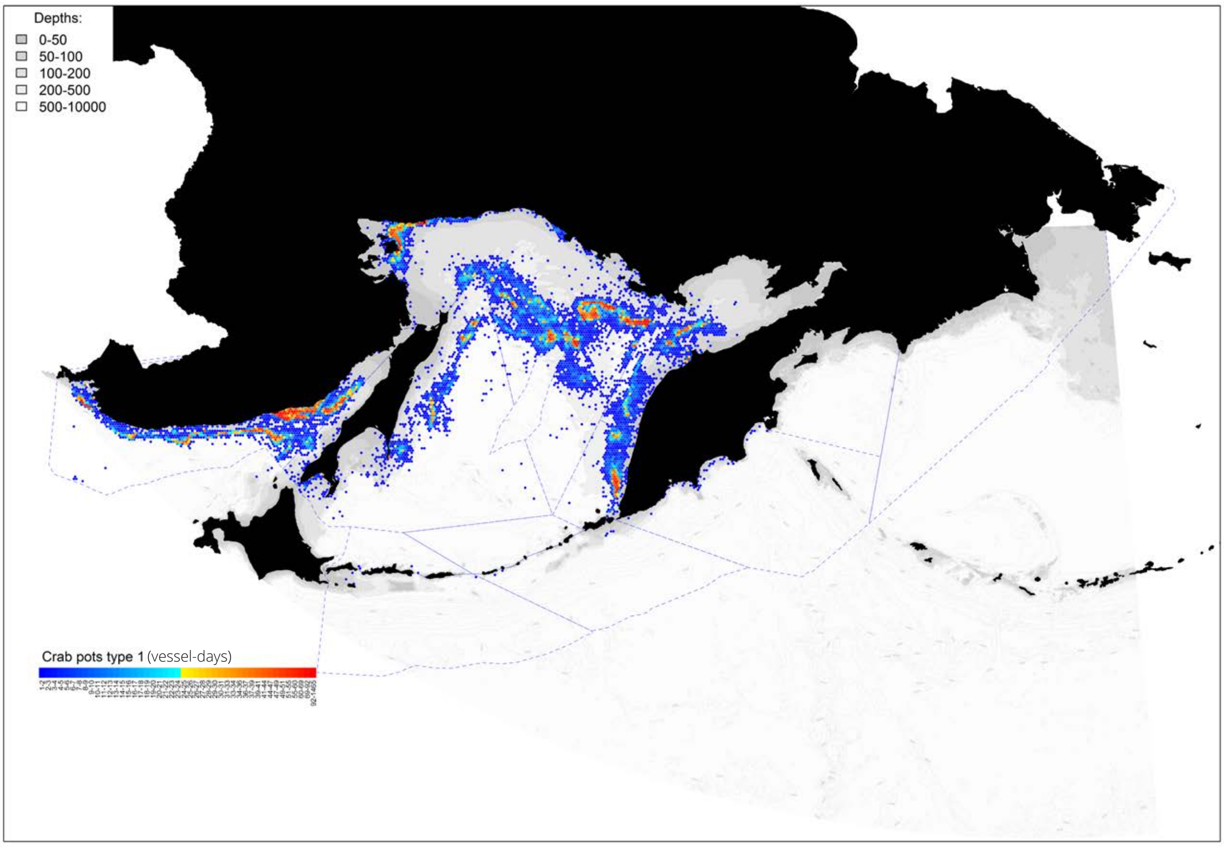

Figure 13. Locations of crab fisheries using standard cone-shape pots in the Russian Far East in 2010-2014 (vessel-days)

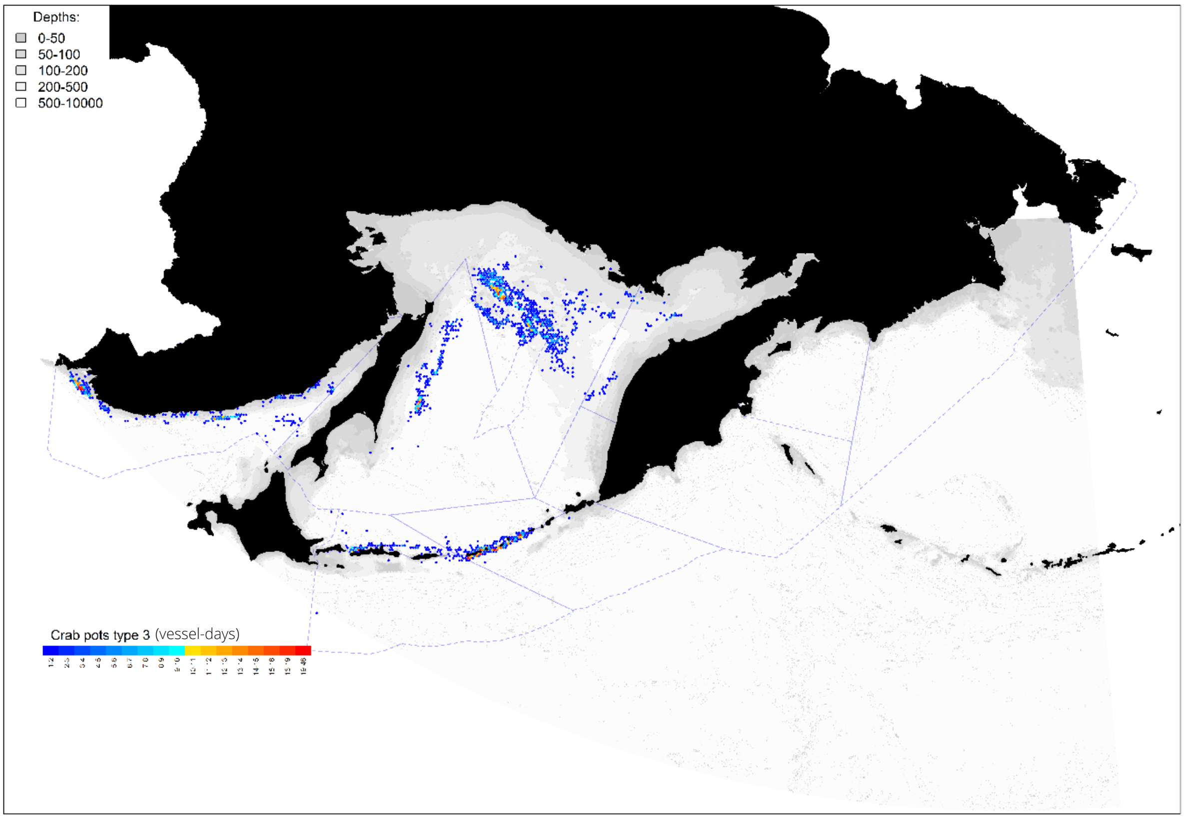

Figure 14. Locations of crab fisheries using large American-style rectangular traps in the Russian Far East in 2010-2014 (vessel-days)

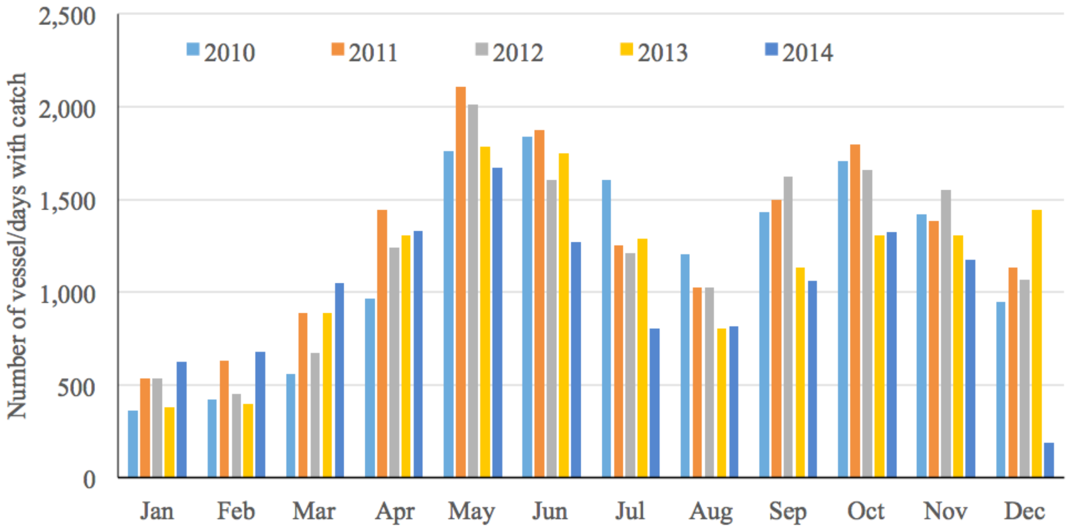

Figure 15. Seasonal changes in the demersal trap and pot fishery effort in the Russian Far East, 2010-2014 (vessel-days)

5 Likelihood of WGW entanglement or entrapment in RFE fisheries

Trap nets are known to entrap or entangle, and kill, WGWs off Japan (Weller *et al*. 2008) and recent observations show that WGWs also become entangled in coastal salmon trap gear in the RFE (Weller *et al*. 2014; WGWAP-17). Heyning and Lewis (1990) reported that most gray whale entanglements off California were attributable to inshore setnets and consisted predominantly of whales three years old or younger. Baird *et al*. (2002) found that gray whale entanglements off the coast of British Columbia, Canada, occurred in salmon drift gillnet, salmon seine, herring net pen, longline, and trap/pot fisheries. While some differences in gear design and deployment strategies exist between geographic regions, recent observations (see section 2.1 above) show clearly that WGWs become entrapped and entangled in fishing gear in the RFE.

While the information presented in this report shows that gray whales in the North Pacific commonly become entangled in fishing gear, and sometimes are seriously injured or killed as a result, it is not possible at this time to estimate how many of those animals are WGWs. Also, all of the figures presented above underestimate the problem because only some, possibly a small fraction, of whales that become entangled are seen by people, reported, and examined to determine species and cause of death. For example, Robbins and Mattila (2004) estimated that only 10% of entanglements of the humpback whales (*Megaptera novaeangliae*) that visit the Gulf of Maine are actually reported (judging by analysis of scars and wounds shown on photographs of the caudal peduncle).

Even without clear knowledge of when, where, and in what fishery whales are becoming entangled, it is possible to use Geographic Information System analysis to assess entanglement risk based on distributions of whales and potentially entangling gear. Saez *et al*. (2013) conducted such a study to investigate the risk of large whale entanglement in commercial fixed-gear fisheries along the coasts of California, Oregon, and Washington. Commercial fishery effort was modeled by combining port-based landings data with depth-defined potential fishing areas, and a model of seasonal gray whale density (DeAngelis *et al*. 2011 and in prep.). The predicted density of whales was overlaid with the estimated amount of fishing effort to identify locations and times when entanglement was predicted to be more likely. Gray whales were at risk of entanglement during their annual migration between December and June, and several areas and times of high co-occurrence were identified.

Results from the study indicated that the Dungeness crab fishery had the highest co-occurrence scores and thus was judged to be the highest-risk fishery for all whale species considered (gray whales, humpback whales, blue whales (*Balaenoptera musculus*), fin whales (*B. physalus)* and sperm whales (*Physeter macrocephalus*).

An analysis similar to that of Saez *et al*. (2013) would be useful to examine risk of WGWs becoming entangled in fishing gear in the RFE. Section 4 above summarizes much of the needed information on characteristics of RFE fisheries, focusing on the types of gear thought to represent the highest risk. However, as discussed in section 3 above, the information available on current WGW distribution and movements (including migration routes) is incomplete and not sufficient to model seasonal density patterns. The best that can be done at present is to conduct a general assessment of risk. We do so below, making three assumptions about WGWs: 1) they may occur at various times of year throughout the RFE region; 2) they are present at the feeding grounds off northeastern Sakhalin at least as early as mid-May, with abundance generally increasing from June to August, and they stay as late as mid-December in at least some years; and 3) at least some individuals migrate from Sakhalin to the west coast of North America and back. The details of that migration, as described by Mate *et al*. (2015) for three whales named “Flex”, “Agent” and “Varvara”, are as follows: Flex was tagged at Sakhalin on 4 October 2010, stayed near Sakhalin until 10 December, then swam eastward across the Okhotsk Sea and along the southwestern and southeastern coasts of Kamchatka. Flex then continued eastward across the Bering Sea, through the Aleutian Islands, and across the Gulf of Alaska to the U.S west coast where the last tag transmission was received on 5 February 2011 off Oregon. Agent was tagged at Sakhalin on 28 August 2011 and stayed near Sakhalin until 24 November. On leaving Sakhalin, Agent followed a course similar to that of Flex at least as far as the central Gulf of Alaska but had not reached the west coast of the U.S. when the last tag transmission was received on 31 December. Varvara was tagged at Sakhalin on 31 August 2011 and also stayed near Sakhalin until 24 November. On leaving Sakhalin, Varvara followed a course similar to those of Flex and Agent but after passing through the Aleutians, she closely followed the west coast of North America eastward and southward to the vicinity of the wintering lagoons in Baja California. Then, starting on 26 February 2012, Varvara moved back northward along the North American coast, turning at about 50° N latitude and swimming westward through the Gulf of Alaska and Aleutians to Kamchatka. She continued westward and was at Sakhalin Island on 14 May when tag transmissions stopped.

5.1 Coastal salmon trap fishery at Sakhalin Island

The coastal salmon trap fishery uses a net fence that extends from shore to 3 km or farther offshore. The fishery operates during summer, which is when more than 100 WGWs, including mother-calf pairs and newly weaned calves, are present and feeding in nearshore (and offshore) waters off northeastern Sakhalin. When these traps are set in areas used by WGWs, they will without question obstruct their movements and result in at least some entanglements or entrapments and injuries or deaths. Many WGWs co-occur with salmon traps in the vicinity of Piltun Lagoon for two months or more, and therefore this fishery poses a very high risk of injuring or killing them.

5.2 Gillnet fisheries

Nets are one of the two most common types of fishing gear that entangle gray whales.

Most of the effort in the commercial salmon driftnet fishery was in the Pacific Ocean far offshore, but there was also a great deal of activity around the northern Kuril Islands straits that some gray whales use during their seasonal migrations. Salmon drift gillnet fishing has recently been banned in Russia and therefore should no longer be an issue for WGWs in the RFE. However, several fishing boats were stopped and their captains arrested in summer 2016 along the Pacific coast of Kamchatka; they were fishing illegally for salmon with driftnets using permits issued for the scientific floating salmon trap fishery. Similar activity was observed along the Pacific side of the northern Kuril Islands in early July 2016 (V. N. Burkanov unpublished data). Although there is currently a ban on drift gillnets, fishermen are exploring ways to get around the ban, for example by anchoring the net in deep water and calling it a “set net”.

The bottom-set gillnet fishery overlaps with WGW distribution in space and time in waters around southern Kamchatka and the northern Kuril Islands. It is important to note that considerable fishing effort occurs close to the coast in southeastern Kamchatka where WGWs are known to be present at least seasonally. Fishing effort is highest in summer months when whales are relatively abundant off southeastern Kamchatka (Vertyankin *et al*. 2004) and continues in the late fall and winter when some WGWs have been tracked moving through this area on migration (Mate *et al*. 2015). Therefore, the bottom-set gillnet fishery poses a risk to WGWs.

5.3 Longline fisheries

Longline fishing gear has only infrequently been identified as entangling gray whales (Baird *et al*. 2002), but rope and line are commonly reported on entangled animals even though it may not be possible to determine the gear's origin.

The demersal longline fishery overlaps in space and time with WGW distribution along southeastern and eastern Kamchatka, around the northern Kuril Islands, and in a large shelf area in the Sea of Okhotsk. There are no known records of WGW interactions with long-line fisheries in the RFE (there have been no observer programs), but based on year-round fishing effort, areas where fishing occurs, and timing that overlaps with the WGW seasonal distribution, there is high likelihood that entanglements occur.

The vertical longline fishery for squid operates in the Sea of Japan during late summer and early fall. The fishery does not overlap with any currently known WGW feeding areas but in the past several decades gray whales have been occasionally reported in the Sea of Japan. WGWs are not likely to interact with this fishery.

5.4 Snurrewad fishery

The snurrewad fishery overlaps with known WGW seasonal distribution along the Kamchatka Peninsula and northern Kuril Islands. Effort in this fishery is the highest of all that are analyzed in this report. It is quite active along the southern Sakhalin coast and the Pacific side of the southern Kuril Islands, and in the Primorie region. Long and loose cables, especially when vessels deploy the gear, may entangle WGWs. There is an anecdotal report of a large dark whale (presumably a gray whale) entangled in snurrewad gear in the northern Kuril Islands in the late 1980s, and firm documentation[2] of a humpback whale entangled in a snurrewad seine near the Kamchatka Peninsula in 2015 (V. N. Burkanov unpublished data). It is likely that some WGWs are entangled in this fishery especially in southern Kamchatka and the Kuril Islands.

5.5 Demersal trap and pot fisheries

Trap/pot gear is one of the two most common types of fishing gear that entangle gray whales, presumably because of the long, loose buoy lines, and lines connecting pots set in strings.

Trap and pot fishing effort is spread widely on the shelf and shelf break of the Okhotsk Sea and Sea of Japan. WGWs are likely to encounter trap and pot gear throughout their distribution in the RFE. Much of the fishing effort occurs in April-October when gray whales are most abundant in the RFE, but the fishery operates year-round with substantial effort in November-December when WGWs are known to be migrating. Demersal pot and trap fisheries pose a high risk of entangling WGWs.

2 Video available at https://www.youtube.com/watch?v=0SP5z1oIsbM

6 Conclusions and recommendations

As a general point, it is clear that for WGWs to recover throughout their historical range, accidental mortality and serious injury in fishing gear must be minimized to the fullest extent possible. Authorities, as well as fishermen and fishing companies, in all of the range states need to be made aware of and acknowledge the risks that fisheries represent to these animals. We are encouraged that the IWC's Memorandum of Cooperation Concerning Conservation Measures for the Western Gray Whale Population has now been signed by Japan, the United States, Mexico, the Republic of Korea, and the Russian Federation, and that a stakeholder workshop to update and complete the Conservation Management Plan for WGWs (see Brownell *et al*. 2010) is being planned by the IWC and IUCN for late 2017 or early 2018 (WGWAP-17 report). This may provide a framework in which diverse groups and individuals can make progress on reducing the risk that fisheries bycatch poses to WGWs.

With regard to the coastal salmon trap fishery we believe that information currently available is sufficient to show that entanglement risk in the nearshore feeding area near Piltun is very high. This is especially of concern because this is an important feeding area for adult females and calves, at a critical time when the females are recovering condition following pregnancy and lactation and the calves are being weaned. While there are several options for reducing this risk (see Lowry 2016), the only way to eliminate it entirely is to stop the setting of salmon traps in or near the areas being used by the whales.

Assessing the risk to WGWs from open-ocean fisheries is much more difficult. A major problem with identifying the co-occurrence of WGWs and those fisheries is a lack of comprehensive understanding of the seasonal distribution and movements of the whales. Mate *et al*. (2015) have demonstrated that satellite-linked tags can provide such information, and recommendations for additional tagging efforts have been made in the draft WGW Conservation Plan (Brownell *et al*. 2010) and by the IWC (IWC 2015a). We believe that collecting additional satellite-tag data from WGWs is the most important next step in refining the assessment of SI/M risk caused by fisheries. Additional research approaches must also be continued, including field surveys (from ships, manned aircraft, drones, and shore), photo-identification, passive acoustics, etc.

In this paper, we have begun to identify and characterize specific fisheries within the RFE most likely to entangle or entrap gray whales (see Table 7 below). Similar work must be done throughout the WGW range. When this information has been collected it should be combined in a Geographic Information System with WGW distribution and movement data, to identify problem "hotspots" of risk (e.g., fishery types, regions, and seasons). The final step must be to identify, evaluate, and implement specific strategies to eliminate or at least mitigate the entanglement risks – something that might best be undertaken regionally, or fishery by fishery.

Fishery	Northeast Sakhalin Island	Okhotsk Sea offshore waters	Southwest Kamchatka	Kuril Islands	Southeast Kamchatka	Action(s) needed
Coastal salmon trap	Very high	None	Some	None	Some	Remove traps from northeastern Sakhalin Monitor bycatch in other areas
Salmon driftnet	None	None	None	None	None	Maintain driftnet prohibition Prevent illegal driftnet fishing
Bottom-set gillnet	Low	Some	Some	Low	Low	Monitor bycatch
Demersal longline	None	High	High	High	High	Monitor bycatch
Squid longline	None	None	None	None	None	None
Snurrewad	Low	None	High	High	High	Monitor bycatch
Trap and pot	Low	High	High	Low	Low	Monitor bycatch

Table 7. Summary of the risk of entanglement or entrapment for western gray whales in Russian Far East fisheries

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Entanglement Risk to Western Gray Whales
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Photo: Western gray whale in Sakhalin © David Weller