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ECHO Program

2020 voluntary inshore lateral displacement in the Strait of Juan de Fuca

Vancouver Fraser Port Authority

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Transport Canada reached out to several Indigenous communities before implementation of the initiative and shared valuable input received from them. The Pacheedaht First Nation also provided valuable input directly to the ECHO Program before, during and after the initiative and the ECHO Program would like to thank Pacheedaht First Nation for making their feedback available for this report.

Executive summary

This report summarizes the development, implementation and results of the 2020 voluntary inshore lateral displacement in the Strait of Juan de Fuca and has been prepared by the Vancouver Fraser Port Authority-led Enhancing Cetacean Habitat and Observation (ECHO) Program. The lateral displacement initiative was coordinated and implemented by the ECHO Program, with support from Transport Canada, Canadian and U.S. Coast Guards, and the Canadian and U.S. marine transportation industries. The ECHO Program's advisory working group and vessel operators committee members provided valuable input and advice throughout the development, implementation and evaluation of the initiative. Fisheries and Oceans Canada evaluated acoustic data and provided results of their analysis to the ECHO Program. The Canadian Coast Guard evaluated tug traffic data and provided results of their participation analysis to the ECHO Program. Transport Canada gathered additional valuable input from the Pacheedaht First Nation before, during and after the initiative.

Context for and purpose of the voluntary inshore lateral displacement

The southern resident killer whale population has wavered over the last several years, with a current population of 74 individuals, as of December 31, 2020 (Center for Whale Research). Research indicates that underwater vessel noise can interfere with the southern resident killer whale's ability to navigate, communicate and find their prey. Historical data indicates that southern resident killer whales are most frequently detected in Salish Sea waters, including the Strait of Juan de Fuca, between June and October.

Building on the lessons and success of the 2018 and 2019 voluntary lateral displacement trials, and in an effort to support ongoing recovery measures for the southern resident killer whales, the ECHO Program engaged the tug sector and other partners to implement another voluntary inshore lateral displacement initiative in 2020. The purpose of the initiative was to reduce underwater vessel noise impacts by laterally displacing tugs away from an enhanced management area defined by the Government of Canada as important feeding habitat for the southern resident killer whales.

Operations and monitoring

To evaluate the effectiveness of the inshore lateral displacement, underwater noise and tug traffic movements were measured and analyzed before and during the initiative to determine participation as well as the level of underwater noise reduction that could be achieved by moving vessels further away from the southern resident killer whale enhanced management area.

Between June 1 and October 31, 2020, when safe and operationally feasible to do so, all tugs transiting in the Canadian inshore area of the Strait of Juan de Fuca were requested to move south of the known killer whale feeding area and navigate through the inshore lateral displacement zone while maintaining a buffer distance of 1,000 metres from the traffic separation scheme. The inshore lateral displacement zone was 1,500 metres wide and covered a distance of approximately 28 nautical miles (approximately 52 kilometres). Tugs transiting in the outbound lane of the traffic separation scheme were also considered to be participating.

Results

The voluntary inshore lateral displacement saw significant participation rates with 138 of 168 (82%) of tugs able to spend over half of their transit in the lateral displacement zone or outbound shipping lane. Of all the tugs that transited the area during the study period, 46% transited in the outbound shipping lane, 36% transited in the inshore lateral displacement zone, with only 8% using the buffer zone and 10% using the enhanced management area for more than half their transit. The primary reason that tugs did not participate was due to a lack of awareness of the initiative. Compared to 2017 baseline tug traffic conditions, tugs shifted an average of 0.66 nautical miles (1,222 metres) away from the enhanced management area in 2020.

Underwater noise was monitored in the southern resident killer whale enhanced management area before and during the initiative using three hydrophones installed and operated by Fisheries and Oceans Canada. One of these hydrophones, installed close to Jordan River, was used to evaluate reductions in total ambient underwater noise as a result of the lateral displacement.

The hydrophone near Jordan River yielded a median reduction in broadband sound level of approximately 1.4 decibels (dB), compared to the pre-lateral displacement period. Underwater noise reductions achieved were greatest in the higher frequencies, with a 3.3 dB noise reduction measured in the SRKW echolocation band (greater than 15 KHz). Detailed analysis of a specific tug transit indicated that a shift of approximately 1,000 metres away from the hydrophone reduced the median received broadband sound level by 5.3 dB. This represents a reduction in sound intensity of approximately 70%.

Although the number of tug transits in the Strait of Juan de Fuca is relatively low compared to other large commercial vessels, results indicate that even a modest shift of tugs away from the southern resident killer whale enhanced management area is an effective way of significantly reducing underwater noise in that area, especially at the higher-frequency bands important for foraging.

According to cetacean sightings data provided by the B.C. Cetacean Sightings Network, there were 241 reported sightings of 1251 marine mammals in the Strait of Juan de Fuca during the lateral displacement period. Of the total marine mammals sighted, 436 (35%) were killer whales, with 78 specifically confirmed to be southern resident killer whales.

In an effort to better understand the presence and behavior of whale species in both Swiftsure Bank and the Strait of Juan de Fuca, the ECHO Program supported Pacheedaht First Nation to undertake marine mammal observations in both regions between August and November 2020. During the 26 field excursions, 128 sightings of 303 animals were recorded in the Strait of Juan de Fuca and Swiftsure Bank, 17 of which were killer whales.

Overall, the voluntary lateral displacement initiative was successfully managed by the ECHO Program and partners with no dangerous occurrences or incidents recorded during the study period. There were no safety or operational concerns recorded with the vessels navigating in the inshore zone during the lateral displacement period.

Any future lateral displacement initiatives in the Strait of Juan de Fuca will build on the lessons learned from 2018, 2019 and 2020.

1. Background

This report summarizes the development, implementation and results of the 2020 voluntary inshore lateral displacement in the Strait of Juan de Fuca. The initiative was coordinated and implemented by the Enhancing Cetacean Habitat and Observation (ECHO) Program, with support from Transport Canada, Canadian and U.S. Coast Guards, Fisheries and Oceans Canada, and the Canadian and U.S. marine transportation industries. The ECHO Program's advisory working group and vessel operators committee members provided valuable input and advice throughout the development, implementation and evaluation of the initiative. Pacheedaht First Nation provided valuable input to the initiative before, during and after the study period.

The purpose of the initiative was to reduce underwater vessel noise impacts by laterally displacing tugs away from known southern resident killer whale (SRKW) feeding areas. Data collection and analysis was undertaken to help measure both the level of underwater noise reduction achieved by moving tugs further away from SRKW feeding areas, as well as the level of voluntary vessel participation achieved.

The lateral displacement took place in the Strait of Juan de Fuca between June 1 and October 31, 2020, and involved the movement of tugs transiting Canadian waters into either an inshore lateral displacement zone or the outbound lane of the traffic separation scheme (Figure 1). The term tugs refers to vessels that are engaged in towing other vessels or objects, or assisting in the maneuvering of ocean-going vessels.

1.1. The ECHO Program

The ECHO Program is a Vancouver Fraser Port Authority-led initiative aimed at better understanding and managing the effects of large commercial vessel-related activities on at-risk whales throughout the southern coast of British Columbia (B.C.).

The geographic scope of the Vancouver Fraser Port Authority's jurisdiction is limited, and so, in order to adequately understand and address the cumulative effects of commercial ship activity on whales regionally, a collaborative approach is required. To this end, since 2014 the port authority has been collaborating with an advisory working group and technical committees made up of Canadian and U.S government agencies, marine transportation industries, Indigenous communities, conservation and environmental groups, and scientists to advance ECHO Program projects within the Salish Sea, including the Strait of Juan de Fuca. The long-term goal of the program is to quantifiably reduce threats to at-risk whales as a result of large commercial vessel-related activities.

1.2. Context for the voluntary inshore lateral displacement

A number of at-risk species of cetaceans (whales, dolphins and porpoises) inhabit the Pacific waters of southern B.C. and northern Washington State. Key among these species is the endangered SRKW, with a population of only 74 individuals (Center for Whale Research, December 31, 2020). The main threats to SRKW and other at-risk whales in this region include acoustic disturbance (underwater noise), physical disturbance (presence and proximity of vessels), environmental contaminants and availability of prey. Acoustic disturbance related to shipping traffic is a priority focus area for the ECHO Program.

In 2017, the Canadian Science Advisory Secretariat published a science advisory report which identified notable SRKW foraging areas of high use along the northern side of the Strait of Juan de Fuca (Ford et al., 2017). Additionally, in early 2018, the minister of fisheries, oceans, and the Canadian Coast Guard and the minister of environment and climate change noted that the SRKW population is facing imminent threats to its survival and recovery.

To address these concerns, in 2018 and 2019 the ECHO Program and Transport Canada coordinated voluntary initiatives—supported by the Canadian and U.S. Coast Guards, Fisheries and Oceans Canada, and the Canadian and U.S. marine transportation industries—to study how moving deep-sea ships and inshore tug traffic further away from known whale feeding areas in the Strait of Juan de Fuca would affect the underwater noise levels in those areas.

Under normal conditions, inshore tug traffic often transits through the SRKW feeding area (shown in Figure 1 as the 'Enhanced Management Area'). In the 2018 and 2019 initiatives, tugs were asked to voluntarily shift their transit southward towards, or into, the outbound shipping lane as appropriate. In both years, a high level of participation was achieved by tugs in the lateral displacement initiative, and a notable reduction in underwater noise was measured at the hydrophone monitoring location near Jordan River.

Building on the findings and success of the 2018 and 2019 voluntary lateral displacement initiatives, and in an effort to support ongoing whale recovery measures for the southern resident killer whales, the ECHO Program again engaged the tug sector and other partners to implement another voluntary lateral displacement in 2020.

1.3. Development of the parameters

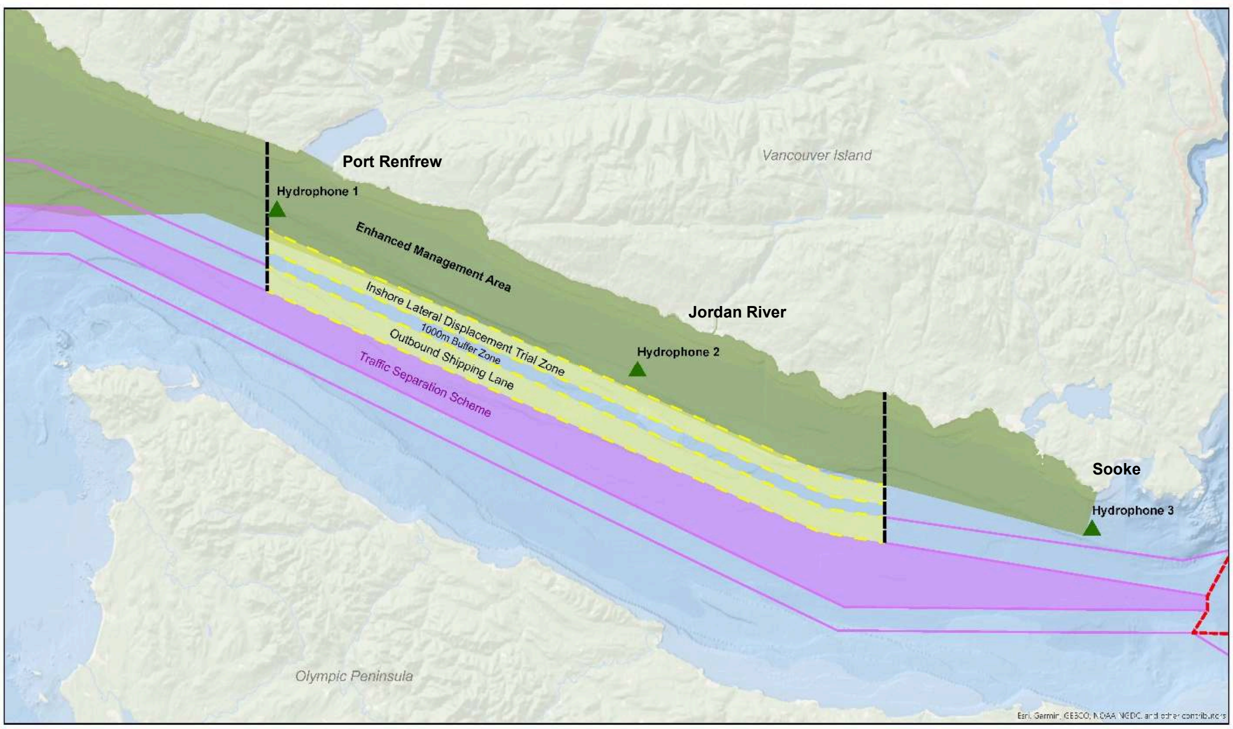
1.3.1. Inshore lateral displacement area

In the lateral displacement area, vessel traffic is cooperatively managed by both Canada and the United States. The Cooperative Vessel Traffic Services Agreement (CVTSA) has been in place since 1979 and establishes the structure for the management of vessel traffic in the region. Under this agreement, vessel traffic services in the Strait of Juan de Fuca are provided by the United States Coast Guard in both Canadian and American waters. A joint coordinating group (JCG) consisting of the Canadian Coast Guard and the United States Coast Guard, and which Transport Canada attends, works to ensure safe and efficient trans-boundary operations. The inshore lateral displacement zone was defined with the support of the JCG.

The majority of the inshore lateral displacement zone is located within the traditional marine territory of the Pacheedaht First Nation.

Unchanged from 2019, the 2020 inshore lateral displacement zone was designed to move tug traffic away from the enhanced management area defined by the Government of Canada as important feeding habitat for the SRKW, while keeping a safe distance from deep-sea vessels transiting in the outbound lane of the traffic separation scheme (Figure 1). The inshore lateral displacement zone was 1,500 metres wide and occurred in the area between 123° 52′ W and 124° 31′ W, covering a distance of approximately 28 nautical miles. As requested by the JCG, the inshore lateral displacement zone was positioned 1,000 metres north of the traffic separation scheme in order to provide a safety buffer.

Figure 1: 2020 voluntary inshore lateral displacement area



Source: Vancouver Fraser Port Authority

1.3.2. Participation instructions

In the area between 123° 52′ W and 124° 31′ W all tugs transiting the inshore area were requested to move southwards and transit within the designated inshore lateral displacement zone while maintaining a 1,000 metre distance from the outbound shipping lane (buffer zone identified in Figure 1).

Under normal conditions, some tugs transit the Strait of Juan de Fuca in the outbound lane of the traffic separation scheme. As these tugs are already transiting further away from the enhanced management area, these tugs were not requested to change their transit pattern, and were deemed to be participating if they were transiting in the outbound lane.

1.3.3. Duration

Historical data from Fisheries and Oceans Canada, Ocean Wise's B.C. Cetacean Sightings Network and Orca Network indicates that southern resident killer whales are most frequently detected in Salish Sea waters—including the Strait of Juan de Fuca—between June and October. The initiative began on June 1, 2020 and ended 22 weeks later on October 31, 2020.

2. Implementation

The implementation of the voluntary inshore lateral displacement initiative required the preparation of materials, communication and engagement with stakeholders, and the technical aspects of evaluating the success of the lateral displacement initiative through tug participation and underwater noise monitoring. The following section provides further details on the implementation of the 2020 voluntary inshore lateral displacement.

2.1. Engagement and communications

The ECHO Program worked closely with Transport Canada, the Canadian and U.S. Coast Guards, Fisheries and Oceans Canada, and the Canadian and U.S. marine transportation industries—in particular the Council of Marine Carriers and the American Waterways Operators—to coordinate the implementation of the voluntary inshore lateral displacement in the Strait of Juan de Fuca.

The ECHO Program team received valuable input, advice and support from the ECHO Program advisory working group which convened three times in 2020 throughout the development, implementation and evaluation phases of the inshore lateral displacement. The Fraser Basin Council provided independent facilitation services for all ECHO Program advisor meetings associated with the development, implementation and evaluation. The advisory working group membership includes:

- BC Coast Pilots
- BC Ferries
- Canadian Coast Guard
- Chamber of Shipping
- Council of Marine Carriers
- Cruise Lines International Association – North West & Canada
- Department of National Defence and the Canadian Armed Forces
- Fisheries and Oceans Canada
- Indigenous individuals
- National Oceanic and Atmospheric Administration (NOAA)
- Natural Resources Defense Council
- Ocean Wise
- Pacific Pilotage Authority
- Shipping Federation of Canada
- Transport Canada
- Vancouver Fraser Port Authority
- Washington State Ferries
- WWF-Canada

The ECHO Program team also received valuable input, advice and support from the vessel operators committee which convened approximately monthly throughout the year to support the development of parameters and the practical implementation and monitoring of vessel participation for various ECHO Program operational noise reduction initiatives, including the lateral displacement. The vessel operators committee includes members from the following organizations:

- BC Coast Pilots
- BC Ferries
- Canadian Coast Guard
- Chamber of Shipping
- Council of Marine Carriers
- Cruise Lines International Association – North West and Canada
- Hapag-Lloyd
- Holland America Group
- International Ship-Owners Alliance of Canada (ISAC)
- Marine Exchange of Puget Sound
- Pacific Merchant Shipping Association
- Pacific Northwest Ship & Cargo Services
- Pacific Pilotage Authority
- Royal Canadian Navy
- Shipping Federation of Canada
- Transport Canada
- U.S. Coast Guard
- Vancouver Fraser Port Authority
- Washington State Ferries

2.1.1. Tug operators engagement

A communications plan was developed by the ECHO Program, in collaboration with members of the ECHO Program vessel operator committee, to ensure that tug operators transiting the area would be aware of the 2020 voluntary inshore lateral displacement and its operational parameters.

Communication materials included fact sheets, maps, newsletters, presentations and a webpage. In addition to the general distribution of materials by the ECHO Program, the Council of Marine Carriers (a trade association which represents Western Canadian tug and barge operators) supported with the targeted distribution of materials and ongoing communication to their members throughout the initiative. The American Waterways Operators (a trade association representing U.S. tug and barge operators) also supported in the distribution of materials and communication to their members regarding the initiative. A Canadian Coast Guard navigational warning (NAVWARN) was issued on the start and end date of the lateral displacement. Email newsletters from the ECHO Program were sent biweekly and included updates on tug participation rates.

In an extra effort to increase participation, more frequent updates and communications were provided to the Council of Marine Carriers and American Waterways Operators. Facebook ads and letters were also used to support the promotion and awareness of the lateral displacement to regional tug operators.

A formal recognition was given after the lateral displacement which included invitation to a virtual appreciation event and a thank you package sent by mail that included a certificate of participation, a thank you letter and a small gift.

2.1.2. Government-led engagement

Transport Canada participated collaboratively in the development of the parameters as a member of the ECHO Program advisory committees, but also helped to support the initiative as a part of its work under the federal Whales Initiative. Transport Canada has existing relationships with, and obligations to, other federal departments and agencies in Canada and the United States.

Transport Canada worked directly with the Canadian Coast Guard and the U.S. Coast Guard through the existing joint coordinating group to ensure that the lateral displacement could be executed and managed safely. In 2019, the joint coordinating group requested a 1,000 metre buffer zone be placed between the outbound shipping lane and the inshore lateral displacement zone to limit the safety risks associated with proximity to deep-sea traffic. The 2020 lateral displacement area was unchanged from 2019.

The Government of Canada created communications materials which outlined many southern resident killer whale measures taking place in the Salish Sea throughout the 2020 season. The inshore lateral displacement zone was highlighted on select maps which were distributed to the public and recreational mariners.

2.1.3. Indigenous engagement

The Government of Canada also has a duty to consult Indigenous communities when contemplating actions that may have an impact on Indigenous rights.

As part of its work under the federal Whales Initiative, since 2018 Transport Canada recognized the potential for future traffic management practices to be informed by the results of the voluntary lateral displacement. As a precautionary measure to avoid or minimize any impacts of the initiative on Indigenous groups, Transport Canada reached out to several Indigenous communities before implementation. Transport Canada, with Fisheries and Oceans Canada, continued to have ongoing communication with Indigenous communities throughout the initiative period. The lateral displacement initiative was also a topic of discussion with Indigenous groups during the Crown consultation on 2020 southern resident killer whale recovery measures implemented by the Government of Canada.

Through engagement with the U.S. Coast Guard, Indigenous communities in Canada, and the Puget Sound Partnership, Transport Canada heard that Indigenous groups (tribes) in the U.S. should also be aware of the lateral displacement initiative as they have rights and interests in the transboundary waters of the Salish Sea and the Strait of Juan de Fuca. With the help of the Puget Sound Partnership and the

U.S. Coast Guard, Transport Canada was able to inform several tribal representatives about the initiative, using existing councils and meetings for engagement.

2.2. Monitoring

2.2.1. Acoustic recorders

Fisheries and Oceans Canada used data from previously deployed hydrophones in the Strait of Juan de Fuca for the time period between April 1 and October 31, 2020 to monitor the underwater soundscape in the known southern resident killer whale feeding area before and during the initiative. The hydrophone sites are shown on Figure 1 and were located off Port Renfrew, Jordan River and Sooke. The results of the 2018 and 2019 initiatives indicated that the hydrophone located near Jordan River provided the most accurate representation of the potential benefits of the inshore lateral displacement, as tug traffic generally transited in consistent east-west tracks in this area. Differing vessel traffic patterns near Sooke and Port Renfrew resulted in challenges interpreting the acoustic data. As such, only the data collected from the Jordan River hydrophone was used to evaluate reductions in total ambient underwater noise from the inshore lateral displacement.

2.2.2. Automatic Identification System monitoring

The Automatic Identification System (AIS) is an automated, autonomous vessel tracking system which is used extensively in the maritime industry for the exchange of navigational information and used by vessel traffic services (VTS) globally to track vessel movements.

In accordance with international convention (Regulation 19 of the International Maritime Organization's International Convention for the Safety of Life at Sea), all vessels travelling in international waters with a gross tonnage of 300 or more, those with a gross tonnage of 500 or more in any waters, and all passenger vessels must carry a Class A AIS transponder. Other vessels, typically fishing and recreational vessels, may choose to carry AIS transponders and typically these would be Class B transponders. Although towage or escort vessels may be below the tonnage threshold requirements for carriage of AIS transponders, best practices and regulations in Canada and the U.S. ensure that the majority of tug traffic is equipped with AIS.

Canadian Coast Guard monitored and analyzed vessel traffic movements during the initiative using both Class A and Class B AIS data from Canadian Coast Guard Terrestrial AIS infrastructure. This analysis was used to determine tug presence and participation in the inshore lateral displacement zone or the outbound shipping lane during the initiative. The analysis also included a comparison to AIS data from the 2019 lateral displacement trial, as well as a comparable baseline time period in 2017.

2.2.3. Marine mammal monitoring

In an effort to better understand the presence and behavior of whale species in both Swiftsure Bank and the Strait of Juan de Fuca, the ECHO Program supported Pacheedaht First Nation to undertake marine mammal observations in both regions between August and November 2020. The full study will be incorporated into the Swiftsure Bank slowdown trial report, available on the ECHO Program website spring 2021.

The results of these monitoring activities are described in the sections below.

3. Tug participation results

The lateral displacement analysis period was from June 1 to October 31, 2020. Participation of tug traffic in the inshore lateral displacement was evaluated over the 22-week period through analysis of the AIS data. A detailed report prepared by Canadian Coast Guard ('2020 Voluntary Lateral Displacement AIS Summary Analysis') is provided in Appendix A.

3.1. Participation analysis approaches

In order to evaluate participation, the AIS data was filtered to include those vessels transmitting their AIS vessel type as a tug. The AIS data was then amalgamated as vessel tracks and analyzed to evaluate participation using three methods:

- Participation rate: an evaluation of the amount of a tug's transit distance spent in the inshore lateral displacement zone or the outbound shipping lane. Participation was categorized as a tug spending 50% or more of their transit within the inshore lateral displacement zone or outbound shipping lane.
- Heat map density analysis: a visual evaluation of the difference in traffic density for individual tug vessels in the inshore lateral displacement zone or outbound lane between 2017 baseline and 2020 lateral displacement to better visualize the impact of the initiative on traffic patterns
- Distribution analysis: a statistical analysis of the shift in the distribution of tug AIS vessel positions in the inshore lateral displacement zone and outbound lane to compare a 2017 baseline to 2019 and 2020 traffic patterns

Transits near the shore with a total length less than half of the typical inshore lateral displacement transit length (approx. 28.2 nautical miles) were filtered out after identifying that some tugs were transiting very short distances between two coastal locations (seen in Figure 2), thus could not reasonably be expected to use the inshore lateral displacement zone or the outbound shipping lane.

3.2. Participation rates

In 2020, inshore tug traffic demonstrated a significant shift southward into the inshore lateral displacement zone and outbound shipping lane relative to baseline conditions, with 138 out of 168 (82%) vessel transits spending more than half their transit in the zone and outbound shipping lane. Participation rates were also seen to increase from 76% in 2019 to 82% in 2020.

The numbers presented in Table 1 show a comparison of the baseline period 2017 (no lateral displacement) and both the 2019 and 2020 years where only inshore traffic was asked to displace. The 2018 trial year is not included in the comparison as 2018 included both tugs and deep sea vessels, and the spatial and temporal parameters were also different to those of the 2019 and 2020 initiatives.

Table 1: Comparison of participation rates for tug traffic in 2017, 2019 and 2020

Period	2017 (baseline, no lateral displacement)		2019 (Year 2 of lateral displacement)		2020 (Year 3 of lateral displacement)	
	August 20 to October 31		June 17 to October 31		June 1 to October 31	
# trips ≥50% in the outbound lane and inshore lateral displacement zone	36	48.5%	93	76%	138	82%
# trips ≥25%–<50% in the outbound lane and inshore lateral displacement zone	2	3%	6	5%	11	7%
# trips >0%–<25% in the outbound lane and inshore lateral displacement zone	6	8%	5	4%	7	4%
# trips 0% in the outbound lane and inshore lateral displacement zone	30	40.5%	18	15%	12	7%
Total # of tug trips	74		122		168	

Source: Canadian Coast Guard

Table 2 shows the breakdown of where tugs spent the majority of their time. Forty-six percent of the total transits (77 out of 168) spent half or more of their time in the outbound shipping lane and 36% (60 out of 168) spent half or more of their time in the inshore lateral displacement zone. Vessels that spent more than half of their transit in either of these zones were deemed to be participating.

Table 2: Summary of tug transit patterns during 2020 lateral displacement

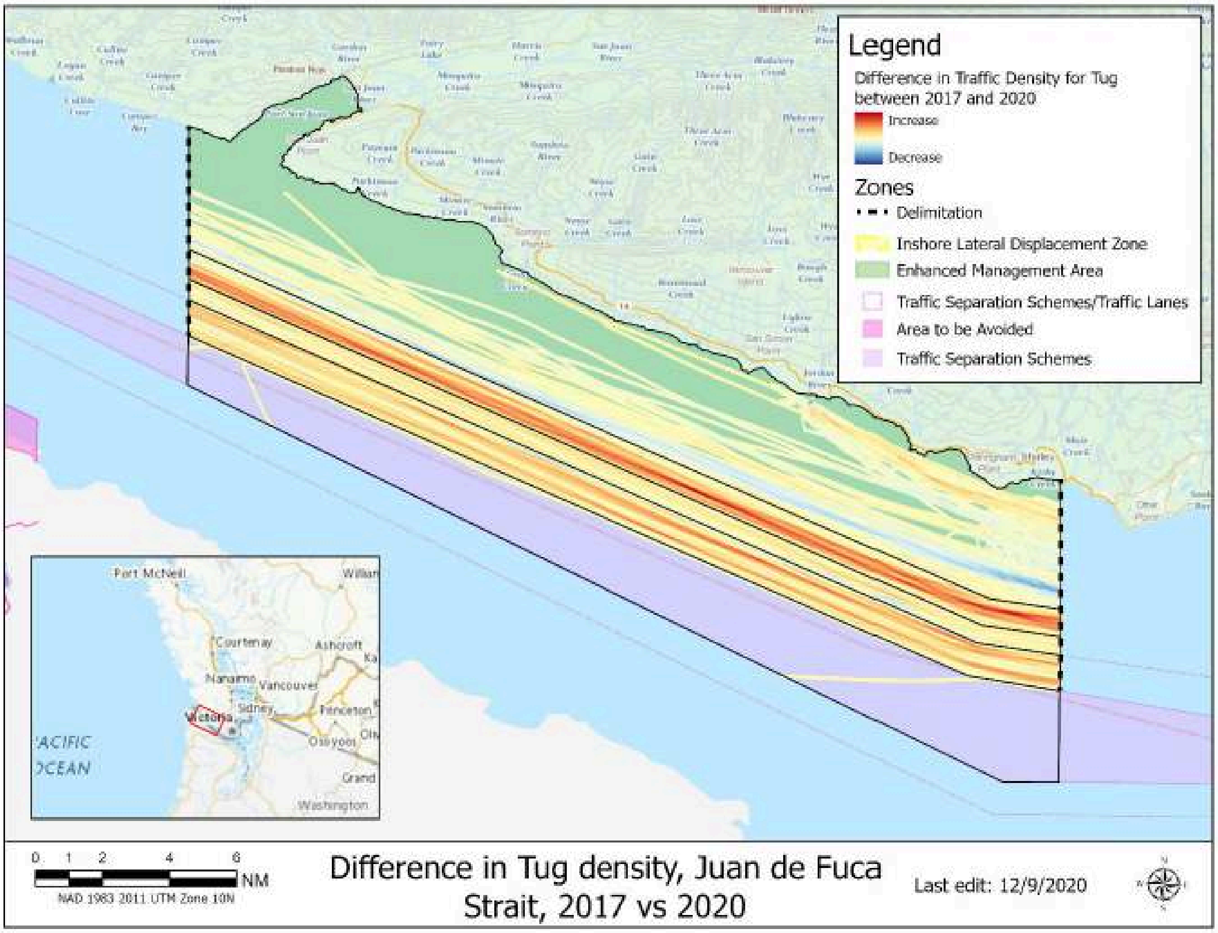
Zone of tug transit (listed north to south)	Number of tug trips that spent ≥50% of transit in each zone	Percentage of tug trips that spent ≥50% of transit in each zone
Enhanced management area	16	9.5%
Inshore lateral displacement zone *(participation zone)*	60	36%
Buffer zone	13	8.5%
Outbound shipping lane *(participation zone)*	77	46%
Not in any zone for >50% of transit	2	1%
Total	168	

Source: Canadian Coast Guard

3.3. Tug traffic density analysis

Heat maps were prepared to visually illustrate the difference in tug traffic density and traffic patterns between the 2017 baseline and the 2020 lateral displacement period. Figure 2 shows the lateral displacement area with orange/red areas representing those areas where tug traffic density increased in 2020 relative to a similar time period under 2017 baseline conditions. This figure shows an increase (orange/red) in tug traffic in both the outbound lane of the traffic separation scheme and in the designated inshore lateral displacement zone in 2020 relative to 2017. A decrease (blue) is shown in the enhanced management area relative to 2017. Traffic density that neither increased nor decreased is shown in light yellow. More information on the traffic density analysis can be found in Appendix A.

Figure 2: Heat map showing difference in traffic density for tugs between 2017 and 2020



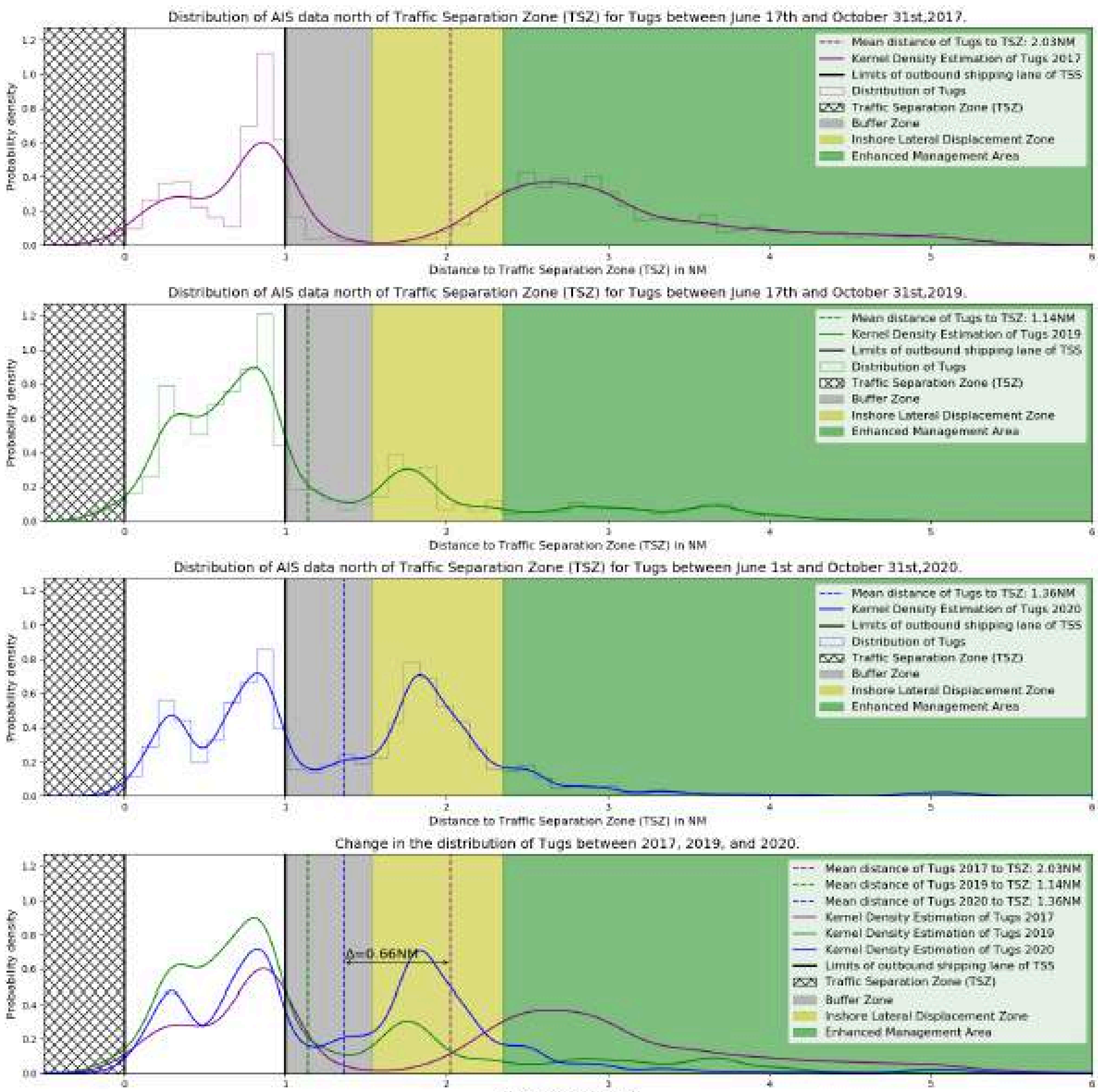
Source: Canadian Coast Guard

3.4. Tug traffic distribution analysis

The distribution of tracks for tug traffic within the outbound lane and inshore lateral displacement zone was analyzed between June 17 and October 31 in 2017 and 2019 and June 1 to October 31, 2020 (Figure 3). Results for 2020 (third panel) show two distinct increases in density of traffic in the two participation zones, and lower traffic density in the buffer zone and enhanced management area compared to 2019 and the 2017 baseline.

In 2020, tugs showed an average shift of 0.66 nautical miles or 1,222 metres southwards, away from the southern resident killer whale enhanced management area during the 2020 lateral displacement period relative to a similar time period under 2017 baseline conditions.

Figure 3: Distribution analysis of tug traffic between 2017, 2019 and 2020

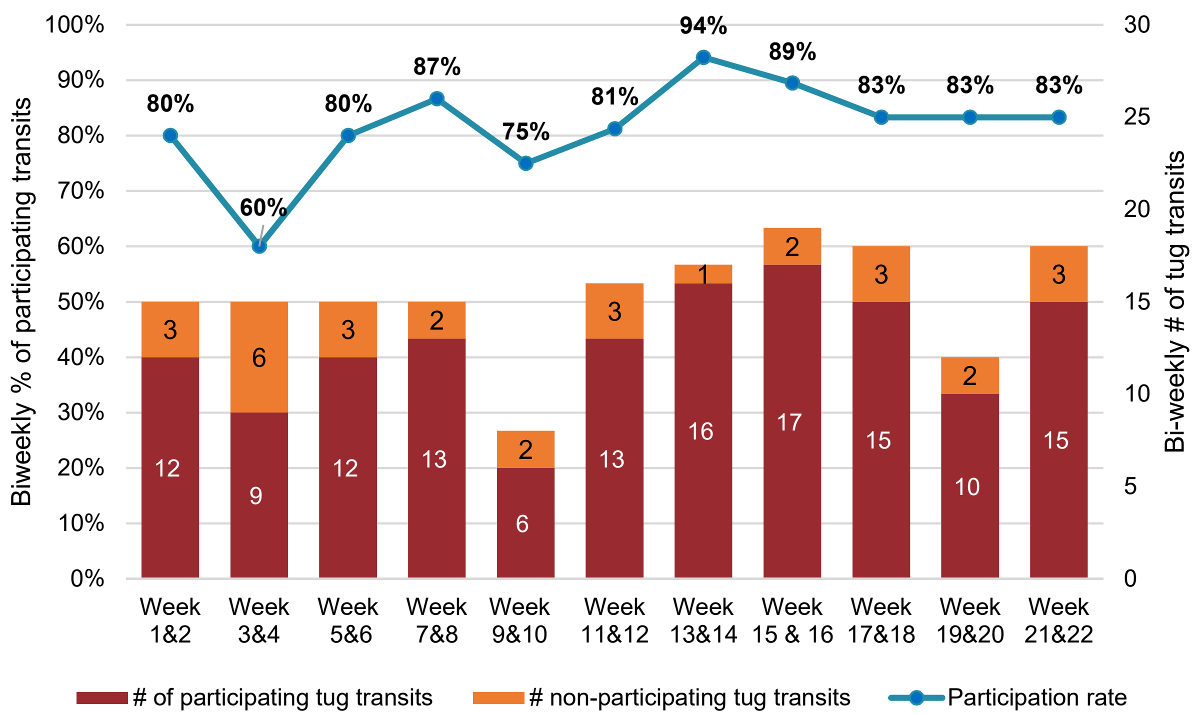


Source: Canadian Coast Guard

3.5. Biweekly participation results

A summary of biweekly participation rates (more than 50% of transit in inshore lateral displacement zone or outbound shipping lane) during the 22-week period is presented in Figure 4. Over the course of the 22-week period, an overall participation rate of 82% was achieved.

Figure 4: Overview of participation rates in 2020



Source: Canadian Coast Guard

AIS data was sent to the ECHO Program on a biweekly basis from the Canadian Coast Guard, allowing these data to be shared with the tug associations and owner/operators as appropriate. In weeks 3 & 4 of the initiative, it was recognized that several tugs were using the buffer zone instead of the inshore lateral displacement area, bringing the participation rate down to 60%. Upon direct communications with the operators of those tugs, it was recognized that the 2018 lateral displacement map was still in use and needed to be updated. Once this was corrected and the 2020 lateral displacement coordinates were provided again, the participation rate increased and remained above 75% for the remainder of the initiative. Due to the generally low total number of tug transits per week, if a small number of tugs were either not aware of the initiative or were unable to fully participate in a particular week, the overall participation rate was impacted.

4. Acoustic results and whale presence

As previously noted in Section 2.2.1 and shown in Figure 1, a hydrophone installed by Fisheries and Oceans Canada near Jordan River to monitor underwater noise in southern resident killer whale critical habitat was used to evaluate the potential acoustic benefit of the lateral displacement.

The underwater noise analysis and evaluation of the potential acoustic benefits of the initiative was conducted by Fisheries and Oceans Canada. The results analyzed for this, and other underwater noise reduction initiatives conducted in the Salish Sea in 2020, are presented in a technical paper recently submitted to the journal *Frontiers in Marine Science* (Burnham et al., 2021). A copy of the technical paper was provided to the Vancouver Fraser Port Authority for review and is summarized below. The technical paper is currently undergoing peer review.

During the lateral displacement period, Pacheedaht First Nation and B.C. Cetacean Sightings Network gathered whale presence data in the Strait of Juan de Fuca. A breakdown of the whale sightings by month and by species is included in Section 4.3.

4.1. Differences in underwater sound levels due to lateral displacement

For the 2020 lateral displacement initiative, baseline sound pressure levels (SPL) were established for a two month baseline period (April 1 to May 31, 2020) before the initiative began. The Jordan River location was deemed to be the location most appropriate for assessment of differences in underwater noise achieved through the lateral displacement, as it is situated proximate to the inshore lateral displacement zone, and tug traffic generally transits in consistent east-west tracks in this area.

For comparison of acoustic data at Jordan River, all tug vessels within 8 kilometres of the hydrophone location were included as possible contributors to the soundscape. Fisheries and Oceans Canada scientists tracked 24 different tugs and a total of 46 transits during the baseline period (April 1- May 31, 2020). During the lateral displacement period (June 1- October 31, 2020) 32 different tugs were tracked with a total of 144 transits. Tugs with repeat transits were also further inspected to evaluate their level of displacement and resulting reduction in contribution to received sound pressure level (SPL) at the hydrophone.

In order to minimize the effects of current and wind-induced low frequency noise on the hydrophone, only data periods with slack tide, where the current was below 0.25 meters/second, and where wind speed was below 5 m/s, were used for the acoustic evaluation of the lateral displacement. Small vessel traffic, not equipped with AIS transmitters, can also contribute to the soundscape and confound measurement of the effects of the lateral displacement initiative. In an attempt to remove the acoustic effects of small vessel presence proximate to the hydrophone, a small vessel detector after Warner et al. (2020) was also applied to the data.

To evaluate the acoustic effects of the lateral displacement initiative, sound pressure levels were compared across the following frequency ranges:

- Broadband (10–100,000 Hz)
- Southern resident killer whale communication band (500–15,000 Hz)
- Southern resident killer whale echolocation band (15,000–100,000 Hz)
- First/lowest decade band (10–100 Hz)
- Second decade band (100–1,000 Hz)
- Third decade band (1,000–10,000 Hz)
- Fourth decade band (10,000–100,000 Hz)

The potential reductions in underwater noise attributable to the lateral displacement initiative were obtained by comparing the cumulative distribution functions (CDFs) of sound pressure levels between the baseline and lateral displacement time periods, for the six frequency ranges described above. In Table 3 provided below, the L_{95} metric represents the quiet ambient conditions (sound pressure level exceeded 95% of the time), whereas L_{50} is the median value and L_5 is the upper level of noise (exceeded only 5% of the time).

Table 3 – Changes in ambient underwater noise between baseline and lateral displacement time periods

Frequency range	dB change in ambient underwater noise sound pressure level		
	L95	**L50**	**L5**
1st decade band 10-100 Hz	-2.4	-2.1	0.0
2nd decade band 100-1000 Hz	-0.3	-0.5	-3.6
3rd decade band 1-10 kHz	-3.4	-1.3	-1.2
4th decade band 10-100 kHz	-0.6	-3.5	-2.3
Broadband 10 – 100,000 Hz	0.8	-1.4	-1.2
SRKW communication (500-15000 Hz)	-1.9	-1.9	-3.0
SRKW echolocation (15-100 kHz)	-0.9	-3.3	-4.7

When evaluating median sound pressure level reductions (highlighted in Table 3), reductions were seen in all frequency ranges, with higher-frequency ranges (4^{th} decade and SRKW echolocation range) showing the most noticeable reductions during the lateral displacement. The median broadband reduction was measured to be 1.4 dB.

The potential reductions from individual tug transits were also quantified by evaluating repeat transits of the same tug. Eight individual tugs were identified in the AIS data to have made transits during both the baseline and lateral displacement time periods, however, seven of these transited within the lateral displacement zone at a consistent distance in both the baseline and lateral displacement periods. One of the eight tugs was found to alter its route from a baseline distance of 750 m from the hydrophone to 1760 m during the lateral displacement period. This increase of more than 1 km distance from the mooring reduced the median broadband sound level by 5.3 dB. This represents a reduction in sound intensity of approximately 70%. Similar reductions were measured in the SRKW communication band (-4.7 dB) and echolocation band (-5.6 dB) (Burnham et al. 2021).

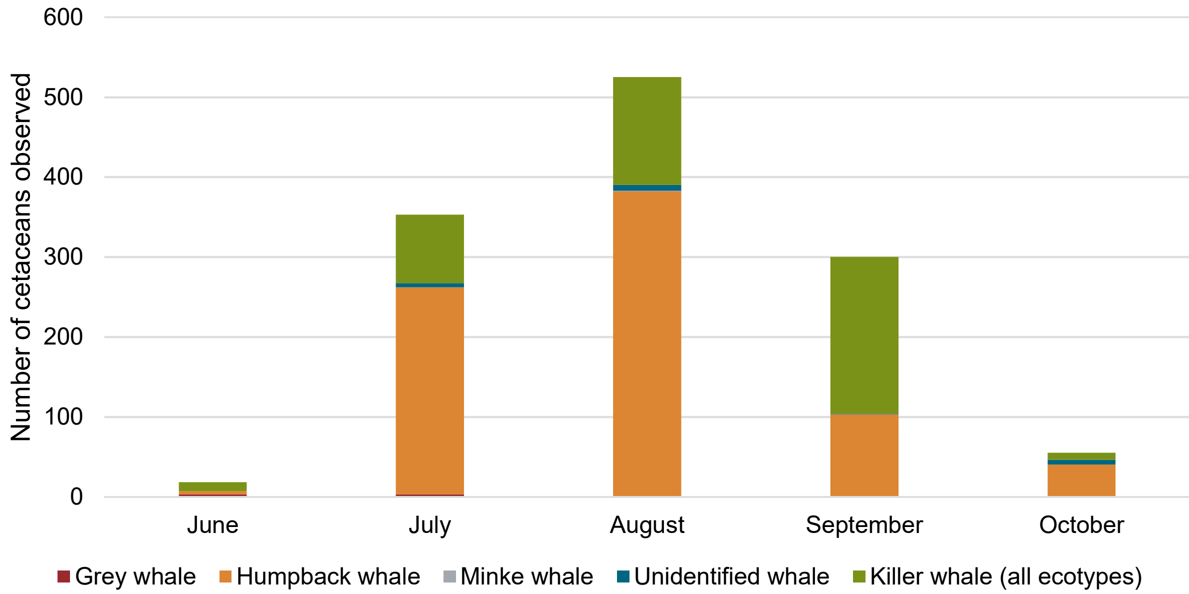
Evaluation of the 2019 lateral displacement (Vagle et al. 2020) indicated that by moving tug traffic to greater than 3 kilometres from the hydrophone receiver—in this instance the Jordan River hydrophone—their contribution to received sound level at most frequencies becomes negligible.

Although the number of tug transits in the Strait of Juan de Fuca proximate to the Jordan River hydrophone is relatively low compared to other commercial vessels, results indicate that the potential underwater noise reduction from even a modest shift away from the SRKW feeding habitat by tug traffic can make a significant difference.

4.2. Whale presence during the inshore lateral displacement

Between June 1 and October 31, 2020, the B.C. Cetacean Sightings Network received 241 reports of humpbacks, killer whale, minke and grey whale sightings in the Strait of Juan de Fuca area. Based on these reports, an estimated 1251 individual marine mammals were observed. Figure 5 shows a breakdown of the individuals observed by month and by species.

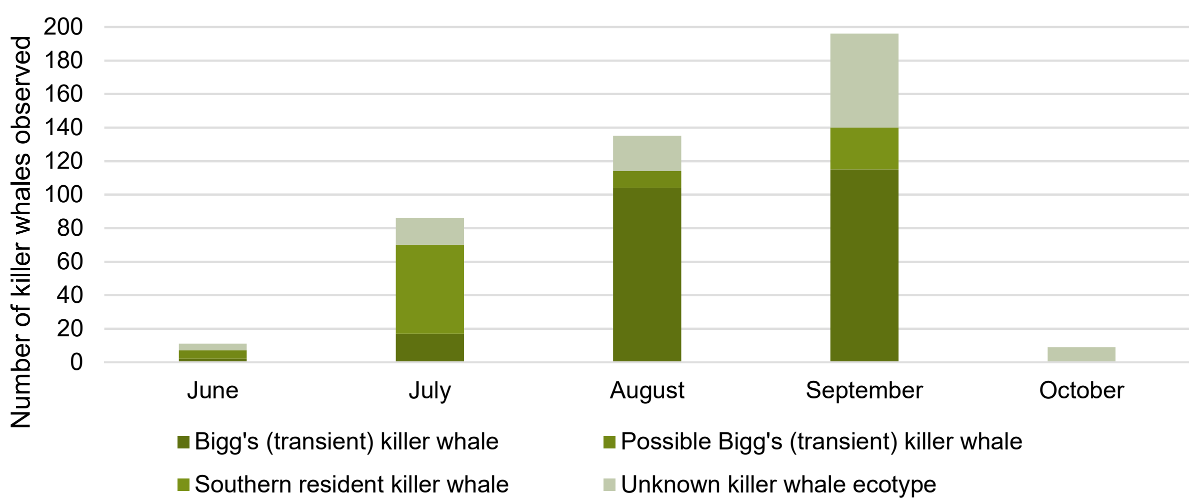
Figure 5: Cetacean count as reported to B.C. Cetacean Sightings Network in Strait of Juan de Fuca during the inshore lateral displacement period, June 1–October 31, 2020



Source: Ocean Wise Research Institute and Fisheries and Oceans Canada. Data not corrected for observer effort. Used with permission.

Of the total estimated 1251 marine mammals observed, 437 (35%) were killer whales of various ecotypes. Figure 6 indicates that the majority of killer whales observed were Bigg's (transient) killer whales, followed by SKRWs. Observers reported 78 SRKWs, 52 in July and 25 in September in the Strait of Juan de Fuca.

Figure 6: Killer whale count as reported to B.C. Cetacean Sightings Network in Strait of Juan de Fuca during the inshore lateral displacement period, June 1–October 31, 2020 by ecotype and month.



Source: Ocean Wise Research Institute and Fisheries and Oceans Canada. Data not corrected for observer effort. Used with permission.

Data obtained from the B.C. Cetacean Sightings Network were collected opportunistically with limited knowledge of the temporal or spatial distribution of observer effort. As a result, absence of sightings at any location does not demonstrate absence of cetaceans.

To further support marine mammal observations in the Strait of Juan de Fuca and Swiftsure Bank, the ECHO Program collaborated with Pacheedaht First Nation to undertake marine mammal observations over 26 field excursions between August and November 2020. The Pacheedaht First Nation marine mammal observers recorded 128 sightings of an estimated 303 animals, 17 of which were killer whales observed on four separate occasions. Humpbacks were the most frequently observed animal during the study, followed by California sea lions (Hall et al., 2021). This study will be incorporated into the Swiftsure Bank slowdown trial report and will be available on the ECHO Program website in spring 2021.

In the summer and fall of 2020, overlapping with the lateral displacement period, Fisheries and Oceans Canada was also advancing the third of a three-year research study in the Strait of Juan de Fuca to monitor the presence and behaviour of southern resident killer whales. It is anticipated that the results of this study will be published by Fisheries and Oceans Canada in spring 2021 and will provide additional insight into southern resident killer whale presence and behavioural activities in the lateral displacement area.

5. Safety and operational results

Before the inshore lateral displacement period, safety considerations were discussed by both the joint coordinating group and the ECHO Program vessel operators committee. These discussions ultimately informed the development of operational procedures to ensure that the initiative could be executed and managed safely. As a result, no dangerous occurrences or safety incidents were recorded during the initiative period.

The following report section summarizes feedback from industry stakeholders and Indigenous communities during and following the initiative regarding its operational impacts and feasibility.

5.1. Industry feedback

The ECHO Program interviewed a representative from the Council of Marine Carriers following the conclusion of the lateral displacement. This feedback, along with general feedback from the ECHO Program vessel operators committee members, indicated that no direct or indirect costs or operational challenges were incurred as a result the inshore lateral displacement. The top reason reported for participating was to support whale conservation and the top reason reported for not participating was lack of awareness of the initiative.

5.2. Feedback from Indigenous communities

The Government of Canada has been undertaking Indigenous engagement on measures in the Strait of Juan de Fuca since 2018, as described in Section 2.1. In 2018, some Indigenous communities expressed an interest in being involved in future decision making, receiving data and results from the initiative and communicating on potential mitigations in the event they might interfere with harvesting and/or travel and/or other Indigenous rights of communities.

Another common message of feedback, in particular from tribal representatives in the United States, was that a temporary initiative was fine, however should the findings of this lateral displacement lead to the development of any more permanent measures or structural changes to the way in which vessels navigate in the transboundary waters of the Salish Sea and the Strait of Juan de Fuca, a more formal consultation process would be required.

While several First Nations expressed an interest in the lateral displacement initiative, Pacheedaht First Nation has been particularly active and involved in the ECHO Program and the development of the initiative since the majority of the displacement takes place within their traditional marine territory. Pacheedaht First Nation actively governs and manages their territory and continues to practice protocols consistent with their Nuu-chah-nulth values. Pacheedaht are a whaling people who are culturally and spiritually tied to whales. In the Pacheedaht world view, the killer whale and wolf are of the same spirit, with the ability to transform from one creature to the other as they move from land and sea. Killer whales, including southern resident killer whales, are held in the highest regard for their cultural importance to the identity and governance system of the Pacheedaht people. Pacheedaht First Nation maintains as a priority seeking data and appropriate engagement related to their marine territory including by participating in decision-making; the community is interested in how the findings from the lateral displacement may inform future work to build on efforts to ensure their aboriginal rights are protected.

In 2020, Pacheedaht First Nation became a member of the ECHO Program's advisory working group. In 2020, the ECHO Program also worked collaboratively with Pacheedaht First Nation to undertake marine mammal observations in the Strait of Juan de Fuca and Swiftsure Bank. As part of this collaboration, marine mammal observer training and certification was provided to a team of observers from Pacheedaht and Ahousaht First Nations by SeaView Marine Sciences and SMRU Consulting. The observers conducted 26 days of on-the-water marine mammal transect surveys in the Strait of Juan de Fuca and Swiftsure Bank between August and November 2020. Results of this study will be included as an appendix to the ECHO Program's Swiftsure Bank slowdown trial report which will be available on the ECHO Program website in spring 2021.

6. Key findings, conclusions and recommendations

The following key findings can be summarized from the 2020 voluntary inshore lateral displacement:

- The inshore lateral displacement saw significant tug traffic participation rates with 82% of tugs able to spend over half of their transit in the inshore lateral displacement zone and outbound shipping lane. The primary reason noted for non-participation was a lack of awareness of the initiative.
- When comparing underwater noise levels in the two months before the lateral displacement (baseline) against those measured during the displacement, filtered for times when tugs are transiting, a median broadband reduction of 1.4 dB was measured at the Jordan River hydrophone. Underwater noise reductions achieved were greatest in the higher frequencies, with a 3.3 dB noise reduction measured in the SRKW echolocation band (greater than 15 KHz).
- Detailed analysis of a specific tug transit indicated that a shift of approximately 1,000 metres away from the hydrophone reduced the median received broadband sound level by 5.3 dB. This represents a reduction in sound intensity of approximately 70%.
- According to currently available sightings data from B.C cetacean Sightings Network, an estimated 1,251 marine mammals were observed in the Strait of Juan de Fuca during the study period. Of those sightings, 437 (35%) were killer whales, with 78 sightings specifically confirmed to be southern resident killer whales. Pacheedaht First Nation marine mammal observers recorded 128 marine mammal sightings, 17 of which were killer whales, in the Strait of Juan de Fuca and Swiftsure Bank on their 26 field excursions between August and November 2020.

Overall, the lateral displacement was successfully managed with no dangerous occurrences or incidents recorded. There were no safety or operational concerns recorded with the vessels navigating in the inshore zone during the study period.

The following key conclusions and recommendations can be drawn from the 2020 voluntary inshore lateral displacement:

- Communications about the initiative and collaborations between transboundary partners were effective and resulted in an overall strong participation rate
- Additional communications with tug operators who are not affiliated with the Council of Marine Carriers or the American Waterway Operators in advance of and throughout future initiatives will further improve participation rates
- With no dangerous occurrences or incidents recorded during the initiative, the 1,000 metre buffer zone is an effective way to manage safety risk
- Significant underwater noise reduction can be achieved by laterally displacing tugs away from areas of importance for SRKW, especially at the higher-frequency bands important for foraging
- Whale presence data should continue to be collected in any future lateral displacement efforts in the Strait of Juan de Fuca to evaluate ongoing southern resident killer whale presence and to estimate potential benefits of the efforts.

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Vancouver Fraser Port Authority
2020 voluntary inshore lateral displacement in the Strait of Juan de Fuca

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Appendix A

ECHO Program Voluntary Lateral Displacement AIS summary report: Canadian Coast Guard 2020

AIS Summary Analysis – June 1st to October 31st, 2020

ECHO PROGRAM

2020 Voluntary Inshore Lateral Displacement / AIS Summary Analysis

Abstract

In order to help reduce vessel noise impacts in key southern resident killer whale feeding areas, the ECHO Program advanced a voluntary inshore lateral displacement in the Strait of Juan de Fuca to study how moving tug vessels away from known feeding areas affects underwater noise levels in those areas. Several analyses were conducted to assess the impact of this initiative, including this AIS analysis. This document describes the high level of engagement for most of the tug traffic in the area of study.

AIS Summary Analysis – June 1st to October 31st, 2020

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List of Acronyms and Abbreviations

AIS	Automatic Identification System
CCG	Canadian Coast Guard
DFO	Department of Fisheries and Oceans Canada
ECHO	Enhancing Cetacean Habitat and Observation
GIS	Geographic Information System
IMO	International Maritime Organization
IQR	Interquartile Range
MMSI	Maritime Mobile Service Identity
NM	Nautical Miles
NMEA	National Marine Electronics Association
OSL	Outbound shipping lane
SOG	Speed Over Ground
SOLAS	Safety Of Life At Sea
SRKW	Southern Resident Killer Whales
TC	Transport Canada
TSS	Traffic Separation Scheme
TSZ	Traffic Separation Zone
USCG	United States Coast Guard
VTS	Vessel Traffic Service

I) CONTEXT

The Enhancing Cetacean Habitat and Observation (ECHO) Program is a Vancouver Fraser Port Authority-led initiative aimed at better understanding and managing the impact on shipping activities on at-risk whales throughout the southern coast of British Columbia.

In 2018, the ECHO Program and Transport Canada supported by U.S. Coast Guard, Fisheries and Oceans Canada (DFO), Canadian Coast Guard (CCG), Canadian and U.S. marine transportation industry and Aboriginal individuals, undertook a voluntary trial to study how laterally displacing commercial vessels away from known southern resident killer whale (SRKW) feeding areas along the northern side of the Strait of Juan de Fuca would affect the underwater noise levels in those areas. Findings showed that displacing inshore tug and barge traffic resulted in a significant reduction in underwater noise within southern resident killer whale foraging habitat.

In 2019, the ECHO Program asked tug and barge vessels to participate again in a voluntary inshore lateral displacement trial. The overall purpose of the trial was to reduce vessel noise impacts in these key SRKW feeding areas.

The 2020 voluntary inshore lateral displacement initiative began on June 1 and ended on October 31, 2020.

During the study, vessel participation rates were monitored via Automatic Identification System (AIS) data collected by the CCG. This was summarized in bi-weekly reports describing traffic patterns provided by the CCG to the ECHO Program team. Regular updates on the initiative were released publicly via the ECHO Program newsletter. Underwater noise was measured before, and during the lateral displacement using a DFO hydrophones located in key foraging areas of the Strait of Juan de Fuca. Throughout this initiative, the CCG provided both data analysis and reporting for analyzing traffic patterns in the Strait of Juan de Fuca to advance the understanding of vessel participation.

The current document summarizes the analysis based on the terrestrial AIS data collected during the initiative. It aims to describe more accurately the changes in traffic pattern in comparison with the baseline data for the same period in 2017 and the lateral displacement trial in 2019.

II) METHODOLOGY

1) Study Area and Time Frame

The study area boundary was restricted to the waters in the Strait of Juan de Fuca, more precisely indicated by the zones defined by the ECHO Program in **Figure 1**.

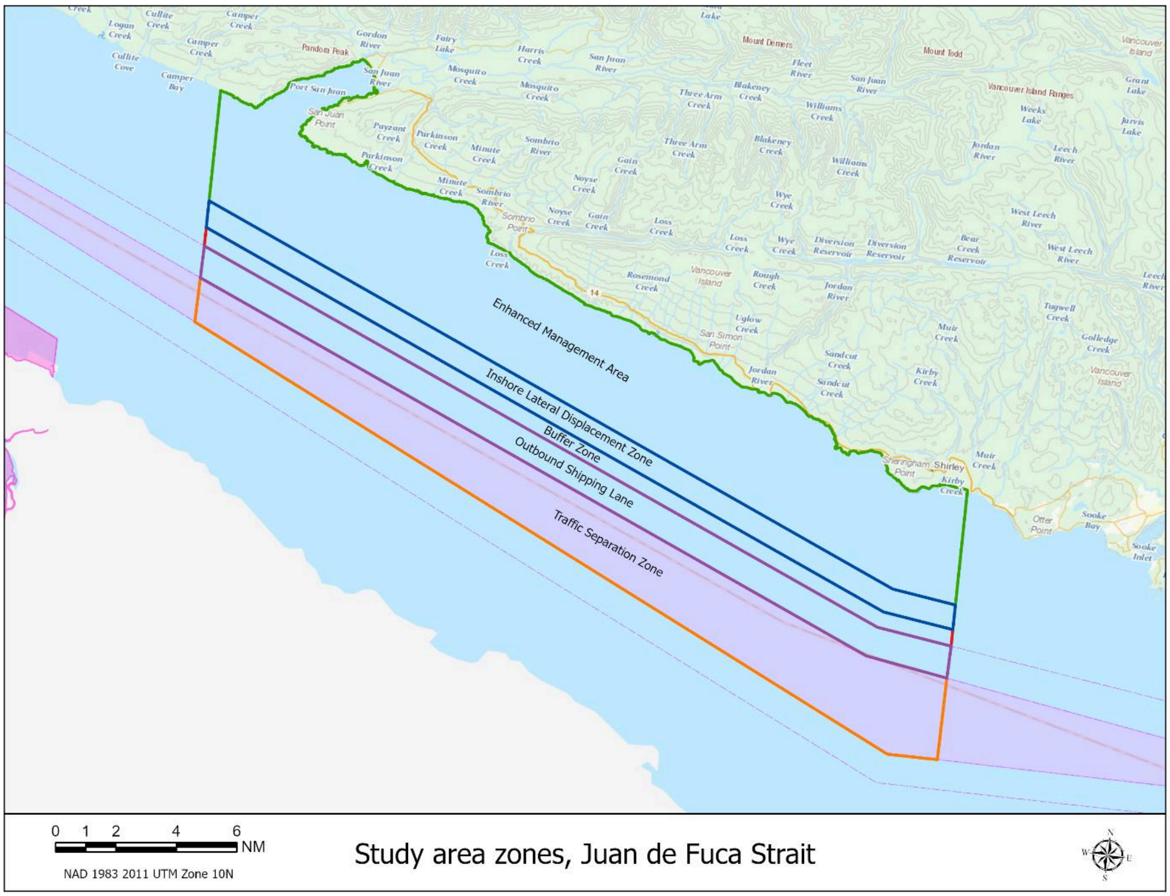

***Figure 1**: Study area zones for the Lateral Displacement Initiative in 2019 and 2020.*

The Inshore Lateral Displacement Zone is 1500 meters wide and occurs in the area between 123° 52' West and 124° 31' West, over a distance of approximately 28 NM (**Figure 1**). The zone is positioned 1,000 meters north of the Traffic Separation Scheme (TSS) area in order to provide a safety buffer for vessels transiting the area. An Enhanced Management Area (EMA) was identified by the Government of Canada along the northern side of the Strait of Juan de Fuca as a key foraging areas for SRKWs (indicated by the green outlined area in **Figure 1**). During the initiative, tugs were requested to transit either in the outbound shipping lane or between the EMA and the buffer zone within the designated Inshore Lateral Displacement Zone.

The data collection and analysis took place for the duration of the trial, from June 1st, 2020 to October 31st, 2020, and reporting was completed on a bi-weekly basis.

2) Data

This analysis is based on CCG Terrestrial AIS data. AIS is a 4-S system (ship-to-shore / ship-to-ship) originally envisioned as a vessel tracking system by Vessel Traffic Services (VTS) and harbour authorities that evolved to improve vessel collision avoidance. In 2004, the International Maritime Organization (IMO) adopted Regulation 19 of the International Convention for the Safety of Life at Sea (SOLAS) Chapter V, "*Carriage requirements for shipborne navigational systems and equipment*", which listed mandatory navigational equipment to be carried on board vessels, based on vessel type. This included a new requirement for all vessels to carry Automatic Identification Systems (AIS).

There are two different types of AIS classes. Class A AIS is required aboard all vessels of 300 gross tonnage and upwards engaged on international voyages, cargo vessels of 500 gross tonnage and upwards not engaged on international voyages and all passenger vessels irrespective of size. Class A transponders transmit AIS position reports more frequently: every 2-10 seconds while moving or every 3 minutes when the vessel is at anchor. Class B AIS position reports are sent every 5-30 seconds and every 3 minutes when speed over ground is less than 2 knots. The transmit power of a Class A AIS transponders is also higher than Class B AIS transponders and therefore allows for comparatively better coverage overall.

In this analysis, both Class A and Class B AIS messages were used. Class B AIS data is mostly produced by fishing vessels and recreational vessels. Due to the specificities of Class B transponders, a gap in the data was observed near Port Renfrew which limits our ability to represent the traffic accurately for Class B vessels in this area.

It is important to note that AIS is subject to the shortfalls common to all transponder-based tracking technology, such as the following:

- Not all vessels will be equipped with AIS. Some vessels such as pleasure crafts, fishing boats and naval vessels may not be fitted with AIS.
- The systems are not fail-safe. If the AIS equipment ceases to operate, the data will not be transmitted.
- The systems require the cooperation of the vessels being tracked. A decision not to carry the required equipment, to disable the equipment or otherwise turn it off, removes the vessel from transmitting data and ultimately being tracked.
- The integrity of the static and dynamic data is not assured. Static data, including data showing the identity of the carrying vessel and cargo, are manually entered by an operator or a technician at the time of installation. All entries can have errors, and some can be changed at will. The vessel's data broadcasted on AIS is taken from the vessel's sensors such as the gyrocompass and the GPS which can also be defective or provide inaccurate data.
- The terrestrial coverage depends on different parameters such as the location of the base stations, the specifics of the antennas (both for the base station and the vessel) and topography. There might be gaps in coverage depending on those multiple factors.

3) Method

a) Filtering and editing the AIS data

In order to perform this analysis, AIS data was collected through Canadian Coast Guard Terrestrial AIS infrastructure. The data was extracted for the area of interest between June 17th and October 31st of 2017 (baseline), 2019 (previous lateral displacement trial), and between June 1st and October 31st 2020 (analysis).

The AIS data was then automatically processed to identify trips based on the Maritime Mobile Service Identity (MMSI) as well as the timestamp for each location. Vessels are assigned to one of 11 different vessel types based on their classification, as transmitted by static AIS messages (type 5 and type 24 messages for Class A and Class B, respectively). However, the classification listed in the AIS messages can contain errors as this information is manually submitted and is therefore prone to human error. In order to identify tugs from other vessels, the vessel type was verified using an external service provided by IHS Sea-Web.

In order to only report participation on eligible transits, every transit with a total length less than half of the typical transit length (approximately 28.2 Nautical Miles) have been filtered out in the participation analysis (Sections *III)1)* and *III)2)*). This measure was taken after identifying that some transits were very short distances between two coastal locations, thus could not reasonably be expected to use the inshore lateral displacement zone or the outbound shipping lane. .

b) Indicators

Indicators were measured for each vessel trip using spatial analysis. These indicators were used to automatically identify whether the trip was to be considered for the analysis or not. This also allowed the quantification of the ratio of each transit within the different zones.

In 2019 and 2020, tug vessels were asked to transit within the outbound lane of the Traffic Separation Scheme (TSS) or inshore lateral displacement zone (See **Figure** 1). The 1000m zone in-between named “Buffer Zone” was intended to act as a separator between inshore traffic and outbound lane traffic.

Figure 2 represents all the tug transits based on Terrestrial AIS data that were used for this analysis of the 2020 trial. The transits filtered out as mentioned in the last sub-section II)3)a) are represented in purple, while all the other transits are represented in orange.

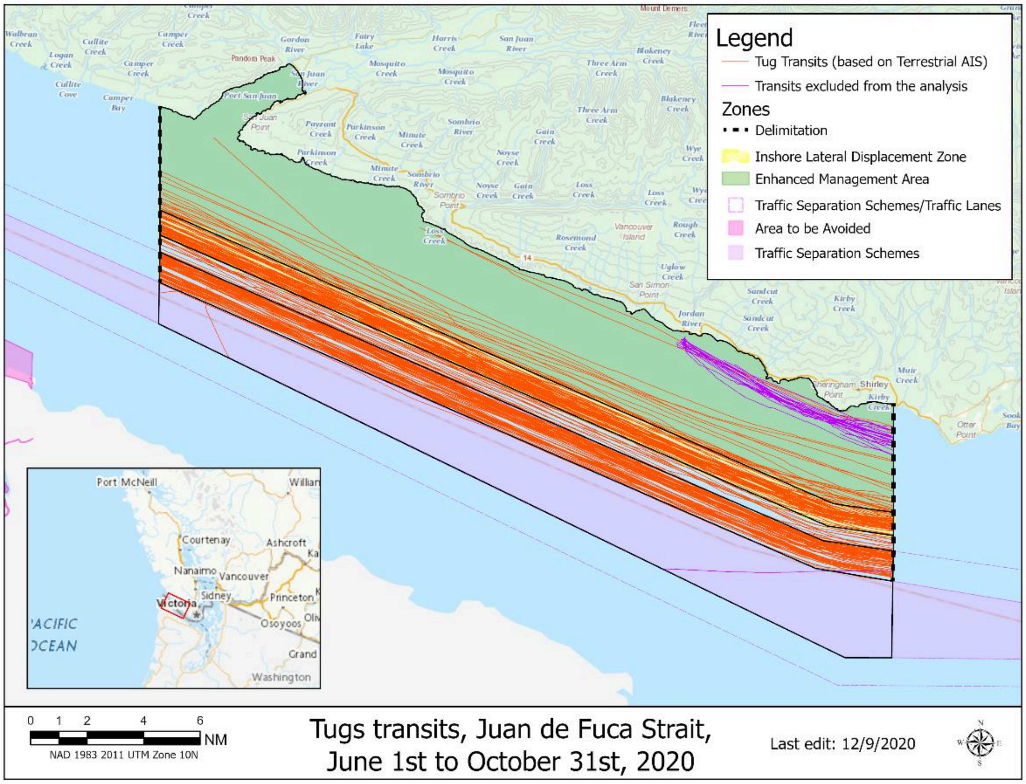

***Figure 2**: All tug transits during the lateral displacement period in 2020.*

c) Heat maps of traffic density change

The vessel tracks were used to create heat maps of the tug traffic for both 2017, 2019 and 2020 and a comparison of the tug traffic density between 2017 and 2020, and between 2019 and 2020 (See Section **III)**, **Figure 6:** Change in Traffic Density for Tugs and **Figure 7:** Change in Traffic Density for Tugs between 2019 and 2020 for a more detailed description).

The heat maps were created using the software ArcGIS Pro (developed by Esri) with the Spatial Analyst extension. The Line Density tool was applied to the tracks previously created from the AIS locations. The parameters used for this analysis are as follows:

- Output Cell Size: 0.0001 degrees
- Search Radius: 0.001 degrees

By comparing the two heat maps from two different years, we can obtain a new heat map showing the change in tug traffic density between those two years to better visualize the impact of the lateral displacement on the traffic patterns.

d) Distribution Analysis

In order to confirm and better quantify the shift in tug traffic in the Strait of Juan de Fuca due to the initiative, a distribution analysis was undertaken on the reported AIS positions in the study area.

The indicator used was the distance of the points to the Traffic Separation Zone (TSZ). By displaying the distribution of the position reports received through AIS, we were able to identify a mean distance to the TSZ and measure the change between 2017, 2019, and 2020 (See Section **III)** and **Figure 5:** Distribution Analysis for Tugs for a more detailed description).

In **Figure 3**, we can see the probability density (measured as the number of AIS position reports divided by the total number of observation multiplied by the bin width) of the position reports received by tugs navigating in the zone in 2020 on the Y-axis and the distance to the TSZ in nautical miles for the X-axis. The integral under the histogram and the Kernel Density Estimation are both equal to one.

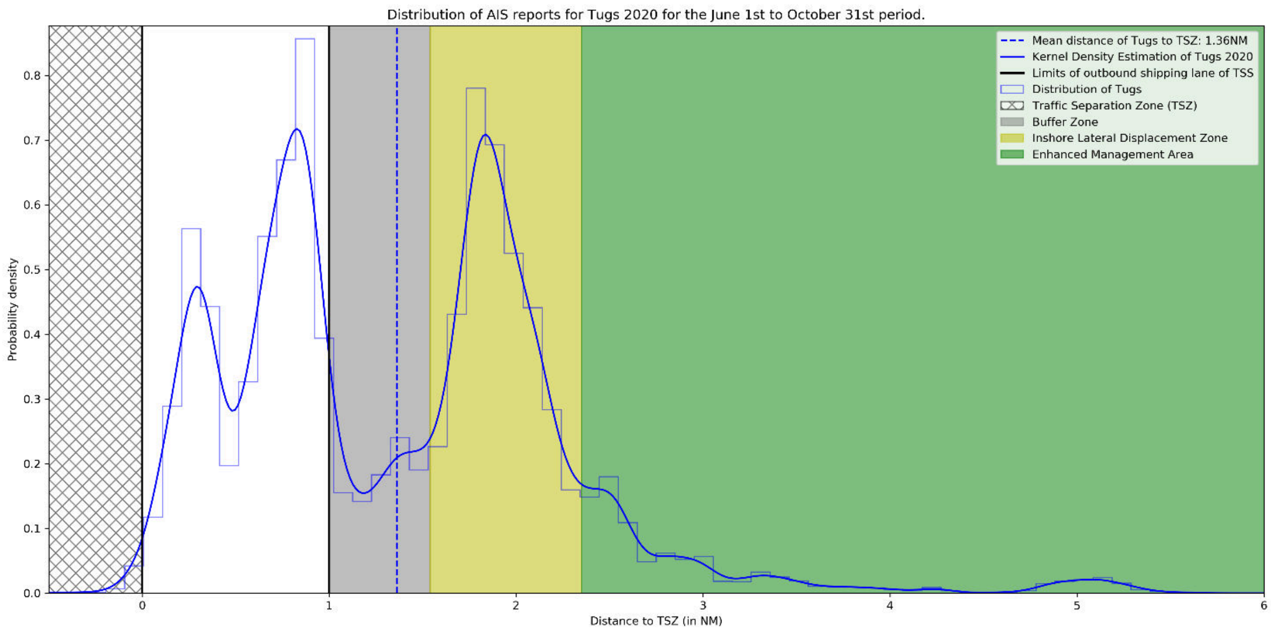

Figure 3: *Distribution analysis (tug vessels positions in 2020)*

III) TUG TRAFFIC ANALYSIS

1) Overall participation

One hundred and sixty-eight (168) tug transits were observed in the study area between June 1 and October 31, 2020 (**Table 1**).

Achieving Rate for Tugs						
	2017 (baseline, no trial) June 17th to October 31st		2019 (Year 2 of Trial) June 17th to October 31st		2020 (Year 3) June 1st to October 31st	
# Trips ≥75% in the Outbound Shipping Lane and Inshore Lateral Displacement Zone	46	48%	85	70%	124	74%
# Trips ≥50%-<75% in the Outbound Shipping Lane and Inshore Lateral Displacement Zone	6	6%	8	7%	14	8%
Subtotal ≥50% in the Outbound Shipping Lane and Inshore Lateral Displacement Zone	**52**	**55%**	**93**	**76%**	**138**	**82%**
# Trips ≥25%-<50% in the Outbound Shipping Lane and Inshore Lateral Displacement Zone	5	5%	6	5%	11	7%
# Trips >0%-<25% in the Outbound Shipping Lane and Inshore Lateral Displacement Zone	12	13%	5	4%	7	4%
# Trips 0% in the Outbound Shipping Lane and Inshore Lateral Displacement Zone	26	27%	18	15%	12	7%
Subtotal <50% in the Outbound Shipping Lane and Inshore Lateral Displacement Zone	**43**	**45%**	**29**	**24%**	**30**	**18%**
Total # of Tug Trips	**95**		**122**		**168**	

***Table 1**: Tugs lateral displacement achieving rates 2017, 2019, 2020*

<u>Note:</u> The numbers presented in **Table 1** for 2017 and 2019 are based on the temporal parameters of the 2019 Lateral Displacement Trial. In 2020, the time period changed, with the 2020 initiative starting seventeen days earlier, which influences the total number of tug transits observed. In 2018, the first year of the trial, tugs were asked to laterally displace as close as possible to the outbound shipping lane. A 1000m buffer was added in 2019 and 2020. Since the geographic study area is different, the results of the 2018 trial year are not included in this comparison report.

Tug transits were classified based on the proportion of the trip conforming to the vessel's presence in the outbound shipping lane ("outbound lane") and Inshore Lateral Displacement Zone ("Inshore Displacement Zone"). In 2020, roughly 74% of tug transits occurred with greater than 75% presence in the outbound lane and Inshore Displacement Zone. Collectively, 82% of trips had greater than or equal to 50% presence in these two zones. The percentage of trips spending greater than 50% of their time in the Inshore Lateral Displacement Zone increased significantly from 55% to 76% between 2017 and 2019 and increased even further in 2020 (82%). Only 7% of the trips for tugs in 2020 did not go through the Outbound shipping lane or the Inshore displacement Zone compared to 15% the previous year, and 27% for the baseline year in 2017.

Zone	2020 cumulative			
	≥50% of the tug transit in the zone		≥75% of the tug transit in the zone	
Outbound shipping lane	77	46%	73	43%
Buffer zone	13	8%	5	3%
Inshore lateral displacement zone	60	36%	50	30%
Enhanced management area	16	10%	14	8%

***Table 2**: Breakdown of tug transits by zone for 2020*

Table 2 presents a breakdown of tug transits by zone (as defined in **Figure 1**: Study area zones for the Lateral Displacement Initiative in 2019 and 2020.**Figure 1**). A majority of the participating transits (77 out of 168) spent 50% of more of their time in the outbound shipping lane. Out of the thirty (30) transits that did not participate, sixteen (16) tug transits spent more than 50% of their time in the enhanced management area while thirteen (13) transits used the buffer zone for more than 50% of their transits.

__Note:__ Some transits are not represented in this table because they did not spend more than 50% of their transit in any of the zone but only a minority of their transit in multiple zones.

2) Temporal distribution

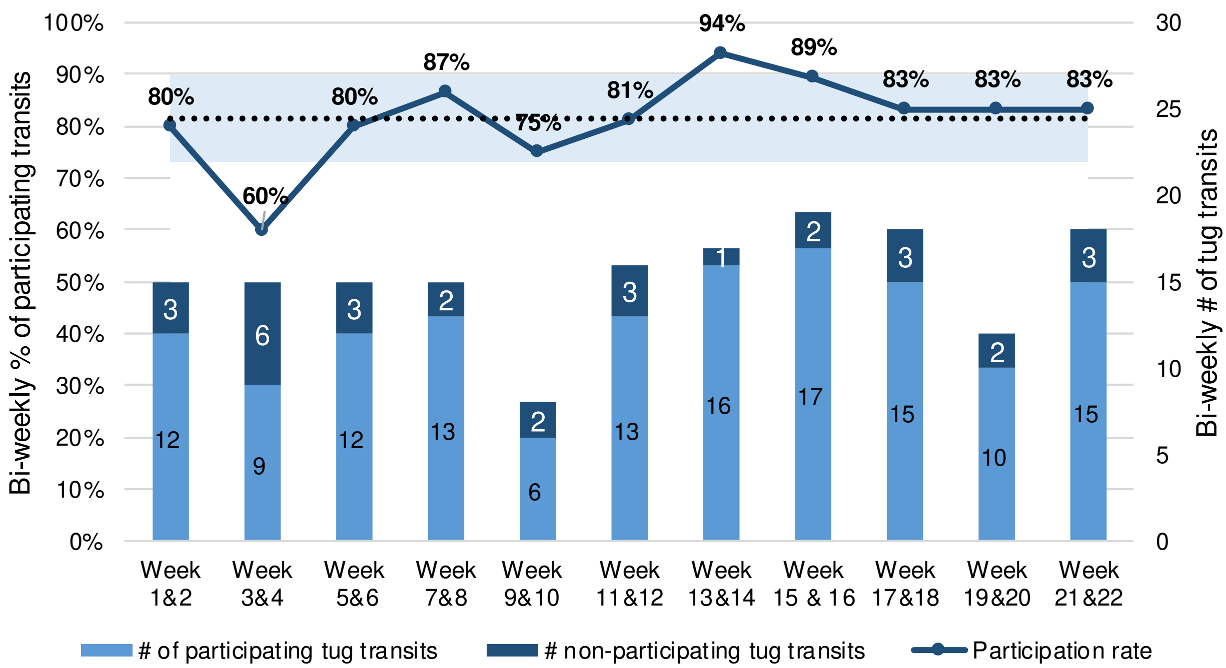

***Figure 4**: Bi-weekly achievement analysis (Trips ≥50% in the outbound shipping lane and Inshore displacement zone)*

The bi-weekly distribution of the participating transits as shown in **Figure 4** shows a certain consistency for the participation with only two outliers (outside of the confidence interval, in grey in the figure above, equal to the average participation rate +/- one standard deviation). The two lowest percentages of participation occurring for week 3 & 4 (60%) and for week 9 & 10 (75%).

3) Spatial distribution

The tug traffic distribution patterns shown in **Figure 5** provides a comparison of the position reports for 2017, 2019 and 2020.

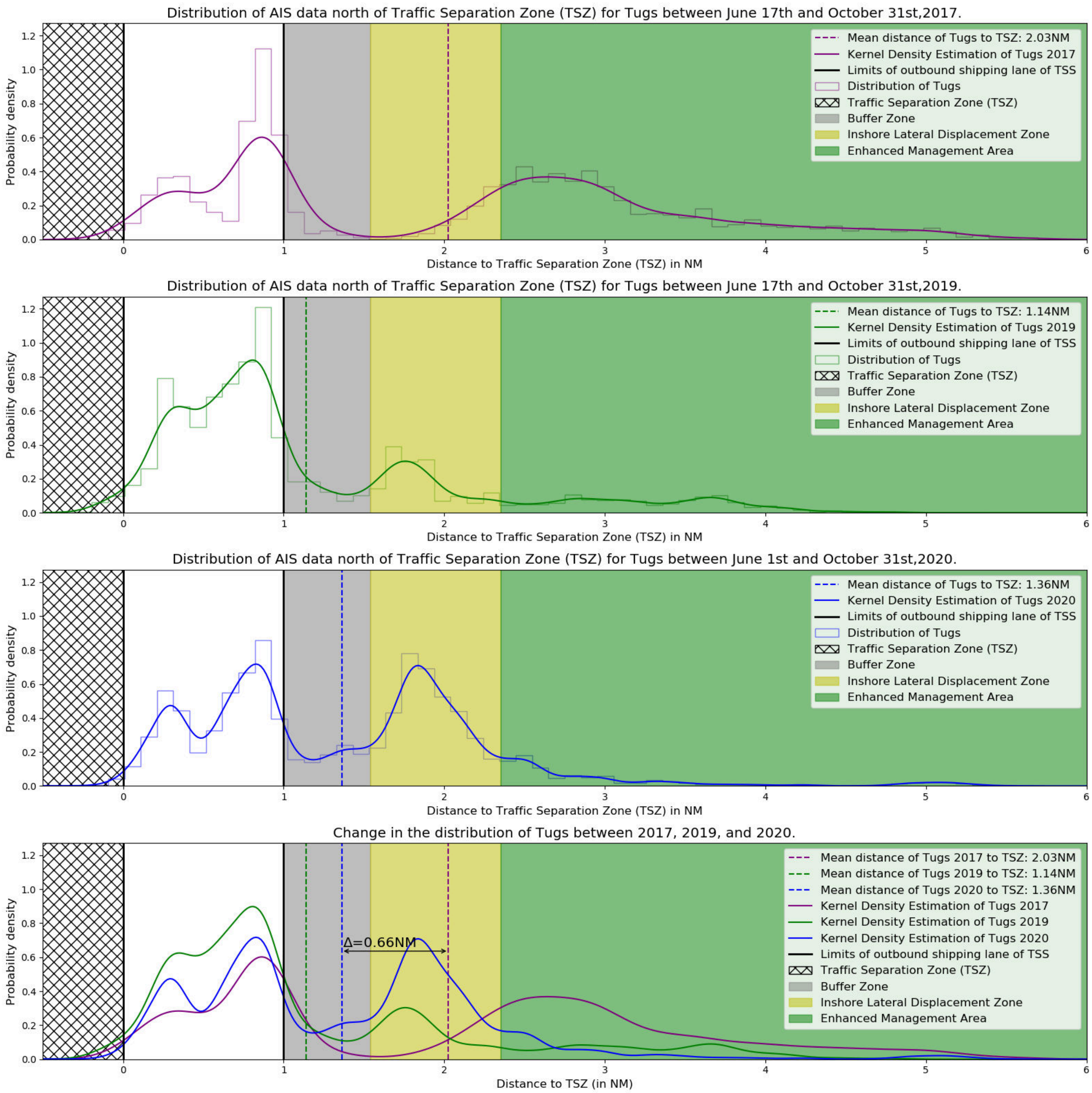

***Figure 5:** Distribution Analysis for Tugs*

This graph clearly shows a change in the traffic pattern for tug vessels following the lateral displacement measures in place in the Strait of Juan de Fuca.

Traffic in the outbound shipping lane of the Traffic Separation Scheme presents a similar distribution for the three periods with two modes, with the one further away from the Traffic Separation Zone displaying a higher density. The density in this zone is lower in 2020 than it was in 2019, but slightly higher than in 2017. This difference can be explained when looking at the other zones on the chart. Indeed the density of tug position reports in the Inshore Lateral Displacement Zone in 2020 is much higher than in 2019 and 2017 (for which it was almost nonexistent). Overall, the mean distance to the TSZ varied from 2.05 NM in 2017 to 1.14NM in 2019 to 1.36NM in 2020, hence a shift of 0.66NM away from the Enhanced Management Area. The increase of that value between 2019 and 2020 is indicative of the higher density of tug position reports in the Inshore Lateral Displacement Zone vs. the outbound shipping lane of the Traffic Separation Scheme. The effect of the initiative is clearly apparent by the reduced distribution within the Enhanced Management Area, with higher modes in both the outbound shipping lane of the TSS and the Inshore Lateral Displacement Zone.

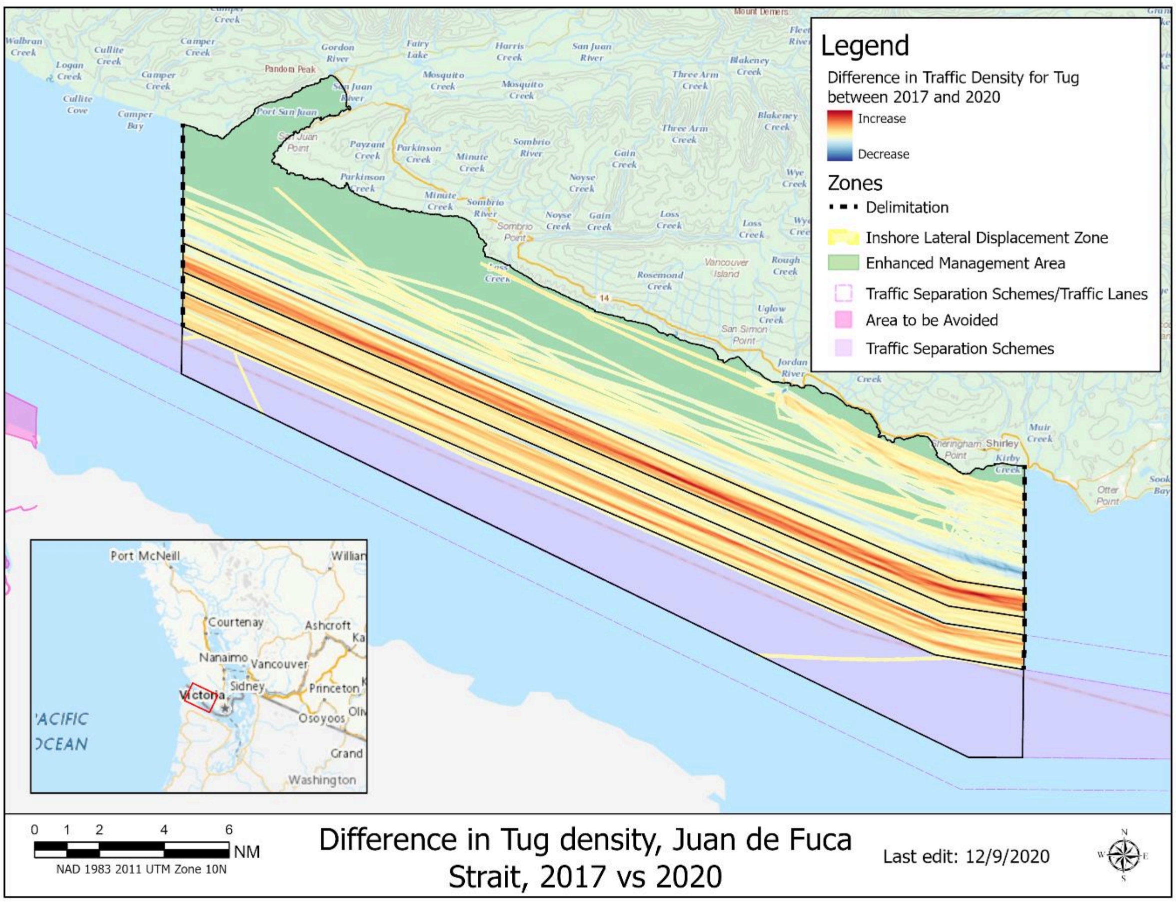

Figure 6: *Change in Traffic Density for Tugs between 2017 and 2020*

Figure 6 displays the trend observed in **Figure 5** as we see a clear increase in traffic for tugs in the northern part of the outbound lane of the TSS as well as in the Inshore Lateral Displacement Zone.

We can also identify a relative decrease in traffic in the Enhanced Management Area in 2020.

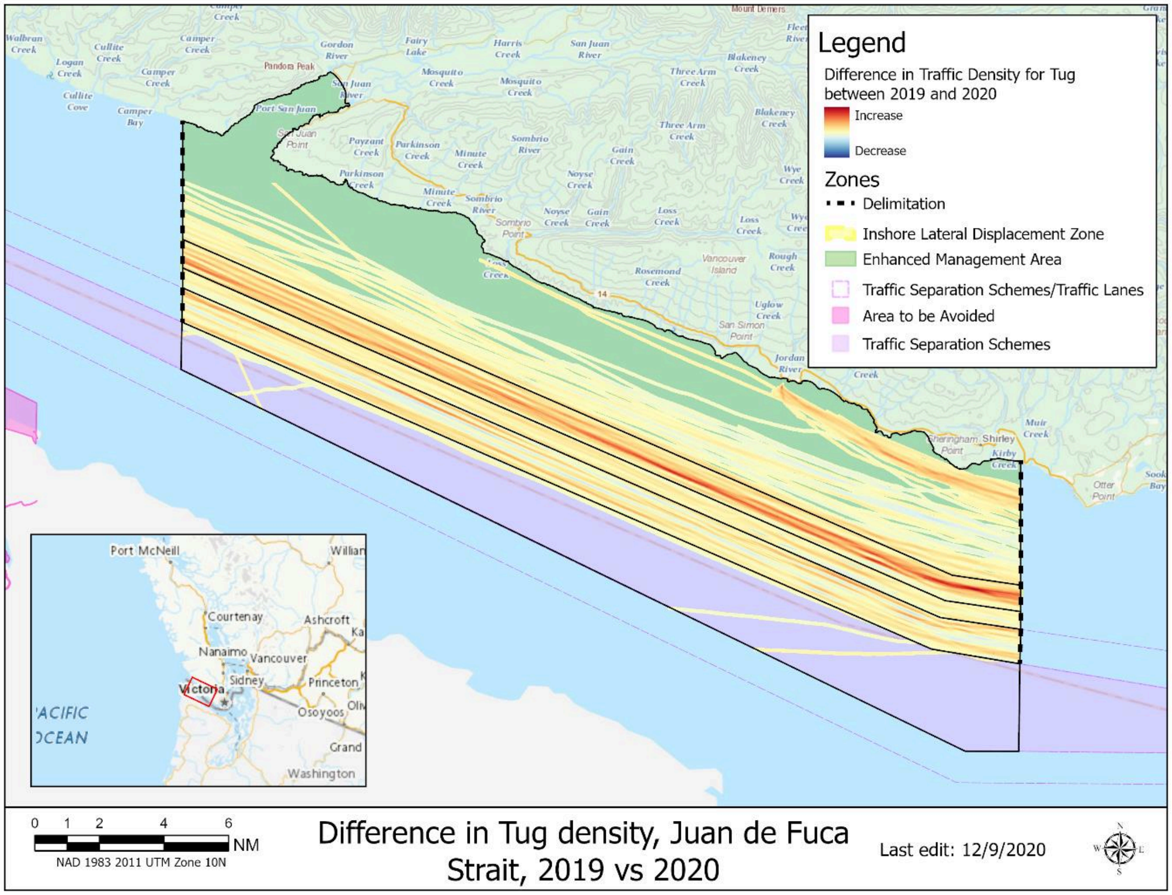

***Figure 7:** Change in Traffic Density for Tugs between 2019 and 2020*

Figure 6 displays the other trend observed in **Figure 5** as we see a clear increase in traffic for tugs in the Inshore Lateral Displacement Zone in comparison to 2019.

IV) TRAFFIC SEPARATION ZONE ANALYSIS

During the initiative, some tug vessels transited through the Traffic Separation Zone (TSZ). The map in **Figure 8** shows all those transits recorded during the study period in 2020.

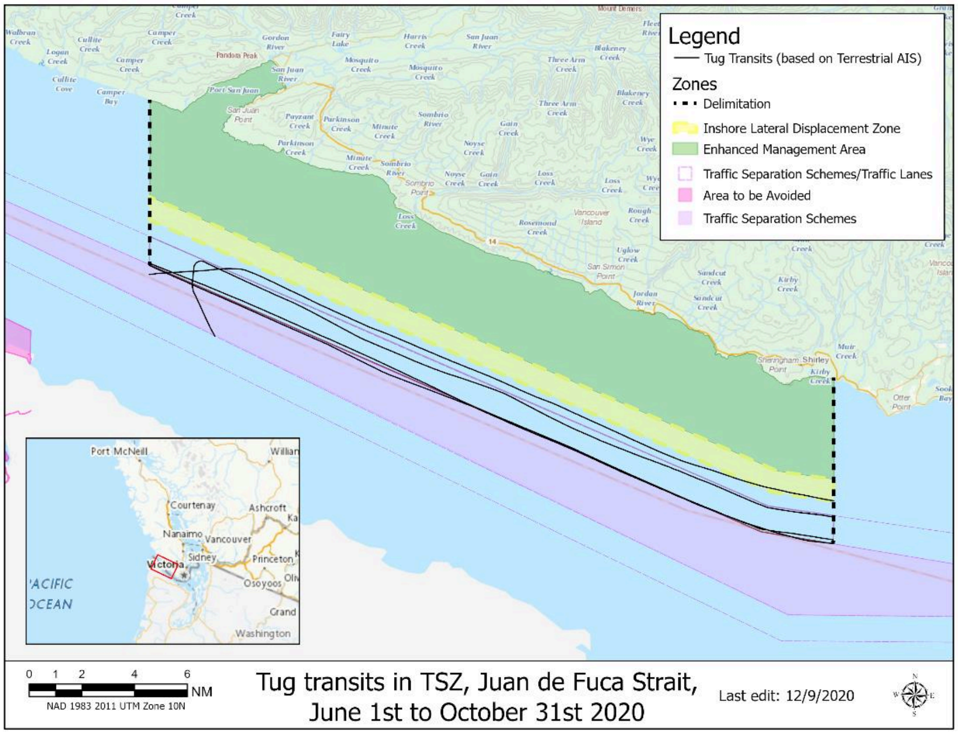

***Figure 8:** Transit of vessels entering the TSZ in the study area in 2020*

The filter used for this analysis is for any trips of 30 minutes or more with at least one AIS position within the Traffic Separation Zone. Overall, four transits were identified as entering the TSZ while transiting in the study area in the outbound lane of the TSS during the study period in 2020.

Figure 9 shows the profile of the tug transits that entered the TSZ during the study period in 2020. The distance to the northern edge of the TSZ is represented on the y-axis, while the relative time elapsed since the vessel entered the study area is depicted on the x-axis. This enables us to see that out of the four transits analyzed here, two of them seems to cross the TSZ to go on the southern side of the TSS (blue and red lines), while the other two transits stay within the first 0.16 NM of the TSZ.

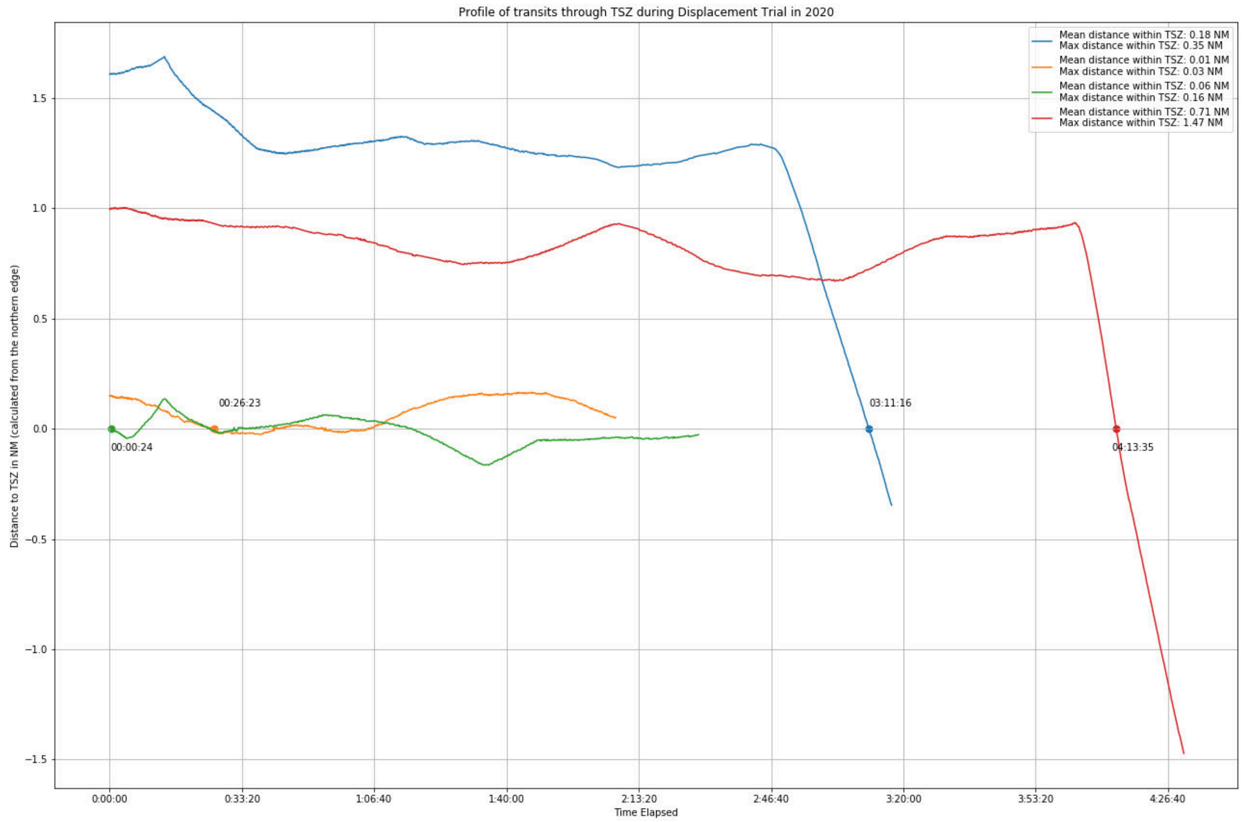

Figure 9: *Distance-Time profile for the TSZ transits in 2020*

V) SPEED ANALYSIS

This analysis represents the average distribution of speed for tugs in the study area per zone in 2017, 2019 and 2020 with boxplots. This type of chart shows the median value with a yellow line, the mean value with a green triangle, the interquartile range (IQR, going from the first quartile to the third quartile) with a blue box, a "minimum" and a "maximum" (defined by Q1 – 1.5 x IQR and Q3 + 1.5 x IQR) with "whiskers". Some outliers are also represented by blue dots outside of whiskers.

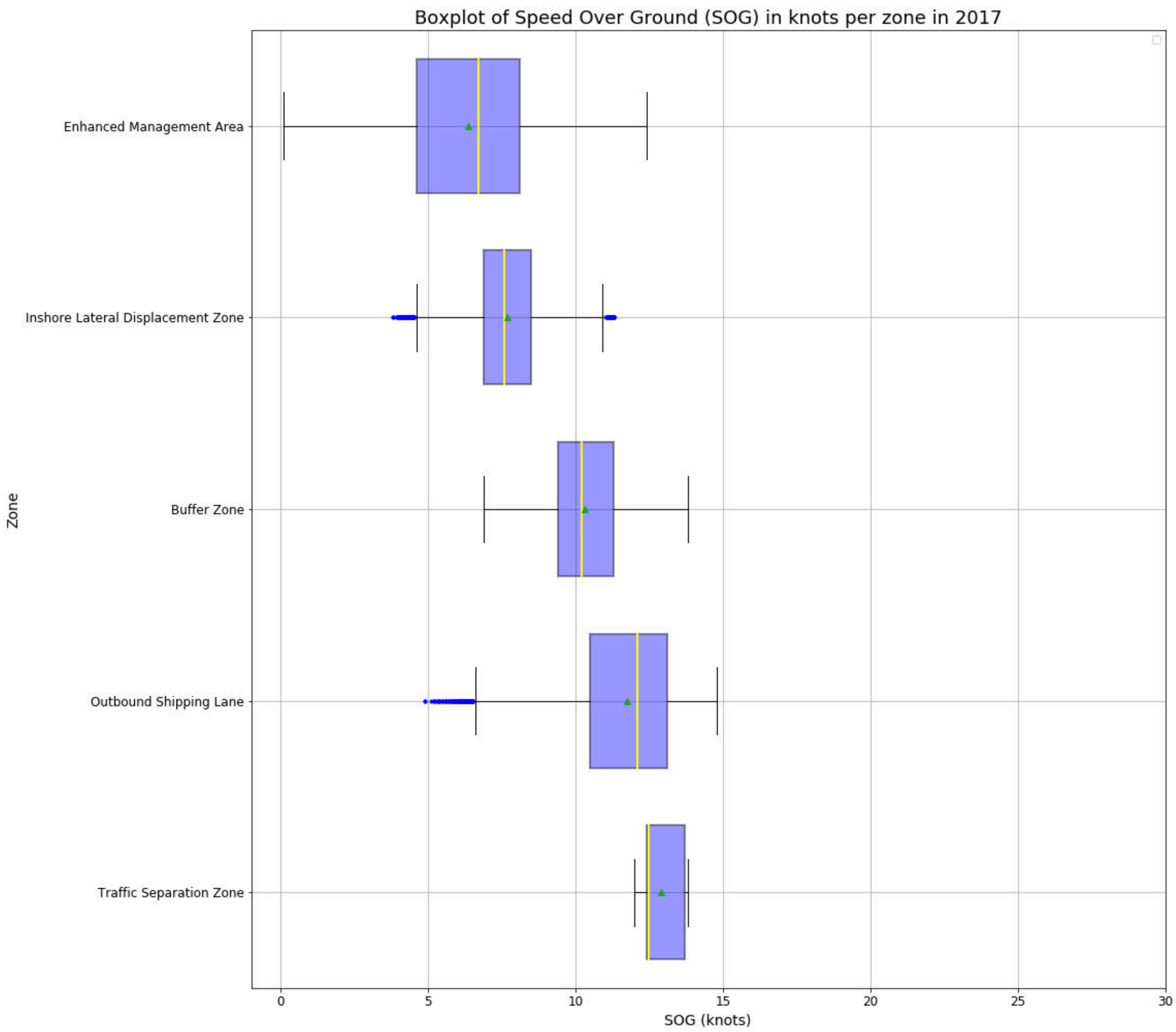

Figure 10: *Boxplot comparing tugs speeds in the Strait of Juan de Fuca during the study period in 2017 measured in the different zones (Source: AIS)*

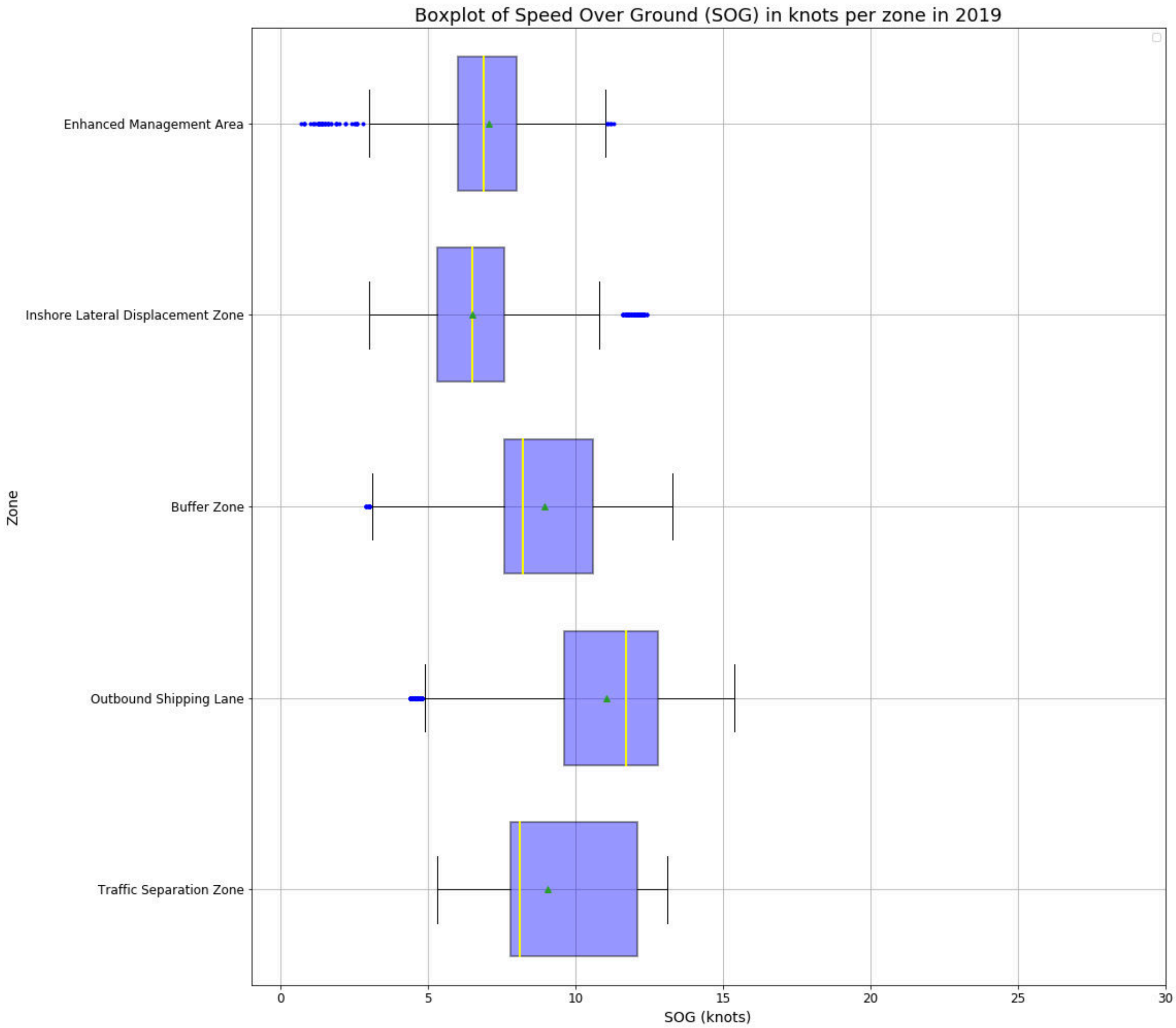

Figure 11: *Boxplot comparing tugs speeds in the Strait of Juan de Fuca during the trial period in 2019 measured in the different zones (Source: AIS)*

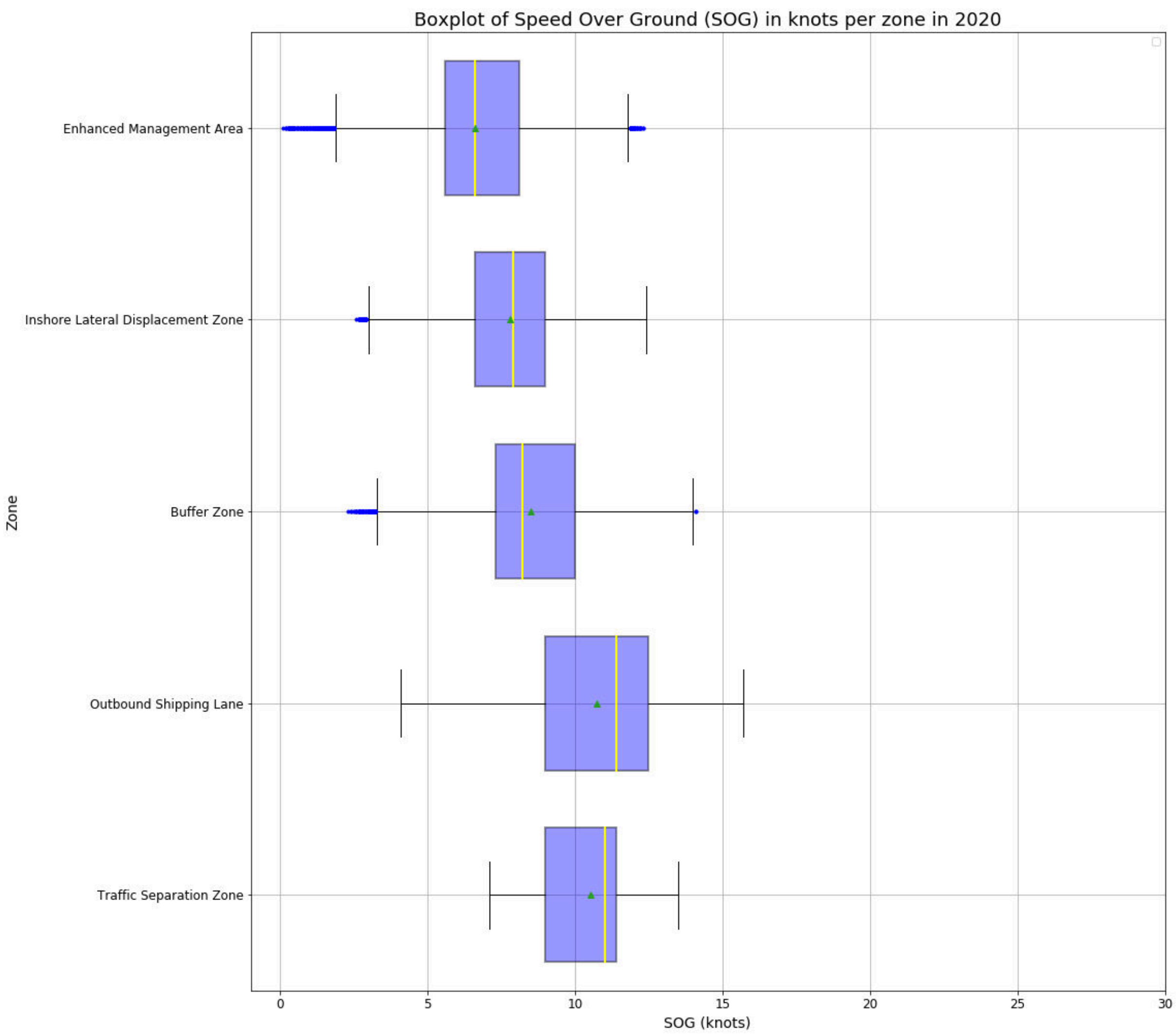

Figure 12: *Boxplot comparing tugs speeds in the Strait of Juan de Fuca during the study period in 2020 measured in the different zones (Source: AIS)*

Mean Speed Over Groung (in knots) by zone per year	Traffic Separation Zone	Outbound Shipping Lane	Buffer Zone	Inshore Lateral Displacement Zone	Enhanced Management Area
2017	12.89	11.74	10.30	7.68	6.35
2019	9.06	11.05	8.95	6.49	7.05
2020	10.53	10.74	8.48	7.79	6.68

Table 3: *Mean Speed Over Ground by Zone per year for tugs (Source: AIS)*

We can see from **Figure 12** and **Table 3** that most tug vessels navigated between 5 and 13 knots in this area in 2020.