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Channel Utilization in South Louisiana Using AIS Data, 2011-2012

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ABSTRACT: South Louisiana is undergoing rapid land loss and the construction and utilization of navigation channels by the offshore oil and gas industry, the commercial fishing industry, the oil refining industry, and freight shippers is one cause. A network of natural and man-made navigation channels support commerce and industry throughout the region, but no quantitative information is available on the users of the channels and their contribution to land loss. The purpose of this note is to characterize utilization across eight channels in South Louisiana using data from the Automatic Identification System. Approximately 125,000 vessels used the channels over a two year period between 2011-2012. The Mississippi River was the most heavily utilized channel with an average of 345 vessels per week across the report zone, followed by Bayou Lafourche and Sabine Pass with about 195 vessels per week. The oil refining industry was the primary user of the Calcasieu and Sabine Pass channels while the freight industry was the primary user of the Mississippi River. The offshore oil and gas industry were the primary users of Bayou Lafourche, the Houma Navigation Canal, the Atchafalaya River and Freshwater Bayou.

1 INTRODUCTION

The U.S. Army Corps of Engineers (COE) constructs and maintains man-made and natural waterways in South Louisiana to support the Gulf of Mexico (GOM) offshore oil and gas industry, serve as a conduit for recreational and commercial fishing, control flooding, provide access to Gulf Coast refineries and liquefied natural gas (LNG) facilities, and link the agricultural and industrial centers of the Mississippi River Valley with global markets. While the waterways provide economic benefits to a large number of users, they also contribute to land loss. The economic and ecological costs of land loss represent an external cost borne by current and future coastal residents, Louisiana taxpayers and ecosystem users.

A question that frequently arises in regulatory hearings and Environmental Impact Statements (BOEM 2012) regards the primary user groups of the channels and their relative proportion of use. No defensible and reliable data exists on channel usage, and even basic questions such as how many vessels utilize a specific channel has not been addressed. This study is the first step in the scientific analysis to support coastal impacts and quantify the manner in which channels are utilized.

When vessels pass through a navigation channel they create wake which transmits energy to the shoreline suspending sediment and leading to shoreline retreat and channel widening (Bauer et al. 2002; Hoffman et al. 2008). The rate of channel widening averages 1 m/yr, but is up to 6 m/yr for some canals in Louisiana (Thatcher et al. 2011). The energy imparted on the shoreline is a function of channel traffic, vessel size, hull shape and speed, as well as the geometry and location of the channel, bottom types and other factors. The ability of ships to mobilize sediments and contribute to channel erosion has been studied in the St. Lawrence River, the San Joaquin river delta, and elsewhere, but to date, no studies in the GOM coastal zone have been conducted.

The purpose of this paper is to quantify vessel utilization patterns in the major navigation channels in South Louisiana to inform future studies and regulatory reform. This is the first attempt to quantify vessel usage in the region and statistics are included on traffic volume and vessel size, class and speed. These data can be coupled with ship-induced wake models to estimate the energy imparted on the shoreline by passing vessels to predict rates of ship-induced channel widening, to understand the impact of specific industries (i.e. the offshore oil and gas industry) on channel widening, and to identify areas of particular concern.

2 METHODS

2.1 *Automatic Identification System*

The Automatic Identification System (AIS) is an automated tracking system used on ships for locating and identifying vessels and avoiding collisions. The automatic identification system broadcasts information on ship identity, speed, direction and position every 2 to 10 seconds while underway, and every 3 minutes while at anchor (Tetreault 2005). Automatic identification system information is recorded by shipping intelligence firms that collect data from onshore and offshore receivers and provide commercial access (Tsou 2010, Yang et al. 2012). Automatic identification system data has been used in studies of human impacts on marine ecosystems, including exhaust emissions from marine traffic and underwater noise, anticollision (Felski and Jaskolski 2013) and safety (Stupak 2014).

Coast Guard regulations require any commercial vessel over 65 ft in length and on an international voyage (other than passenger vessels less than 150 gross tons and fishing vessels) to carry an operational AIS transmitter. In addition, commercial vessels over 65 ft navigating in certain specified areas (including Berwick Bay, the Lower Mississippi River, Port Arthur and Galveston Bay) are required to carry operational AIS systems (Tetreault 2005). The AIS uses a numeric code, the maritime mobile service identity or MMSI number assigned by the Federal Communication Commission, to identify vessels.

2.2 *Report Zones*

Report zones for each channel were located inland (north) of GOM shorebases to capture movements on inland waterways (Figure 1). Most shorebases in Louisiana are located near the mouth of navigation channels adjacent to the Gulf of Mexico. Thus, the report zones collected information on movements from inland suppliers to shorebases, but did not collect data on vessel traffic from shorebases to offshore locations.

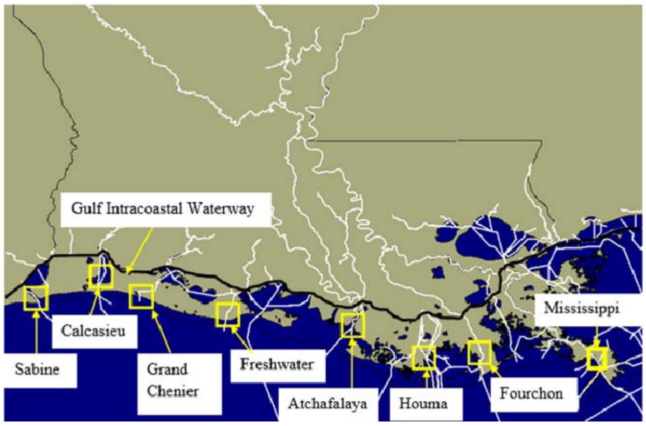

Figure 1. Top: Navigation channels and approximate locations of the report zones included. Bottom: the Houma (left) and Bayou LaFourche (right) report zones.

2.3 *Evaluation Period*

The AIS system collects data on ship name, MMSI number, and zone entry and exit time every time a ship transited each report zone. Data were collected over 104 weeks from January 1, 2011 through January 1, 2013 using the commercial vendor ShipTracks. Data collection occurred after the response to the *Deepwater Horizon* oil spill was concluded and the deepwater drilling moratorium had been lifted, and after the Mississippi River Gulf Outlet, a navigation channel linking New Orleans with the GOM, had been closed.

2.4 *Data Processing*

Ship name and MMSI number were matched to ship data using the U.S. Coast Guard and U.S. FCC vessel databases. These databases provided information on vessel gross tonnage, class and length. Gross tonnage and length were selected as proxies of vessel size because they were available for a larger portion of the data set than other measures of size such as draft, breadth, and deadweight. Gross tonnage correlates with other relevant size measures. The directionality of vessels was not recorded.

The U.S. Coast Guard and FCC use different classification systems, and classes for many vessels were not identified in the datasets. Vessel class information is critical in the analysis, and when class was not identified in the FCC or Coast Guard databases a vessel tracking website (marinetraffic.com) was employed. Classifications were consolidated into thirteen vessel classes (Table1).

Average speed in the zone was determined as the difference between the entry and exit time divided by the zone length. Vessel speeds were excluded if less than 2.5 knots[1] or greater than 20 knots as it was assumed that vessels either stopped or did not travel the entire length of the zone.

[1] One knot is one nautical mile per hour.

Table 1. Average characteristics of vessels transiting eight South Louisiana navigation channels, 2011-2012.

Class	Average length (ft)	Gross tonnage	Number of entries	Percentage (%)	Speed (knots)
Barge	144	783	351	0.3	7.8
Crewboat	134	96	10,899	8.7	11.8
Cruise ship	873	118,328	595	0.5	12.2
Fishing vessel	49	507	1,150	0.9	9.2
Freight	611	16,663	14,593	11.6	10.3
Government/pilot	26	82	6,253	5.0	6.8
Industrial vessel	127	1,031	344	0.3	6.4
OSV	149	179	34,469	27.5	8.7
Other commercial	67	125	763	0.6	7.6
Recreational	29	113	1,109	0.9	8.7
Tank ship	674	23,806	14,376	11.5	9.8
Tug	74	126	37,602	30.0	6.5
Unknown			2,799	2.2	8.2
Total			125,303		8.6

2.5 *Missing Data*

For vessels where gross tonnage data were not available, the average gross tonnage of vessels of the same class in the same channel was used as an estimate. For a small portion of vessels (about 2%), reliable information about class was unavailable from any source and gross tonnage was ignored in these cases. "Empty" periods in which no vessel movements were recorded for at least 12 hours were generally isolated and associated with known periods of low activity (e.g. December 25, during tropical storms). In other cases, empty periods appear correlated with other empty periods and it is likely that these occurred due to errors in the transmission or recording system. When these occurred, all data from the suspect week was removed from the analysis. As a result, the number of weeks in the analysis ranges by channel from 93 to 104.

3 RESULTS

3.1 *Regional Characteristics*

3.1.1 *Aggregate Count*

In total, 125,303 entries were recorded from January 1, 2011 to January 1, 2013 (Table 1). Tugs and OSVs are the most common channel users and together account for 57% of zone entries. Tank and freight ships account for 23% of entries, and crewboats and pilot vessels account for most of the remainder. On average, 171 vessels per day transited the navigation channels: 51 tugs, 47 OSVs, 20 freight ships, 20 tank ships, and 15 crewboats. Fishing and recreational vessels each accounted for about 1% of vessel traffic, but many fishing and recreational vessels do not carry AIS transmitters and would not be included in the count.

3.1.2 *Size Distribution*

Cruise ships and tank ships are the largest vessels using the channels, and government/pilot and recreational vessels were the smallest users (Table 1). A majority of OSVs and tugs are between 50 to 100 GT, but on average OSVs are larger (Figure 2). A large number of utility boats, mini-supply vessels, and crewboats are approximately 90 to 100 GT. The number of large PSVs and AHTSs (>1,000 GT) using the channels is relatively low which is likely due to the placement of the report zones. Most large PSV and AHTS movements occur from shorebases to the Gulf of Mexico.

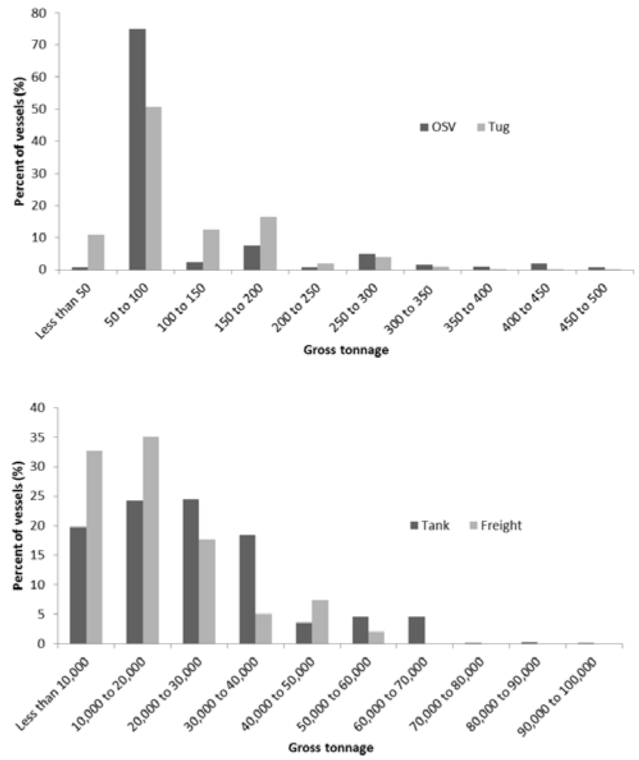

Figure 2. Size distribution of vessels using navigation channels in South Louisiana, 2011-2012.

Tank ships passing through the channels were larger than freight ships. Approximately 90% of tank ships were less than 50,000 GT and 10% of tanks ships were 50,000 to 70,000 GT. Less than 1% of tank ships were greater than 70,000 GT with the largest tank ships being 150,000 GT. Approximately 85% of freight ships were under 30,000 GT, 15% were 30,000 to 60,000 GT and none were larger than 60,000 GT. Very large tank ships, container ships, and bulk carriers do not typically use the ports of South Louisiana because of the depth of the waterways.

3.1.3 *Speed*

Vessels moved through the channels at an average speed of 8.6 knots (Table 1). Crewboats and cruise ships were the fastest channel users, consistent with the time-sensitive nature of their activities, while tugs and industrial vessels moved more slowly than other vessel classes. Freight ships and tankers moved relatively quickly, likely due to their heavy utilization in the larger Mississippi and Calcasieu Rivers.

In the crewboat and OSV classes, a significant number of vessels were recorded as travelling over 20 knots and in the tug class, a significant number were estimated to travel less than 2.5 knots. These data points were excluded for the estimation of average speed. All vessel classes showed a similar rightward skew with long tails, suggesting that a minority of vessels travel through the channels at relatively high speeds, potentially increasing wake effects on the shoreline (Figure 3).

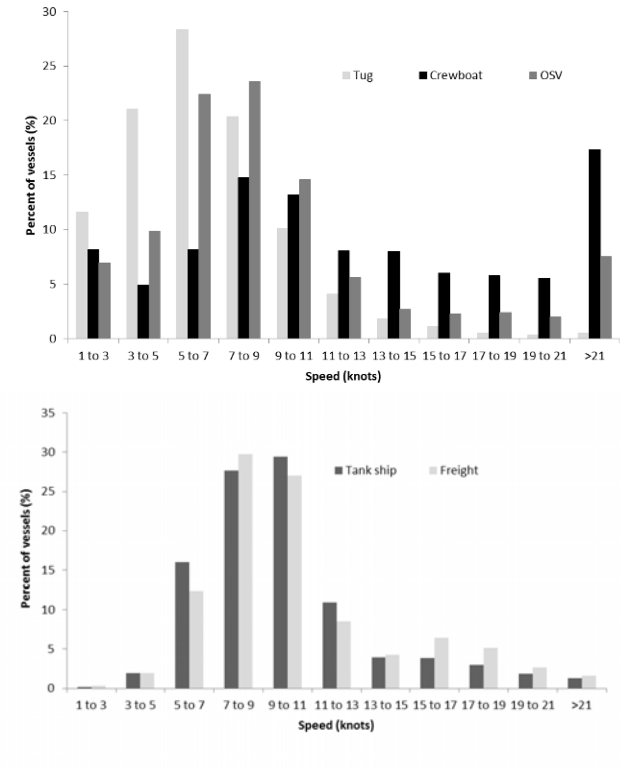

Figure 3. Distribution of vessel speeds by class using navigation channels in South Louisiana, 2011-2012.

3.2 *Channel Characteristics*

3.2.1 *Aggregate Count*

The Mississippi River is the most heavily utilized channel with 35,880 vessel entries over a 104 week period, or about 345 vessels per week, and a total of 433 million GT (Table 2). Bayou Lafourche and Sabine Pass had an intermediate level of utilization in terms of traffic at about 20,000 total entries or 195 vessels per week. The amount of gross tonnage passing through Sabine Pass was 174 million GT while Bayou Lafourche was only 2.5 million GT, indicative of the different types of vessels transiting the channels. Calcasieu experienced a relatively large quantity of gross tonnage (63 million GT), but a modest level of traffic (72 trips per week) due to the large tanks ships that are the primary channel users. Houma, the Atchafalaya River and Freshwater Bayou experienced relatively similar levels of tonnage and traffic with between 118 and 158 trips per week and between 1.6 and 2.2 million GT. The Mermentau River experienced minimal traffic during the period of evaluation.

Table 2. South Louisiana navigation channel utilization and gross tonnage, 2011-2012.

	Number of weeks	Million GT	Number of entries	Traffic/ week	GT/ week
Mississippi	104	433.4	35,880	345	4,167,452
Bayou Lafourche	104	2.5	20,710	199	24,459
Houma	93	1.6	10,984	118	17,122
Atchafalaya	97	2.2	15,330	158	22,486
Freshwater Bayou	100	2.2	15,678	157	21,878
Mermentau	104	0.06	373	4	542
Calcasieu	104	63.0	7,519	72	606,183
Sabine Pass	104	173.5	19,869	191	1,666,836

3.2.2 *Size Distribution*

In the Mississippi River, Sabine Pass, and Calcasieu, the average vessel was at least 282 ft long and 9,000 GT, while in all other channels, the average vessel was under 150 ft long and 160 GT (Table 3). In Bayou Lafourche, 80% of channel users were under 100 GT and nearly all channel users were under 1,000 GT (Figure 4). Size distributions in the Houma Navigation Canal, Atchafalaya River, Freshwater Bayou, and Mermentau River are similar to those in Bayou Lafourche and were not depicted. In the Mississippi River, a majority of recorded traffic is between 10,000 to 100,000 GT. Calcasieu experienced a relatively uniform distribution of vessels across gross tonnage categories. Sabine Pass is similar to Calcasieu and in all channels very few vessels are in the 1,000 to 10,000 GT range.

Table 3. Average vessel speed and size using South Louisiana navigation channels, 2011-2012.

	Average speed (knots)	Average GT	Average length (ft)
Mississippi	9.8	14,063	405
Bayou Lafourche	6.0	125	129
Houma	7.7	148	98
Atchafalaya	6.5	160	109
Freshwater Bayou	11.8	143	134
Mermentau	6.9	157	130
Calcasieu	6.6	9,576	321
Sabine Pass	9.2	8,911	282

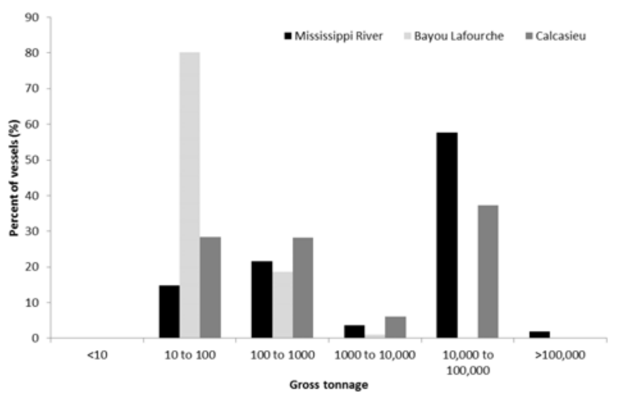

Figure 4. Distribution of vessel size in selected channels, 2011-2012.

3.2.3 *Speed*

Vessels transiting the Mississippi River, Sabine Pass and Freshwater Bayou experienced relatively high average speeds (> 9 knots), while most other channels had average speeds less than seven knots (Table 3). Freight ships and tank ships were primary users of the Mississippi River, while OSVs and tugs were the primary users of Bayou Lafourche, and these vessels moved relatively slowly.

3.2.4 *Class Distribution*

Sabine Pass and Calcasieu show a similar and relatively even distribution of traffic with the tug, OSV and crewboat, and tank ship classes each accounting for 20 to 35% of traffic in both channels and freight ships accounting for about 10% of traffic (Table 4; Figure 5). In the Mississippi River, freight, tank ships and tugs accounted for nearly 90% of traffic and OSVs and crewboat traffic was negligible. In Bayou Lafourche, Houma, the Atchafalaya River, Freshwater Bayou, and the Mermentau River, OSVs and crewboats accounted for about half of traffic with tugs accounting for most of the remainder. Offshore supply vessels were particularly heavy users of Bayou Lafourche, Freshwater Bayou, and the Mermentau River.

In the Mississippi River and Sabine Pass, other vessels (vessels other than freight, tank ships, OSVs, crewboats and tugs) accounted for a significant (>10%) portion of traffic. In Sabine Pass, most of these vessels were small pilot vessels used to ferry maritime pilots to the large tank ships passing through the channel. In the Mississippi River, the other vessel category included a broad range of vessels.

3.2.5 *Industry Users*

The primary industry sector using each channel was determined by assigning each vessel class to one of four industries: offshore oil and gas, refining, freight, or commercial fishing. Offshore supply vessels, crewboats and industrial vessels were assigned to the offshore oil and gas industry, tank ships were assigned to the refining industry, freight ships were assigned to the freight industry, and commercial fishing vessels were assigned to the commercial fishing industry. The assignment of tugs to an industry user is difficult because a single tug may be employed by multiple industries. Therefore, we assumed that tug utilization reflected the overall utilization in a channel and assigned tug trips to industries accordingly. For example, if 30% of vessel traffic in a given channel was composed of tank ships, we assumed that 30% of tug traffic supported the refining industry.

The primary industry by gross tonnage was identical to the primary user by traffic (Table 5). The oil refining industry is the major user of the Sabine and Calcasieu channels, with the freight shipping industry playing an important secondary role. In the Mississippi River, freight shipping accounts for about half of the gross tonnage passing through the channel, and the oil refining industry plays an important secondary role. In all other channels, the offshore oil and gas industry is the primary channel user.

Table 4. Number of trips in South Louisiana navigation channels by vessel type, 2011-2012.

	OSVs/ Crewboats	Tugs	Freight	Tankers	Others	Total
Mississippi	418	11,223	11,875	7,213	5,151	35,880
Bayou Lafourche	13,403	6,240	37	1	1,029	20,710
Houma	4,838	5,430	112	0	604	10,984
Atchafalaya	7,479	6,854	43	4	950	15,330
Freshwater Bayou	13,814	699	41	0	1,124	15,678
Mermentau	270	32	0	0	71	373
Calcasieu	1,687	2,226	876	2,323	407	7,519
Sabine Pass	3,468	4,517	1,687	5,199	4,998	19,869

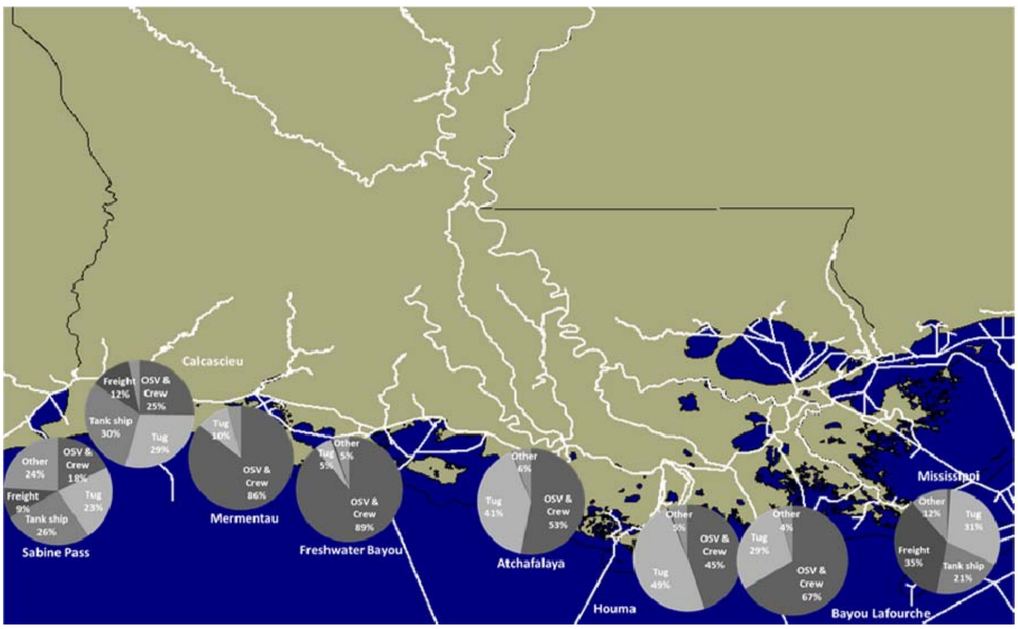

Figure 5. Distribution of the number of vessel entries by class, 2011-2012.

Table 5. Largest users of navigation channels in South Louisiana and relative usage, 2011-2012.

	Largest user	Percentage of GT (%)	Percentage of trips (%)
Mississippi	Freight	48	45
Bayou Lafourche	Offshore oil & gas	93	86
Houma	Offshore oil & gas	77	67
Atchafalaya	Offshore oil & gas	84	75
Freshwater Bayou	Offshore oil & gas	88	93
Mermentau	Offshore oil & gas	90	95
Calcasieu	Refining	77	38
Sabine Pass	Refining	77	38

3.3 *Vessel Frequency*

The time between sequential vessel movement is an important factor in determining coastal impacts and to support scientific investigation in the area. As ships pass through a channel, the energy imparted on the shoreline mobilizes sediment. As the frequency of vessel movements increases, the time between sequential sediment disruptions decreases (Parchure et al. 2007). If vessels pass so frequently that sediment from a previous vessel passage remains suspended in the water column when the next vessel passes, effects on land loss and aquatic and benthic organisms are likely to be more severe. Wake-induced particle settling times are unknown in the study channels and will depend on the characteristics of the sediment and the energy imparted.

Channels with a large volume of traffic will have less time between sequential channel entries (Figure 6). Calcasieu, which has a relatively low volume of traffic has the longest time between sequential entries, and half of the time at least 1.35 hours elapses between entries. In all other channels less than one hour elapses, on average, between sequential vessel passages and in the Mississippi River, half of the time less than 0.32 hours elapses between sequential entries.

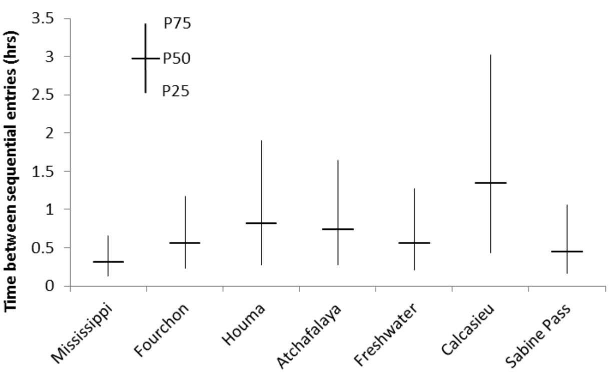

Figure 6. The distribution of times between sequential entries by channel. P50 denotes the median value; P75(P25) denotes the value at which 75(25)% of times between sequential entries are less than the value.

The distributions of times between sequential entries in Bayou Lafourche and the Calcasieu Navigation Canal are exponential (Figure 7) as expected by theory and common in queuing models (Gross and Harris 1998). All of the other channels showed similar patterns. In most channels, a large proportion of traffic occurs at less than 30 minute intervals, and these passages are expected to lead to disproportionate shoreline impacts.

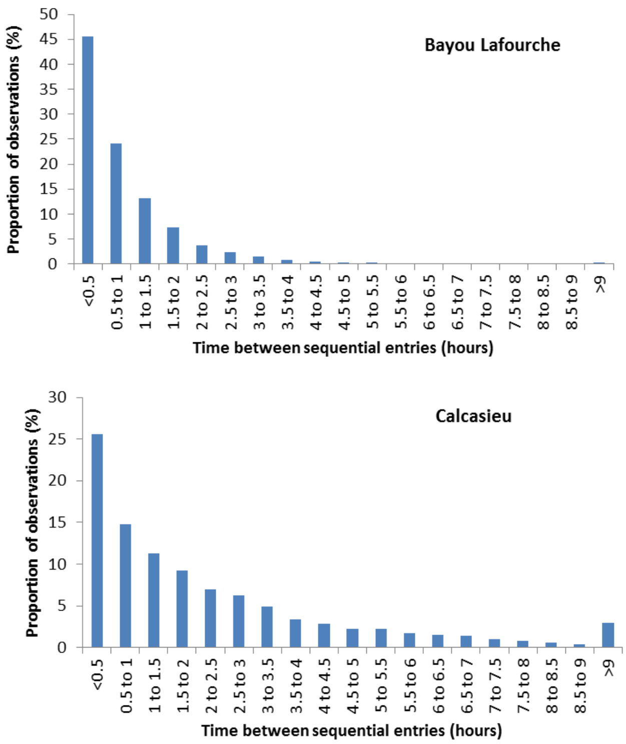

Figure 7. Distribution of times between sequential entries in Bayou Lafourche and Calcasieu, 2011-2012.

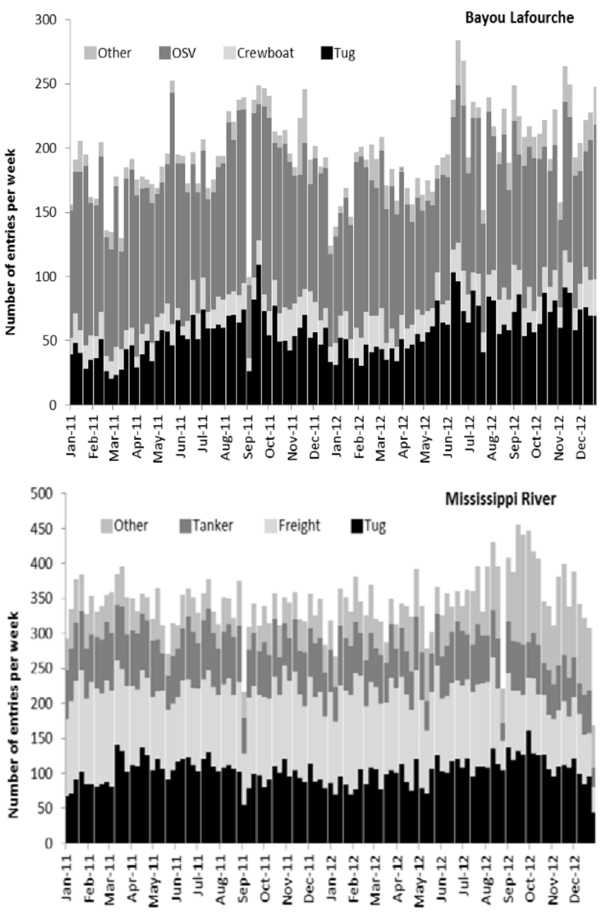

Figure 8. Vessel entries in the Bayou Lafourche and Mississippi River report zones, 2011-2012.

3.4 *Seasonality*

Seasonality in vessel use could alter the impact of wake on erosion. If vessels traffic was highest during the summer when plant growth was highest, the impact of sediment suspension on light availability may be increased. Traffic on the Mississippi River is expected to peak in the fall when agricultural commodity traffic and offshore construction and drilling activity is highest. However, no seasonality was apparent in the data (Figure 8). There is no obvious pattern of seasonality in Bayou Lafourche or the Mississippi River and no trends were apparent in the other report zones. Offshore supply vessels and crewboats are engaged in support of production activity throughout the year which normalizes vessel activity.

4 LIMITATIONS

4.1 *Data Coverage*

There are a number of technical limitations which impact vessel counts. The number of ships crossing report zones represents a lower bound on traffic volume since not all ships carry an AIS transmitter, and therefore many smaller fishing and recreational craft are not enumerated. The vast majority of commercial vessels operating in the Gulf of Mexico are believed to carry AIS systems for safety and insurance reasons, however, there are a number of reasons why ships carrying AIS transmitters may not be counted. The transmitter may not be operational, the receiver may not be operational, there may be interference between the transmitter and receiver, or the system may not be able to record data into the database (Chang 2004).

4.2 *Vessel Size Uncertainty*

For a small number of vessels, no information about size or class was available and gross tonnage was not included. As a result, the total reported gross tonnage underestimates the actual gross tonnage but the magnitude of the error is expected to be small.

The draft of vessels will vary depending on whether or not they are laden, and no attempt was made to account for this difference. Some freight ships may be laden both entering and leaving the region, but in general, vessels will only be laden in one direction. For example, crude oil tankers will be laden while entering ports while OSVs and many bulk carriers will be laden while leaving port.

4.3 *Temporal Uncertainty*

As shallow water production in the Gulf of Mexico continues to decline and production in the deepwater increases, the quantity, type and spatial distribution of activity is expected to change and the number of small OSVs will be replaced by larger OSVs. In addition, the movement of tank ships and LNG carriers into the channels depends on the quantity of oil and gas imported into the United States. Increases in domestic oil and gas production or decreases in domestic consumption would reduce traffic in the channels, particularly in the Calcasieu and Sabine Pass channels. The construction of the Keystone XL pipeline linking the Athabasca oil sands with Gulf Coast refineries may also reduce traffic through these channels. Conversely, the construction of proposed LNG export terminals at the Cameron or Sabin Pass LNG facilities would increase traffic.

Data collection began in January 2011, approximately three months after the 2010 deepwater drilling moratorium was lifted. In early 2011, many in the offshore industry complained of a “de facto” drilling moratorium due to the slow issuance of drilling permits. This could have reduced the quantity of vessel traffic in the early part of the sample, however, no reduction was notable.

4.4 *Attribution Uncertainty*

The attribution of tugs to offshore support or non-offshore support roles is difficult to assess. Some tugs are specialized for offshore support, but many tugs support a variety of industries and it is not possible to differentiate between roles. Not all OSVs and crewboats are used in support of federal oil and gas activity. A small portion of vessel movements are used in support of oil and gas activity in state and inland waters. However, based on the level of state and OCS production and development activity, the vast majority of OSV and crewboat traffic is in support of federal projects.

5 FUTURE DIRECTIONS

Automatic identification system data provides the opportunity to quantify the quantity, size, speed, and temporal distribution of vessels using the channels. Using the data and results presented in this paper, a model of the wake impacts on the shoreline may be parameterized if complemented with experimental studies. Wake effects on the shoreline are dependent on the shape of the channel and shoreline composition, and empirical measurements of the effects of vessel passage on wave energy and sediment suspension are required for additional assessment.

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