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Scientific Letter

Rigid-Hulled Inflatable Boat (RIB) use by Canadian Frigates in 2008

Background

The Rigid-hulled Inflatable Boat (RIB) is a primary auxiliary vehicle used to support naval ship activities. Increasing use of RIBs by the Royal Canadian Navy (RCN) has resulted in the over-utilization of the boats, davits, and cranes on board the ships. Through the Multi-Role Boat project (MRB) (former title Surface Combatant Boat (SCB) project), the Director of Naval Requirements (DNR) aims to replace the RIB and its associated storage, launch, and recovery system on the Halifax Class frigates with a larger and more capable boat (9 metre class RIB), and a higher capacity, multi-purpose launch and recovery system (articulated crane).

To support the MRB project, the Maritime Operational Research Team (MORT) of Defence Research and Development Canada (DRDC) Centre for Operational Research and Analysis (CORA) was tasked with the RIB Usage Study [1]. The study examines the 2008 activities of the frigates, as documented in the ships' logs, in an effort to characterize the conditions under which the RIBs were used [2]. Although there are two different types of RIBs - a small one (the Zodiac SR2) that holds two sailors and is used primarily for search and rescue, and a larger one (the RIB-P(C)) that can hold 10 - they are not consistently differentiated in the ships' logs and so are grouped together in the present analysis. Information extracted from these logs was cross-referenced with ship Operational Schedules (OpScheds) to record RIB-usage profiles during Force Employment (FE) and Force Generation (FG) activities.¹

This study used 2008 data for the following reasons. First, ship's logs are stored at Library and Archives Canada (LAC) and 2008 was the most recent year available at the time that data collection was completed. Second, in 2008 the RCN led Combined Task Force 150 (CTF 150), resulting in a high and sustained FE level compared to other recent years.

This Scientific Letter provides the key results derived from the study and will be used to support the MRB project's options analysis, which is scheduled to be completed by June 2014. A more detailed review of the methods and results will be presented in an upcoming DRDC Scientific Report.

Statement of results

The results are divided into two sections. The first, entitled "RIB usage", describes the frequency with which the frigates used their RIBs in 2008. The second, entitled "Environmental conditions", describes the conditions (sea state, wind speed, and lighting) under which the RIBs were launched.

RIB usage

In 2008, the Canadian frigates spent approximately 1020 days at sea, with 439 days categorized as FE activities and 556 days categorized as FG activities. Note that the sum of days assigned to FE and FG is not equal to the total days at

¹In some cases, the distinction between FE and FG is debatable. For example, some may argue that recent activities such as Op Nanook or Sovereignty Patrols are FE, while others will view them more as training opportunities. This study offers the view that to be FE, a Force Element must actually be responding to an incident, issue, or threat. In the absence of such a condition, the primary value of the deployment reverts to the training, or FG, value that can be obtained.



sea. This discrepancy is likely due to the resolution of the dataset. For example, a ship could launch a RIB while on a day trip or a completing a transit of less than one day. These days would not be identified as a day at sea in the OpSched, and thus may not be classified as FE or FG.

Table 1 provides a breakdown of how many RIBs were launched during FE and FG activities, as well as all days at sea. It also presents the fraction of days that included RIB launches, indicating that RIBs were used more frequently during FG activities (37% of days) than during FE activities (23% of days).

Table 1: Number of RIB launches compared to days at sea.

	FE	FG	All entries
Days at sea	439	556	1020
Total RIB launches	255	407	701
Days with one or more RIB launches	103 (23%)	207 (37%)	330 (32%)
Days with no RIB launches	336 (77%)	349 (63%)	690 (68%)

RIB launches per day

As is clear from Table 1, there are approximately twice as many RIB launches as there are days with RIB launches, indicating that some days must include more than one RIB launch event. A breakdown of RIB launches per day is presented as a probability distribution in Figure 1. The figure provides distributions labeled FE (blue), FG (green), and All entries (gray). For clarity, the probability of not launching a RIB on a given day is not presented, although that value is provided in Table 1. Hence, the totals of the distributions presented in Figure 1 sum to 23% (FE), 37% (FG), and 32% (All entries), consistent with the fraction of days when at least one RIB was launched (Table 1). Results from the figure are presented in tabular format in Annex A (see in particular Table A.1).

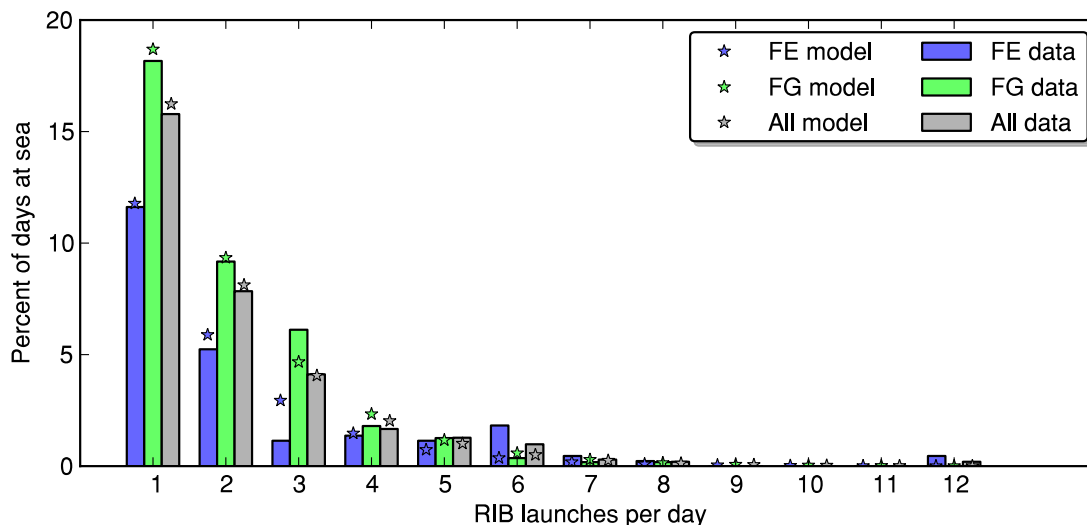


Figure 1: Number of times RIB used in a day, not including no uses (Legend: ■ - FE entries; ■ - FG entries; and ■ - All entries).

The decay in the probability of RIB launches can be modeled as halving for each additional launch, i.e., given a 16% chance of having one launch per day, one would expect an 8% likelihood of two launches per day, a 4% chance of three



launches per day, and so forth. The resulting expectation from this model is presented as the stars in Figure 1, suggesting that one can approximate the distribution as follows: 1. Given the total number of days when one or more RIBs were launched, assume that only one was launched on 50% (1/2) of those days; 2. Assume that two RIBs were launched on 25% (1/4) of the days; 3. Assume that three RIBs were launched on 12.5% (1/8) of the days; and so forth.

Duration of RIB activities

The duration of RIB activities, defined here as the time between RIB launch and recovery, can be useful for identifying activities on the ships (e.g., whether Action Stations or Boarding Stations are likely to remain stood up while a RIB is deployed from the ship). Duration may also provide some indication of the likely endurance required for the RIBs themselves. Figure 2 shows the duration of RIB activities.

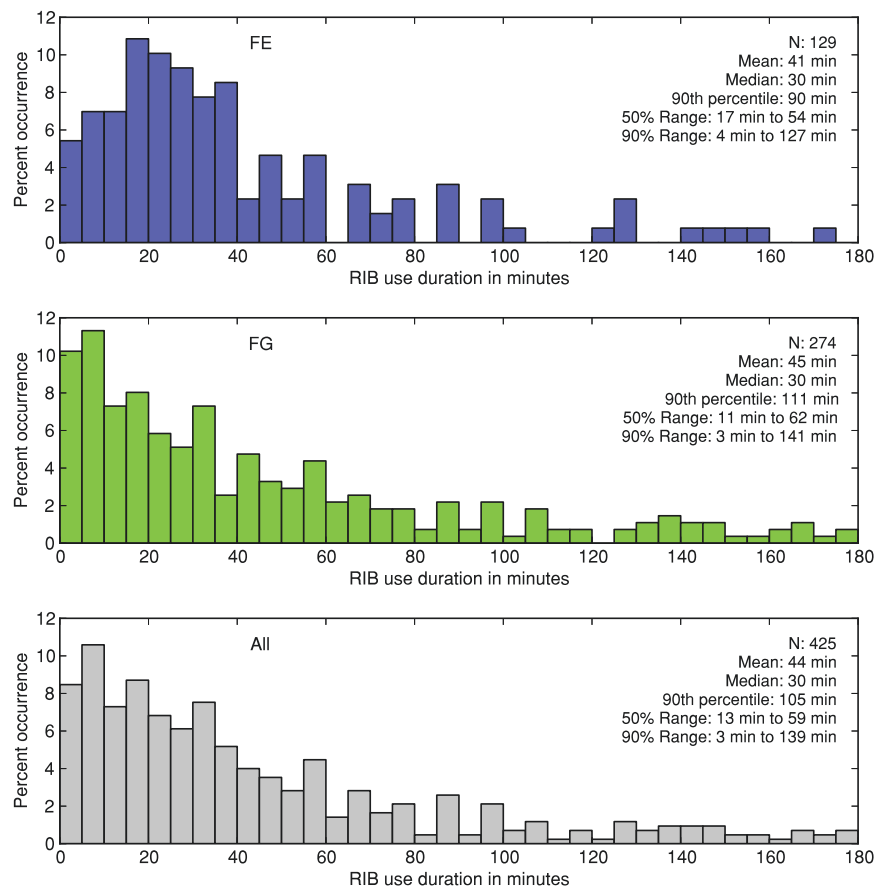


Figure 2: Launch durations (Legend: ■ - FE entries; ■ - FG entries; and ■ - All entries).

Because of the manner in which activities are recorded in the ships' logs, it is not always clear how long a RIB may have been deployed. For example, if there are two RIBs launching from a ship within 30 minutes, and then two being recovered some time later, it is often impossible to know whether the first or second RIB launched is the first to be recovered. In addition, likely due to the tempo of activities taking place, there are occasionally omissions from the logs. For example, there may be a record of a RIB launch with no corresponding recovery noted (or a recovery without record of a launch). In the figure below, a Last In First Out (LIFO) model was used, in which the most recently launched RIB is assumed to be the first to recover. This model is likely to produce a broader distribution, with more short and long RIB deployments than actually encountered.



Figure 2 shows the duration of RIB deployments. The duration of FE and FG deployments share the same median, with 50% of all deployments lasting 30 minutes or less. However, the FG profile shows more short- and long- duration events than the FE profile. Based on the LIFO model described above, this difference could be created if it is more likely in an FE event than in an FG event that only a single RIB would be deployed at any given time, although further analysis would be required to ensure that this is the case.

Environmental conditions

This section examines RIB deployments under different sea state and wind speed environments, as well as the timing of RIB deployments relative to sunrise and sunset.

Sea state

The relationship between RIB launches and various sea states is shown in Figure 3. Figure 3a shows the frequency distribution of ship exposure to different sea states, Figure 3b shows the fraction of RIB launches that occurred under each sea state, and Figure 3c shows the probability that a RIB launch will occur on any given watch based on the sea state experienced during that watch. This final panel was calculated by identifying the sea state of each watch and whether a RIB was launched during that watch. Then for each sea state, the number of watches with RIB launches was divided by the total number watches to yield a fraction which, when multiplied by 100, provides the percent shown in the table. It is noted that tabular results for this figure are presented in Table A.2 in Annex A.

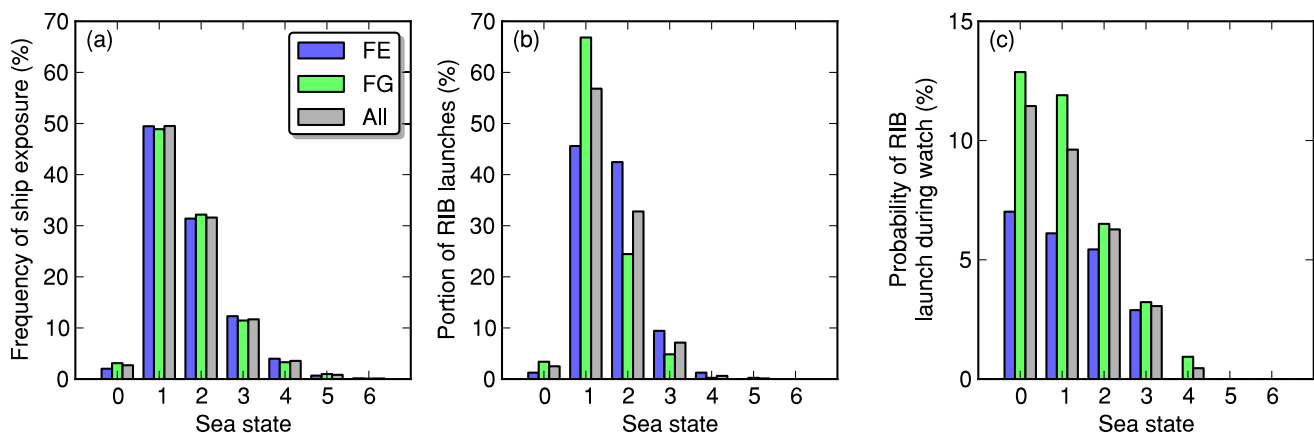


Figure 3: Ship and RIB activity in different sea states (Legend: ■ - FE entries; ■ - FG entries; and ■ - All entries).

In terms of ship exposure to different sea states, there is little difference between FE and FG activities (Figure 3a). However, Figure 3b shows differences in when RIB launches occur between FE and FG activities. Compared to FE activities, a higher fraction of RIB launches during FG activities occur under sea states 0 or 1, with a considerably lower fraction taking place under sea states 2 or 3. From Figure 3c, it becomes clear that there is little differentiation between sea states 0, 1, and 2 for FE activities, with the probability of RIB use being 7%, 6%, and 5%, respectively. Under FG activities, the probability of launch under sea state 0 and 1 are similar: 13% and 12%. However, for sea state 2, the probability of RIB use in FG activities drops almost by half, down to 7%.

When compared to FE activities, FG activities in Figure 3c show a higher probability of launch. This is related to the fact that the probability of launching a RIB on a day labeled FG is 1.6 times higher than the probability of launching a RIB on a day labeled FE (Table 1). These higher probabilities in general translate directly to higher probabilities of launch during any given watch, so one would expect the total probabilities for FG activities in Figure 3 to be 1.6 times higher than for FE activities. This expectation is consistent with the tabular results provided in Table A.2.



A closer examination of events taking place in sea state 4 indicated that all took place close to North America during FG-labelled activities: four events took place in the North Pacific, three off the West Coast, and two off the Eastern Seaboard.

Wind speed

Figure 4 shows the relationship between RIB launches and wind speed. The figure format is the same as Figure 3, except that wind speed has replaced sea state. For clarity, wind speed data are placed into bins of five kts (i.e., 0 to 5 kts, 5 to 10 kts, and so forth).

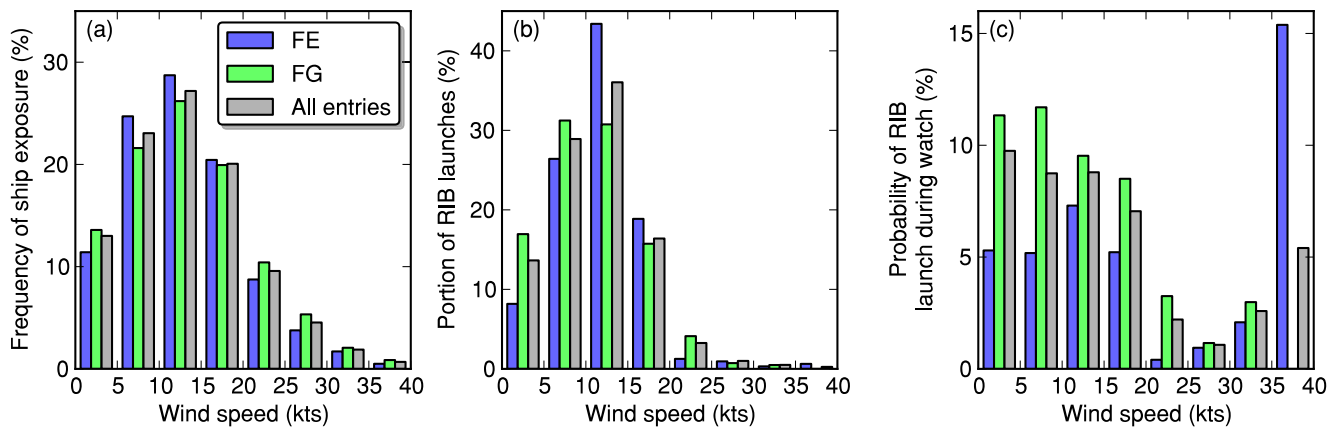


Figure 4: Ship and RIB activity in different wind speeds (Legend: ■ - FE entries; ■ - FG entries; and ■ - All entries).

Like sea state, the frequency distribution of wind speeds under which the frigates operate does not depend on whether the ship is engaged in FE or FG activities (Figure 4a). However, unlike sea states, this lack of dependence continues when considering the portion of RIB launches (Figure 4b). From Figure 4c, it is clear that most launches take place in winds under 20 kts, with both FE and FG launch probabilities dropping significantly in higher winds. The exceptionally high launch probability during FE at 35 to 40 kts is likely an outlier due to a very limited dataset. The authors would advise caution in inferring information from it.

A closer examination of events taking place in wind speeds exceeding 30 kts indicated that most took place close to North America during FG-labeled activities: with the exception of one RIB launch in the Gulf of Aden in winds of 30 kts, remaining launches took place during FG activities in the North Pacific (two launches) and off the West Coast (one launch).

Daylight

The light conditions under which RIB launches and recoveries took place are presented in Table 2. The table lists three light conditions: daylight, twilight, and darkness. Daylight refers to any time between sunrise and sunset. Twilight refers to *civil twilight* which is the time before sunrise and after sunset when the sun is below the horizon but when one can still clearly distinguish objects.² The proper determination of twilight requires a detailed astronomical model that identifies twilight periods based on the date, latitude, and longitude. Such a model which was not available at the time of preparing this report, so a conservative estimate of 30 minutes was used to define twilight – it is likely that some activities categorized as taking place in darkness may have occurred during twilight instead.

As is clear from Table 2, the majority of RIB launch and recovery operations occur during full daylight hours, with some taking place on the cusp of darkness during twilight. A significant portion (12%) occur under darkness. In particular, it is noted that 17% of RIB recoveries that took place during FE activities were at night.

²Civil twilight is not to be confused with nautical twilight, during which one can still navigate by the stars and see the outlines of objects, but not perform detailed outdoor operations.



Table 2: *Light conditions during RIB launch and recovery.*

Condition	Launch			Recovery		
	FE	FG	All	FE	FG	All
Daylight	84%	88%	85%	80%	89%	84%
Twilight	5%	2%	4%	3%	3%	3%
Darkness	11%	10%	12%	17%	8%	12%
Data points	183	281	495	112	236	376

Since the vast majority (approximately 85%) of RIB launches occur during the day, and given that RIB use durations often exceed 60 minutes (Figure 2), it seems likely that a ship will often have more than one RIB deployed at a time, particularly under FG-related activities.

Discussion

The results presented in this letter provide insights into RIB usage rates by Halifax Class frigates and the conditions under which they operate. Due to time and resource constraints, data extraction was completed only for the 2008 ships' logs. Assuming the usage rates (per day at sea) from 2008 are representative of modern RCN requirements, the following statements can be made about RIB usage:

- As a useful heuristic, based on the fact that Frigates can be expected to deploy their RIB(s) on approximately 32% of their days at sea (Table 1) and using the model presented in Figure 1, a Frigate will launch its RIB(s) once per day on 16% of its days at sea, twice per day on 8% of its days at sea, three times per day on 4% of its days at sea, four times per day on 2% of its days at sea, and five or more times per day on 2% of its days at sea.
- The relationships that sea state (Figure 3) and wind speed (Figure 4) share with RIB-launch frequencies suggest that RIBs are not used above sea state 4 and rarely used in winds exceeding 30 kts. These thresholds provide an upper limit to the RIB operating envelop, at least for 2008.
- Approximately 85% of all RIB launches and recoveries occur during daylight hours, with about 5% taking place during twilight, and the remaining 10% being carried out in darkness.

The items listed above provide the key observations extracted from the information in the ships' logs and can provide a baseline under which any future MRB can operate safely.

Conclusion

This letter provides a historical reference of RIB use by Halifax Class frigates. Data were extracted from various entries contained in the ships' logs of the Halifax Class frigates for the calendar year of 2008 and provide a reference for the rate at which ships use their RIBs and the conditions under which they operate. Ensuring any future system can safely operate at the tempo and in the weather conditions described herein is recommended.

References

- [1] De Smedt, M. (2013), Request for DRDC Support: SCB Project- Frigate Ship's Boat Usage Studies Task.
- [2] Hagan, L. (2013), 2008 Canadian Fleet Activity Study, (DRDC CORA CR 2013-135) Defence R&D Canada – CORA.

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Attachments

Annex A: Tabular Results



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Table A.1: Results from Figure 1.

Launches per day	FE		FG		All entries	
	Days	Percent	Days	Percent	Days	Percent
0	336	77	349	63	690	68
1	51	12	101	18	161	16
2	23	5	51	9	80	8
3	5	1	34	6	42	4
4	6	1	10	2	17	2
5	5	1	7		13	1
6	8	2	2	0	10	1
7	2	0	1	0	3	0
8	1	0	1	0	2	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	2	0	0	0	2	0

Table A.2: Results from Figure 3.

Sea state	Ship exposure (%)			RIB launches (%)			Launch probability during watch (%)		
	FE	FG	All	FE	FG	All	FE	FG	All
0	2	3	3	1	3	3	7	13	11
1	49	49	50	46	67	57	6	12	10
2	31	32	32	42	24	33	5	7	6
3	12	11	12	9	5	7	3	3	3
4	4	3	4	1	0	1	0	1	0
5	1	1	1	0	0	0	0	0	0

Table A.3: Results from Figure 4.

Wind speed (kts)	Ship exposure (%)			RIB launches (%)			Launch probability during watch (%)		
	FE	FG	All	FE	FG	All	FE	FG	All
0 to 5	11	14	13	8	17	14	5	11	10
5 to 10	25	22	23	26	31	29	5	12	9
10 to 15	29	26	27	43	31	36	7	10	9
15 to 20	20	20	20	19	16	16	5	9	7
20 to 25	9	10	10	1	4	3	0	3	2
25 to 30	4	5	5	1	1	1	1	1	1
30 to 35	2	2	2	0	0	1	2	3	3
35 to 40	0	1	1	1	0	0	15	0	5



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