SCIENTIFIC COMMITTEE

FIFTH REGULAR SESSION

10-21 August 2009

Port Vila, Vanuatu

ANALYSIS OF PURSE SEINE SET TIMES FOR DIFFERENT SCHOOL ASSOCIATIONS: A FURTHER TOOL TO ASSIST IN COMPLIANCE WITH FAD CLOSURES?

WCPFC-SC5-2009/ST- WP-07

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Analysis of purse seine set times for different school associations: a further tool to assist in compliance with FAD closures?

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Summary

One of the key components to CMM2008-01 adopted at WCPFC-5 in Busan in December 2008, was a prohibition on setting on FADs for a period in 2009, 2010, and 2011. The application of FAD restrictions in other RFMO's has suffered from problems of compliance and monitoring. Here we examined operational level purse seine catch and effort data for almost 50,000 sets, in particular records of the start of set time, to see if there are any major differences in other characteristics between sets on various floating objects. We found that 94% of sets on FADs occurred prior to 'official' sunrise, while only 3% of unassociated school sets occurred before sunrise, with the remainder occurring at consistent rates during daylight hours.

This finding is likely to be useful for enforcing, or estimating compliance with, the WCPFC FAD restrictions contained within CMM2008-01 and the Third Implementing Agreement of the Parties to the Nauru Agreement.

If further work of this type is thought to be useful, then three streams of future work should include: 1) expansion of the data set available for analysis by standardizing set time records; 2) conducting similar analyses with observer data; and 3) developing statistical techniques to distinguish set types based on the species composition of the catch.

Introduction

In December 2008 at WCPFC a Conservation and Management Measure (CMM) was adopted for bigeye and yellowfin tuna (CMM2008-01). An important part of the attempt to reduce mortality on bigeye tuna from the purse seine fleet was provisions for seasonal prohibitions on the setting on schools associated with FADs (paragraphs 11 and 13, but note paragraph 15):

> *11. For the members of the FFA who belong to the PNA, this measure will be implemented through their domestic processes and legislation, including the Vessel Day (VDS) Scheme which limits total days fished in the EEZs of PNA members to no greater than 2004 levels (Attachment C). The purse seine fishery in EEZs in the area bounded by 20ºN and 20ºS shall be closed to fishing on FADs between 0000 hours on 1 August and 2400 hours on 30 September. During this period all purse seine vessels required to carry an observer from the Regional Observer Program*

on board, and without such an observer on board, will cease fishing and return directly to port. During this period, a vessel may only engage in fishing operations if the vessel carries on board an observer from the Regional Observer Program to monitor that at no time does the vessel deploy or service any FAD or associated electronic devices or fish on schools in association with FADs.

13. The purse seine fishery on the high seas in the area bounded by 20ºN and 20ºS shall be closed to fishing on FADs between 0000 hours on 1 August and 2400 hours on 30 September. During this period all purse seine vessels without an observer from the Regional Observer Program on board will cease fishing and return directly to port. During this period, a vessel may only engage in fishing operations if the vessel carries on board an observer from the Regional Observer Program to monitor that at no time does the vessel deploy or service any FAD or associated electronic devices or fish on schools in association with FADs.

Also relevant to this measure is the Commission's definition of a FAD provided in paragraph 12 of CMM2005-01:

12. For the purposes of these measures, the term Fish Aggregation Device (FAD) means any man-made device, or natural floating object, whether anchored or not, that is capable of aggregating fish.

When FAD closures have been applied in other RFMO's there have often been problems in terms of monitoring and compliance. Whilst this FAD closure does not allow the servicing or deployment of FADs, it does not require that all FADs be removed from the water prior to the closure[2]. Therefore, during the closure, FADs will be in the water aggregating fish, and the definition of a FAD includes so-called natural floating objects like logs and rope which have not formally been deployed, but may be encountered and associated with fish. A further difficulty is that scientific studies suggest that tuna schools are thought to be associated with FADs at considerable distances (D. G. Itano *pers. comm*.). Many FAD closures consider 1 nautical mile distance from a FAD to constitute an unassociated school and this distance has little scientific basis and is almost impossible for an observer to monitor.

For these reasons, SPC was requested to see if there were other attributes of FAD sets that might be useful for monitoring and compliance purposes. The most obvious one is the composition of the catch, from the presence of juvenile bigeye and yellowfin tuna, to the wide variety of other bycatch species taken far more commonly in associated than unassociated sets. The second attribute, which is the focus of this paper, is the time of the day at which the set took place, specifically the time relative to local sunrise.

We will first describe the data sources that were used in this analysis and the algorithms that were used determine the time of sunrise associated with each set. We then compare set times for the different categories of FAD sets to those of unassociated school sets.

[2] this is because the large number of anchored FADs would be impossible to remove for a short-term closure.

Methods

Data

The analysis was based on operational level catch and effort data since 2003 and covering the area of application of the FAD closure (20 N to 20 S). This period was chosen as it covers the period of increased purse seine fishing activity (more vessels and fleets) and also represents a period when we have more certainty about the times reported on the logsheets. As the goal of the analysis was to calculate set time relative to sunrise, we could only include records where location was recorded and where we were confident that set time was recorded in GMT. This second requirement considerably reduced the number of records available for the analysis (see Table 1). It is possible that some of the data included were not reported against GMT and it is certainly true that there will be data that we excluded that were in fact reported against GMT. If considered to be useful, further examination of the data with a goal of increasing the size and representativeness (with respect to flag) of the data set available for analysis should be undertaken.

Table 1: Data sets used in the analysis by flag

Flag	Sets used in analysis	Total sets	% Coverage
CN	1,736	9,135	19.0%
EC	192	503	38.2%
ES	89	1,111	8.0%
FM	2,734	5,065	54.0%
JP	0	27,530	0.0%
KI	910	960	94.8%
KR	2,261	43,755	5.2%
MH	4,003	5,700	70.2%
NZ	3,155	3,554	88.8%
PG	4,376	38,100	11.5%
PH	443	9,911	4.5%
SB	839	3,515	23.9%
TW	9,900	33,042	30.0%
US	16,088	18,842	85.4%
VU	2,347	6,109	38.4%
Total	**49,073**	**206,833**	**23.7%**

For each observation, the time of sunrise (in GMT) was estimated using a simple algorithm[3] that incorporates the date and location. For our analysis sunrise was defined as the time that the sun's zenith is at 90°, which is referred to as the "official" version in contrast to the "civil", "nautical" and astronomical" versions.

The logsheets allow for several types of school association to be assigned to a set and these are provided in Table 2. We have grouped some of the set types for the purpose of comparing unassociated and associated set types.

[3] http://williams.best.vwh.net/sunrise_sunset_algorithm.htm

Results and Discussion

There are clear patterns in set time relative to local sunrise for the different school associations (Figure 1) with the unassociated set types categories predominating through daylight hours and the associated set types being predominantly in the period just prior to sunrise. One exception among the associated set types, were anchored FADs with there being a second peak of set activity in early afternoon about eight hours after sunrise. Further investigation of that second peak is required to determine if it is real or potentially an artifact of non-GMT time reporting. Sets of schools associated with 'living FADs', e.g. whales and whale sharks, were very uncommon, and almost always during daylight hours.

Table 2: Set type codes used on the regional logsheet and set types grouped together for the purpose of defining unassociated and associated sets.

Set-type	Description	Group
0	No information	
1	Unassociated	Unassociated
2	Feeding on baitfish	Unassociated
3	Drifting log	Associated
4	Drifting FAD	Associated
5	Anchored FAD	Associated
6	Live whale	
7	Live whale shark	
8	Other	

As there are few differences within the types of associated and unassociated sets (aside from the anchored FAD peak for PNG) it seems reasonable to combine these and this is done in Figure 2. We found that 94% of sets on FADs occurred prior to local sunrise, while only 3% of unassociated school sets occurred before sunrise, with the remainder occurring at consistent rates during daylight hours. These patterns were consistent across fleets (see Appendix). Further investigation of this 3% is required to determine if it is real or potentially an artifact of non-GMT time reporting or miss-reporting of the set type.

This information and analyses described here could be useful in enforcing or monitoring compliance with the WCPFC FAD closures, but it will be important to ensure that such analysis can be undertaken for all fleets. Primarily this involves determining how set times are being recorded, e.g. local time, GMT, time in the last port etc., and standardizing for this.

While the patterns here are clear, it would be useful to develop further diagnostics that could be used to determine (with sufficiently high probability) set type in the absence of that reported by the skipper. Given the clear differences reported in the juvenile BET and YFT catches from the different set types, it should be possible to determine school association from estimates of the species composition of a set (Pallarés et al. 2003).

Therefore, if further work of this type is thought to be useful, then three streams of future work could include: 1) expansion of the data set available for analysis by standardizing the recording of set times; 2)

examining observer data to look for similar trends; and 2) developing statistical techniques to distinguish set types based on the species composition of the catch.

References

Lawson, T. (2005). Update on the proportion of bigeye in 'yellowfin plus bigeye' caught by purse seiners in the western and central Pacific Ocean. WCPFC-SC1 SA WP-3, Noumea, New Caledonia, 8-19 August 2008.

Pallarés ,P., Nordstrom, V., Fonteneau, A., Delgado de Molina, A., and Ariz, J. (2003). Definition of criteria to identify FAD and free school sets based on the species composition and average weight of the samples from the Indian Ocean European fleet of purse seiners. IOTC Proceedings no. 6, pages 256-263.

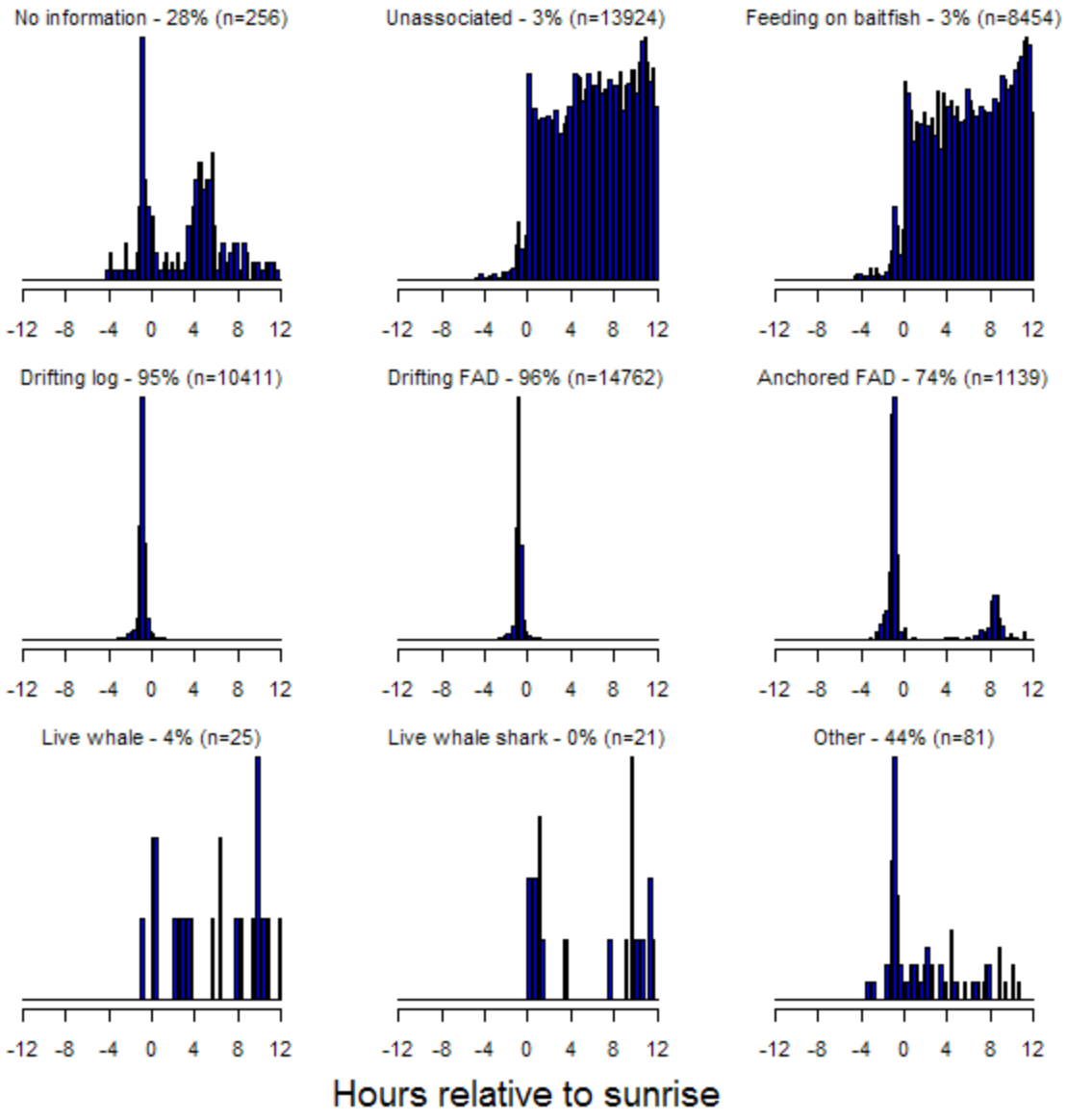


Figure 1: Set times relative to local sunrise for all fleets by school association code in 15 minute blocks. The x% refers to the percentage of sets undertaken prior to sunrise. The value in parentheses is the number of sets.

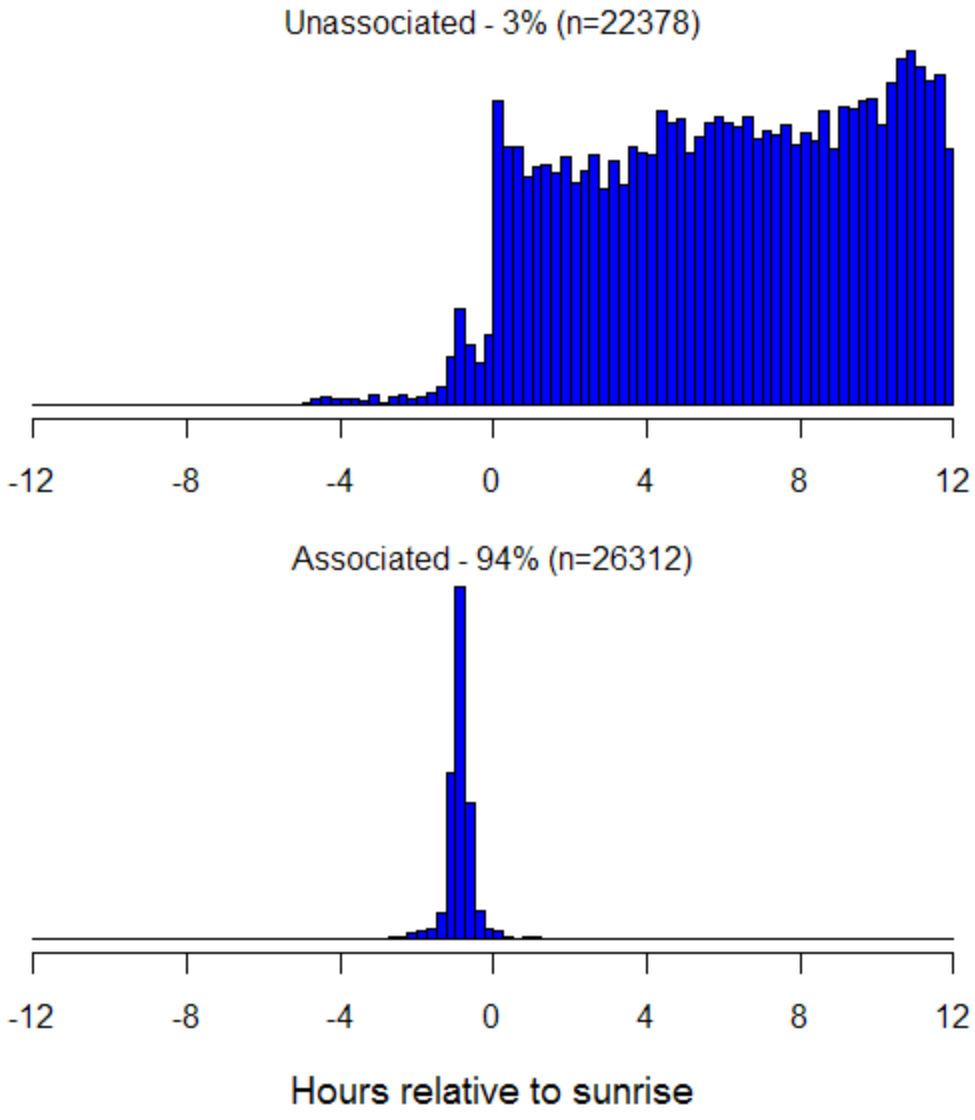
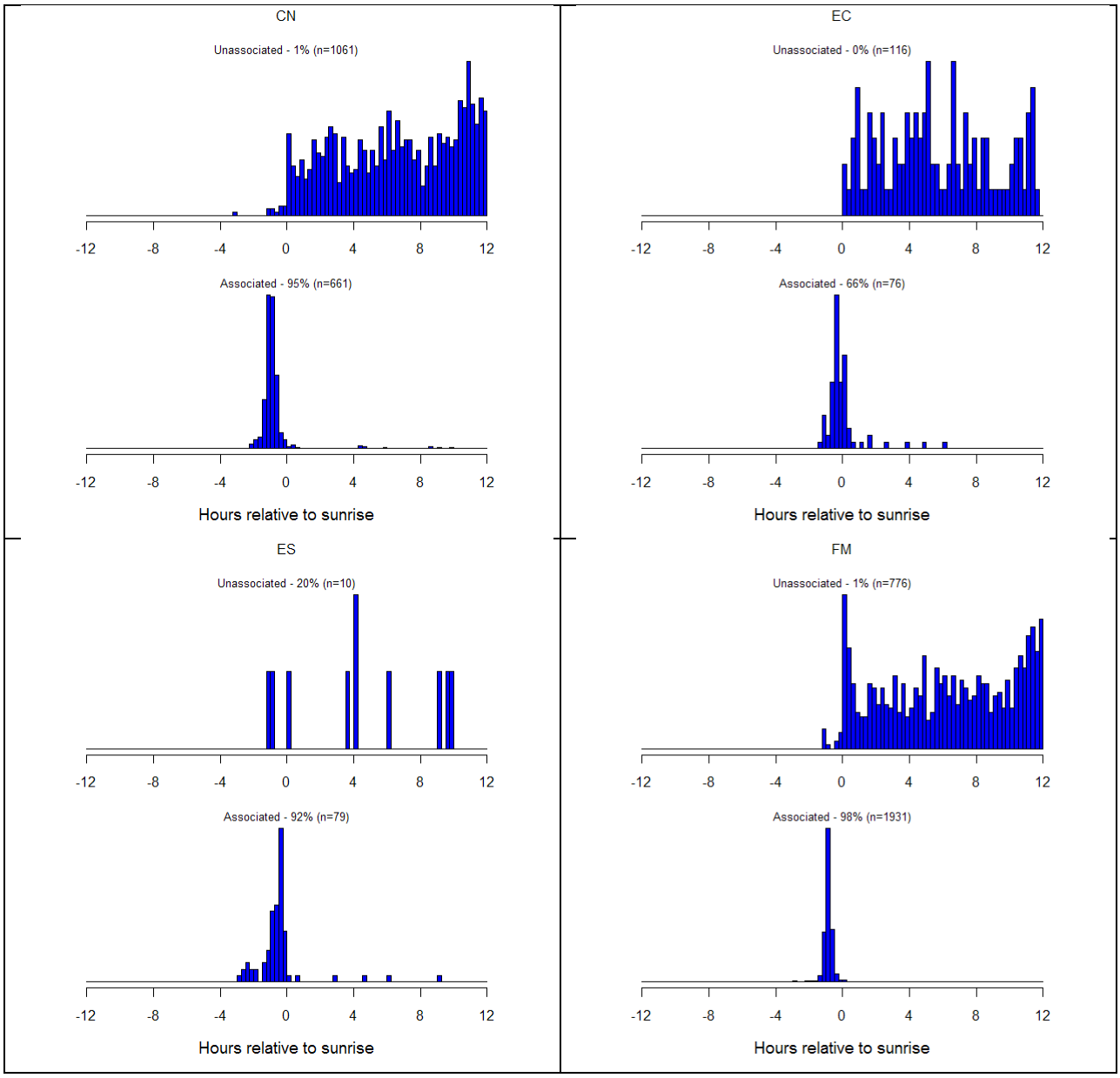
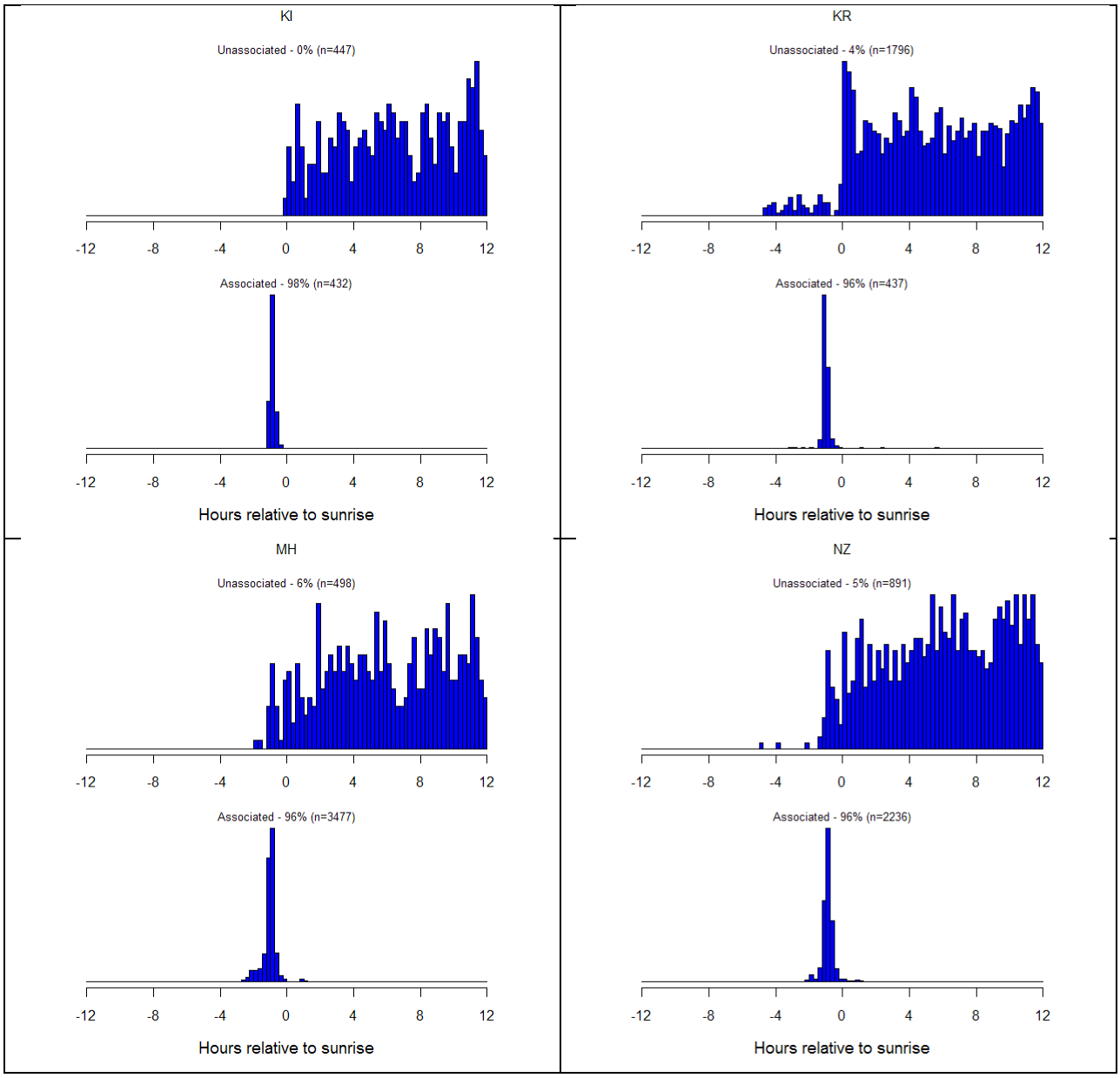
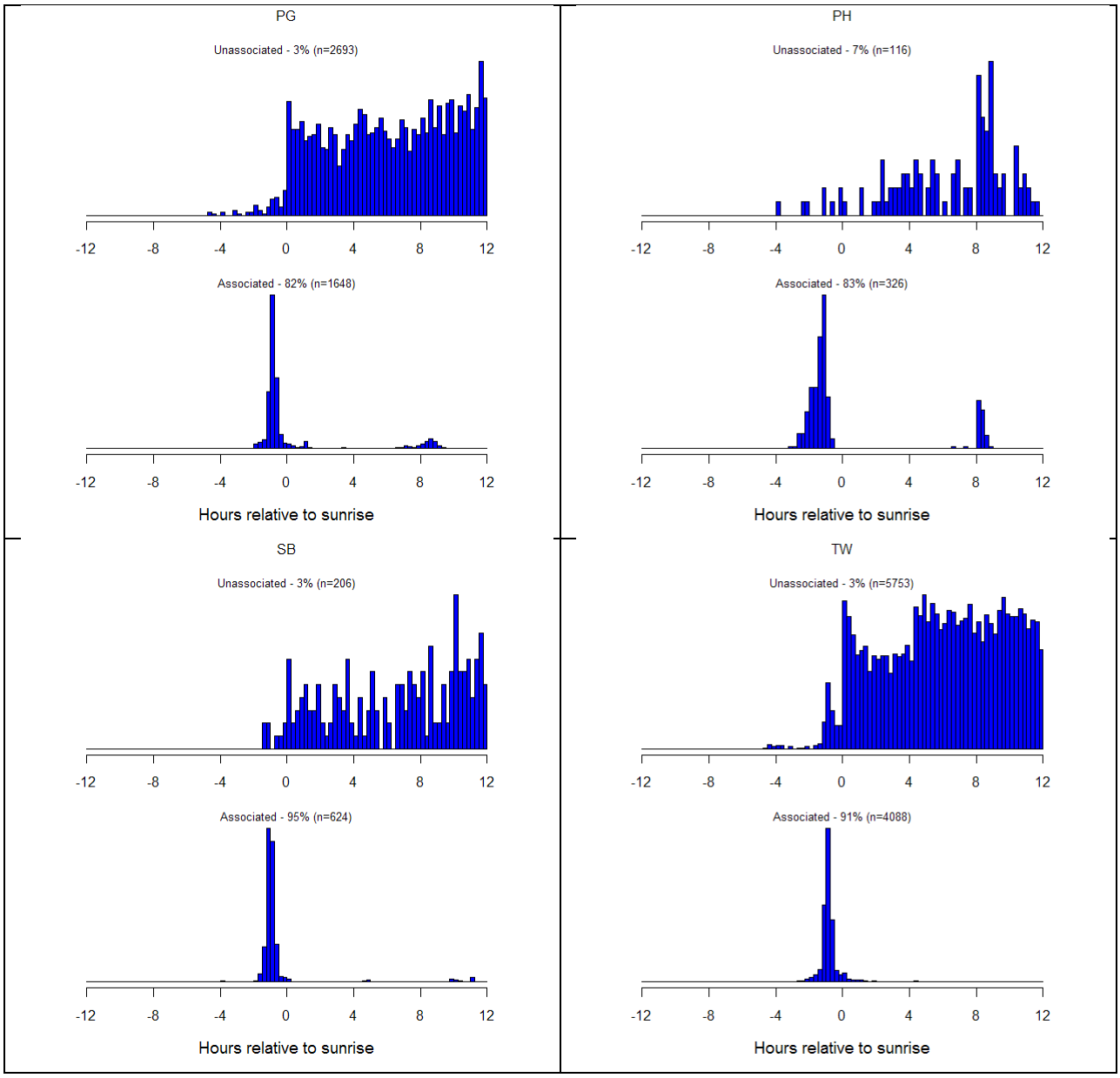


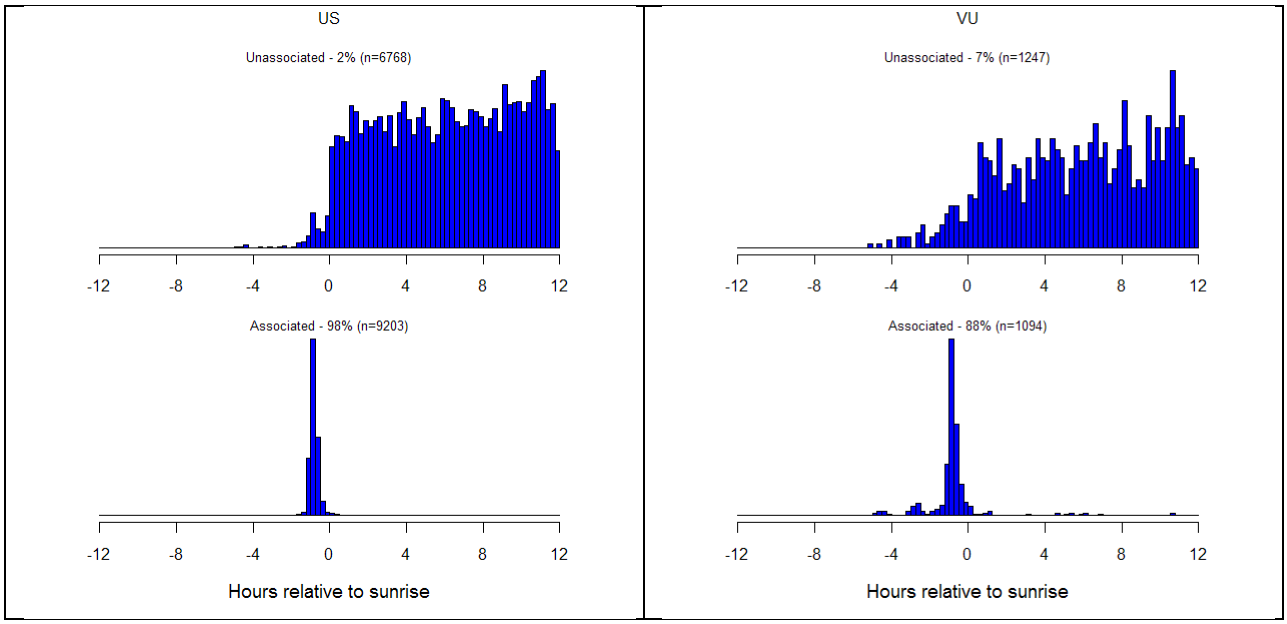
Figure 2: Set times relative to local sunrise for all fleets by the two grouped set-types (unassociated and associated) in 15 minute blocks. The x% refers to the percentage of sets undertaken prior to sunrise. The value in parentheses is the number of sets.

Appendix: Set-times relative to local sunrise by fleets by the two grouped set-types (unassociated and associated) in 15 minute blocks.


CN
Unassociated - 1% (n=1061)
Associated - 95% (n=661)
-12 -8 -4 0 4 8 12
Hours relative to sunrise
EC
Unassociated - 0% (n=116)
Associated - 66% (n=76)
-12 -8 -4 0 4 8 12
Hours relative to sunrise
ES
Unassociated - 20% (n=10)
Associated - 92% (n=79)
-12 -8 -4 0 4 8 12
Hours relative to sunrise
FM
Unassociated - 1% (n=776)
Associated - 98% (n=1931)
-12 -8 -4 0 4 8 12
Hours relative to sunrise


KI
Unassociated - 0% (n=447)
Associated - 98% (n=432)
-12 -8 -4 0 4 8 12
Hours relative to sunrise
KR
Unassociated - 4% (n=1796)
Associated - 96% (n=437)
-12 -8 -4 0 4 8 12
Hours relative to sunrise
MH
Unassociated - 6% (n=498)
Associated - 96% (n=3477)
-12 -8 -4 0 4 8 12
Hours relative to sunrise
NZ
Unassociated - 5% (n=891)
Associated - 96% (n=2236)
-12 -8 -4 0 4 8 12
Hours relative to sunrise


PG
Unassociated - 3% (n=2693)
Associated - 82% (n=1648)
-12
-8
-4
0
4
8
12
Hours relative to sunrise
PH
Unassociated - 7% (n=116)
Associated - 83% (n=326)
-12
-8
-4
0
4
8
12
Hours relative to sunrise
SB
Unassociated - 3% (n=206)
Associated - 95% (n=624)
-12
-8
-4
0
4
8
12
Hours relative to sunrise
TW
Unassociated - 3% (n=5753)
Associated - 91% (n=4088)
-12
-8
-4
0
4
8
12
Hours relative to sunrise


US
Unassociated - 2% (n=6768)
-12
-8
-4
0
4
8
12
Associated - 98% (n=9203)
-12
-8
-4
0
4
8
12
Hours relative to sunrise
VU
Unassociated - 7% (n=1247)
-12
-8
-4
0
4
8
12
Associated - 88% (n=1094)
-12
-8
-4
0
4
8
12
Hours relative to sunrise