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Seabird interaction rates estimated from observer data (2004-2011) in the Hawaii-based shallow and deep-set longline fisheries[1]

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Seabird interactions have occurred in both the shallow (swordfish targeting) and deep-set (tuna targeting) U.S longline fisheries that are based in Hawaii. Incidental seabird interactions are documented by fishery observers from the Pacific Islands Regional Observer Program (http://www.fpir.noaa.gov/OBS/obs_index.html). Annual fleet-wide estimates are reported in Part 1 of the U.S. Annual Report of the WCPFC (2010) by raising the number of observed interactions by a factor determined according to the design of the observer sampling program.

The Pacific Islands Regional Office (PIRO) of the National Marine Fisheries Service (NMFS) provides additional seabird information as an annual report on Seabird Interactions and Mitigation Efforts in the Hawaii Longline Fisheries. The most recent summary (NMFS 2010) describes observed and estimated total numbers of interactions with Laysan (*Phoebastria immutabilis*) and blackfooted (*P. nigripes*) albatrosses and other seabird species, notes the levels of observer coverage on Hawaii-based longline vessels, describes sightings of short-tailed albatrosses and any interaction, i.e., hooking or entanglement in fishing gear, within the Hawaii-based pelagic longline fisheries. The NMFS (2010) report also contains an assessment on the effectiveness of required seabird interaction deterrents, and a summary of the results of protected species workshops.

The shallow set fishery was closed in 2001 and subsequently reopened in April 2004 under a suite of new management measures that required new gear configurations, and specialized turtle dehooking equipment and handling procedures were put in place to reduce incidental captures of sea turtles and increase their posthooking survival. Seabird mitigation measures were initially adopted in 2001 and subsequently amended in 2005. A summary of current seabird regulations for both the shallow and deep-set Hawaii–based longline fleet is provided in Table 1. The measures have been effective as the estimated total number of interactions with albatrosses hooked or entangled incidentally in Hawaii pelagic longline since 2004 fisheries has been reduced by 92 to 99% annually compared to year the 2000 or pre-regulation estimates (NMFS 2010).

WCPFC CMM 2007-04 contains measures to mitigate the impact of fishing for highly migratory fish stocks on seabirds. Mitigation methods apply to longline vessels to the north of 23ºN in the North Pacific. Part 1 of the U.S. Annual Report of the WCPFC (2010) contains estimates of observations for all U.S. longline fisheries and this report characterizes observed seabird interactions and operational attributes of Hawaii-based longline fleet disaggregated by the shallow-set, deep-set at or north of 23ºN and south of 23ºN. The report analyses observer data from 2004 to May 2011, a period after substantial mitigation methods were mandated in the fisheries.

Observer coverage, interactions and interaction rates

Since 2004, annual observer coverage rates were 100% for the shallow-set fishery and ranged from 20.1 to 26.1% for the deep-set fishery. Most of the incidental interactions occur with the two albatross species (Table 2) to the north of the Hawaiian archipelago (Figures 1–2). There is some spatial overlap among the two fisheries north of the archipelago, especially during summer months when deep-set longlining occurs at more northern latitudes. Some interactions occur to the south of the archipelago, though most interactions occur to the north. Both shallow and deep-set seabird interactions typically occurred from January to June with minimal interactions during September and October (Figures 3–5).

The annual observed interaction rate in the shallow-set fishery averaged 0.044 seabirds per 1,000 hooks (Table 2, 2004–2010 range=0.009–0.066). The annual observed interaction rate in the deep-set fishery at or north of 23ºN averaged 0.009 (2004–2010 range=0.002–0.014) and 0.002 (2004–2011 range=0.001–0.005) to the south of 23ºN. The ratio of seabird interaction rate between the shallow and deep-set fishery is 4.73 and 22.91 for deep sets at or north of 23ºN and south of 23ºN, respectively. These ratios are calculated by dividing the aggregate shallow-set interaction rate by the deep-set interaction rate, for example the ratio for sets south of 23ºN is 22.91=(415/9,365,351)/(64/33,091,260). The seabird interaction rate is higher for the shallow-set which does not use line shooters and lower in the deep-set fishery which uses a line shooter. While the annual shallow-set interaction rate (seabirds per 1,000 hooks) is always higher than the deep-set, the actual magnitude per longline set is reduced because the deep-set fishery deploys more fishing effort (hooks) per set. Total observed interactions, effort and nominal catch rates depicted in Table 3 differ slightly from NMFS (2010) estimates because some observed effort from experimental or research longline trips was deleted in this analysis.

Total estimates for the Hawaii-based longline fisheries are determined by combining the estimated interactions (i.e., point estimates) in the deep-set fishery with the total number of observed shallow-set interactions (Table 4, NMFS 2010). The total estimates from the deep-set fishery are expanded by an algorithm based on observer coverage, whereas total estimates for the shallow-set fishery are not expanded because the coverage rate is 100%. Annual fleet-wide albatross interactions for both fisheries (estimated deep-set plus observed shallow-set) have ranged from 26 to 281 from 2004 to 2009. Increasing albatross interactions from 2007 to 2009 may be related to the increase of deep-set effort at northern latitudes and requires further investigation.

Longline gear and operational attributes

Longline gear attributes are illustrated in Table 4 for the two fisheries with the deep-set disaggregated at latitudes to the north and south of 23ºN. Longline gear and operational characteristics in Table 4 were similar to previous descriptions of the Hawaii-based longline fisheries (Bigelow et al. 2006, Curran and Bigelow 2011). The list of longline operational aspects was expanded by illustrating when the longline was deployed and retrieved in relation to

daylight. Observers document the beginning and ending time when the longline is set and retrieved (hauled). Since interactions occur with North Pacific surface feeding searbirds which are thought to be mostly caught during daylight hours, the beginning of the longline set and retrieval was characterized with regard to sunrise, sunset and civil and nautical twilight. Observer data on the date, latitude and longitude of the location of the longline set and retrieval where used as inputs to estimate sunrise, sunset and civil and nautical twilight with a c-program (http://stjarnhimlen.se/comp/sunriset.c). Sunrise was defined as when the upper part of the Sun is visible, and sunset is when the last part of the Sun is about to disappear below the horizon. The beginning time of deep-sets was also characterized in relation to civil and nautical twilight as birds may be able to forage before sunrise. Morning civil twilight (civil dawn) begins when the geometric center of the sun is 6° below the horizon and ends at sunrise. Nautical twilight is the time when the center of the sun is between 6° and 12° below the horizon. In general, nautical dawn twilight begins when there is enough light such that navigation via the horizon at sea is possible.

On average, the shallow-set fishery begins to deploy gear about 1 hour and 13 minutes after sunset and retrieval is initiated about 22 minutes after sunrise (Figure 6). The deep-set fishery at or north of 23ºN begins to deploy gear about 1 hour and 52 minutes after sunrise and retrieval is initiated about 58 minutes before sunset (Figure 7). The deep-set fishery south of 23ºN begins to deploy gear about 1 hour and 18 minutes after sunrise and retrieval is initiated about 1 hour and 30 minutes before sunset (Figure 8). About 95% of the deep-sets at or north of 23ºN begin to deploy gear after sunrise with a smaller percentage (90%) for deep-set to the south of 23ºN. The larger percentage to the north of 23ºN is related to the earlier time of sunrise at northern latitudes, especially during summer. Almost all (99%) of the deep-set fishery begins to deploy gear after the period of nautical dawn, suggesting that there is sufficient light for potential seabird foraging and interactions.

Observed mortality

An observed seabird interaction is automatically classified as “injured”, if the seabird is not “dead”, and is seldom given an “alive” release code. ”alive” is a rare release condition, and could only happen if a seabird were to become lightly entangled, not hooked, and freed itself without the aid of the observer (NMFS 2010). Most seabirds captured in the deep-set fishery were dead upon retrieval and there were no observation of a seabird released alive (Table 5). The shallow-set fishery has a higher seabird interaction rate than the deep-set fishery, but the majority (73%) of seabirds captured in the shallow-set fishery were released injured. One-percent (1%) of seabird interactions in the shallow-set fishery were released alive and the remaining 26% resulted in mortalities. Recorded observer comments illustrate that the differential mortality between fisheries is probably related to when the longline gear is set (NMFS 2010). Seabirds are unlikely to survive the interaction and gear soak period in the deep-set fishery which typically deploys gear after sunrise (Table 4, Figures 8-9). In contrast, the majority of seabirds caught in the shallow-set fishery are usually released injured because they are caught after sunrise during gear retrieval (Figure 7).

References

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Table 1. Summary of current seabird as well as relevant deep-setting regulations for the Hawaii longline fleet, effective January 18, 2006.
(Source: Pacific Islands Regional Office)

X = Required Measure * = Not required, but must be done to be "side-setting" #=Required to be "Deep Set"	Side-Setting			Stern-Setting		
	Shallow Set	Deep Set >23° N	Deep Set <23° N	Shallow Set	Deep Set >23° N	Deep Set <23° N
Weights (minimum 45 g) attached within 1 m of the hook	X	X	*		X	
Set from port or starboard side	X	X	*			
Setting station at least 1 m forward of stern corner	X	X	*			
Line shooter at least 1 m forward of stern corner (if used)	X	X	*			
Deploy gear so that hooks do not resurface	X	X	*			
Use bird curtain	X	X	*			
Use thawed & blue-dyed bait				X	X	
Maintain at least 2 -one lb containers of blue dye on board the vessel at all times				X	X	
Use line shooter					X	
Employ strategic offal discards				X	X	
Begin set 1 hr after local sunset & complete before dawn				X		
Follow all seabird handling procedures	X	X	X	X	X	X
Float lines at least 20 m (65 ft 7 in)		#	#		#	#
At least 15 branch lines between any two floats (except basket gear: at least 10 branch lines between floats)		#	#		#	#
No more than 10 swordfish possessed or landed at any time during a given trip		#	#		#	#

Table 2. Summary of observed seabird interactions and nominal catch rates in the Hawaii-based shallow and deep-set fisheries from 2004 to May 2011.

Year	No. Laysan albatross caught	No. black-footed albatross caught	No. shearwaters (not identified to species level) caught	No. other unidentified birds	Total birds observed caught	Total observed effort (hooks)	Nominal seabird catch rate (birds per 1,000 hooks)	Ratio of shallow catch rate to deep-set catch rate
Shallow set								
2004	1	0	0	0	1	115718	0.009	
2005	62	7	0	0	69	1358247	0.051	
2006	8	3	0	0	11	676716	0.016	
2007	40	8	0	0	48	1352822	0.035	
2008	33	6	0	0	39	1460993	0.027	
2009	81	30	0	0	111	1694260	0.066	
2010	40	38	1	0	79	1832471	0.043	
2011 (Jan-May)	43	13	0	1	57	874124	0.065	
Total	308	105	1	1	415	9365351	0.044	
All deep sets								
2004	2	5	2	0	9	7863254	0.001	7.55
2005	6	11	0	1	18	6908497	0.003	19.50
2006	1	17	5	0	23	7005649	0.003	4.95
2007	7	18	0	0	25	7720664	0.003	10.96
2008	14	30	14	2	60	8745233	0.007	3.89
2009	19	23	4	0	46	7874307	0.006	11.21
2010	37	17	0	0	54	7646949	0.007	6.10
2011 (Jan-May)	32	11	0	0	43	2183643	0.020	3.31
Total	118	132	25	3	278	55948196	0.005	8.92
Deep sets (latitude =>23N)								
2004	0	1	2	0	3	1270446	0.002	3.66
2005	5	7	0	0	12	3345218	0.004	14.16
2006	1	9	3	0	13	2300566	0.006	2.88

2007	1	11	0	0	12	2476815	0.005	7.32
2008	14	28	0	0	42	4926298	0.009	3.13
2009	19	20	2	0	41	4161085	0.010	6.65
2010	37	17	0	0	54	3888479	0.014	3.10
2011 (Jan-May)	29	8	0	0	37	488029	0.076	0.86
Total	106	101	7	0	214	22856936	0.009	4.73
Deep set (latitude <23N)								
2004	2	4	0	0	6	6592808	0.001	9.50
2005	1	4	0	1	6	3563279	0.002	30.17
2006	0	8	2	0	10	4705083	0.002	7.65
2007	6	7	0	0	13	5243849	0.002	14.31
2008	0	2	14	2	18	3818935	0.005	5.66
2009	0	3	2	0	5	3713222	0.001	48.65
2010	0	0	0	0	0	3758470	0.000	
2011 (Jan-May)	3	3	0	0	6	1695614	0.004	18.43
Total	12	31	18	3	64	33091260	0.002	22.91

Table 3. Total estimated fleet-wide albatrosses (Laysan and black-footed) incidentally taken by Hawaii-based longline vessels. Source: NMFS (2010).

Year	Total estimate of Laysan albatross	Total estimate of black-footed albatross	Total estimates fleet-wide albatrosses
2004	10	16	26
2005	105	89	194
2006	15	73	88
2007	88	85	173
2008	88	124	212
2009	141	140	281

Table 4. Mean and standard deviation among attributes on shallow or deep longline sets monitored by observers from 2004 to May 2011. Time is expressed as hours and minutes, e.g. 1936 is 1900 hours and 36 minutes.

	Shallow set (n=10,297)	Deep set (latitude => 23ºN, n=10,263)	Deep set (latitude <23ºN, n=15,675)
Variable	Mean±standard deviation	Mean±standard deviation	Mean±standard deviation
Begin deployment time (h)	1936 ± 0110	0800 ± 0122	0755 ± 0117
End deployment time (h)	0135 ± 0125	1244 ± 0126	1230 ± 0124
Begin haul time (h)	0654 ± 0100	1742 ± 0138	1708 ± 0142
End haul time (h)	1546 ± 0152	0355 ± 0228	0323 ± 0227
Begin set (hrs after sunset)	0113 ± 0039	n.a.	n.a.
Begin haul (hrs after sunrise)	0022 ± 0103	n.a.	n.a.
Begin set (hrs after sunrise)	n.a.	0152 ± 0126	0118 ± 0117
Begin haul (hrs after sunset)	n.a.	-0058 ± 0155 (prior to sunset)	-0130 ± 0151 (prior to sunset)
Begin set (hrs after civil dawn twilight)	n.a.	0216 ± 0126	0141 ± 0117
Begin set (hrs after nautical dawn twilight)	n.a.	0245 ± 0127	0207 ± 0117
Percentage of sets begun after sunrise	n.a.	95.7	90.1
Percentage of sets begun after civil dawn twilight	n.a.	99.2	97.3
Percentage of sets begun after nautical dawn twilight	n.a.	99.9	99.1
Hooks per set	909 ± 169	2227 ± 395	2111 ± 396
Hooks between floats	4.4 ± 0.8	26.0 ± 2.9	26.7 ± 2.9
Floatline (m)	8.0 ± 1.7	23.5 ± 2.9	23.7 ± 3.0
Branchline+Leader (m)	17.4 ± 2.9	12.9 ± 2.1	13.0 ± 2.2
Leader material	1% wire, 99% monofilament	91% wire, 9% monofilament	91% wire, 9% monofilament
Dropper weight size (g)	72.5 ± 11.9	48.3 ± 7.3	48.8 ± 8.1
Bait	1.3% sauries (*Cololabis saira*) 96.6% mackerel, 1.0% mixed 0.3% other, 0.8% sardine	70.7% sauries (*Cololabis saira*) 1.6% mackerel, 14.6% mixed 0.1% other, 13.0% sardine	61.9% sauries (*Cololabis saira*) 1.6% mackerel, 14.9% mixed 0.3% other, 21.3% sardine

Table 5. Release condition for all birds captured incidentally in Hawaii-based shallow and deep-set longline fisheries from 2004 to May 2011.

	Number (percentage (%))		
Condition upon gear retrieval	Shallow-set	Deep-set (north of 23ºN)	Deep-set (south of 23ºN)
Alive	3 (1%)	0 (0%)	0 (0%)
Injured	281 (73%)	5 (3%)	1 (2%)
Dead	99 (26%)	194 (97%)	50 (98%)

Figure 1. Spatial distribution of observed shallow-set seabird interactions from 2004 to May 2011. Line illustrates latitude 23°N.

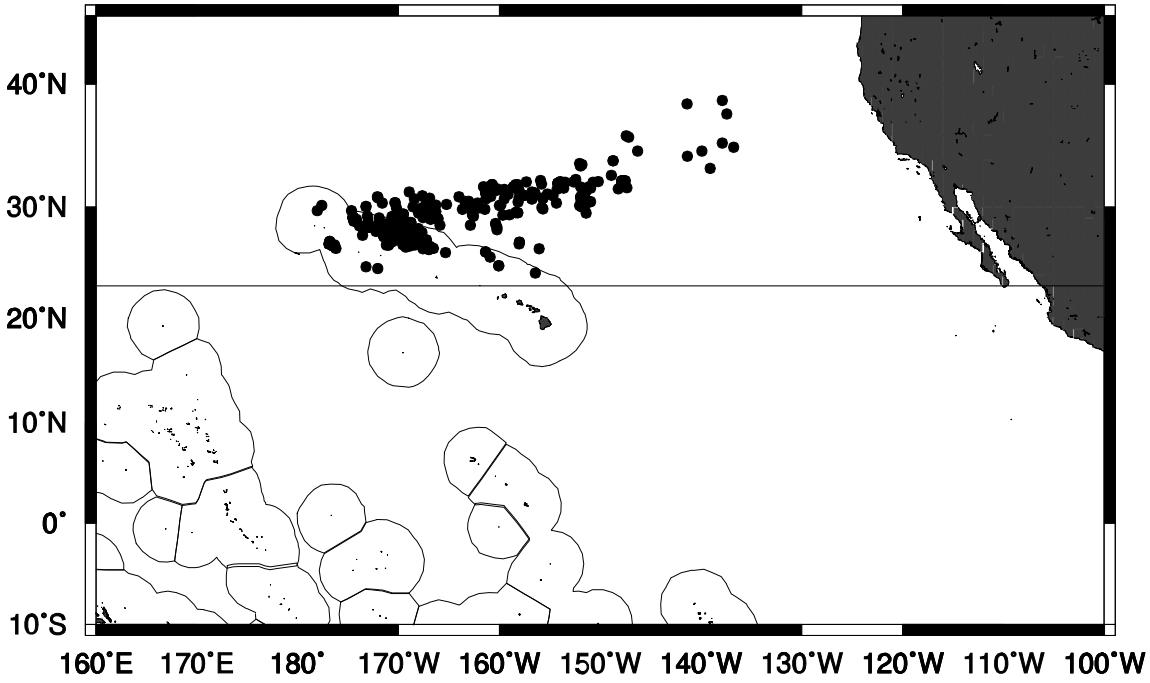

Figure 2. Spatial distribution of observed deep-set seabird interactions from 2004 to May 2011. Line illustrates latitude 23°N.

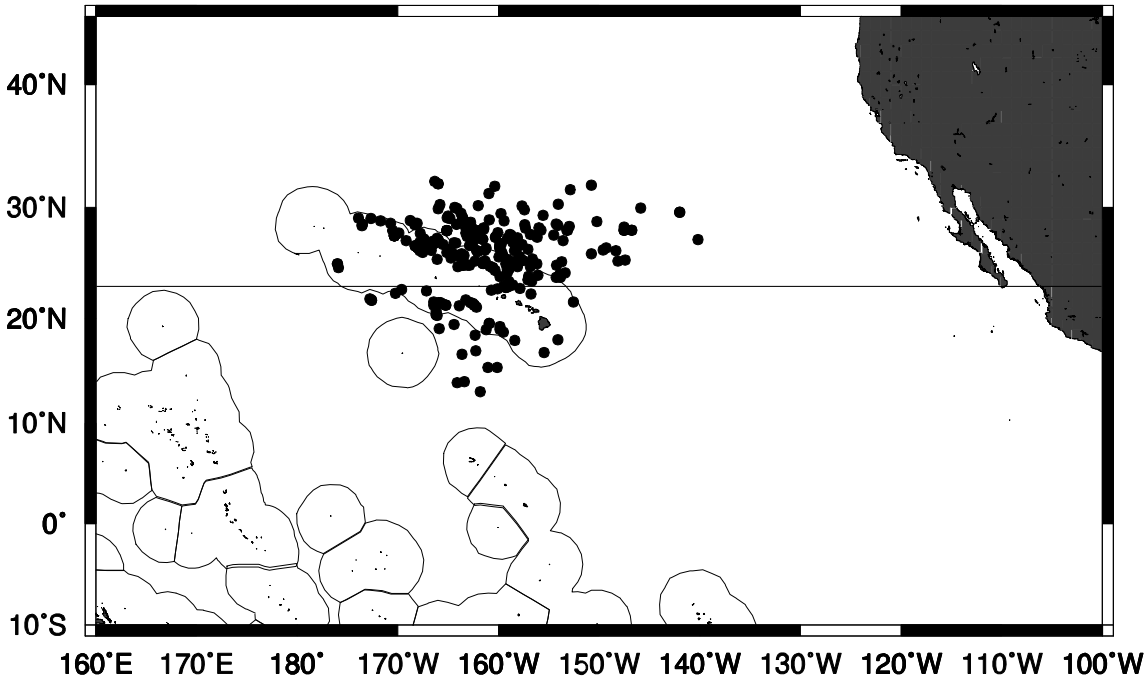

Figure 3. Monthly distribution of observed shallow-set seabird interactions from 2004 to May 2011.

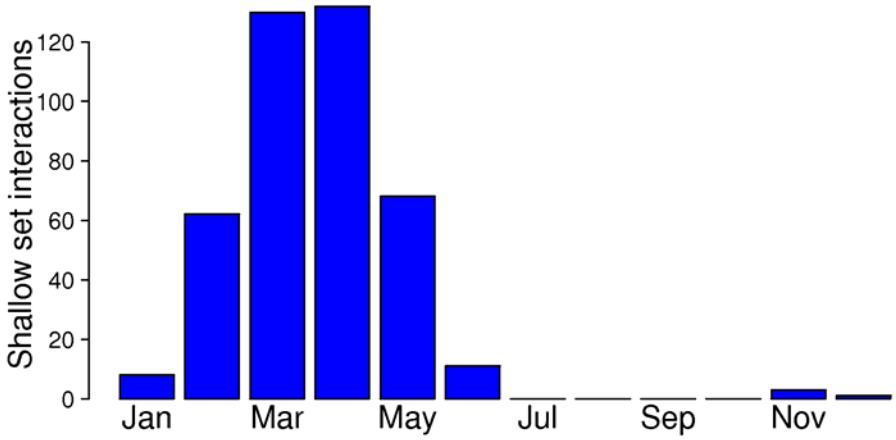

Figure 4. Monthly distribution of observed deep set seabird interactions north of 23ºN from 2004 to May 2011.

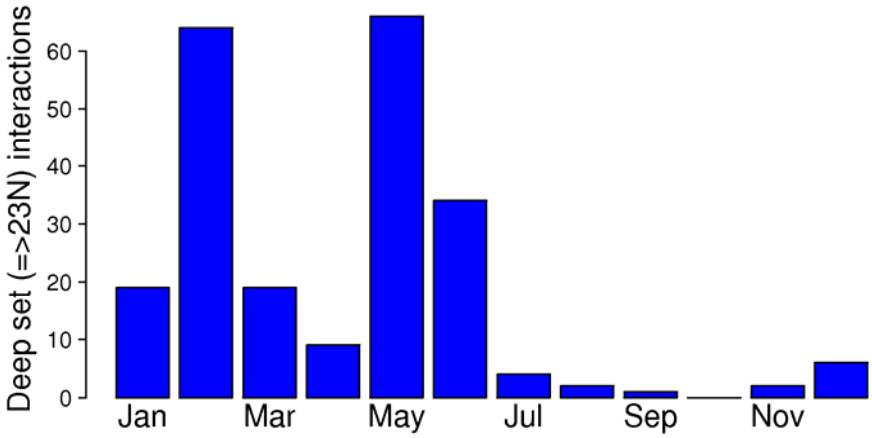

Figure 5. Monthly distribution of observed deep-set seabird interactions South of 23ºN from 2004 to May 2011.

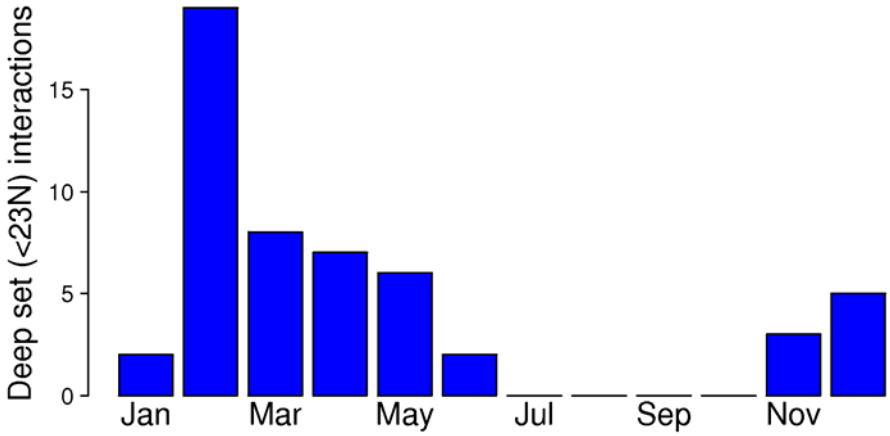

Figure 6. The time at the beginning of the longline set in relation to sunset (left) and time at the beginning of the longline haul in relation to sunrise (right) for the shallow-set fishery. Sunrise and sunset were estimated from date, latitude and longitude of fishing.

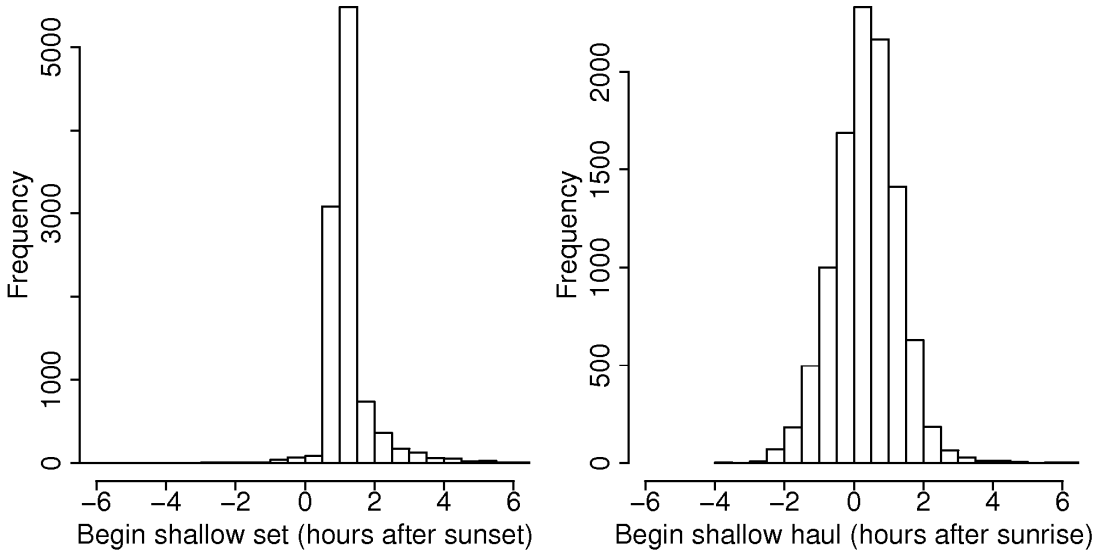

Figure 7. The time at the beginning of the longline set in relation to sunrise (left) and time at the beginning of the longline haul in relation to sunset for the deep-set fishery north of 23ºN. Sunrise and sunset were estimated from date, latitude and longitude of fishing.

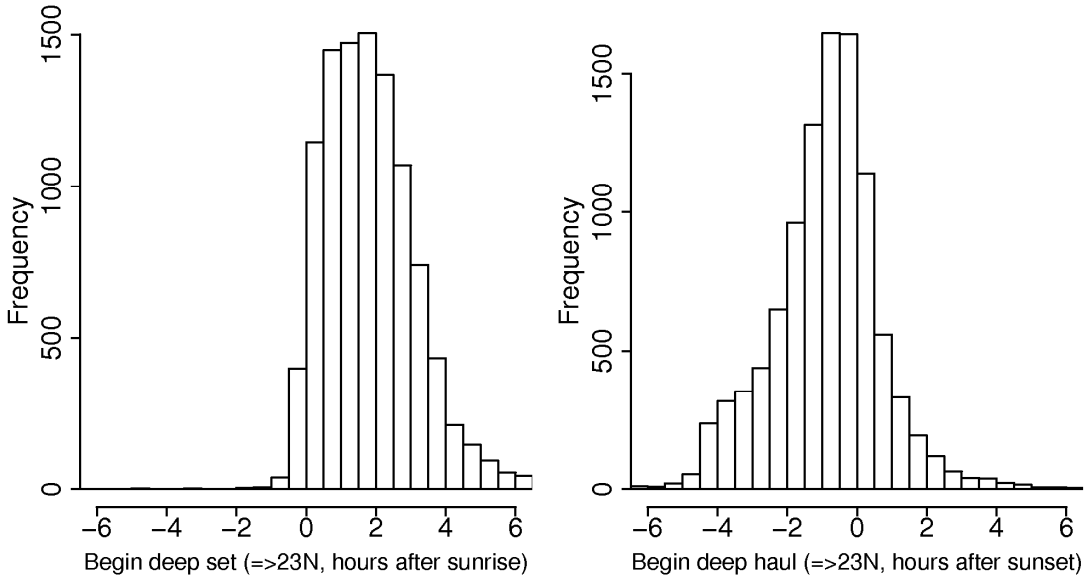

Figure 8. The time at the beginning of the longline set in relation to sunrise (left) and time at the beginning of the longline haul in relation to sunset for the deep-set fishery sorth of 23ºN. Sunrise and sunset were estimated from date, latitude and longitude of fishing.