The status and trends of small cetacean landings at Dixcove artisanal fishing port, western Ghana

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Abstract

One of the largest documented takes of small cetaceans in western Africa occurs in Western regional coastal waters of Ghana. This temporally coincided with steadily decreasing catches of finfish, especially small pelagics (sardinellas, anchovies, mackerel) over the past two decades, attributed to both climate change and indiscriminate exploitation methods. Dixcove, a key fishing port for cetacean landings was surveyed during 96 days between 12 September -17 December 2018. Our goal was to update insights from earlier surveys, especially on catch rates, catch per unit effort and species composition. A total of 57 delphinids of 10 species were observed landed: *Stenella attenuata* (28.1%), *Stenella clymene* (17.5%), *Lagenodelphis hosei* (10.5%), *Steno bredanensis* (10.5%), unidentified stenellids (8.8%), *Grampus griseus* (3.5%), *Delphinus* sp. (3.5%), *Pseudorca crassidens* (3.5%) and single specimens of *Tursiops truncatus*, *Stenella longirostris* and *Stenella frontalis.* The observed cetacean catch per diem (cpd =0.59) at Dixcove was low compared to earlier rates for this port (*e.g.* cpd =2.82, in 2013-2014). However, fishing effort, measured as the number of canoes landing per diem (range 0-25; mean= 8.82 ± 6.05; n=22) was also reduced. Poor fish catches forced many canoes to remain in port. The prevalence in landings of common bottlenose dolphins and common dolphins has significantly decreased in the period 2000-2018. The prevalence of Fraser's dolphins and false killer whales increased. Indications are that a higher proportion of cetacean carcasses may be utilised offshore as shark bait. Hooks baited with cetacean parts are deployed in auxiliary longlines set longside large-mesh drift gillnets with a shark aggregating purpose, a first report in Africa. Shore-based incidental sightings of humpback whales suggest the potential for small scale whale-watching ecotourism in Ghanaian coastal waters, as pertains in the nearby waters of the Republic of Benin.

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Introduction

Ghana has a long fisheries history and, together with Senegal and Morocco, has the largest fishing industry in West Africa (WAF) (Atta-Mills *et al.*, 2004). Ghana's marine fisheries are suffering a major crisis of overfishing that has been brewing for decades and is starting to generate a significant impact on Ghanaian society (*e.g.* Atta-Mills *et al.*, 2004; Pabi *et al.*, 2014; Ofori-Danson and Nunoo, 2015). Small scale or artisanal fisheries contribute 70-80% of the total fish catch and provide a livelihood for some 2 million people, including around 135,000 small scale fishers (NAFAG, 2014; Pabi *et al*., 2014). The long-term decline in fish stocks, and especially of small pelagic fishes such as round sardinella (*Sardinella aurita*), flat sardinella (*S. maderensis*), anchovy (*Engraulis encrasicolis*) and chub mackerel (*Scomber colias*) have been blamed both on climate change and over-exploitation following misguided fishing practices (Atta-Mills *et al*., 2004; Pabi *et al*., 2014; Lazar *et al*., 2017).

In 2018 for the first time the Ministry of Fisheries and Aquaculture Development (MOFAD) declared a one-month closed season for all marine fishing fleets except industrial tuna vessels from 6 August onwards along the entire 560 km Ghanaian coastline. However, severe opposition emerged among the artisanal fishers' communities, mainly due for want of sufficient public awareness provision from the Ghana's Fisheries Commission. Finally enforcement of the fishing ban was suspended due to the protests. With improved consultation and communication with stakeholders in 2019, the Ministry of Fisheries and Aquaculture Development has declared a closed season on all marine fishing fleets except tuna for the period of May 15 to June 15, 2019 (artisanal fisheries) and August 1 to September 1, 2019 (inshore or semi-industrial fisheries and trawlers).

In order to understand the impacts of this management measure, the primary objective is to ensure successful fish recruitment and contribute to rebuilding fish stocks by allowing fish to reproduce during the peak of the spawning season (before capture). However, many concerns have been expressed about the socio-economic impacts of this closure and that efforts will be needed to assess these impacts among the fishermen, including canoe–owners and crew, the small scale fish processors and traders. More specifically, the assessment should seek to answer a number of questions and test hypotheses concerning individual and household coping strategies of fisheries resource users in the harvest and post-harvest sectors.

While field biologists have recorded captures of small cetaceans in many WAF coastal nations (*e.g.* Bamy *et al.*, 2010; Collins *et al.*, 2010; Mullié *et al.* 2013; Sohou *et al.*, 2013; Leeney *et al*., 2015; Segniagbeto *et al.*, 2014; Van Waerebeek *et al*., 2003, 2017; Weir *et al.*, 2008; CMS/UNEP, 2012), Ghana's Western Region (Figure 1) holds the dubious distinction of hosting one of the largest dolphin captures documented in western Africa. For instance, in 263 survey days in 2013-14 some 743 small cetaceans were landed at Dixcove port which, extrapolated from a mean catch per day, amounts to more than 1,000 animals per year in that port alone (Van Waerebeek and Ofori-Danson, 1999; Ofori-Danson *et al*., 2003, 2012; Debrah, 2000; Debrah *et al*., 2010; Van Waerebeek *et al*., 2014). At least 16 species of small cetaceans are affected by what is a hybrid exploitation of both incidental (bycatch) and directed catches mainly by harpooning (Van Waerebeek *et al*., 2009). An equivalent level of captures are suspected in Nigeria but there are few firm observational data and even conflicting conclusions (*e.g.*, Uwagbae and Van Waerebeek, 2010; Solarin, 2010; Ambrose and Obienu, 2016).

At least three cetacean species i.e. Clymene dolphin *Stenella clymene*, pantropical spotted dolphin *Stenella attenuata*, and (recently) melon-headed whale *Peponocephala electra* are landed in such

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appreciable numbers so that serious conservation concern has been raised (Ofori-Danson *et al*., 2003; Debrah *et al.*, 2010; Van Waerebeek *et al*., 2014). The West African population of Clymene dolphin was feared to be threatened by the removals and was listed on CMS Appendix II (Van Waerebeek and Perrin, 2007).

No governmental data collecting programme of cetacean takes is operational in Ghana, hence the status and impact of the *de facto* exploitation is largely unknown. Biologists of the Department of Marine and Fisheries Sciences of the University of Ghana at Legon, in collaboration with the Ghana-based ngo Conservation and Research of West African Aquatic Mammals (COREWAM) have periodically surveyed cetacean takes since 1998. Because of minimal resources, our efforts have focused on a few ports (Dixcove, Apam, Axim) and especially the former which is thought to account for the largest takes (Van Waerebeek and Ofori-Danson, 1999; Debrah, 2000; Ofori-Danson *et al*., 2003, 2012; Debrah *et al*., 2010, Van Waerebeek *et al*., 2014; this paper). The reason presumably is because the large majority of Dixcove fishers deploy large-mesh drift gillnets which cause the highest dolphin mortality by entanglement, and possibly partly also because of the port's geographic location near Cape Three Points which juts out into the Gulf of Guinea, nearest to the pelagic habitat of oceanic delphinids. Off Ghana, de Boer *et al.* (2016) observed the distant-most fishing canoes at 99.5 km from shore and in up to 2,586 m deep water. Similarly in Côte d'Ivoire waters the farthest canoe was seen at 89.8 km from the coast (de Boer *et al.*, 2016). We here report on a new survey effort of cetaceans landed at Dixcove port and attempt, with earlier data, to detect trends.

Materials and Methods

The artisanal fishing port of Dixcove located in Ghana's Western Region (N 04.79368°,W 01.94612°) (Figure 1) consists of three landing beaches. It was monitored by the authors and senior fisheries officer Mr. Johnson Amiah (J.A.) for 96 days in the period 9 September - 17 December 2018 in order to determine numbers and species of cetaceans and associated fishes brought ashore. More than 400 large dug-out canoes are registered at Dixcove and canoes from other ports visit regularly, including some from Côte d'Ivoire. A survey day consisted of the active monitoring of port activities by 1-2 observers approximately from 08:00 till 18:00 when fish traders congregate at the landing beaches. Qualitative and quantitative information on the ongoing fishery, in particular daily landed fish species and daily fishing effort (number of canoes observed landing) were recorded. The catch per unit of effort (CPUE) was measured both as the number of cetaceans landed per full day monitored (cpd = catch per diem) and (more accurately) as the number of cetaceans landed per canoe (cpc).

As in earlier field work the observed canoe landings were deemed to represent the large majority (estimated at >90%) of the actual daily landings, as only a few canoes may have escaped attention. In September 2018 coverage was close to 100% while two observers checked on landings most of the time. A mean cetacean catch per diem rate (cpd) was calculated, stratified per month, for between-month comparisons, as well as a mean cpd for the entire study period.
It was attempted to photograph all landed dolphins as voucher evidence and species identification. Either *in situ* or from photographs, the animal was sexed and its standard body length (SL) measured or estimated photogrammetrically by placing a 30cm ruler on the body parallel to its axis. The integument was inspected macroscopically for any cutaneous conditions, such as tattoo skin disease (TSD) and lobomycosis-like disease (e.g. Van Bressem *et al*., 2015). No biological sampling was attempted as traders do not allow it, because all dolphin parts are utilized or commercialized.

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No formal interviews were conducted to avoid arousing suspicion of collecting potential forensic evidence concerning takes. However many fishermen were queried opportunistically about fishing activities during routine daily encounters. Conversations were often conducted in the predominant local language (Fanti) by fisheries officer J.A. and translated to K.V.W. In order to avoid misunderstandings during conversations on dolphins and whales their respective Fanti names '*etsui*' and '*bonsu*' were repeated several times. In earlier work we referred to common dolphins as *D. capensis* (Debrah *et al*., 2010) or *Delphinus* cf. *capensis* (Van Waerebeek et al., 2014) considering that a long-beaked form is involved. Here we list them as *Delphinus* sp., pending a comprehensive review of common dolphin taxonomy in the Gulf of Guinea.

To detect temporal trends in species composition, for each species, relative prevalences (%) were calculated for nine samples distributed over an 18 year period, *i.e.* 2000-2010 (pooled because small samples) and annual values for 2011 till 2018. In order to check the significance of a potential long-term temporal trend in species prevalences (increasing or decreasing), linear regressions and Pearson correlation test were computed for the main species. In order to test differences in population proportions, Z-score tests were applied. For statistical tests we used RKWard, a frontend to R statistics language for Linux (Leap 42.2). RKWard is freely available under a GNU General Public License version 2.

Results and Discussion

Dolphin catches

Details of survey effort and CPUE data for an effective 96 full days of Dixcove port monitoring during the period 9 September - 17 December 2018 are provided in Table 1. The mean number of canoes landing and surveyed per diem was about constant (8-9) for September-November (no data for December), which is very low for the port of Dixcove where in earlier years more typically 25-30 canoes were landing daily. Much as before, fishing trips from Dixcove had typical durations of 2-4 days, exceptionally took only a single day when good catches were had immediately, and rarely lasted more than 4 days. Ice is stowed onboard to keep catches fresh. Normally canoes disembark catches only during day-time when wholesale fishmongers, mainly women, congregate on the landing beaches. Traditionally Tuesdays are considered ‘fishing holidays’ when no landing operations are meant to occur. This custom however has partially eroded as occasionally a few canoes disembarked catches irrespectively, either very early or very late, therefore we maintained vigilance.

Potential biases

We discern two potential sources of negative bias that may cause catch underestimates. Fishermen claim that almost all captured dolphins are landed, however on-board observations are lacking and it is likely that a few animals may be cut up at sea, partially or completely, and utilised directly as bait. Secondly, we estimated that 90-100% of all dolphin landings had been observed in the case of a single observer, and probably ≈100% during September when two observers (J.A., K.V.W.) were present. At any rate, a few landings may have been missed.

Table 1. Descriptive statistics for monthly survey effort, drift gillnet fishing effort and dolphin landings at the Dixcove port in September- December 2018, and summed over the 4-month study period. Values marked by asterisk did not include December data.

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Parameter	September	October	November	December	Σ 4m
Number of full days of port monitoring	21	30	28	17	96
Number of dolphins observed landed	9	21	20	7	57
Estimated number of landed dolphins	12.86	21.7	21.4	12.76	68.72
Mean dolphin landings per diem	0.429	0.70	0.71	0.41	0.594
SD of dolphin landings per diem	0.926	1.02	1.72	0.87	1.22
Number of canoe landings surveyed	180	264	230	na	674 *
Mean number of canoes surveyed per diem	8.57	8.8	8.21	na	8.53 *
SD of canoes surveyed per diem	6.19	5.03	3.28	na	
Mean dolphin landings per canoe	0.050	0.080	0.087	na	0.074 *

In total, 57 delphinids belonging to 10 species were observed landed over 96 monitoring days (Table 2), or an overall mean catch rate for Dixcove port of cpd =0.594. Unidentified delphinids (8.8%) consist mostly of dolphins that were found already cut in small pieces, and could have included (an) additional species. In comparison, the 2001-2003 cpd =0.74 (Debrah *et al.*, 2010) was slightly higher than current landings rate. However, the 2013-2014 cpd =2.82 (Van Waerebeek *et al.*, 2014) was almost 5x higher than in 2018. So, after 2014 there has been a marked decrease in the number of dolphins landed at Dixcove port. This is explained at least partly due to a reduced fishing effort. The number of canoes observed landing per day in 2018 ranged 0-25 but on the average was unusually low (mean =8.82 ±6.05; n=22; median =8). Indications are, from the July 2016 cpd =0.40 (COREWAM, unpublished data) that this decline in captured dolphins occurred earlier. It was equally associated with a modest fishing effort (number of canoes landing per diem: range = 6-20; median =12; mean =12.86 ±4.74) but still 50% higher than in 2018, however sample days with all data were few (n=7). It is uncertain if anything else but reduced fishing effort from Dixcove causes the comparatively low cpd.

Table 2. Species composition of 57 Delphinidae recorded landed at the Dixcove port in the study period 9 September - 17 December 2018, stratified per month and summed over the 4 months.

Species/ survey months in 2018	September	October	November	December	Σ 4m
Stenella attenuata	1	10	3	2	16
Stenella clymene	0	0	9	1	10
Stenella longirostris	0	0	1	0	1
Stenella frontalis	0	1	0	0	1
Stenella sp.	2	1	1	1	5
Delphinus sp.	0	2	0	0	2
Lagenodelphis hosei	3	0	3	0	6
Tursiops truncatus	0	0	0	1	1
Steno bredanensis	1	2	1	2	6
Grampus griseus	1	0	1	0	2
Pseudorca crassidens	0	2	0	0	2
Unidentified delphinid	1	3	1	0	5
Subtotal	9	21	20	7	57

Species composition

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As found also in past surveys (Debrah *et al.*, 2010; Van Waerebeek *et al.*, 2014), the most commonly captured species in 2018 were pantropical spotted dolphin *Stenella attenuata* (28.1%) and Clymene dolphin *Stenella clymene* (17.5%). Regularly landed were also Fraser's dolphin *Lagenodelphis hosei* (10.5%) and rough-toothed dolphin *Steno bredanensis* (10.5%). Unidentified *Stenella* spp. (mostly spotted dolphins) accounted for 8.8%. Three other species accounted each for 3.5%, including Risso's dolphin *Grampus griseus*, common dolphin *Delphinus* sp. and false killer whale *Pseudorca crassidens*. Finallly, spinner dolphin *Stenella longirostris*, common bottlenose dolphin *Tursiops truncatus* and Atlantic spotted dolphin *Stenella frontalis* were landed only once (Table 2). Surprisingly, melon-headed whale *Peponocephala electra*, an otherwise regularly captured species in Ghana, was not encountered. Also, no kogiids or ziphiids were taken.

Except for specimens examined in port by a biologist, dolphins were identified from digital photos. Several animals were classified as either 'delphinid' or *Stenella* sp., because either the dolphin was already cut into small pieces, or photographic records did not clearly show diagnostic characteristics (e.g. neonate stenellids with a non-defined colouration pattern).

Long-term trends

For two decades the Clymene dolphin had been the dominant species landed at Dixcove, with pantropical spotted dolphin coming 2nd, *cf.* representative samples in 1995-2010 (*S. clymene* 24.5%, n=212) and in 2013-2014 (*S. clymene* 32.1%, n=109) (Debrah *et al.*, 2010; Van Waerebeek *et al.*, 2014). Since 2017, Clymene dolphin landings have relatively diminished and now place behind *S. attenuata*, accounting for 'only' 17.5% of landings in 2018, a significant drop from 2013-2014 ($Z= 2.0047$; $p=0.045$). However, long-term, no significant decline in capture prevalence is detected ($R^2 =0.050$; see Table 3). Warnings about potentially non-sustainable removals led to the listing of the West African population of *S. clymene* on CMS Appendix II (Van Waerebeek and Perrin, 2007).

Table 3 reveals that the relative prevalence (%) of *T. truncatus*, and possibly *Delphinus* sp. show a declining trend since 2010 (respectively $p= 0.0075$ and $p= 0.071$) while *L. hosei* ($p= 0.0244$) and *P. crassidens* ($p= 0.023$) show a statistically significant increase in prevalence. Any significant change in the long term from common to infrequent deserves our concern. For instance, the dusky dolphin's *Lagenorhynchus obscurus* gradual retrogression in large samples of bycatch and stranding records on Peru's central coast, from 77.5% of all small cetaceans in 1985-1990, 52.8% in 1991-1993, to 25.4% in 2018, is thought to reflect a real decline in the abundance of the dusky dolphin population in Peruvian waters (Van Waerebeek *et al.*, 2018).

Table 3. Pearson correlation tests for linear regressions of % species prevalence in landings *versus* time (years), confirming or rejecting the significance of any apparent long-term temporal trend in the landings (Dixcove port) of 13 delphinid species. The time series consisted of one pooled sample (2000-2010) and eight annual samples (2011-2018). Species with statistically significant trends (either at $p =0.05$ or $p =0.10$) are highlighted.

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Species	R^2	F-statistic	df	P	Statistical trend	Apparent trend
Stenella clymene	0.050	0.3699	1,7	0.562	not significant	declining recently
Stenella attenuata	0.324	3.352	1,7	0.11	not significant	increasing recently
Steno bredanensis	0.411	4.8796	1,7	0.063	maybe increasing (p=0.10)	increasing
Peponocephala electra	0.108	0.851	1,7	0.387	not significant	no trend
Stenella longirostris	0.006	0.045	1,7	0.837	not significant	no trend
Globicephala macrorhynchus	0.308	3.114	1,7	0.121	not significant	declining
Tursiops truncatus	0.663	13.79	1,7	0.0075	declining (p=0.05)	declining
Delphinus sp.	0.392	4.522	1,7	0.071	maybe declining (p=0.10)	declining
Lagenodelphis hosei	0.549	8.522	1,7	0.0224	increasing (p=0.05)	increasing
Grampus griseus	0.007	0.0519	1,7	0.826	not significant	no trend
Pseudorca crassidens	0.545	8.4058	1,7	0.023	increasing (p=0.05)	increasing
Feresa attenuata	0.049	0.3628	1,7	0.5659	not significant	slow increase
Stenella frontalis	0.136	1.1003	1,7	0.329	not significant	no trend

Capture circumstances and utilisation

Of eight dolphin specimens carefully inspected by K.V.W., incisive marks were consistent with multifilament gillnet entanglement. In December a batch of dolphin carcasses were landed, as evidenced by photos, showing wide and deep incisive injuries that pierced the abdominal cavity exposing protruding intestines, either harpoon or lancing wounds. Other photographs were inconclusive as to the cause of death. Nonetheless indications are that the majority of animals died from net entanglement in the drift gillnet (DGN) fishery, which is consistent with results from former years.
Further analysis should shed light on whether the incidence of severe piercing traumata remained stable or has changed in comparison with before (e.g. Debrah, 2000; Ofori-Danson *et al*., 2003). Precise incidence of harpooning/lancing however is difficult to determine from photos alone as for many specimens only one flank is visible, and some incisive wounds are hard to interpret. Many dolphins also showed pierced, often bleeding, throats or underlips, however these were identifed as post-mortem damage as fishers manipulate and pull dolphin carcasses by the mouth (mandibles) with gaff hooks.

The exploitation of small cetaceans in Ghana is thus of hybrid type, considering the combination of salvaged by-catch after entanglement and some directed takes. We suggest that small cetaceans, unless harpooned, should be considered a secondary target, because numerically far exceeded by various species of billfishes, tunas and sharks taken. However their relative contribution to the economic viability of fishing seems to vary temporally (both seasonally and from year-to-year), between ports, and probably also between individual canoe owners/fishers as some may seek to take dolphins more than others. However it is quite evident that small cetaceans form an integral part of the economic viability of small-scale marine fisheries in Western Ghana, as the totality of small cetaceans are traded and utilised. Although illegal in Ghana's marine waters (Yamoah, 2012), small-mesh monofilament set-nets have been around for a long time (Atta-Mills *et al*. 2004) and are set mainly in nearshore waters.

Processing and trade

As customary, shortly after brought to shore (usually within 30 min), without filleting or deboning, dolphin carcasses are hacked into small chunks with machetes. Nothing gets discarded, not even the head, fins or gastro-intestinal tract. This butchering procedure explains why beach-combing along Ghana's

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shoreline in search of washed-ashore cetacean remains has rarely resulted in specimens. Biological sampling would only be feasible if the entire animal would be purchased, which however would be ethically problematic as it could promote takes and lead to inflated prices. One small Fraser's dolphin sold wholesale for GHS 300 (Euro 55) was considered a low price. A larger animal like a pilot whale can fetch in port GHS 2,500-3,000 (euro 455-545). In the secondary markets, prices are considerably higher.

Figure 1. Study area in the Western Region of Ghana, showing the fishing ports of Dixcove and Axim and the much smaller fish landing beach at Busua. Agona is the inland town from where marine bushmeat is traded to the hinterland. Major commercial port areas of Sekondi and Takoradi are east of the study area.

Dolphin products are destined for human consumption, *i.e.* marine bushmeat (*sensu* Clapham and Van Waerebeek, 2007; Oxley, 2018), as well as for bait in the shark hook-fishery. The principal shark species taken with dolphin bait include blue, mako and hammerhead. Most sharks belonging to these species observed in September 2018 had been hooked, as hooks were still attached inside the mouth. Nurse sharks apparently had been caught in the drift gillnets.

Marine bushmeat

Unlike in Senegal, in Ghana the dolphin parts destined for human consumption are practically exclusively smoked. As found before, local people infrequently consume dolphin meat and prefer fish or goat as protein sources. This is supported by our observations that no dolphin meat is served in the many popular food stalls that cater to fishers and other villagers of Dixcove, Busua and Axim (Figure 1). From various independent sources we learned that the majority of smoked marine bushmeat from Dixcove is traded by wholesale merchants at the Agona junction, *ca*. 9 km inland of Dixcove (Figure 1), for distribution to the northern hinterland where it reportedly merges with the traditional (terrestrial) bushmeat markets. Segniagbeto *et al.* (2012) documented a similar situation for the Lomé port in neighbouring Togo, where smoked cetacean bushmeat was reported traded as far away as northern Togo, Burkina Faso, Niger and Mali. The aspect, chunk size, price and strong taste of cetacean bushmeat are comparable with the terrestrial varieties. The term bushmeat, and its French equivalent *viande de brousse*, are deeply ingrained socio-economic concepts with which all sub-Saharan African cultures are familiar. They have formed part

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of mainstream language for generations while it is universally used in literature and legal texts (e.g. Brashares *et al*., 2004; Clapham and Van Waerebeek, 2007; Oxley, 2018; Van Waerebeek *et al*. 2017).

Use as fish bait

As known from our earlier work, several fishermen re-confirmed that chunks of dolphin are used also to bait long-line hooks in the shark fishery. Some of the dolphins are butchered and used directly at sea, in part or completely, while others are brought ashore. Calves and small juveniles are preferred as bait as these fetch lower bushmeat market prices (quantity of meat is limited). Several bisected dolphins, both anterior halves and tailstocks, were landed or seen in cool storage, one half already used as fish bait at sea. One, stored for 2 weeks, was not so fresh. Storage of frozen dolphin parts had rarely been witnessed before in Ghana. Some fishers reported that the (unknown) proportion of dolphins destined for bait had increased which, if confirmed, may also help explain the relatively lower number of dolphin landings. Small-mesh monofilament set gillnets, deployed mostly nearshore, may not currently represent a significant threat of lethal entanglement in Ghana, as inshore occurring odontocetes such as a (hypothetical) coastal ecotype of the common bottlenose dolphin and the Atlantic humpback dolphin (*Sousa teuszii*) are either not present or extremely rare (Van Waerebeek *et al*., 2009), perhaps due to high bycatch mortality in the past. Harpooned or lanced dolphins were seen in batches, several landed by the same canoe, especially in December 2018.

Fisheries characteristics

Fish and some squid landings overall were surprisingly homogeneous, with the same species composition recurring over the weeks and months (Table 3). In numerical terms, an estimated 50-75% of landed catches consisted of skipjack tuna (*Katsuwonus pelamis*). Other commercial species that were taken practically daily and often in appreciable quantities included: chub mackerel (*Scomber colias*), juvenile yellowfin tuna (*Thunnus albacares*), Atlantic little tunny (*Euthynnus alletteratus*) and (in smaller numbers) a single unidentified species of brown-red squid (Cephalopoda). Fish species that were landed commonly to occasionally included blue shark (*Prionace glauca)*, short-fin mako shark (*Isurus oxyrinchus*), nurse shark (*Ginglymostoma cirratum)*, manta ray *(Manta* sp.), unidentified drums (Sciaenidae), and dorado or dolphin fish (*Coryphaena hippurus).* Fish species seen only irregularly in September 2018, but became increasingly more common in October-December included hammerhead shark (*Sphyrna* sp.), thresher shark (*Alopias vulpinus*), Atlantic sailfish (*Istiophorus albicans)*, Atlantic blue marlin (*Makaira nigricans)*, swordfish (*Xiphias gladius)*, triggerfish (*Balistes capriscus*), wahoo (*Acanthocybium solanderi*), and a large, unidentified species of flying fish (Exocoetidae).
Similarly as observed in 2016 (COREWAM, unpublished data), almost completely absent were round sardinella (*S. aurita*), flat sardinella (*S. maderensis*), and anchovy (*Engraulis encrasicolus).* In the past, up to about 2000, these fish species were abundant in July-September. Round sardinella reproduces perhaps year-round off West Africa, but the Central Upwelling Zone stock off Ghana and Côte d'Ivoire seems to spawn in July-August (Whitehead, 1985). One fisher who specialized in spiny lobster (*Palinurus* sp.) taken in bottom set nets, stated that lobster captures also have gone down markedly which he attributed to over-exploitation. There is no evidence of cetacean mortality in bottom set gillnets in Ghana.
One green turtle (*Chelonia mydas)* and two loggerhead turtles (*Caretta caretta)* were recorded landed alive, as is usual practice. The fisheries officer enquired to whom the green turtle belonged to, in view of their protected species status. With nobody stepping forward the turtle was seized and successfully released. Sea turtle meat is highly prized locally and a middle-sized specimen would fetch at the port *ca.* GHS 120-130.

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Other ports in Western Region

Busua (N04.80667°, W01.93844°). This village (Figure 1) has a small landing beach which hosts a few (5-7) canoes but apparently these often land catches at near-by Dixcove and mainly haul canoes onshore as their owners live in Busua. Nonetheless occasionally a few dolphins are landed according to Busua villagers. On 25 September, a hotel owner described witnessing 'some months ago' (i.e. mid-2018) the landing of 'a very large dolphin of about 5m, with a bulbous head', likely *G. macrorhynchus* or *Pseudorca crassidens*, both species known to be landed at Dixcove (Van Waerebeek *et al*., 2009).

Axim (04°51.3'N, 02°13.5'W). This important artisanal fishing port (Figure 1) was visited on 22 September 2018 with J.A. who was stationed there as fisheries officer for 28 yrs. The two current fisheries officers (Bright Mensah Akoto and Emmanuel Adjei) summarized the current status of Axim fisheries. They reported a similar deceleration in fisheries activities as in Dixcove and blamed the same causes. The chief officer is responsible to report back on landed fish catches to the national fisheries authorities, including species and estimated quantities. However cetaceans are not reported. Reporting is done via a custom-designed application on a cellphone.
The Axim officers claimed a single dolphin seen landed over the past month, describing it as 'a small calf with a rounded head'. They believed that many more dolphins are taken but since increased surveillance by the maritime police when they seize protected species including dolphins and sea turtles, the former are now more likely to be cut up at sea and applied as fish bait. The same argument was heard also at Dixcove. This could lead also to a tendency of covert landings, which developed for instance in Benin, and also in Peru when the ban on captures of dolphins became enforced (Van Waerebeek and Reyes, 1994). One senior fisherman explained that a relatively small longline with some 150 baited hooks is deployed close and parallel to the main floatline of a gillnet, as to attract sharks. Baiting of gillnets has been a common practice in some fishing nations *e.g.* Peru (Van Waerebeek and Reyes, 1994; Mangel *et al*., 2010) but was unreported for Ghana.

As in Dixcove, Axim villagers hardly consume dolphin meat and it is not available in local eateries. Most dolphins that are not used as bait, but are brought ashore, also are processed (smoked) for the bushmeat trade in the hinterland. Largely the same finfish species are landed at Axim as in Dixcove, but perhaps fewer sharks. Manta rays are landed with some regularity but, unlike before, hardly any stingrays (Myliobatiformes) are taken. In contrast with the past when ringnets and small scale purse-seines were the main fishing arts deployed by Axim fishermen, drift gillnets are now the primary apparel and higher incidental mortality of dolphins would be expected. The reason for the shift is because small pelagics like sardinella and anchovy have gradually disappeared from purse-seine catches over the past decade, where before these fishes were predominant. This situation was already observed in 2016 (unpublished data).

Biological aspects

Common bottlenose dolphins
No evidence of an extant inshore (coastal) population of *Tursiops truncatus* has so far been found in Ghana (Van Waerebeek *et al*., 2009, 2016). In contrast with humpback whales sightings, nearshore occurring dolphins are rarely reported, and the authors have not confirmed any. However, near the Volta Delta in eastern Ghana locals reported that, in the past, groups of inshore dolphins were regularly seen from the beach. With accumulating opportunistic observer effort at Busua and Dixcove it becomes increasingly unlikely that any inshore population is thriving in the Western Region. Globally, in areas

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where inshore *T. truncatus* populations exist, dolphins are seen on a regular, almost daily basis (K.V.W., pers. observations). The geographically closest confirmed nearshore *T. truncatus* sighting consist of two

Table 3. Chronological overview of fish (key species) and dolphin landings, with daily fishing effort (number of canoes landing) during the study period at Dixcove port, western Ghana. na= not applicable.

	SEPTEMBER 2018			OCTOBER 2018			NOVEMBER 2018			DECEMBER
Day of month	Canoes landing	Dolphins landed	Comments and key fish species	Canoes landing	Dolphins landed	Comments and key fish species	Canoes landing	Dolphins landed	Comments and key fish species	Dolphins landed
1	na	na	na	14	0	skipjack tuna, yellowfin tuna, triggerfish	8	0	skipjack tuna, yellowfin tuna, triggerfish	2
2	na	na	na	3	0	billfish;flying fish; sailfish	11	0	sailfish;king fish;sharks; skipjack tuna	0
3	na	na	na	12	0	frigate mackerel;dolphin fish;skipjack	6	0	sailfish; skipjack; blue marlin	1
4	na	na	na	15	0	Shark; dolphin-fish (Coryphaena)	12	0	shark; Coryphaena	0
5	na	na	na	12	0	skipjack;yellowfin tuna; triggerfish	12	0	skipjack;yellowfin tuna; triggerfish	0
6	na	na	na	13	0	skipjack;yellowfin tuna; triggerfish	na	na	no observer effort	0
7	na	na	na	20	0	skipjack;yellowfin tuna; triggerfish	13	1	skipjack;yellowfin tuna; triggerfish	0
8	na	na	na	6	1	blue marlin; doctorfish; skipjack	6	2	billfish; blue marlin; sharks	0
9	4	0	mostly skipjack tuna, some blue and mako shark; little activity	0	0	fishing holiday; no fish landing	8	0	triggerfish;blue marlin; skipjack	0
10	8	1	mostly skipjack and mackerel; 1 green turtle (alive)	8	0	skipjack tuna; squid	8	0	skipjack tuna; squid	1
11	0	0	traditional tuesday "fishing holiday", no canoes landing	13	0	hammerhead shark; bigeye tuna	na	na	no observer effort	0
12	13	0	mostly skipjack and mackerel, some yellowfin, squid, little tunny; few flying fish, dorado	na	na	no observer effort	6	1	sailfish; hammerhead shark; skipjack	0
13	15	0	mostly skipjack, some mackerel, yellowfin, grouper, blue shark; 2 dolphins allegedly landed (night)	15	1	blue marlin; shark; yellowfin tuna	0	0	no fishing/landing	0
14	6	0	skipjack, mackerel, 7 mako sharks, blue sharks, yellowfin, 2 sailfish	8	0	skipjack; frigate mackerel	10	0	skipjack; frigate mackerel	0
15	18	0	skipjack primarily, mackerel, yellowfin, little tunny	6	1	blue marlin; skipjack; common dolphinfish	6	0	blue marlin; skipjack; common dolphinfish	0
16	13	0	mackerel, skipjack, yellowfin tuna, squid (many), nurse sharks, 1 blue marlin	4	0	skipjack; frigate mackerel	12	0	skipjack; frigate mackerel	0
17	25	1	landed with blue shark ; skin sample collected	13	0	Coryphaena; skipjack	7	0	blue marlin; sailfish; lobster; manta ray	3
18	5	0	tuesday fishing holiday, still some landing. mostly skipjack, some blue shark, squid	6	1	king fish;blue marlin;squid	7	8	sharks;skipjack tuna; yellowfin tuna; squid	na
19	10	0	skipjack, mackerel, squid, 1 small mako shark, 1 thresher shark (not hooked)	10	2	blue marlin; sword fish; skipjack; yellowfintuna	10	0	blue marlin; sword fish; skipjack; yellowfintuna	na
20	15	0	skipjack primarily, 1 blue marlin, many yellowfin tuna; chub mackerel; Atlantic little tunny; triggerfish	9	3	manta ray; blue marlin; skipjack tuna	4	0	skipjack; yellowfin tuna; sharks; atlantic little tuna	na
21	10	0	skipjack primarily, some yellowfin tuna	6	3	blue marlin; skipjack; common dolphinfish	12	0	blue marlin; skipjack; common dolphinfish	na
22	na	na	no survey effort in Dixcove. Surveying Axim port (no dolphins landed)	4	3	triggerfish;blue marlin; skipjack	8	0	triggerfish;blue marlin; skipjack	na
23	8	1	AM: no effort. after 3 PM; Atlantic little tunny, Sciaenidae, squid	0	0	fishing holiday; no fish landing	10	0	blue marlin; skipjack; common dolphinfish	na
24	7	4	blue sharks, skipjack, Sciaenidae, Atlantic little tunny; yellowfin tuna; mackerel; squid; 1 manta ray; 1 juv. Lhosei butchered (was frozen)	10	2	blue marlin; frigate mackerel; skipjack	6	2	blue marlin; frigate mackerel; skipjack	na
25	1	0	tuesday fishing holiday; skipjack primarily by one canoe; port monitored till 17:00	10	0	sharks; yellowfin tuna; atlantic little tuna	12	0	blue marlin;skipjack;sailfish; triggerfish	na
26	2	0	AM no landing; sciaenids; skipjack; 2 blue sharks	16	1	scad mackerel; skipjack; yellowfin tuna	6	2	bill fish; blue marlin; sharks	na
27	4	0	yellowfin; dorado (juveniles); sciaenids; 5 blue sharks; skipjack; mackerel; 1 large blue marlin	7	2	skipjack; frigate mackerel	2	0	sharks;skipjack tuna; yellowfin tuna; squid	na
28	8	1	dolphin landed with skipjack primarily; Sciaenidae; blue sharks	6	0	triggerfish;blue marlin; skipjack	10	0	triggerfish;blue marlin; skipjack	na
29	5	0	skipjack primarily, manta ray, blue shark, Atlantic little tunny, mackerel	12	0	shark;blue marlin	6	0	manta ray;frigate mackerel; skipjack	na
30	3	1	PM monitoring by JA.	0	0	fishing holiday; no fish landing	12	4	blue marlin; sailfish; sharks	na
31				6	1	hammerhead shark; bigeye tuna				na

dolphins seen foraging in and around an encircling gillnet west of Cotonou, Benin, in September 2001 (Van Waerebeek et al., 2009). Fisheries personnel pointed out that inshore occurring dolphins are highly accessible, would be readily captured and have a high chance of becoming eradicated. The absence of confirmed records in Ghana of Atlantic humpback dolphin *Sousa teuszii*, another species of neritic habitat, is also thought to be due to local eradication (Van Waerebeek et al., 2009, 2016).

Spinner dolphins

Cadenat and Doutre (1959) and Cadenat (1959) described a peculiar morphotype of spinner dolphin based on four specimens captured off Senegal. External features included variable degrees of spotting (*moucheté*) on the white ventral field and on the flanks, a poorly defined dorsal field, deep post-anal keels in two adult males and triangular dorsal fins. These features are not in concordance with the pantropical subspecies *S. longirostris longirostris.* Post-anal keels, for instance, have only been reported from *S. longirostris orientalis* in the eastern tropical Pacific (Perrin, 1990, 1998). In Ghana, Ofori-Danson *et al.* (2003) first noted the long mandibular ramus in two spinner dolphin skulls, and having observed similar external features as Cadenat and Doutre (1959) did, they concluded that this form 'could represent a [new] subspecies which would be confirmed from extra data' (Ofori-Danson *et al.* 2003). From slowly accumulating data, it seems evident that the 'spotted spinner dolphin' from west African waters indeed represents at the very least an evolutionary significant unit (ESU) and may qualify for subspecies status.

Humpback whales

A northern Gulf of Guinea stock of humpback whales (*Megaptera novaeangliae*) breeds and calves off Benin, Nigeria (Van Waerebeek *et al*., 2001; Sohou *et al*., 2013), Togo (Seniagbeto *et al*. 2014) and Ghana (Van Waerebeek *et al*., 2009). Seasonality is from July to early December, indicative of a Southern Hemisphere stock. An adult-calf pair of humpback whale was sighted by K.V.W. from shore at Busua, at 11:14 on 16 September 2018. The apparent neonate, its colouration almost entirely dark, breached >20 times in a row. The adult, presumably parental female, was seen surfacing 3 times, exposing diagnostic dorsal fin, hump and producing low bushy blow. The animals moved slowly west parallel to the shoreline at *ca.* 2 km distance (visibility excellent; SS 2 Beaufort). On 18 September 2018, J.A. sighted a single adult humpback whale also nearshore, off Fort Iron Cross, Dixcove. Considering similar opportunistic shore-based observations in September 2008 and by others since 1978 (Van Waerebeek *et al*., 2009), it would be worthwhile to explore whether sufficient sightings can be assured that could make whale-watching commercially viable, as it is from Cotonou, Benin (Van Waerebeek *et al*., 2001; Sohou *et al*., 2013).

Humpback whales in the Gulf of Guinea, as elsewhere, enter shallow nearshore waters when nursing thus entailing a high risk of lethal gillnet entanglement, especially for calves, as documented in Ghana (Van Waerebeek *et al*., 2009), Togo (Seniagbeto *et al*., 2014) and Cameroon (Ayissi *et al.*, 2011). All entangled or otherwise stranded whales have been butchered and utilised as bushmeat by villagers. The level of calf mortality due to fishery interactions is unknown as surely many cases go unreported. In 2018 very few reports of stranded whales were received, in contrast to the many strandings recorded in 2013-2014 (Environmental Protection Agency, 2014; Van Waerebeek *et al*., 2014).

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Conclusions

The dolphin exploitation in western Ghana continues largely unchanged since it was first reported on two decades ago (Ofori-Danson and Odei, 1997). It is intimately linked to the dynamics of the artisanal fisheries and to the high poverty levels among small-scale fisher communities (Asiedu *et al.*, 2013) who would not ignore any marine resource. The decreased fishing effort in September-December 2018 has had a positive effect in that dolphin mortality was noticably less than earlier years.

There is some concern however that in the long term fishermen may proactively increase directed dolphin takes as to compensate for lost income from diminished fish catches. Also, despite their present desinterest in local dolphin meat consumption, a further decline in available fish protein sources could drive fisher communities to reconsider and consume dolphins also among fisher families. Brashares *et al*. (2004) precisely showed such a correlation between a reduced availability of fish resources in Ghana and an increased demand for (terrestrial) bushmeat. Muslim communities in coastal Senegal had traditionally refused consumption of by-caught cetaceans for being non-halal (i.e. unbled mammals). However following a severe downturn in fish landings and sharp price increases due to overfishing, this food taboo had eroded and increasingly many muslims were found to also eat dolphin meat on Senegal's Petite Côte, where before it was exclusively christian communities who did so (Van Waerebeek *et al*. , 2003). Senior fishermen at Dixcove admitted their community had become acutely aware of the problem of over-fishing as CPUE and mean fish sizes have conspicuously decreased over the years, while several small schooling fishes have virtually disappeared. Some fishermen enquired what should be done to recover healthy fish stocks. Many agreed about the need of some form of restriction and better control of fisheries, including a closed season. However, telling from the ubiquitous (illegal) small-meshed monofilament nets, discussion about the dire status and actually changing destructive fishing habits are two different matters. We believe that a month-long fishing ban, scheduled for 2019, may be hard to enforce as fishermen's families obtain most of their protein intake from seafood and few have the resources to bridge such a long moratorium. Perhaps several shorter (e.g. one week) closed periods until fisher communities can fully adapt may be less problematic and ultimately more successful.

Possible reasons for low catches

Compared to earlier monitoring periods at Dixcove, 2018 has seen some of the lower dolphin landing rates (cpd), explainable in part by markedly reduced fishing effort. In September, a shortage of fuel (and high prices) due to a petrol truckers' strike limited fishing trips. Also the low fish catches were considered unsatisfactory and many fishermen opted to remain in port. Potential contributary explanations were considered :

(i) Possibly a lower abundance of dolphins on the fishing grounds in September 2018, either seasonally (cf. upwelling) or permanent. Two fishermen independently pointed out that they saw 'very few dolphins' while out fishing. Sea surface temperatures were low in September (pers. observations) which might impact the distribution of some tropical delphinids. *Peponocephala electra* and *S. longirostris* were notably absent or scarce, repectively, but then *L. hosei* was more prevalent than in other years. If any correlation with SST exists, it would be complex.

(ii) Another question is whether the absence of small pelagics as likely prey could have contributed to the low dolphin cpd rate. However, the same scarcity of sardinellas, anchovies and chub mackerel already existed in 2013-2014 when cpd rate was very high at 2.82 (Van Waerebeek *et al*., 2014).

(iii) An increasing usage of captured dolphins at sea, for fish bait, would contribute to a lower landing rate. One senior fisherman described short longlines of some 150 baited hooks that are deployed simultaneously with drift gillnets to attract sharks. Individual large hooks with metal branch lines (snoods)

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were commonly seen handled by fishers at the port. Similar deployments are well-documented in other countries. In Peru, for instance, when the landing of dolphins was outlawed (Van Waerebeek and Reyes, 1994; Mangel *et al*., 2014), offshore use of dolphin carcasses as shark bait increased notably. However quantification of this practice is difficult, requiring onboard observers.

Due to a lack of monitoring, the great unknown are the cetacean bycatches in industrial fisheries, and especially foreign fleet IUU (illegal, unregulated and unreported) fisheries. These form a pervasive menace in Ghana's coastal waters (see de Boer *et al*., 2016) as in most of western Africa.

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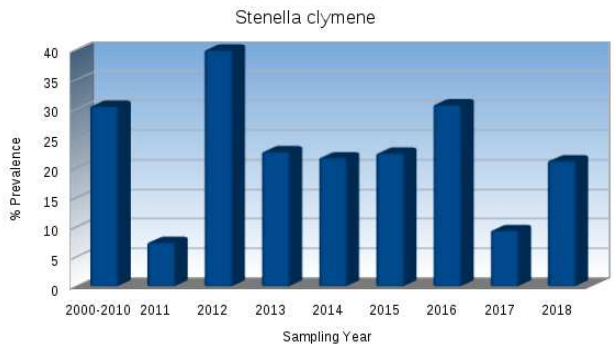
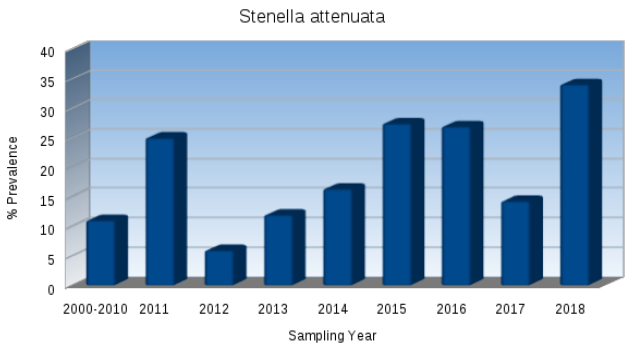

Stenella clymene
% Prevalence
0 5 10 15 20 25 30 35 40
2000-2010 2011 2012 2013 2014 2015 2016 2017 2018
Sampling Year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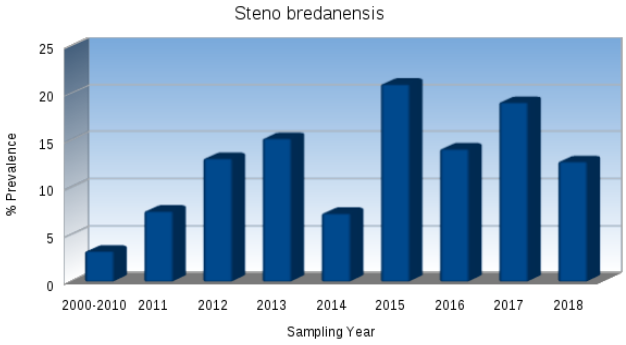
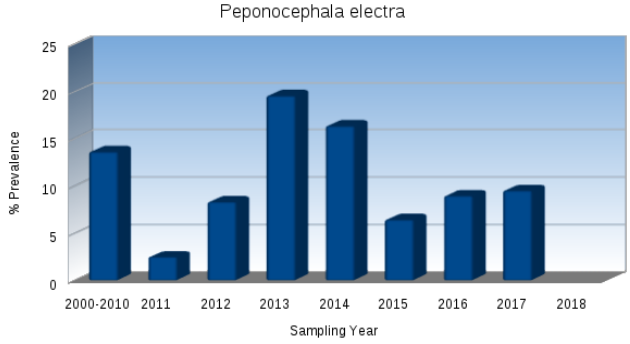
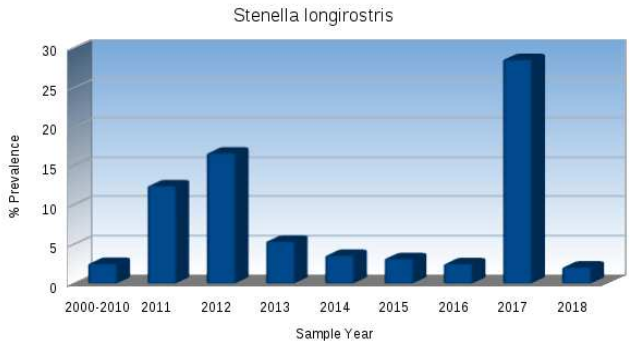
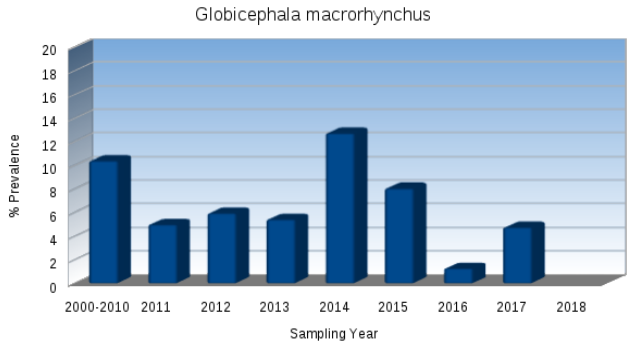
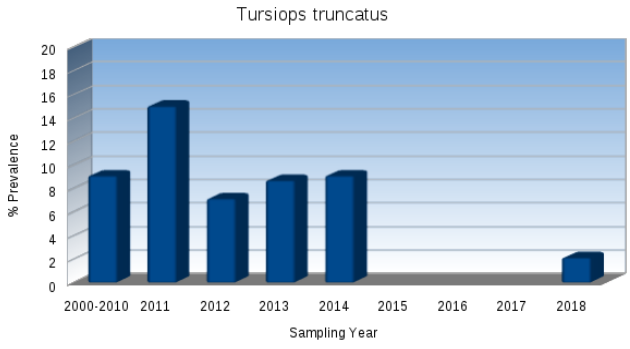
% Prevalence
0 5 10 15 20 25 30 35 40
2000-2010 2011 2012 2013 2014 2015 2016 2017 2018
Sampling Year

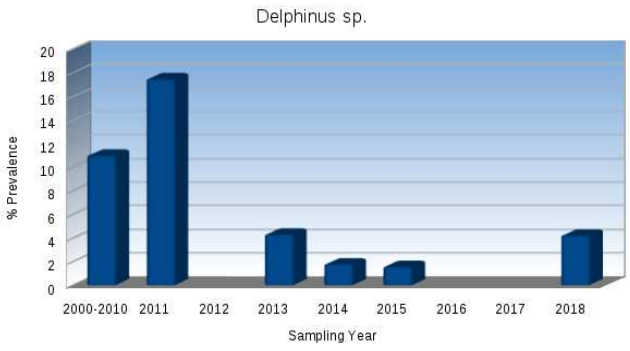

Steno bredanensis
% Prevalence
0 5 10 15 20 25
2000-2010 2011 2012 2013 2014 2015 2016 2017 2018
Sampling Year


Peponocephala electra
% Prevalence
0 5 10 15 20 25
2000-2010 2011 2012 2013 2014 2015 2016 2017 2018
Sampling Year


Stenella longirostris
% Prevalence
0 5 10 15 20 25 30
2000-2010 2011 2012 2013 2014 2015 2016 2017 2018
Sample Year


Globicephala macrorhynchus
% Prevalence
0 2 4 6 8 10 12 14 16 18 20
2000-2010 2011 2012 2013 2014 2015 2016 2017 2018
Sampling Year


Tursiops truncatus
% Prevalence
0 2 4 6 8 10 12 14 16 18 20
2000-2010 2011 2012 2013 2014 2015 2016 2017 2018
Sampling Year


Delphinus sp.
% Prevalence
0 2 4 6 8 10 12 14 16 18 20
2000-2010 2011 2012 2013 2014 2015 2016 2017 2018
Sampling Year

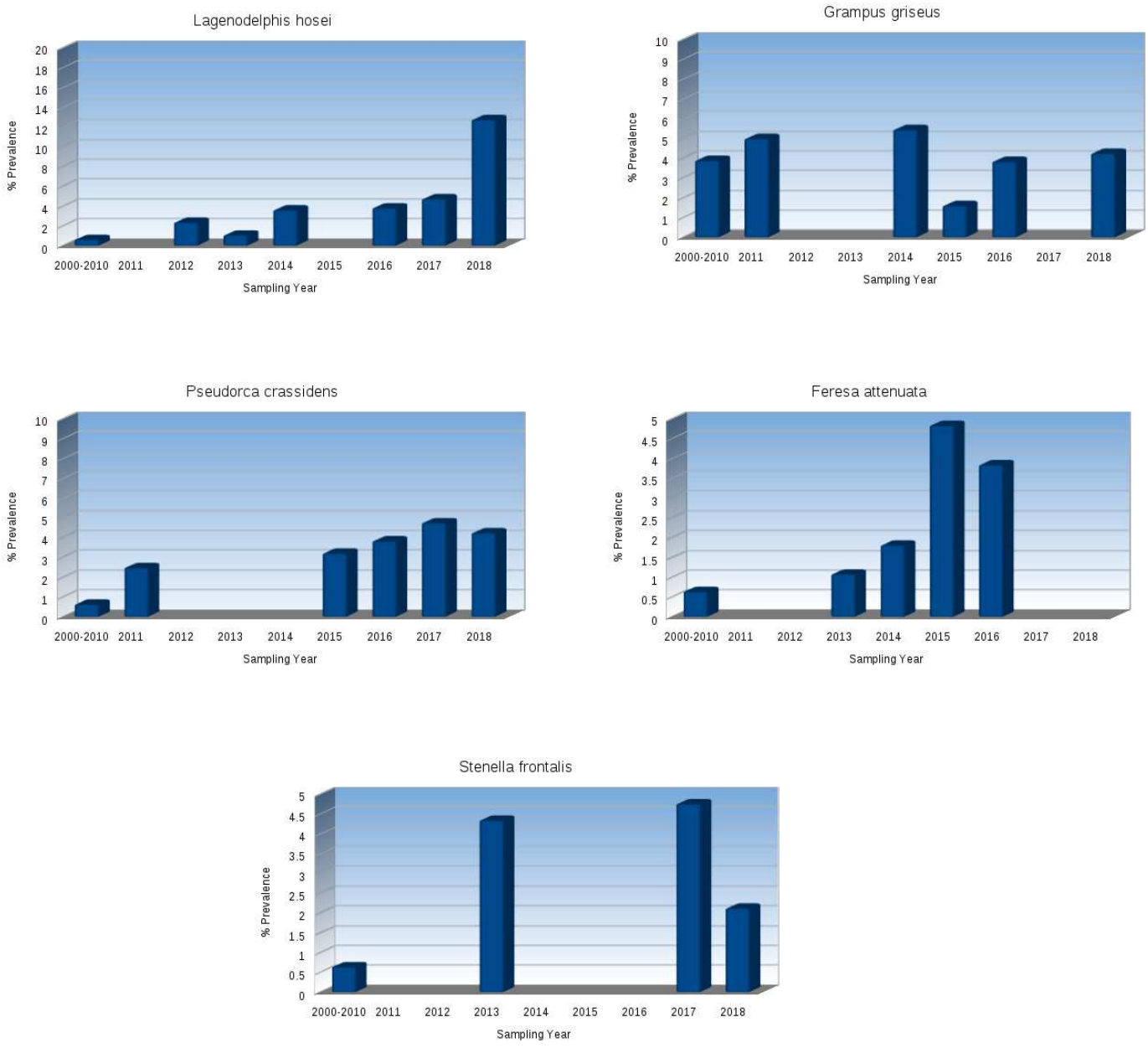


Figure 2. Inter-annual variation in the % prevalence of 13 small cetacean species landed at Dixcove port, relative to the total number of landed small cetaceans. The years 2000-2010 are pooled due to small annual samples. Statistical significance of long-term trends are summarized in Table 3. Species shown (from upper left to lower right) include: *Stenella clymene*, *Stenella attenuata*, *Steno bredanensis*, *Peponocephala electra*, *Stenella longirostris*, *Globicephala macrorhynchus*, *Tursiops truncatus*, *Delphinus sp.*, *Lagenodelphis hosei*, *Grampus griseus*, *Pseudorca crassidens*, *Feresa attenuata*, and *Stenella frontalis*.

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