FINAL REPORT TO

FUND FOR MARINE MAMMAL BYCATCH SOLUTIONS

Mitigating marine mammal bycatch in Senegal and The Gambia, West Africa

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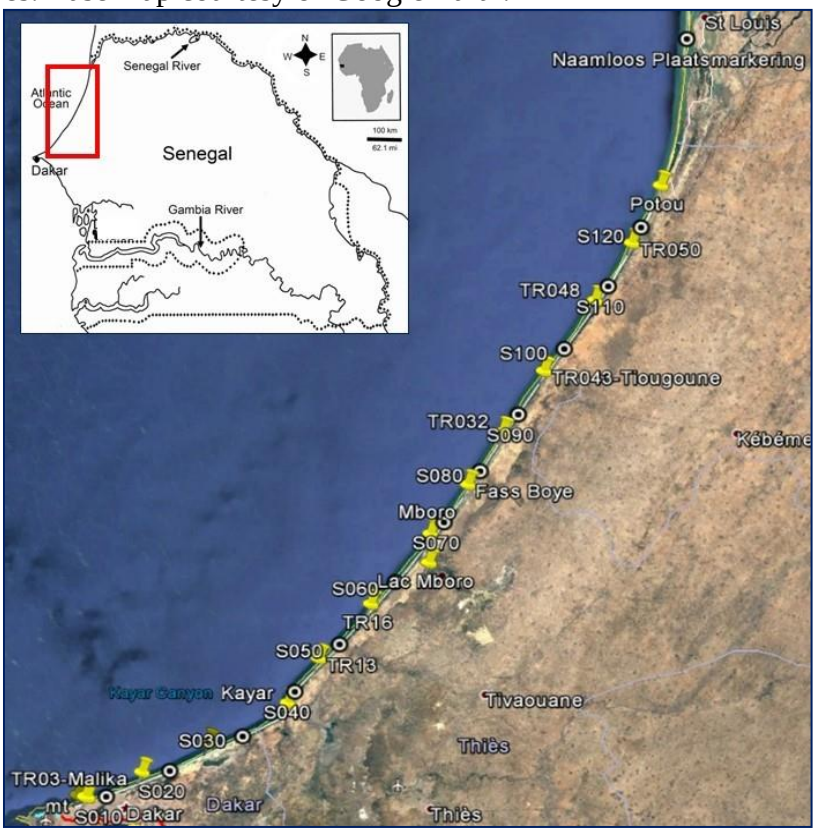
Project Activities – Stranding Surveys

This final report covers all activities during the entire performance period from June 1, 2022, to December 15, 2023.

The Senegal Stranding Network conducted ten stranding surveys during the study period. These included nine surveys of Senegal's north coast between Dakar and St. Louis, and the first ever stranding survey of the barrier islands of Delta Saloum in central Senegal. For the north coast surveys, the coast was divided into 12 transects (named from S010 to S120), each 10-15 km long, for later analysis (Figure 1).

Figure 1. Map of Senegal's north coast survey area between Dakar and St. Louis, showing transect boundaries. Base map courtesy of Google Earth.



North coast surveys ranged from Diamalaye in Dakar (14.76599 N, -17.44741 W) to Potou (15.74382 N, -16.5576W) just south of St. Louis, a total distance of 150 km. We were unable to drive all the way to St. Louis due to unstable and unsafe sand conditions on the long sandbars at the mouth of the Senegal River. Surveys were carried out by one or two teams of four people each, using one or two four-wheel drive vehicles. Surveys always began in the morning, two to three hours before low tide, and lasted each day until one to two hours before the following high tide. A vehicle speed of 30-35 km h^{-1} was maintained while searching for carcasses along the high tide line and higher up the beach, when possible. Depending on the number of carcasses encountered, surveys lasted from two to four days. Because of frequent

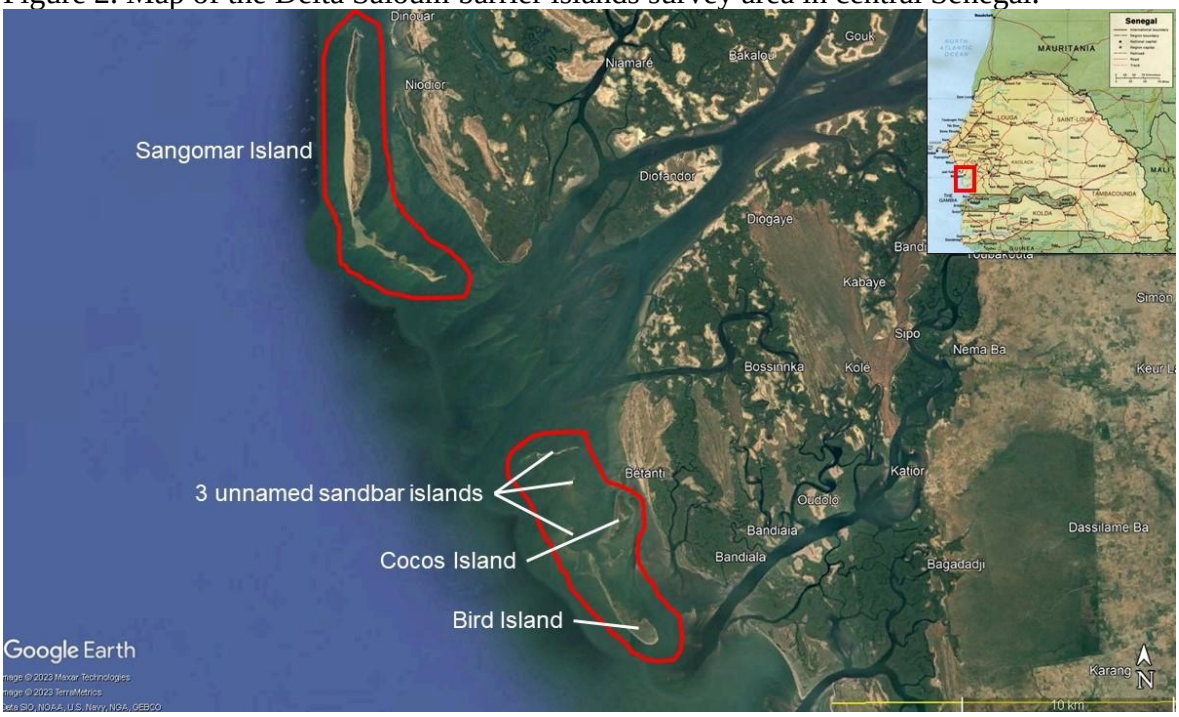
changes in the morphology of the beach, in particular after storms or spring tides, small parts were sometimes difficult to search, which will have led to missing individuals. From June to October 2023, after completing the survey to the north end, we returned south via the beach, surveying in reverse order again, to account for individuals missed during the main survey or for new strandings in the past one to three days, as well as documenting carcasses that had disappeared since the northbound trip, allowing for the calculation of disappearance and novel stranding rates.

Upon finding a stranded carcass, it was inspected, date, time, and the geographical coordinates were recorded, standard length measurements and photographs were taken and DNA samples were systematically collected from skin, muscle or bone samples, depending on the stage of decomposition, for later molecular analysis (Photo 1). In some cases, skulls or other bones were also collected as voucher material. Gross *in situ* necropsies were only done in a limited number of carcasses due to time restrictions. If the stage of decomposition (categorized as 1-5 following Geraci and Lounsbury, [2005]) permitted, the sex was recorded as well. Individuals were identified by using the survey team's expert knowledge or by consultation of reference works such as Jefferson et al. (1993).

Signs of bycatch (e.g. net marks, cut-off tails or flippers/fins, wounds by stabbing, gear attached, see examples in Photos 2 and 3) and/or butchering (e.g. sharply cut edges and other knife marks, muscle removed) were recorded and other indications of possible causes of stranding collected. From fresher carcasses of Mysticetes, information was also collected of the number and length of ventral pleats relative to the position of the umbilicus. As large whales rarely were entirely ventrally exposed, the number of pleats was taken from the ventral midline till the start of a pectoral fin and multiplied by two. Baleen plates could only be inspected or collected on rare occasions. After leaving the remains, spray paint was sometimes used to mark carcasses to avoid double counting them during later surveys. This proved particularly helpful when carcasses had been displaced by tides between surveys.

A survey of the barrier islands of Delta Saloum, Senegal was carried out from January 4-6, 2023 (Figure 2). Two AACF staff were joined by two agents from Sangomar Marine Protected Area and one from Delta Saloum National Park. We boated to seven islands then walked the perimeters, a total of 29 km over three days. No marine mammal remains were found, but it gave us an opportunity to work with local protected area managers, who have since reported other carcasses to us, including the skeleton of an unknown whale species (genetics results are pending to identify the species) that was struck and likely killed by a ship, documented on Sangomar Island on April 12, 2023 (Photo 4).

Figure 2. Map of the Delta Saloum barrier islands survey area in central Senegal.



Additional carcass records from throughout Senegal's coastal region were reported through our network of partners at marine protected areas, at Langue de Barbarie and Delta Saloum National Parks, and from the public. We also included information on strandings obtained from the national press and from social media. The latter are incomplete as they contain more stranding records which we did not extract, of whales in particular. An example is shown in Photo 5.

All stranding information was recorded on preprinted datasheets in the field. After returning to our office, all information was entered in a database for later analysis. All stranding data was analyzed by species, locality, season, and cause of mortality to detect potential trends in stranding occurrence.

Processed and verified daily industrial fisheries fishing effort data (hours fished per 0.01° x 0.01°) for the Senegal Exclusive Economic Zone (EEZ) from 2022 through 2023 were directly downloaded from the GFW apparent fishing map (Figure 1, https://globalfishingwatch.org/map/). These latter data had not undergone post-verification and therefore may still contain some inaccuracies. Data were obtained from the Automatic Identification System (AIS) on board fishing vessels. As AIS can be manually turned on and off, these may be incomplete as well, particularly during Illegal, Unreported and Unregulated (IUU) fishing. However, AIS data as provided by GFW are the only freely available data on industrial fishing effort in the public domain. Data were sliced to the nearest 0.1° latitude in an E-W direction to obtain separate values for each transect S010 through S120 (see also under Beach Surveys and Data Handling).

Project Activities – Training and Stakeholder Meetings

From July 6-8, 2023, we led a 3-day training workshop at Gunjur, The Gambia for colleagues from four non-profit wildlife research organizations to begin a stranding network for

The Gambia. The following organizations each sent two to four people for training: The Center for Climate Action, Environment, and Marine Research, The Gambian Marine and Environmental Conservation Initiative, The African Fish and Wildlife Conservancy, and Smile For Life. The workshop included one and a half days of classroom presentations and practical training (taking standard measurements, filing out datasheets, etc.) and one and a half days of practice beach surveys (Photo 6).

In early December 2023 we held three stakeholder meetings in St. Louis, Lompoul, and Kayar, Senegal, on the north coast of Senegal where the majority of cetaceans strand. Invited guests included representatives from Senegal's Ministry of Water and Forestry, Marine Protected Areas, National Parks, Senegal's Fisheries Service, and local leaders of fishing cooperatives, and the public. After the meetings we had evening presentations of a skit and a video talking about the importance of protecting cetaceans, as well as the dangers of bycatch and who to report strandings to (Photos 7 - 9).

Project Results – Stranding Surveys and Opportunistic Reports

The Senegal Stranding Network conducted nine stranding surveys during the study period. These included eight surveys of Senegal's north coast between Dakar and St. Louis, and the first ever stranding survey of the barrier islands of Delta Saloum in central Senegal. In 2022 and early 2023 we conducted quarterly surveys, then we conducted monthly surveys between May and October 2023 to give us much more information on numbers of carcasses during the time of year when we have traditionally found the highest numbers (Table 1).

Table 1. Survey Dates, locations surveyed, and marine mammals documented during the study period. Genetic samples have been collected for all unknown dolphins and whales and have been submitted to the Smithsonian National Museum of Natural History for DNA analysis.

Dates	**Area Covered**	**Cetaceans Documented**
June 10-12, 2022	Dakar to Potou	28 cetaceans: 21 *Delphinus delphis*, 2 Stenella sp., 2 *Grampus griseus*, 1 *Globicephala macrorhyhus*, 1 Balenoptera sp., 1 unknown dolphin sp.
July 25-26, 2022	Dakar to Potou	7 cetaceans: 2 *Globicephala macrorhyhus*, 2 Stenella sp., 3 unknown dolphin sp.
January 4-7, 2023	All barrier islands of Delta Saloum	No marine mammals found
May 15-17, 2023	Dakar to Potou	22 cetaceans: 8 *Delphinus delphis*, 2 *Phocoena phocoena*, 2 *Globicephala macrorhynchus*, 1 *Feresa attenuata*, 6 Balaenoptera sp., 2 Unknown dolphin sp.
May 30-June 1, 2023	Malika to Potou	33 cetaceans: 25 *Delphinus delphis*, 4 *Phocoena phocoena*, 1 *Grampus griseus*, 1 *Globicephala macrorhynchus*, 1 Balaenoptera sp., 1 unknown dolphin sp.

Dates	Area Covered	Cetaceans Documented
June 14-16, 2023	Dakar to Potou	73 cetaceans: 64 *Delphinus delphis*, 2 Globicephala sp., 2 *Grampus griseus*, 1 *Phocoena phocoena*, 4 Balaenoptera sp.
July 15-16, 2023	Dakar to Potou	18 cetaceans: 11 *Delphinus delphis*, 1 *Feresa attenuata*, 1 *Grampus griseus*, 1 *Globicephala macrorhynchus*, 1 *Stenella clymene*, 2 unknown dolphin sp.
August 12-14, 2023	Dakar to Potou	11 cetaceans: 3 *Delphinus delphis*, 2 *Globicephala macrorhynchus*, 1 *Tursiops truncatus*, 1 *Kogia sima*, 1 Stenella sp., 1 unknown dolphin sp., 1 unknown cetacean.
September 12-14 2023	Dakar to Potou	7 cetaceans: 1 *Delphinus delphis*, 1 *Globicephala macrorhynchus*, 1 *Physeter macrocephalus*, 1 *Tursiops truncatus*, 2 Balaenoptera sp., 1 unknown whale sp.
October 10-12 2023	Dakar to Potou	9 cetaceans: 1 *Delphinus delphis*, 1 *Phocoena phocoena*, 1 *Stenella frontalis*, 1 *Megaptera novaeangliae*, 5 unknown whale sp.

A total of 225 cetaceans were recorded during the study period (Table 2). Of these, 208 were documented and sampled during surveys, and 17 were recorded outside of surveys. All cetaceans from north coast surveys showed a regular stranding pattern across transects. Peak occurrences near artisanal fish landing sites were not significant. Common dolphins were by far the most frequently documented species, with 139 carcasses recorded, or 62% of total carcasses. Several other species had not been recorded in Senegal for many years: our two records of *Feresa attenuata* are the first since Cadenat recorded the species in 1958, 65 years ago (Cadenat, 1958), and *Kogia sima* had not been recorded in Senegal for 42 years (Maigret and Robineau, 1981). We are still waiting for species identifications from unknown carcasses from DNA analyses being conducted by the Smithsonian National Museum of Natural History.

Stranding numbers peaked in May and June annually. This coincides with the peak period of increased prevalence of W-NW winds and correlated oceanographic factors. However, this period is after the main upwelling season (December-May) and the highest trawler fisheries effort (March-May). These events are assumed to have attracted large numbers of cetaceans to coastal waters. Therefore, it is likely that a higher probability of stranding in the period June-July is responsible for these high stranding rates, rather than a drastic increase in the presence of cetaceans. Oceanographic factors outside the time window of May-August will favor the transport of carcasses towards the ocean rather than to the beach and strongly reduce the probability of strandings, and hence of recording them during surveys. This assumption is corroborated by data on currents off the Senegalese coast which show southward flows in the period from December - May with coastward currents in June which change to a northward flow in the warmer period from July till November. However, tidal currents close to the beach complicate the general patterns, as shown during our monthly surveys in 2023 from May through October: carcasses that were recovered after initial discovery were systematically displaced in a southerly direction, sometimes over several kilometers within a month.

Twenty-eight percent of cetaceans documented (n= 62) were confirmed as bycaught by the presence of net marks on the carcass and/or by flippers, dorsal fins or tails that had been cut off (Table 2, Photos 2, 3 and 10). An additional 57% (n= 129) of carcasses were too decomposed to determine if they were bycaught. Unsurprisingly, incidences of bycatch were easier to document for fresher carcasses, but the majority of the carcasses we documented were badly decomposed (44%) or only bones (18%), making it much more unlikely that bycatch could be determined (Table 3).

Table 2. All stranded cetaceans documented by the Senegal Stranding Network between June 1, 2022 and December 15, 2023, including the total numbers by species, and the numbers documented as bycaught and/or butchered.

Species	**Common Name**	**Total Number Recovered**	**Number Confirmed Bycaught**	**Unable to confirm if Bycaught ****	**Number Confirmed Butchered**	**Unable to confirm if Butchered ****
Balaenoptera borealis	Sei whale	1	0	0	1	0
Balenoptera sp.*	Unidentified Balaenoptera *	10	0	10	0	0
Delphinus delphis	Common dolphin	139	54	67	23	12
Feresa attenuata	Pygmy Killer Whale	2	0	1	0	1
Globicephala macrorhyhus	Short-finned Pilot Whale	13	2	7	1	4
Grampus griseus	Risso's Dolphin	6	0	5	0	1
Kogia breviceps	Pygmy Sperm Whale	1	0	0	0	0
Kogia sima	Dwarf Sperm Whale	1	0	1	0	1
Megaptera novaeangliae	Humpback Whale	1	0	1	0	1
Phocoena phocoena	Harbor Porpoise	8	1	7	0	3
Physeter macrocephalus	Sperm Whale	1	0	1	0	1
Sousa teuszii	Atlantic Humpback Dolphin	2	1	0	1	0
Stenella clymene	Clymene Dolphin	1	0	0	0	0

Species	Common Name	Total Number Recovered	Number Confirmed Bycaught	Unable to confirm if Bycaught **	Number Confirmed Butchered	Unable to confirm if Butchered **
Stenella frontalis	Atlantic Spotted Dolphin	1	1	0	0	0
Stenella sp.*	Unidentified Stenella sp.	5	0	3	2	1
Tursiops truncatus	Bottlenose Dolphin	5	1	3	1	2
Unknown cetacean*		2	0	2	1	1
Unknown dolphin sp.*		10	2	6	5	2
Unknown whale sp.*		16	0	15	0	14
	TOTALS	**225**	**62**	**129**	**35**	**44**

*Samples taken from unidentified carcasses were submitted for genetics analysis to determine species.

**Carcasses were too decomposed to determine if bycaught or butchered.

Table 3. Percentage of carcasses confirmed as bycaught by decomposition stage. Stage 2 is defined as a fresh carcass, stage 3 is moderately decomposed, 4 is badly decomposed and 5 is bones only. The decomposition stage was recorded for 213 carcasses.

Decomp. Stage	Number of strandings	Percentage Confirmed Bycaught	Percentage of Unknown
2	12	42%	17%
3	69	12%	6%
4	94	31%	60%
5	38	5%	95%

Eighteen carcasses had evidence of both bycatch and butchering. These data add to our database of over 530 stranded cetaceans of 26 species that we have recorded since we began the Senegal Stranding Network in July 2014. Analyses of all stranded cetaceans recovered by our network for the first ten years (2014-2023) were begun by postdoc Dr. Wim Mullié for a scientific publication which we expect to submit to a journal in early 2024. Our data analyses are focusing on the seasonality of strandings, association with fishing ports, and the prevalence of bycatch and butchering for human consumption. We will share the publication with you as soon as it is accepted by the journal.

In addition to cetaceans, we had one African manatee stranding during the performance period. An adult female manatee (TL= 290 cm) was found dead on the beach at Ngazobil Seminary, less than two miles from our office on February 23, 2023 (Photo 5). Genetics samples and the skull were collected. The ear bones will be used to age the manatee and for future feeding ecology studies, the skull will be used for taxonomy studies. Unfortunately, no cause of

death was able to be determined. During our annual education programs for primary and secondary schools in Joal, Senegal, we often hear about bycaught manatees from children whose fathers have caught them and brought the meat home to feed the family, but we have been unable to get fishermen to report it when they accidentally catch manatees in nets. They are aware it's illegal and butcher them at sea, bringing only meat home hidden in their boats. Therefore, so far it has been impossible to accurately determine the numbers killed by bycatch each year, but based on reports from school children, at least five are killed in nets annually in Joal.

Project Results – Training and Stakeholder Meetings

Ten people from four organizations attended the training workshop in The Gambia (Photos 11 and 12). Most had prior experience with sea turtle strandings, but little or no experience with cetaceans. Trainees were very enthusiastic and asked lots of good questions. As a result of this training, we documented the first Cuvier's beaked whale record for the Gambia (Photo 13) and we created a WhatsApp group for trainees to share their news, ask us questions and more. This group has become very active in the months since the training, and we have been able to help them identify the species of carcasses, and we have connected them with our colleague Dr. Aristide Kamla from Cameroon who has developed a citizen science app called Siren that they will implement in the Gambia.

At the stakeholder meetings in Senegal December 4 -8, 2023, we hosted 70 people in St. Louis, another 70 people in Lompoul, and 56 people in Kayar, for a total of 196 people from four government agencies, five fisheries cooperatives and the public. In St. Louis we also hosted approximately 500 students from four primary schools at booths, activity stations and a video explaining the protected status of marine mammals, their threats and the importance of protecting them (Photos 14 -15). At night we also showed the video and had a live skit performance at a fish landing port in St. Louis that attracted at least 150 people (Photo 16). In Lompoul and Kayar the skit performance and the video were shown directly after the stakeholder meetings,

Project Conclusions

The numbers of stranded cetaceans and sea turtles documented by this study likely represent only a small portion of those that have died at sea. Previous work in other parts of the world have shown that only from 2%-20% of all carcasses reach the beach (Faerber and Baird, 2010, Williams *et al*. 2011) due to drift, ocean currents, sinking, scavenging, and other factors. However, our regular beach surveys and documentation since 2014 represents the longest dataset of strandings in West Africa. Additionally, the numbers of bycaught cetaceans that we recorded is likely an under representation of the true number killed by artisanal and industrial fishing vessels off Senegal, due to decomposition.

Our ability to detect bycatch is strongly based on stage of decomposition of carcasses. While quarterly surveys give us much more information than previously existed for Senegal, it often means we don't find as many fresh carcasses. Even monthly surveys during the summer of 2023 did not provide as many fresh carcasses as we had expected, and it appears that the only way to truly document the full extent of carcasses that wash ashore and to document as many fresh carcasses as possible is to conduct daily beach surveys of the north coast. We hope to raise funds to have two graduate students do this work during the peak summer months in the future.

Strandings of cetaceans were significantly more numerous in May-August annually, peaking in June during the study period. Cetacean strandings in general are evenly distributed along the coast. Individual species show slight variations in these patterns. *D. delphis* (peaking in June) were found more often in the southern portion of the north coast but *P. phocoena* (peaking in May) carcasses were found more in the northern portion of the north coast. We will include further analyses in our upcoming stranding publication.

Acknowledgements

All work was carried out under permits issued to AACF by Senegal Ministry of Water and Forestry, and under an MOU from the Senegal Direction of Marine Protected Areas. All cetacean genetics analyses are provided by the Smithsonian National Museum of Natural History.

Project Expenses

Expenses for the entire project to date are shown in the budget table below. Overall, the Gambia training workshop cost much less than anticipated, but the three necropsy kits we provided for them cost more than budgeted. The stakeholder meetings attracted many more people than originally budgeted for, and we had the opportunity to increase from two to three meetings, therefore those cost more than anticipated, but still were within the approved overall budget. We originally budgeted for 30 attendees at two meetings, but ended up hosting 196 people at three meetings, which greatly increased awareness of the problem of bycatch and significantly increased our reporting network all along the north coast. All other costs were closely aligned with our original budget.

We greatly appreciated the no cost extension of this grant until December 31, 2023, which allowed us to effectively complete the work we proposed.

Category / Budget Item	Cost Calculation	Total	Amount Spent
Surveys and year-round stranding response			
Transportation (4x4 car rental or other transportation to field sites)	$100/day x 30 days annually	$3,000	$3,000
Fuel (truck, boat)	$100/day x 30 days annually	$3,000	$2,550
Lodging & subsistence (per diem), PI and collaborators	$60/day x 20 days x 3 people	$3,600	$2,130
Replacement knives, scalpels, gloves and other necropsy tools	$300	$300	$415
Equipment cleaning and maintenance supplies	Gloves, sponges, bleach, dish soap, WD40, etc.	$100	$130

Category / Budget Item	Cost Calculation	Total	Amount Spent
Meetings and Workshops with Senegal Fisheries & NGO collaborators			
Travel stipends for 30 attendees at 2 meetings	30 x $37.50/day x 2 meetings	$2,250	$4,000
Lunch and coffee breaks (expected in West African countries during meetings)	Coffee breaks: $5/person x 30 people x 3 meetings. Lunches: 10/person 30 people x 3 meetings	$1,350	$2,940
Transportation for PIs to travel to fisheries meetings (fuel, tolls, parking or public transportation)	$120/meeting x 2 meetings	$240	$400
Gambia Training Workshop			
Stipends for 10 attendees	10 x $25/day x 4 days	$1,000	$250
Venue rental	$100/day x 3 days	$300	$300
Lunch and coffee breaks	Coffee breaks: $5/person x 10 people x 3 meetings. Lunches: $10/person x 10 people x 4 days	$550	$300
Transportation for workshop to travel to field site for practice survey	$100/day x 1 day	$100	$0
Transportation for 2 trainers to travel from Senegal to The Gambia	$200/person x round trip	$400	$213
Lodging for 2 trainers traveling from Senegal	$80/person x 2 people x 5 days	$800	$66
Necropsy tool kit for Gambian colleagues (knives, meat hooks, scalpels, tweezers, scissors, measuring tape, gloves, tool box, cleaning supplies, etc.)	$200 each	$200	$679
Other Logistics			
Communication (Phone credit, internet)	Communication with network members, $25/month	$300	$227

Category / Budget Item	Cost Calculation	Total	Amount Spent
Printing (training materials, hotline info. flyers)		$150	$41
Currency exchange fees	$5 per ATM cash withdrawal in Senegal x 20 withdrawals	$100	$100
Administrative			
Salary for PI L. Keith-Diagne to lead/run the project, lead training workshops/meetings, and analyze all data	1 month salary ($64,000 annual salary) + $667 benefits for 1 month	$6,000	$6,000
Stipend for Senegalese post-doctoral researcher	$1000 x 6 months	$6,000	$6,000
	GRAND TOTALS	**$29,740**	**$29,740**

Project Photos

We are happy to provide additional photos of the project on request.

Photo 1. Total length measurement collection on a dolphin carcass during a stranding survey in July 2023. Photo by Khadim Seck.

Photos 2 and 3. Signs of bycatch on a stranded Striped dolphin (*Stenella coeruleoalba*) documented on June 10, 2022: A) the tail has been cut off and B) linear marks around the melon and lower jaw were likely made by a net. Photos by Lucy Keith-Diagne.

Photo 4. An agent from Sangomar Marine Protected Area is shown with the skeleton of an unknown whale species documented on Sangomar Island on April 12. 2023. The vertebrae at the bottom of the photo have been sheared off. Likely by a large boat propeller. Photo by L. Keith-Diagne.

Photo 5. Blue or Fin whale carcass reported by a member of Senegal Fisheries Service who joined our reporting network after the stakeholder meetings in December 2023. Photo courtesy of Pape Moustapha Ngom, Senegal Service des Pêches.

Photo 6. Lucy Keith-Diagne demonstrates how to take a standard length measurement during a training session for a new national stranding network in The Gambia, July 5, 2023. Photo by Tomas Diagne.

Photo 7. Lucy Keith-Diagne gives a presentation on cetaceans and bycatch during a stakeholder meeting in St. Louis, Senegal. Photo by Khadim Seck.

Photo 8. Diana Seck discusses the problem of bycatch in artisanal fisheries during a stakeholder meeting in Lompoul, Senegal. Photo by L. Keith-Diagne.

Photo 9. Stakeholder meeting in Kayar, Senegal. Photo by L. Keith-Diagne.

Photo 10. Net marks on a dead Common dolphin indicate it was likely killed by bycatch. Photo by L. Keith-Diagne.

Photo 11. Lucy Keith-Diagne and Gambian stranding network trainees Ahmed Manjang and Sulayman Njai examine a dolphin skull during a practice beach survey in Gunjur, The Gambia on July 7, 2023. Photo by Tomas Diagne.

Photo 12. Tomas Diagne (second from left) and Lucy Keith-Diagne (second from right) led a three day training workshop for ten trainees from four local marine wildlife organizations from July 6-8, 2023.

Photo 13. The skull of a Cuvier's Beaked whale found during a training survey of Gunjur Beach, The Gambia is the first record of this species for the country. Photo by L. Keith-Diagne.

Photo14. Diana Seck discusses the importance of protecting dolphins from bycatch to school children during an educational event in St. Louis, Senegal. Photo by L. Keith-Diagne.

Photo 15. AACF staff Ayouba Sarr talks to school children before a video about protecting cetaceans from bycatch in St. Louis, Senegal. Photo by L. Keith-Diagne.

Photo 16. Fishermen and their families watch an educational skit about protecting dolphins during an evening performance at a fishing port in St. Louis, Senegal. The skit actors speak in Wolof, the local language, to best convey the message of protecting dolphins and reducing bycatch to the fishing community. Photo by L. Keith-Diagne.

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