Australian Marine Mammal Centre Grants Program
Final Report
(subclause 9 and Schedule Item 5 of the Funding Agreement)

- **Project No**. –
- **Title** - Coastal Marine Mammals along the Eastern Gulf of Thailand
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- **Organisation** – San Francisco State Universitiy

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1. Project Summary

Little is known about nearshore Irrawaddy dolphins (*Orcaella brevirostris*) in the Gulf of Thailand. The Irrawaddy dolphin is generally found in shallow estuaries and coastal waters throughout Southeast Asia (Reeves *et al*. 2008). For example, in the Philippines, most sightings were made within 6 meters of depth (Dolar *et al*. 2002). Like the dugong, Irrawaddy dolphins are vulnerable to incidental fisheries catch and proximity to coastal development (Dolar *et al*. 2002, Reeves *et al*. 2003). All three of the species we have sighted (*Orcaella brevirostris, Sousa chinensis*, and *Neophocaena phocaenoides*) had not been studied in this area previous to our project's commencement in 2008. We found a relatively large population of *Orcaella*, and have had repeated sightings of the other 2 species.

Chantrapornsyl *et al*. (1996), Stacey and Leatherwood (1997), Stacey and Arnold (1999), and Andersen and Kinze (1999) note that while records of occurrence are few, Irrawaddy dolphins have been reported along the Gulf coast, with one report of a skull found in Khlong Yai, in Trat province, in 1914 (Andersen and Kinze 1999). The IUCN classes the Irrawaddy dolphin as a vulnerable species with a decreasing trend on its Red List of Threatened Species (Reeves et al. 2008). In Thailand, the Irrawaddy dolphin is included under the 1992 Wild Animals Preservation and Protection Act. In the IUCN/SSC Cetacean Specialist Groups's 2002-2010 Conservation Action Plan for the World's Cetaceans, one of the recommended research initiatives concerning the status of coastal cetaceans in Thailand addresses a need to identify special areas of "cetacean abundance for special conservation attention", as well as to document fishing intensity in these areas (Reeves *et al.* 2003, pg. 60). These dolphins are a species of concern in Thailand, as is evidenced by Thailand's sponsorship of Irrawaddy dolphins for CITES Appendix I protection in Bangkok, 2004.

The aim of the proposed research is to assess the conservation status of coastal cetaceans in Trat province and to provide recommendations towards their management and conservation in a multi-year interdisciplinary project, overseen by the principal investigators. This 2014 project was the continuation of research in 2008, 2009, 2012 and 2013 to locate coastal marine mammals and assess the numbers of Irrawaddy dolphins and the location of population groups along the eastern Gulf of Thailand. This year, we conducted line transect boat surveys in within Trat province in Thailand. We conducted line transect surveys for 13 days between Ban Mai Rut and Khlong Yai along the eastern coast of Trat province along a nearshore survey area. We completed surveys along all transect lines two times and had 67 on-effort sightings of 151 Irrawaddy dolphins (*Orcaella brevirostris*), two on-effort sighting of three Indo-Pacific finless porpoises (*Neophocaena phocaeniodes*) and three on-effort sightings of 11 Indo-Pacific humpback dolphins (*Sousa chinensis*). Using DISTANCE software, we combined and analyzed our survey data for all five years, resulting in an average relative abundance estimate of 423 Irrawaddy dolphins throughout our nearshore study area. Our colleagues from the Eastern Marine and Coastal Resources

Center conducted 74 interviews in local villages. The Thai coast along the eastern Gulf of Thailand is an important opportunity to study coastal marine mammals; local communities and the Thai government are supportive of these efforts.

2. The Outcomes and Objectives –Key Findings

1. Investigate the spatial distribution of coastal cetaceans along the coastal waters of Trat province.
2. Estimate the relative abundance of Irrawaddy dolphins in Trat province.
3. Determine the habitat use of Irrawaddy dolphins in Trat province.
4. Investigate their behavior, group dynamics, and movement patterns.
5. Investigate the potential threat local fishing practices pose to coastal cetaceans in Trat province.
6. Interview members of surrounding communities to assess their modern and historical relationship and interactions with dolphins
7. Train Thai scientists in research methods so that this work can be continued throughout the year.
8. Contribute research results as input to educational materials and national conservation planning.

Our methods towards achieving these first four objectives are based in part on techniques developed for research on the Irrawaddy dolphin in Australia (now described as the Australian snubfin dolphin *Orcaella heinsohni*, a coastal dolphin of the same genus) by Dr. Guido Parra (2005 and Parra *et al*. 2006) Our zig-zag survey design for boat-based transects is based on Strindberg and Buckland (2004). Research objectives rely upon the principal hypothesis that a practical and repeatable systematic survey can be designed for this north-south oriented area that will allow for quantitative statistical analysis and long-term monitoring of the dolphin population. Nested within the larger hypothesis are three smaller hypotheses: H_1: an abundance estimate for the population can be determined using distance sampling, H_2: the population exhibits spatial distribution patterns within the area and H_3: the population uses the area unevenly and exhibits obvious preferences to certain habitat characteristics or locations. To test

these hypotheses we developed a systematic survey design for the near-shore survey using the geographic information system (GIS) software ArcMap 9.3 (ESRI 2007) and the statistical modeling software Distance 6.0 (Thomas et al. 2009) (used to estimate animal abundance) (Figure 1). The design ensured even coverage across the study area while maximizing on-effort time. Field ground-truthing of each line was conducted to account or adjust for shallow or impassable areas and to ensure the transect lines can be run in perpetuity with minimal difficulty.

Distance sampling surveys along line transects that are widely used to estimate density and abundance of cetacean populations (Buckland *et al.*, 2004), were used for Irrawaddy dolphin dolphins in a stratified study area in the Gulf of Thailand during five field seasons in 2008, 2009, 2012, 2013 and 2014. During the survey, boat-based observers moved along zig-zag transect lines in each of the three survey strata: North, Middle, and South (see Figure 1). For each dolphin group observed, the radial distance (r) together with the angle (θ) between the transect line and the line of the detection, as well as the group is recorded. Density of Irrawaddy dolphin groups within the area surveyed is estimated as $\hat{D}_s = \frac{n\hat{f}(0)}{2L}$, where L denotes the aggregate length of the transects, n is the number of groups observed, $f(0)$ is the probability density function of observed perpendicular distances evaluated at zero distance from the line. The density of groups $\hat{D}_s$ is multiplied by the estimated expected group size $\hat{E}(s)$ to obtain density of individuals $\hat{D}$, and this estimate is multiplied by the surface area of each survey stratum to obtain the corresponding abundance estimate of dolphins by stratum ($\hat{N}$). Stratum-specific encounter rates and expected group size $\hat{E}(s)$ by year were used to estimate stratum specific densities of groups and individuals per year. Overall density for the study area per year was obtained by calculating a mean of stratum estimates weighted by stratum area.

DISTANCE software (Thomas *et al*., 2010) was used to analyze the data. The on-effort observations of Irrawaddy dolphin groups made from the line transects shown in Figure 1 were used for the distance sampling analysis. Options using a stratified (by stratum or year) or pooled data approach were considered in fitting the detection function. Various combinations of key functions and adjustment term were considered to model the detection function (e.g., uniform + cosine or simple polynomial, half-normal + cosine or simple polynomial, hazard rate + cosine or hermite polynomial). Goodness of fit tests were used to identify violations of assumptions.

Exploratory analyses were conducted to examine options for truncation and grouping intervals to improve model fit for the detection function. Akaike's Information Criterion adjusted for small sample size (AICc) was used in final model selection. Encounter rate was estimated within each of the survey strata per year and its variance was estimated empirically using the replicate transect lines as samples. There may be a tendency for smaller dolphin groups to be missed more often than larger groups at large distances from the transect line, which can lead to "size bias" if the average group size is simply used during the estimation process. To test for bias in the estimate of group size, we applied a statistical hypothesis test at the 15% α – level to the regression of natural logarithm of group size against the probability of detection at distance *x* from the line within the Distance software. If the regression was statistically significant the expected group size $[E(s)]$ is used, otherwise average group size was used to estimate density and abundance. Group size estimation was also stratified by survey stratum and year. Individual Irrawaddy dolphin density per stratum for each year and between sequential years was tested for statistically significant difference at the 5% significance level using a two-sided t test (Buckland *et al.*, 2004).

All surveys were conducted in closing mode from a 12-meter fishing boat equipped with inboard engines and boat speed was kept at 10 km hr^{-1}. A team of three observers continuously scanned from the bow to 90 degrees Port and Starboard with the naked eye and 7x50 binoculars while on effort. For each dolphin sighting detected during on effort searching, three variables necessary to estimate abundance were immediately recorded: the distance from the survey boat, the angle of the sighting and number of animals seen. Once the initial data were recorded the dolphin group was approached off effort, to within 10m to record their location using a handheld GPS unit. We also collected data on group size, general age composition (adult or calf), photographs for photo-identification when possible, behavioral data and environmental parameters. Environmental parameters for species distribution modeling were also collected every 30 minutes while on transect.

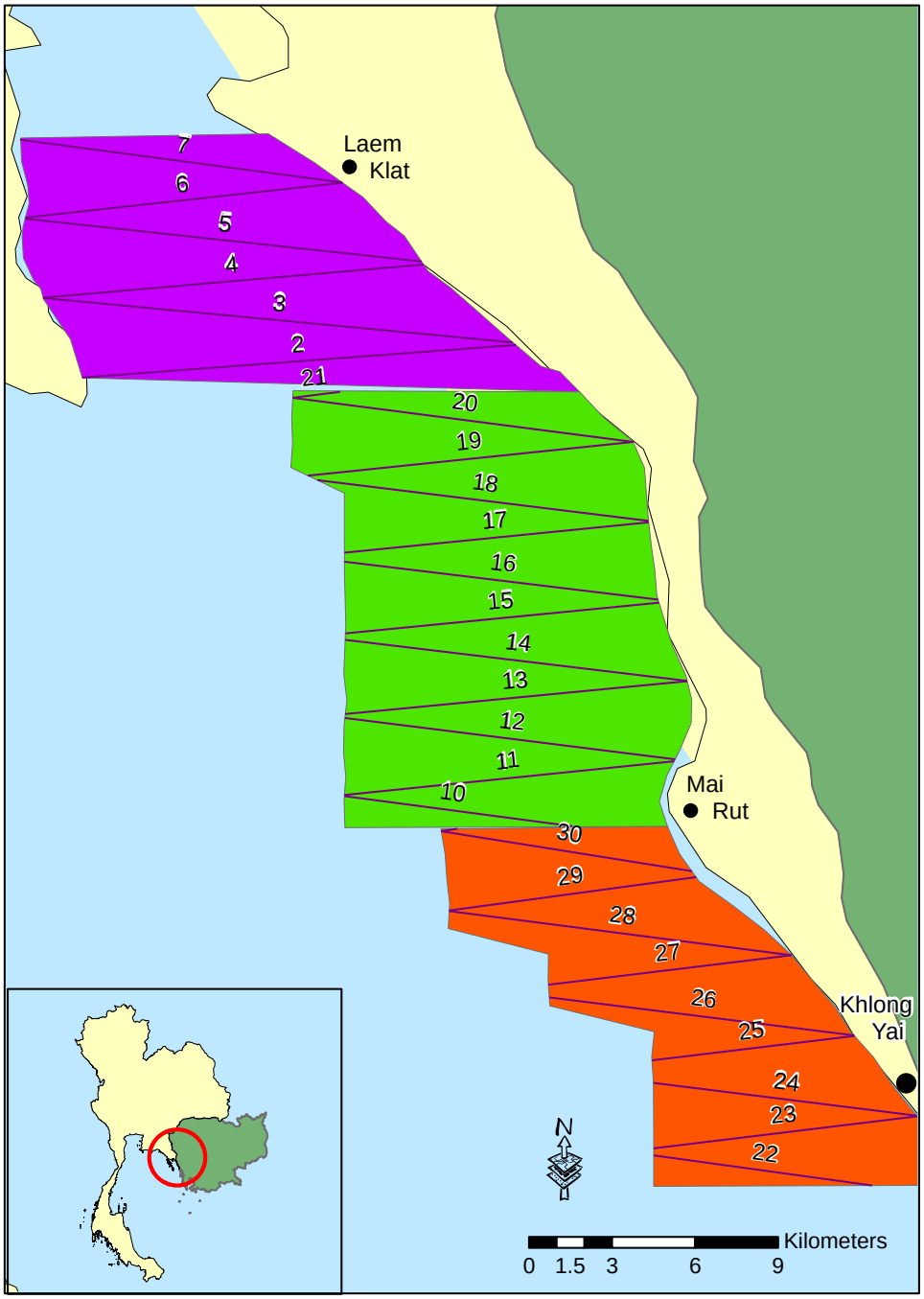
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Figure 1. Transects and sampling strata in the nearshore survey area. Purple is the north strata, green is the middle and orange is the south strata.

In the nearshore survey area we conducted line transect surveys for 13 days between Ban Mai Rut and Khlong Yai along the eastern coast of Trat province (Figure 1). We completed surveys along all transect lines twice. Throughout the 2014 survey, we had 67 on-effort sightings of 151 Irrawaddy dolphins, two sightings of 3 Indo-Pacific finless porpoises and three on-effort sightings of 11 Indo-Pacific humpback dolphins (*Sousa chinensis*) (Figure 4).

Table 1. Sightings and numbers of the three cetacean species seen in four years along the eastern Gulf Coast of Thailand.

Year	**Species**	**No. of on-effort sightings**	**Numbers of animals seen**
2008	*Orcaella brevirostris*	62	248
2008	*Sousa chinensis*	3	12
2008	*Neophocaena phocaenoides*	5	15
2009	*Orcaella brevirostris*	83	341
2009	*Sousa chinensis*	2	7
2009	*Neophocaena phocaenoides*	1	4
2012	*Orcaella brevirostris*	52	266
2012	*Sousa chinensis*	6	25
2012	*Neophocaena phocaenoides*	2	11-16
2013	*Orcaella brevirostris*	45	161
2013	*Sousa chinensis*	3	14
2013	*Neophocaena phocaenoides*	1	3
2014	*Orcaella brevirostris*	67	151

2014	*Sousa chinensis*	3	11
2014	*Neophocaena phocaenoides*	2	3

Even with all years combined, we did not have enough sightings of Indo-Pacific humpback dolphins or Indo-Pacific finless porpoises for an accurate abundance estimate. The encounter rate for Indo-Pacific humpback dolphins for example, was 0.06 sightings km^{-1} of effort.

The total effort per stratum and year for Irrawaddy dolphins are detailed in Table 2. In the final models, data were pooled across survey strata and years and grouped into 5 equal-spaced intervals with right truncation at 450 m (10% of the data). Pooling provided a more robust detection function (see Figure 3) due to some sample size issues when stratifying per year or survey stratum, and also due to some issues with the data measurements. In the early years there was heaping at zero and indications that particularly small angle sizes were not being measured accurately. In the later years it seemed that observers may have been overcompensating as there were more observations than expected some distance from the line (with no movement of dolphins away from the observers before measurements were taken). The final model was a half-normal with cosine adjustment terms, which gave a detection probability of about 38% and an effective half strip width of 171.26m (see Figure 4). Estimates of encounter rate and expected group size for each species and survey stratum are also detailed in Table 2. There is some indication of "size bias" in the North and Middle stratum in 2009 and in the South in 2012, so the expected group size was used in those cases and the average group size for the remainder of the stratum-year combinations. The final estimates of Irrawaddy dolphin group and individual density, and abundance for each survey stratum per year and overall per year is shown in Table 3. Although there were differences between the strata per year and overall by sequential survey years, given the fairly high variance associated with the estimates, individual Irrawaddy dolphin densities overall were only significantly lower in 2012 compared to 2009. Only when considering one-tailed t- test results was the South stratum significantly lower than the Middle stratum in 2009, the South stratum was also significantly lower than the North stratum in 2013, and the North stratum significantly lower than the middle in 2014.

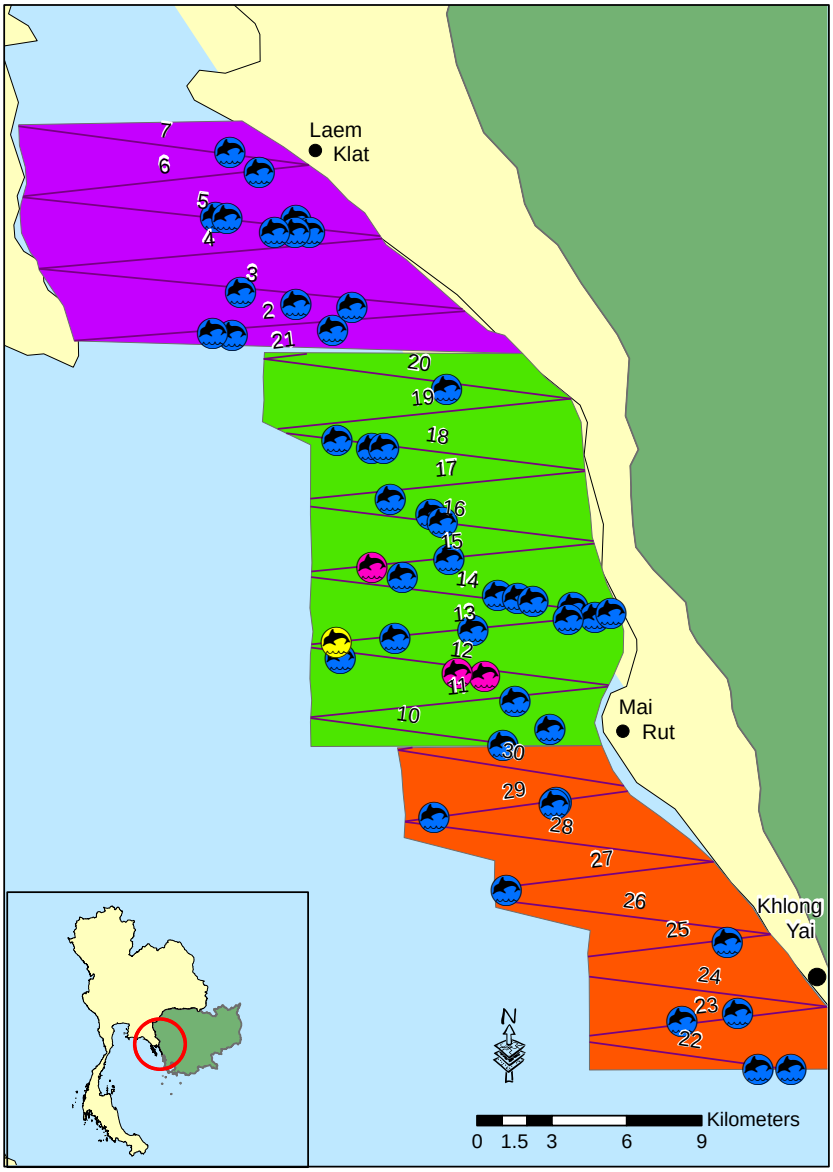

Figure 2. All on-effort sightings in 2014 for the nearshore survey. The transect numbers are noted on the transect lines. The blue area is the Top strata closer to the shallow bay. The green area is the shallow Middle strata near several river mouths. The orange area is the Bottom strata, a deeper area closer to the major fishing port of Khlong Yai. Blue points: Irrawaddy dolphin sightings, yellow: Indo-Pacific finless porpoises and pink: Indo-Pacific humpback dolphins.

Table 2. Details of the total effort (*L*) per year in the North (140.37 km^2 with 6 transects), Middle (179.02 km^2 with 12 transects) and South (118.06 km^2 with 10 transects) survey stratum. The number of observed of Irrawaddy dolphin groups (*n*) post right truncation, the estimate of group encounter rate (*n*/*L*), and the expected group size ($E(\hat{S})$) for each survey stratum per year with the corresponding 95% confidence interval (95% CI).

Year	Stratum	*L* (km)	*n*	*n*/*L* (km^{-1})	95% CI	$E(\hat{S})$	95% CI
2008	North	125.89	10	0.079	(0.042 – 0.151)	3.7	(2.19 - 6.25)
	Middle	363.77	36	0.099	(0.057 – 0.171)	3.53	(2.91- 4.27)
	South	240.36	11	0.046	(0.022 – 0.096)	4.64	(3.01 - 7.14)
2009	North	125.89	17	0.135	(0.079 – 0.230)	3.10	(2.09 - 4.61)
	Middle	363.77	50	0.137	(0.094 – 0.201)	3.74	(2.91 - 4.81)
	South	240.36	16	0.066	(0.038 – 0.116)	3.81	(2.71 - 5.36)
2012	North	125.88	20	0.159	(0.061 – 0.415)	2.90	(2.00 - 4.20)
	Middle	241.14	13	0.054	(0.021 – 0.138)	2.85	(2.07 - 3.92)
	South	160.24	10	0.062	(0.037 – 0.106)	5.67	(2.16 -14.89)
2013	North	83.92	12	0.143	(0.061 – 0.333)	3.67	(2.40 – 5.60)
	Middle	241.14	22	0.091	(0.049 – 0.171)	3.64	(2.57 - 5.14)
	South	160.24	8	0.050	(0.022 – 0.114)	2.38	(1.51 - 3.74)
2014	North	83.92	10	0.119	(0.043 -- 0.331)	1.60	(1.00 - 2.574)
	Middle	241.14	31	0.129	(0.093 – 0.179)	2.74	(1.90 – 3.96)
	South	160.24	22	0.137	(0.089 – 0.212)	2.32	(1.83 – 2.94)

Table 3. Estimates of density ($\hat{D}$) in number/km^2 (group density $\hat{D}_s$ in parentheses) and abundance ($\hat{N}$) of Irrawaddy dolphins for each survey stratum per year and overall per year with their corresponding 95% confidence intervals (95% CI), and the percent coefficient of variation (%CV).

Year	Stratum	$\hat{D}$ ($\hat{D}_s$)	95% CI	$\hat{N}$	95% CI	(%CV)
2008	North	0.858 (0.232)	(0.410 - 1.795)	120	(58 - 252)	35.27
	Middle	1.019 (0.289)	(0.571 - 1.821)	182	(102 - 326)	27.92
	South	0.619 (0.134)	(0.277 - 1.388)	73	(33 - 164)	39.39
	Total	0.860 (0.229)	(0.577 - 1.281)	376	(252 - 561)	20.02
2009	North	1.222 (0.394)	(0.667 - 2.237)	172	(94 - 314)	28.97
	Middle	1.501 (0.401)	(0.953 - 2.362)	269	(171 - 423)	22.48
	South	0.741 (0.194)	(0.396 - 1.388)	87	(47 - 164)	30.57
	Total	1.206 (0.343)	(0.868 - 1.676)	528	(380 - 733)	16.6
2012	North	1.345 (0.464)	(0.514 - 3.520)	189	(72 - 494)	43.23
	Middle	0.448 (0.157)	(0.170 - 1.183)	80	(30 - 212)	47.71
	South	1.032 (0.182)	(0.369 - 2.885)	122	(44 - 341)	50.38
	Total	0.894 (0.262)	(0.501 - 1.595)	391	(219 - 698)	28.46
2013	North	1.531 (0.417)	(0.645 - 3.636)	215	(90 - 510)	39.65
	Middle	0.969 (0.266)	(0.483 - 1.943)	173	(86 - 348)	34.34
	South	0.346 (0.146)	(0.143 - 0.839)	41	(17 - 99)	43.08
	Total	0.981 (0.282)	(0.586 - 1.642)	429	(256 - 718)	25.14
2014	North	0.589 (0.368)	(0.210 – 1.649)	83	(29-231)	46.92
	Middle	1.088 (0.397)	(0.671 – 1.763)	195	(120 – 316)	24.27
	South	0.982 (0.424)	(0.605 – 1.594)	116	(71 – 188)	23.33
	Total			391		

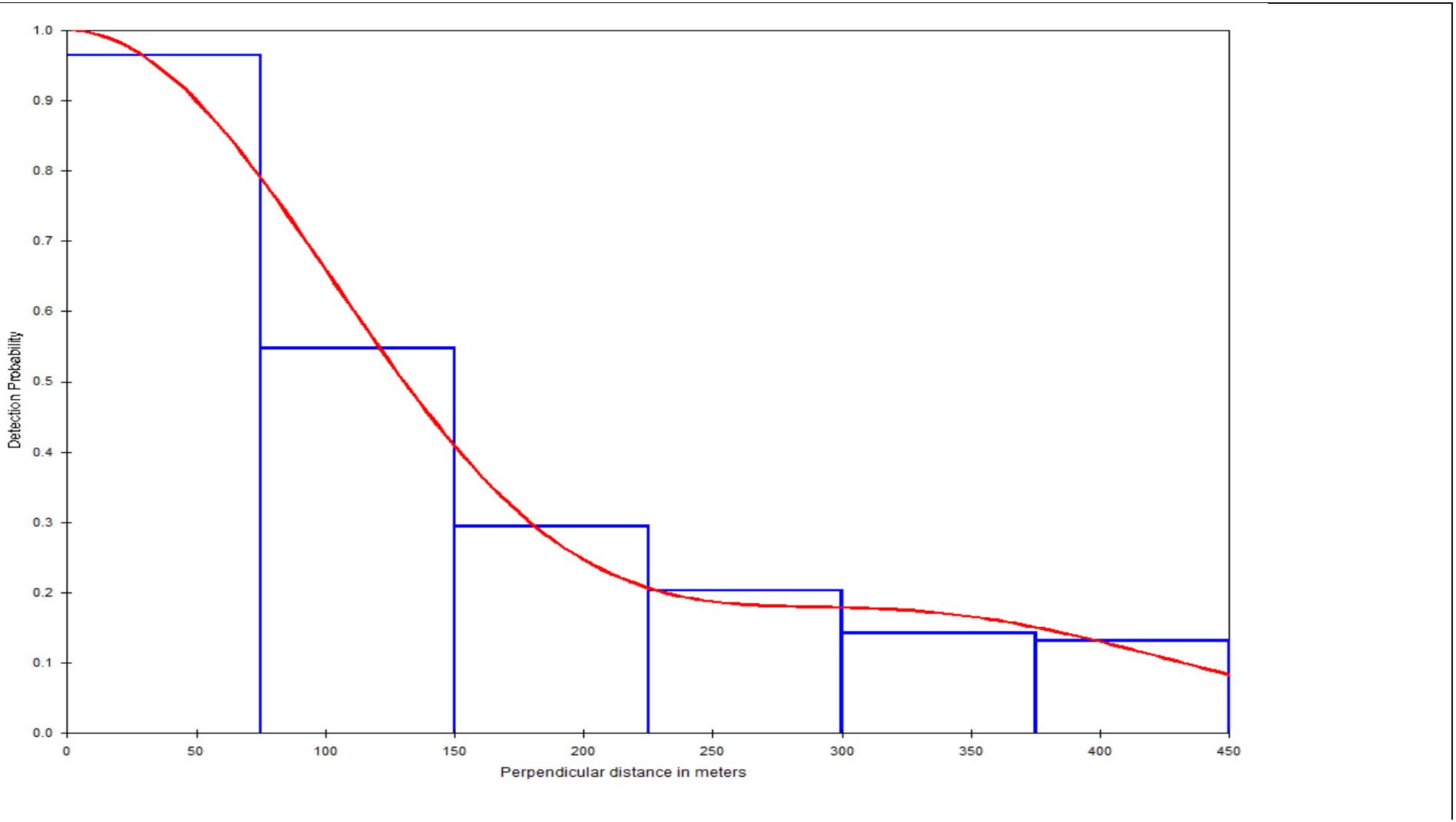

Figure 3: Detection functions fitted to the perpendicular distances of observations of groups of Irrawaddy dolphins. On-effort sightings are pooled across survey strata and survey years. Data were grouped for final analysis using 6 equal-spaced intervals with right truncation at 450 m.

5. **Investigate the potential threat local fishing practices pose to coastal cetaceans in Trat province.**
6. **Interview members of surrounding communities to assess their modern and historical relationship and interactions with dolphins**

We conducted interviews with local people, mostly small-scale fishers, in villages along the Trat coast. These interviews focused on marine mammals, their relationship with villagers, stranding events, patterns of movement and sightings, and fishing practices that may affect dolphins. We attended village meetings and gave lectures in local schools in Trat province. At these meetings and presentations, we explained our research and concerns about cetacean bycatch and plastic pollution, our fieldwork and research methods, and distributed posters, stickers and button badges about the "Trat Coastal Dolphin Project" and the new coastal stranding network that our collaborators at the DMCR have created. We have had several discussions with local conservation NGOs, and worked with a local conservation group to assess cases of recently stranded Irrawaddy dolphins.

Our colleagues from the Eastern Marine and Coastal Resources Center conducted 74 interviews in local villages. Respondents comprised 70 men and 4 women, with an average age of 43, minimum of 27 and maximum of 64 years. Table 4 shows the village, profession, boat size and fishing gear of respondents. Figure 6 shows interview locations.

Table 4. The villages, type of employment, fishing gear and boat size of interview respondents.

Village address/Profession Pivot

	Profession			
Village address	**Fisher's helper**	**Ferry Boat driver**	**Fisher**	**Total**
Ao Yai			5	5
Jek Rak			4	4
Khlong Yai		1	6	7
Kloa Meow			5	5
Klong Kud			4	4
Klong Manao			5	5
Klong Son	1		5	6
Laem Klut			12	12
Laem Ngob			9	9
Mai Rut	1		11	12
Namchieo			4	4
Nong Kansong			6	6
Total	**2**	**1**	**71**	**74**

Fishing gear/Boat size (more than one gear possible)

	Boat size(S=<10 m, M=10-20 m, L=>20 m)			
Fishing gear	**L**	**M**	**S**	**Total**
Bamboo stake trap		1		1
Crab Gill Net		3	19	22
Crab Trap		2	23	25
Crab Trap, Crab Gill Net			2	2
Fish Gill Net		4	32	36
Fish Trap			1	1
Long line for Octopus			5	5
Long line hook		2	7	9
Purse seine		1		1
Push net		2		2
Shrimp gill net		2	25	27
Shrimp Trawler	1	7		8
Squid Trap		1		1
(Blank)		1		1
Total	**1**	**26**	**114**	**141**

Figure 4. Interview locations along the coast of Trat province in 2014.

Out of 67 responses, no respondents had hunted dolphins in the past or present. Forty-one respondents see more dolphins in the dry season, between October and April, 25 believe they can be seen all year, one respondent sees dolphins in the wet season, between May and September.

When asked the number of dolphins seen in groups, 56 respondents reported seeing only small groups of animals (<5), 11 had no response. No respondent mentioned having seen calves. Only two respondents said they had found stranded dolphins, both Irrawaddy dolphins. One

person left the carcass at sea where they found it, the other informed local authorities. These same people were the only two that had heard about strandings.

Nineteen respondents believe that the local dolphin population is increasing. Thirty-two people believe the population is decreasing, and five respondents say that the population is not changing (Table 6 for comments). All respondents do not feel that dolphins interfere with fishing. No respondents mentioned catching animals in nets. Table 7 shows respondent opinions on conservation issues. Table 8 summarizes respondent comments on dolphin conservation.

Table 6. Reasons for Irrawaddy dolphin populations increasing, decreasing, or staying the same.

Comment	#
Fishers see less often	30 (45%)
Fishers see more often	18
Fishers see the same number	5
Too many boats	1
Need more conservation	1
Don't know	11
Total	**66**

Table 7. Interview respondent opinions on the importance of dolphin conservation, endangered species, seagrass, mangroves, coral reefs (5=very important, 4= important, 3=neutral, 2=moderately negative,1=very negative) and conservation in general (5=extremely positive, 4=moderately positive, 3=neutral, 2=negative, 1=extremely negative).

	Dolphin conservation (%)	Endangered species (%)	Seagrass (%)	Mangroves (%)	Coral reefs (%)	Conservation (%)	Totals (%)
5	22 (33)	13 (20)	17 (26)	21 (32)	19 (29)	37 (56)	129 (33)
4	40 (61)	49 (74)	49 (74)	45 (68)	47 (71)	25 (38)	255 (64)
3	4 (1)	4 (1)	0	0	0	4 (1)	12 (1)
Totals	66	66	66	66	66	66	396

Table 8. Respondent comments on dolphin conservation.

Comment summaries	Number of respondents
When dolphins are here, tourists will come and people will benefit	3
When dolphins are here, tourists will come and people will stop hurting dolphins	1
Dolphins are an indicator of diversity, we need to conserve them, but this area still has a problem with trawlers and push net	4
Dolphins are lovely and friendly, they are not aggressive to people so we should save them	5
Dolphins are important for diversity , no one needs to hurt them, we should save them for the next generation	1
Dolphins make more abundance of resources	2
Mangrove forest replantation can be helpful to increase the number of resources including dolphins	2
Need to save sea grass bed from trawlers and push net	4
Need to create more fishery networking for dolphin conservation in this area, protect the dolphins from trawlers	4
Need to save the dolphin for next generation, the water pollution from the community should be reduced.	1
Government officers should give more knowledge to fishermen about the sustainable use of marine resources	1
Support to do conservation in this area for dolphin watch	4
Need to have artificial reefs, it is a tool to conserve resources, then the dolphin will come more	2
Proud that dolphins are here, they need to be	1

saved	
Agrees with all efforts to save dolphins	1
Don't know	10

7. **Train Thai scientists in research methods so that this work can be continued throughout the year.**
8. **Contribute research results as input to educational materials and national conservation planning.**

We have shown over five years of research that we were successful in creating a practical and repeatable systematic survey for this north-south oriented area that allows for quantitative statistical analysis and long-term monitoring of the Irrawaddy dolphin population. Enough Irrawaddy dolphins were seen in the combined years for robust statistical analysis, with lower coefficients of variation, which shows the increasing skills of the international and Thai scientists trained in these methods. Also critical, each year the visibility of the scientists and our research increases conservation awareness in local villages. We stayed in local hotels run by villagers for all five years, hired a driver who is an active community member and ran our research on local fishing boats. As part of our commitment to local education, we have given presentations and lectures at elementary schools in Trat province, attended village council meetings and explained our research and concerns about cetacean bycatch and plastic pollution, had local teachers and students on our boats and explained our fieldwork and research methods to them, and worked with a local conservation group to take samples and teach about incidental bycatch in a local village after bycaught animals were found both on several beaches and floating in the water during our surveys.

The average relative abundance estimate of 423 Irrawaddy dolphins along the nearshore survey area reflects the estimate of animals in our survey area based on the number of sightings averaged over the five years (Table 3). Averaged over these years, based on our sighting patterns, the top and middle strata had slightly more sightings and groups of animals, and the bottom strata the least, with the exception of 2012 (Table 3). My colleagues believe this is because of the increased fishing activity near the port of Khlong Yai. These abundance results

will be written up and submitted as a journal article. The number of animals caught in nets is high as compared to the abundance estimate, as evidenced by the bycatch we encountered this year in the field and as stated in past reports (Hines et al. 2003,2004, 2008, 2009, 2012 and 2013). This reflects the important global threat of marine mammal bycatch.

As in past years, the majority of respondents are small-scale fishers with small to medium-sized boats. Based on the interviews from all years, we believe that the local people in this area are growing more aware of the significance of conservation. However, as compared to our previous interview results, more people believe that the numbers of Irrawaddy dolphins are decreasing. For example, in 2012, 44% of respondents thought the numbers of dolphins was increasing. In 2014, that percentage was 34%. Those who thought the number of dolphins was decreasing grew from 31% in 2012 to 57% in 2014. In 2012, 22% of respondents mentioned that they saw less dolphins while fishing; this percentage grew to 45% in 2014. The comments about dolphin conservation are varied, showing various concerns about dolphin and marine conservation in general, as well as an awareness of the dolphin's role in nearshore ecosystems and ecotourism. All of our respondents believe conservation is of importance. However, no respondents mentioned either bycaught animals or stranded animals being found this year, while last year's responses showed that 14 animals were found incidentally caught in fishing nets and drowned by the fishers we interviewed. This is a vital issue that should be explored in more detail in future community surveys, and the numbers compared with DMCR records of stranded animals. Strandings and bycatch should be made one of the foci of educational programs; the other being coastal pollution, as we saw quite a substantial amount of plastic marine debris on our surveys.

There are still questions that we would like to continue to explore while doing more transects and interviews in coming years about the ecology, foraging and habitat use of Irrawaddy dolphins and other coastal cetaceans in this area. One of our biggest questions is still the possible change of foraging and habitat patterns in various seasons. To begin to address this question, Ms. Junchompoo and her team are continuing bi-monthly photo-identification surveys.
Now that we have an abundance estimate, the next step is to continue to monitor the population for trends; to see whether the numbers and increase or decrease or remain the same over the next five years. Getting the estimate now is just a first step – but knowing the trends gives us a clearer

idea of status. One of our biggest questions is the possible change of foraging and habitat patterns in various seasons, and increased gathering of environmental data to use as covariates for further distribution analysis. Another question is how education and environmental change are shifting, how local fishers see and value their environment and the role of these top predators, and how their ideas of conservation are changing.

3. Implications for Management

Being able to work so closely with the Thai Department of Marine and Coastal Resources (DMCR), and create a good working relationship with the scientists and directors has been an incredible privilege. This has enabled our work to be meaningfully applied in management planning. Thai government agencies that govern the coastal areas are complicated, to say the least. For example, the DMCR has the ability to do research and some enforcement, and contribute to management planning. However, the Royal Forestry Department oversees Marine Protected Areas. While our scientists worked with local conservation and village groups, and gave educational presentations in the context of our project, there is a special division within DMCR that oversees communication with the public, and the two divisions rarely communicate. While this makes concrete management actions challenging, the long-term nature of this project has brought local and national attention to these marine mammals and the threats they face. Incidents of bycatch are featured in national media, and are communicated widely by local conservation organizations. DMCR scientists and directors concerned are convinced that protected area zoning, and increased protection from bycatch are needed, and have begun pressing for conservation planning. At present, the Director General has sent four scientists, including Chalatip, to work with me in the US this month to consult on coastal resilience planning in the eastern Gulf coast. Chalatip and a colleague are visiting Justine Jackson-Ricketts for 10 days in May to train with her and assist her in analyzing isotope samples.

4. Other Benefits

Since 2000, as a deliberate policy, Dr. Hines has worked in close collaboration with local scientists and to establish strong links with local communities to continue the research and increase our knowledge of these animals, their habitats, and their conservation needs. Our team consists of: Ms. Junchumpoo, a marine biologist for the Eastern Marine and Coastal Resources

Center, which is part of the DMCR, and a scientist in the their Endangered Marine Species Unit. Ms. Junchumpoo is applying for her doctoral degree, and would like to do her dissertation on the photo-identification of cetaceans from our project. Ms. Junchumpoo brings with her a team of Thai scientists who train in our methods, as part of our project's objective in building capacity. Some of these Thai scientists have worked with us since 2008, and have gained quite a bit of expertise in survey methods. Dr. Ponnampalam and Ms. Ilangakoon have been assisting in the project since 2008, and are both experienced cetacean scientists who have provided inputs for survey design, methodology and analysis. Ms. Whitty is a doctoral candidate at Scripps Institute of Oceanography with Drs. Lisa Balance, Ellen Hines, William Perrin, Louella Dolar and Paul Dayton on her committee, and is looking at issues of dolphin conservation and bycatch in small-scale fisheries in Southeast Asia. She completed her fieldwork in 2013 and is defending in August of 2014. Ms. Jackson-Ricketts is a doctoral candidate in Dr. Dan Costa's lab at the University of California, Santa Cruz, and is looking at two research questions: 1) spatio-temporal modelling of dolphin habitat use using environmental data and oceanographic variables, and 2) to discover which of the potential prey species in the Gulf of Thailand are eaten by resident Irrawaddy dolphins, what general types of habitats (nearshore, offshore, freshwater) they occupy over their lifetimes, and how their feeding habits change over time, using three separate analyses.

Tara Whitty, one of the PhD students in the project, is working on bycatch issues for our study, as well as comparing our results to Irrawaddy dolphin populations in Indonesia and the Philippines. Justine Jackson-Ricketts is busy analyzing the species distribution/environmental parameters modeling, and has submitted a request for permits to be able to export Irrawaddy dolphin teeth and stomach samples from Thailand for her isotope analysis. Ms. Jackson-Ricketts is planning on using sightings and environmental data from 2008, 2009, 2012, 2013 and 2014 to model species distribution of the Irrawaddy dolphins as correlated to physical and environmental variables, as well as fishing boat size and distribution. She has received a National Geographic Society Young Explorers grant.

5. Problems Encountered

The only major problem we encountered were when we had to interrupt our surveys to document, sample and necropsy stranded animals. Withstanding, we were able to complete our surveys and interviews.

6. Communication

Both Justine and Tara had abstracts accepted for presentation at the New Zealand Society for Marine Mammalogy Biennial in December of 2013. Justine's abstract is pasted below:

Status of Knowledge on Irrawaddy Dolphins, *Orcaella brevirostris*, in Southeast Asia

Justine Jackson-Ricketts, poster abstract for the Society of Marine Mammalogy 20th Biennial Conference on the Biology of Marine Mammals

The Irrawaddy dolphin, *Orcaella brevirostris,* is an imperiled Southeast Asian coastal and freshwater mammal species. It is only one of three cetaceans (with the finless porpoise, *Neophocaena phocaenoides*, and the tucuxi, *Sotalia fluviatilis*) able to inhabit both marine and freshwater. Until 2008, the IUCN listed *O. brevirostris* as Data Deficient. Now, it is considered Vulnerable over its range with five Critically Endangered subpopulations. However, some subpopulations still have not been evaluated, including the Gulf of Thailand subpopulation and a new subpopulation found in the Philippines. Some other gaps in research and conservation, however, remain undiscovered. I believe this is due to the patchy nature of published research on this species. I performed an exhaustive literature review and spoke to experts in the field to unite all *O. brevirostris* research into one comprehensive meta-analysis. Research gaps include diet, habitat, physiology, life history, and marine populations. There have been no formal studies focused on diet. Diet knowledge is limited to three stomach contents from the Mekong River. Very little has been published on *O. brevirostris* habitat. As with diet data, most work has been on freshwater populations and is preliminary in nature. There is a strong need for more detailed diet and habitat information. There are no published reports on *O. brevirostris* physiology and none of the experts in the field could report having heard of such a study. There have been some patchy life history studies, most notably on the cooperative fishing practice between *O. brevirostris* and small-scale fishermen in the Ayeyarwady River of Myanmar. Further research is needed on marine populations, of which only one has been formally evaluated by the IUCN and

is Critically Endangered (Malampaya Sound, Philippines). This work highlights critical areas in which research is needed if we are to conserve this at-risk species.

Also accepted was an abstract led by Dr. Hines on changing conservation values along the eastern Gulf coast of Thailand based on interviews since 2003. The abstract is pasted below, and a journal article on these results is in process and will be submitted the end of summer 2014. Another article is in process which concerns the Distance transect samples and abundance estimates that will also be completed and submitted summer of 2014.

Coastal marine mammals, small-scale fishers and bycatch: changing conservation values in Thailand

Hines, Ellen[1]; Junchumpoo, Chalatip[2]

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(2) Chalatip Junchumpoo, Eastern Marine and Coastal Resources Center, Rayong, -, -, Thailand

(3) Somchai Mananunsap, Department of Marine and Coastal Resources, Songkhla Lake, -, -, Thailand

(4) Kanjana Adulyanukosol, Marine and Coastal Resources Research Center, Samut Sakorn, -, -, Thailand

(5) Anoukchika Ilangakoon, 215 Grandburg Pl, Maharagama, -, -, Sri Lanka

(6) Louisa Ponnampalam, Institute of Ocean and Earth Sciences, University of Malays, Kuala Lumpur, -, 50604, Malaysia

(7) Justine Jackson-Ricketts, Long Marine Lab, University of California, Santa Cruz, Santa Cruz, California, 95064, USA

As part of a long-term project to document abundance, distribution and conservation issues of marine mammals along the eastern Gulf coast of Thailand, we conducted interviews over the course of a decade with small-scale coastal fishers about the perceived importance of marine species and systems conservation in local fishing villages. Between 2003 and 2013, we interviewed 673 fishers in this region between the ages of 13 and 80. We used a standardized semi-structured questionnaire including both closed and open-ended questions, administered by representatives from the Thai Department of Marine and Coastal Resources. Villagers were asked to rank the importance of conservation on a Likert scale of increasing importance (1-5). Responses about the importance of conservation did not differ significantly between age groups. However, results indicate that respondents' perceptions of the importance of coastal conservation have increased significantly in later years as compared to earlier years. For example, the average importance of coastal conservation in 2009 was 4.29 vs. 3.89 in 2003 ($p < 0.05$). The results suggest that, as direct resource users, small-scale fishers are increasingly aware of the importance of the conservation of resources for their livelihoods. These interviews document changing perceptions and values and point towards education needs and enforceable economic and management solutions that address local conservation practices. Values can change as the result of various factors, such as the perception of threats and scarcity, political and economic circumstances, community cohesion and pressures, generational memories and exposure to media.

We also were able to document Irrawaddy dolphin mating herd behavior that has not been seen before in a coastal population (this has been seen in the Bang PaKong River, (Adulyanukosol,

pers. comm.). This topic was presented as a poster at the 2009 Society of Marine Mammalogy Conference in Quebec, Canada, and a paper written collaboratively by our research team and headed by Dr. Louisa Ponnampalam was published by the journal *Aquatic Mammals* in 2013 (Ponnampalam et al 2013).

Between 2012 and 2014, we designed and distributed t-shirts, buttons, badges and posters in the villages when we did presentations as well as for school and village council visits, and have created a Facebook page for the Trat Coastal Dolphin Project (https://www.facebook.com/groups/580820581934377/). We also worked closely with a national NGO, the Sustainable Development Foundation, and with village conservation groups. These groups are becoming more common in Thai villages. In Ban Mai Rut, a young fisher, who was concerned about bycatch and stranded animals along nearby shores, is working closely with others in this village to increase knowledge about dolphin ecology and conservation. Our team met with him repeatedly to exchange information and answer his questions. Representatives from our team also attended conservation group meetings and distributed our educational materials, as well as materials published by DMCR.

7. Project Outputs

1. **Coastal marine mammals, small-scale fishers and bycatch: changing conservation values in Thailand**

Hines, Ellen[1]; Junchumpoo, Chalatip[2]

(1) San Francisco State University, Romberg Tiburon Center , Tiburon, California, 94920, USA

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(7) Justine Jackson-Ricketts, Long Marine Lab, University of California, Santa Cruz, Santa Cruz, California, 95064, USA

Presentation at the 20th Biennial meeting of the Society for Marine Mammalogy, December 2013.

2. **Status of Knowledge on Irrawaddy Dolphins, *Orcaella brevirostris*, in Southeast Asia**

Justine Jackson-Ricketts, poster abstract for the Society of Marine Mammalogy 20th Biennial Conference on the Biology of Marine Mammals, December 2013.

3. Mapping conservation-scapes of Irrawaddy dolphins (*Orcaella brevirostris*) and small-scale fisheries in Southeast Asia: An interdisciplinary approach
Whitty, Tara Sayuri presentation abstract for the Society of Marine Mammalogy 20th Biennial Conference on the Biology of Marine Mammals, December 2013.

Please note: Tara was awarded the Stephen Leatherwood Prize by the Society for her presentation (Given for student research in SE Asia).

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Mitigating bycatch of cetaceans in small-scale fisheries (SSF) is an urgent conservation priority, inextricably linked to the pressing need for improved SSF management. To more holistically understand cetacean bycatch in SSF, I developed an interdisciplinary approach, "mapping conservation-scapes," synthesizing methods from ecology and social sciences. Conservation-scapes are the set of factors composing a conservation situation, encompassing: how human activity overlaps with and impacts organisms; sociocultural and economic drivers of human activity; and governance structure and potential for management. Focusing on Irrawaddy dolphins (*Orcaella brevirostris*), I conducted in-depth conservationscape mapping at Malampaya Sound, Philippines, and rapid mapping at three additional sites (Guimaras Strait, Philippines; Trat coastline, Thailand; Mahakam River, Indonesia). I employed line-transect surveys and photo-identification to characterize overlap between dolphins and human activity. Through 750 household surveys and 115 key informant interviews, I assessed: local ecological knowledge, bycatch rates, fisheries characteristics and trends, sociocultural and economic ties to fishing, governance, and perceptions of management. The diversity and intensity of anthropogenic activity ranges from primarily SSF in Malampaya Sound, to differing degrees of SSF and industrial fisheries, boat traffic, and pollution at other sites. Results suggest that Irrawaddy dolphin populations at all sites have decreased in recent decades, likely due to bycatch in SSF (confirmed as unsustainable in Malampaya Sound) and industrial fisheries. The potential magnitude of bycatch in each type of fishery varies across sites, as does local government capacity for managing these fisheries. Management of Malampaya Sound is severely restricted by government corruption and lack of village-level coordination, while Trat demonstrates strong community-level initiative and greater government engagement. Guimaras Strait and the Mahakam River exhibit intermediate levels of potential for top-down and communitybased management. These results demonstrate the utility of mapping conservation-scapes for collecting management relevant data and offering new perspective into potential bycatch mitigation pathways at diverse sites.

4. Ponnampalam, L., Hines, E., Manananansap, S., Ilangakoon, A., Junchompoo, C., Adulyanukosol, A., and L. J. Morse. 2013. Behavioral observations on Irrawaddy dolphins (*Orcaella brevirostris*) in Trat Province, Eastern Gulf of Thailand. *Aquatic Mammals* 39(4): 401-409.

5. Hines, E., Strindberg, S., Jumchumpoo, C., Ponnampalam, L, Ilangakoon, A., and J. Jackson-Ricketts. Line transect estimates of Irrawaddy dolphin abundance along the eastern

Gulf of Thailand. In Prep: *Marine Mammal Science* NOTE: second draft, presently incorporating 2014 data. Will be submitted by end of August, 2014.

6. Hines, E., Jumchumpoo, C., Ponnampalam, L, Ilangakoon, A. Coastal marine mammals, small-scale fishers and bycatch: changing conservation values in Thailand. In Prep: will be completed and submitted (*Environmental Conservation*), by end of August, 2014

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8. Financial Account of the Activity

Include reasons for any variation to the budget, underspends and difficulties

Signature of Chief Investigator	
Name	Professor Ellen Hines
Date	April 30, 2014
Signature of Organisation Representative	
Name	
Date	

Please forward 1 hard copy, and one electronic Word document of this report to:

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