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## **Investigating Reef Contact Rates of Snorkel Visitors at Koh Sak, Pattaya on Guided and Non-guided Coral Reef Tours**

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### **Abstract**

Recreational snorkelling is a popular activity at Koh Sak, Pattaya Bay and although most snorkel visitors to the island arrive by speedboat on guided tours, many visitors arrive on tours that do not provide a guide. Because there is widespread agreement that reef-based tourism negatively impacts coral reefs it is important to understand the potential role guides play in reducing visitor impacts. In this study 421 snorkelers (35 % of whom came on non-guided tours) were observed on the reef for a period of 10 minutes. The following information was recorded so that a per person reef-contact rate could be calculated: the snorkelers' distance from their guide (if they had one), the number of people in their snorkelling group, and the number of contacts with the reef. There was no difference in contact rate between males (0.09 contacts min<sup>-1</sup>) and females (0.11 contacts min<sup>-1</sup>) nor was there any difference based on the group size (2-7 people). However, contact rates for snorkelers on tours with no guide (0.09 contacts min<sup>-1</sup>) and snorkelers far from their guide (0.08 contacts min<sup>-1</sup>) were significantly lower than visitors who snorkelled near their guide (0.18 contacts min<sup>-1</sup>;  $p < 0.001$ ). The contact rate of guides (0.36 contacts min<sup>-1</sup>) was significantly greater than the snorkelers they were looking after (0.17 contacts min<sup>-1</sup>) in part due to the lack of knowledge and experience of snorkelers and guides alike. To reduce negative impacts to the coral reefs of Koh Sak guides need to change their destructive behaviour and improve their knowledge of reef biology and ecology.

**Keywords:** Koh Sak; Coral reefs; Recreational snorkelling impacts

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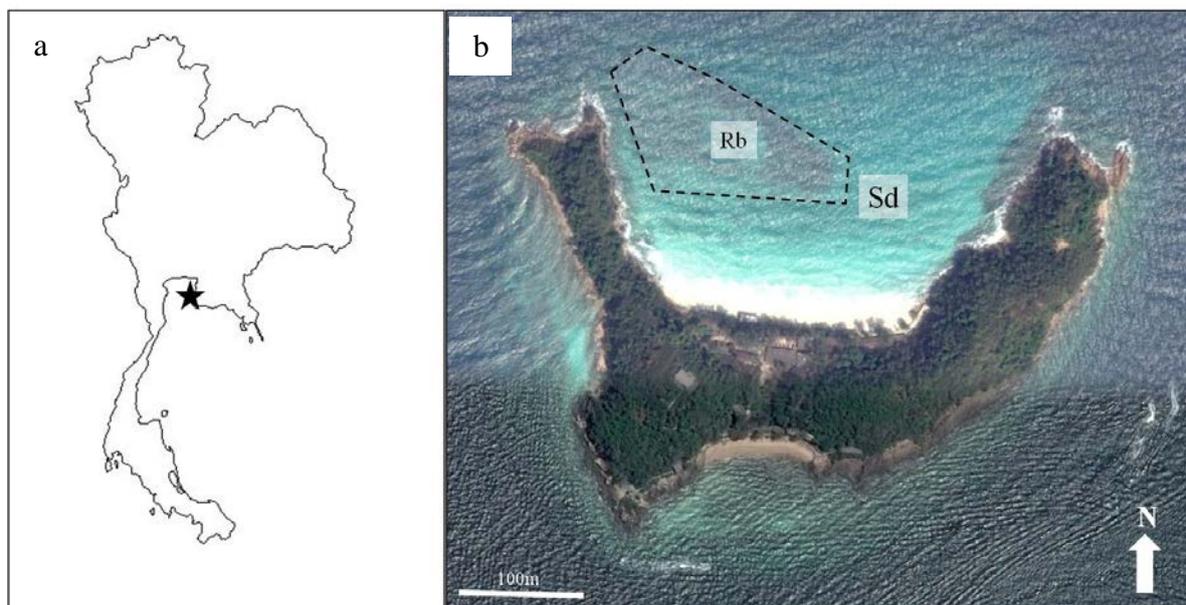
## Introduction

Coral reefs are particularly susceptible to the effects of global climate change including bleaching and ocean acidification [1]; their global decline is well documented in the literature [2-4]. Local anthropogenic stressors such as fishing and tourism undermine the reef's structural complexity and challenge the balance between corals and macroalgae [5-6]. After bleaching events, however, reefs that experience more intense tourism show slower recovery rates [7], implying that reefs facing local chronic negative impacts are less likely to survive global climate change.

Tourism, including nature-based tourism [8], is increasingly important to Thailand's economy; in 2016 the total contribution was 20.6 % of GDP and this is set to rise to 31.7 % of GDP by 2027 [9]. The islands and coral reefs in Pattaya Bay (see Figure 1a) are under increasing pressure from fishing and tourism. The near islands (Koh Sak and Koh Larn) are only fifteen minutes by speedboat from Pattaya and host the majority of tours, providing a

readily-accessible island and reef experience for visitors. Because marine tourism is vital to the local economy and negative impacts to the local reefs could drive visitors to other destinations in search of a better reef experience, it would be particularly prudent to minimize the negative impacts of tourism on coral reefs and other natural areas.

Most snorkel visitors to Pattaya's reefs go by speedboat on guided tours of 10-30 people but many others come on speedboat tours of 5-20 people that do not provide a guide. Once on the reef, visitors snorkel alone, with one other friend or with a group of friends; if the visitors came on a guided tour they may choose to snorkel near or far from the guide. Intervention by guides is known to decrease damage to reefs by reducing rates of contact with the coral reef substratum [10-11] and here the reef contact rate of visitors (and guides) on guided and non-guided tours to the North Reef of Koh Sak (see Figure 1b) was assessed to determine any difference.



**Figure 1** (a) Location of Koh Sak, Pattaya Bay, Thailand and (b) Koh Sak's North Bay; the reef is indicated by the stippled outline showing the rubble area (Rb) and sandy area (Sd) where most snorkel speedboat tours anchor.

### Study site

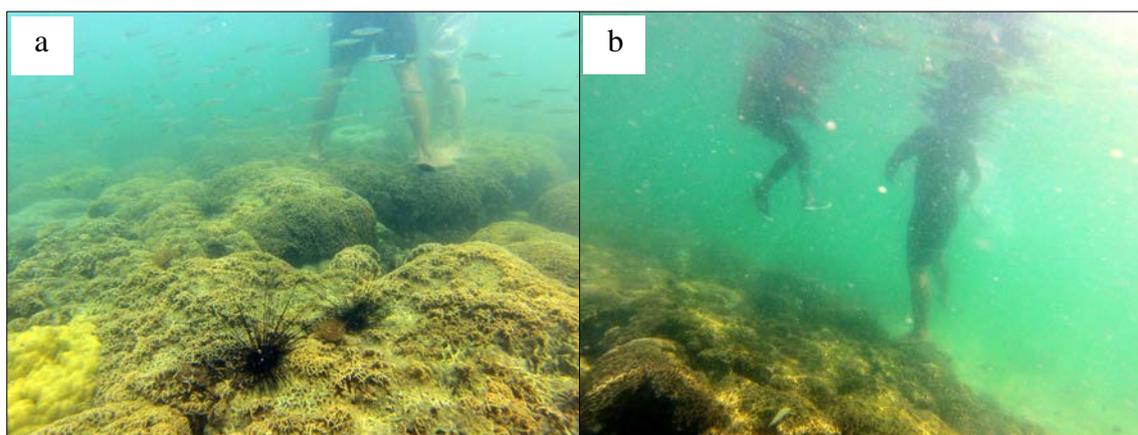
Koh Sak (12° 56' 36.36" N, 100° 47' 30.29" E) is the nearest accessible island to Pattaya and experiences 1-3,000 morning visitors, depending on season. During the southwest monsoon (February to November) most visitors arrive at the North Beach by speedboat and all water-based activities (jetski and banana-boat rides; snorkelling; SCUBA diving) take place in the North Bay over the coral reef [12]. Because there are no proper moorings at the island, anchor use is prevalent and there is much evidence of broken colonies especially in the Rubble Zone (Figure 1b); 49 % of all hard corals show some sort of damage. *Porites* is the dominant coral at the island, and 50 % of colonies show evidence of footprints. Moreover, 70 % of delicate foliose corals such as *Pavona* spp are also damaged [12] (Figure 2).

### Materials and methods

In 2015 and 2016 snorkelers were observed on the reef in the North Bay during the southwest monsoon (February to November) when wind and sea conditions were favorable for snorkel tours. Observations were started as soon

as the snorkel tours began to arrive at the North Bay, usually at about 1 pm. Sampling was conducted for a period of 2-3 h with 5-8 observations made at each sampling event. Observations were made on 40 d over the two year period (20 d each year) and sampling days were randomised as much as possible; however, sampling dates tended to fall on weekends for convenience. Sampling was constrained to those days and times in which the level of the tide would "allow" people to contact the reef - sampling was not done, for example, during high tide on days when the reef is too deep for contact. There was roughly equal number of days that had a rising tide as a falling tide.

No interaction was made with the visitors or guides and preliminary investigations revealed nine distinct types of snorkeler at the island based on how far visitors snorkelled from their reef-tour guide if they had one (< 3m; > 5m or no guide) and whether they snorkelled alone, with one other friend or with more than one friend. For each type of snorkeler, twenty visitors were observed totalling 180 visitors being followed and observed on the reef.



**Figure 2** (a) A reef-tour guide (dark shorts) helps a visitor adjust the straps of their mask and snorkel; in order to do so, they stand on the reef. In this instance the snorkelers remained in location (but changed foot position numerous times) for about five minutes. Note the footprint-sized and shaped areas of damaged coral in the foreground, and (b) a tour guide (right) stands on the reef while talking to a visitor (left). Note the guide is holding his mask and snorkel in his left hand and the visitor is in an upright position because she is wearing a personal flotation device (PFD).

The photos were not taken during observation periods (sampling).

Snorkelers were selected using random-number tables printed on waterproof paper; observations included gender and whether they wore a Personal Flotation Device (PFD). When visitors entered the water they were given a few minutes to orient to the reef; they were then followed for 10 minutes at a discreet distance to ensure they were not aware they were being observed; this could have altered their behavior.

The following information was recorded about each observed snorkeler: (i) the number of times the snorkeler contacted the reef and (ii) the number of times the accompanying guide (if present and < 3 m away) contacted the reef (recorded as (0) 0, (1) 1, (2) 2-3 or (3) 3+ times). If the snorkeler swam in a group, the number of people in the group and the total number of contacts with the reef made by the group (but not the guide) was recorded. No attempt was made to count the number of contacts of snorkelers outside the immediate group being followed, nor was there any differentiation made between contacts by males or females in the group, only the total number of contacts made by the visitor group being followed. In this study a contact was recorded if any body part touched the reef and no differentiation was made between types of contact; however, most contacts were made with the feet.

Independent of observations of visitors, tour guides were also followed for 10 minutes as soon as they entered the water and the following information recorded: (i) whether the guide contacted the reef or handled marine organisms (typically sea urchins or sea cucumbers) within the first two minutes; (ii) the total number of contacts with marine organisms and the reef and (iii) the number of visitors snorkelling with the guide during the observation and the total number of contacts made by the group.

In this study, once an observation was completed the next visitor to follow and observe

was selected, using random number tables, from the next arriving speedboat. Only one person (visitor or guide) was observed from each speedboat reef-tour. If the subject stood on or touched a coral with one foot it was counted as one contact; if the subject stood or touched with both feet it was counted as two contacts.

The average per person contact rate was calculated from the total number of contacts made by the visitor (group) and/or guide; all data were square root transformed before analysis. Factorial ANOVA was conducted to compare the main effects of guide (presence/absence and proximity), group size and the interaction of the main effects on snorkelers' rate of contact with the coral reef. An independent-sample t-test was conducted to compare the rate of contact for guides and the snorkelers under their immediate care and to compare contact rates between males and females when snorkelling alone (regardless of presence/proximity of guide). Group wise odds ratio of proportions of visitors who wore a PFD and the proportion of visitors who made no reef contact was conducted to assess likelihood of contact in the presence of the tour guide.

## Results and discussion

In total 87 % of the speedboat tours used anchors: 51 % anchored in the sandy area adjacent to the reef, 36 % anchored in the rubble area that was once healthy reef (see Figure 1b) and 13 % tied-off to other speedboats that were already anchored. There is much evidence of anchor damage at Koh Sak and the use of anchors has long been known to cause problems for coral reefs [13] with lasting impacts [14]. Continued anchor use at Koh Sak is likely to further reduce reef complexity and prevent regrowth and survival of coral recruits in the rubble area, thereby reducing the chance for reef recovery and expansion. It is clear that proper moorings are needed at the island to prevent further damage and habitat loss.

Of the 20 tour guides directly observed in this study, 45 % handled a marine organism within two minutes of entering the water (Table 1). Only two of the guides made no contact with marine organisms at all and 90 % intentionally contacted at least one, usually the long-spined sea urchin (*Diadema* spp) which is abundant at the reef and easier to find than sea cucumbers, which were handled by only two of the guides (Table 1).

Handling reef organisms is known to cause them stress [15-16], and because many guides handled marine organisms within minutes of being in the water, there is the potential for visitors to imitate such behavior. Visitors from guided tours were observed handling marine life (without their guide) on at least seven independent occasions during observations but no snorkeler on non-guided tours was seen doing the same. Sixty percent of the guides contacted the reef within two minutes of entering the water; eighty percent of them contacted the reef at least two times (one tour guide contacted the reef 18 times in 10 min) and only one guide did not contact the reef at all. No guides were ever seen or heard to intervene when visitors contacted the reef even though such interventions, coupled with pre-snorkel briefings about proper reef etiquette and behaviour are known to reduce contact rates, at least with SCUBA divers [17-18]. On three occasions when guides standing on a

*Porites* colony were challenged at the end of the observation period they insisted they were standing on rock and pointed at other *Porites* colonies as an example of a coral - indicating a general lack of knowledge about coral reefs.

Altogether 180 visitors were randomly selected from snorkel tours and followed on the reef. Because some of them snorkelled with friends 421 visitors were observed to make 587 contacts with the coral reef (Table 2). The 20 tour guides observed during the study contacted the reef 87 times whereas the 65 visitors in close proximity (< 3 m) to the tour guides contacted the reef a total of 113 times (Table 2)

Although the severity of contact with the reef was not recorded in this study, most contacts were intentional; visitors and guides stood on the reef (see Figure 2). The contact rate of tour guides was significantly higher ( $M = 0.36, SD = 0.063$ ) than the snorkelers under their immediate care ( $M = 0.17, SD = 0.012$ );  $t(26) = 2.68, p = 0.01$  (see Figure 3a *Guide* vs *Guided group*). The guides are as naive as visitors concerning the proper use of mask and snorkel equipment and were observed standing on coral to adjust straps and to empty water-flooded masks as frequently as visitors. When visitors had the same problems the guide stood on the reef to help the visitor, probably explaining why guide contact rates are two times higher than visitor contact rates.

**Table 1** Tour guide behavior at Koh Sak during 10 min of observation (n=20)

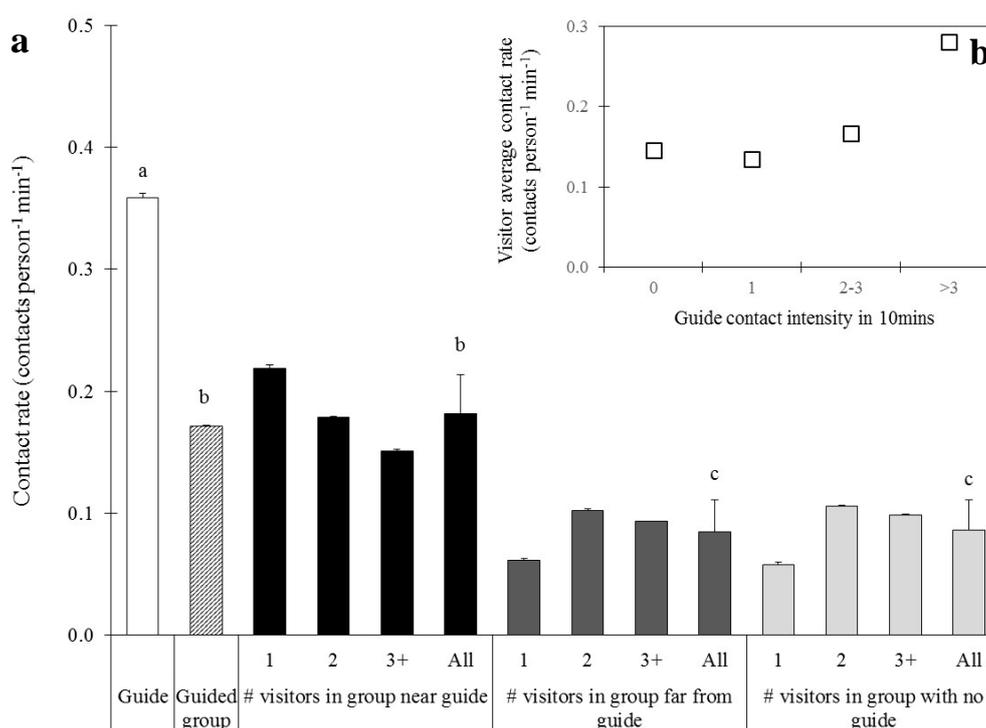
	Handled <sup>a</sup> marine organism in the first two minutes	Total number of contacts with marine organisms in 10 min			Contacted the reef in the first two minutes	Total number of contacts with reef substrate in 10 min		
		0	1	2		0	1	> 2
% of guides	45	10	80	10	60	5	15	80

<sup>a</sup> Tour guides pick up an organism to show visitors, who may then subsequently also handle the organism. The organism is often taken out of the water.

**Table 2** Number of contacts made with the coral reef in 10 min by snorkel groups of different sizes who snorkelled near their guide, far from their guide or who snorkelled without a guide. The same information for tour guides and the visitors with them is also shown.

Type of snorkeler	Number of visitors in observed snorkel group	Number of observations	Number of visitors observed	Number of contacts with reef made by the groups
Visitors < 3 m from their guide	1	20	20	54
	2	20	40	79
	≥ 3	20	67	125
	<i>Total</i>	<i>60</i>	<i>127</i>	<i>258</i>
Visitors > 5 m from their guide	1	20	20	18
	2	20	40	55
	≥ 3	20	86	86
	<i>Total</i>	<i>60</i>	<i>146</i>	<i>159</i>
Visitors on tours with no guide	1	20	20	20
	2	20	40	48
	≥ 3	20	88	102
	<i>Total</i>	<i>60</i>	<i>148</i>	<i>170</i>
Tour guides	n/a	20	n/a	87
Visitors with tour guides <sup>a</sup>	Modal group size =3	-	65	113

<sup>a</sup> visitors snorkelled < 3m from their guide



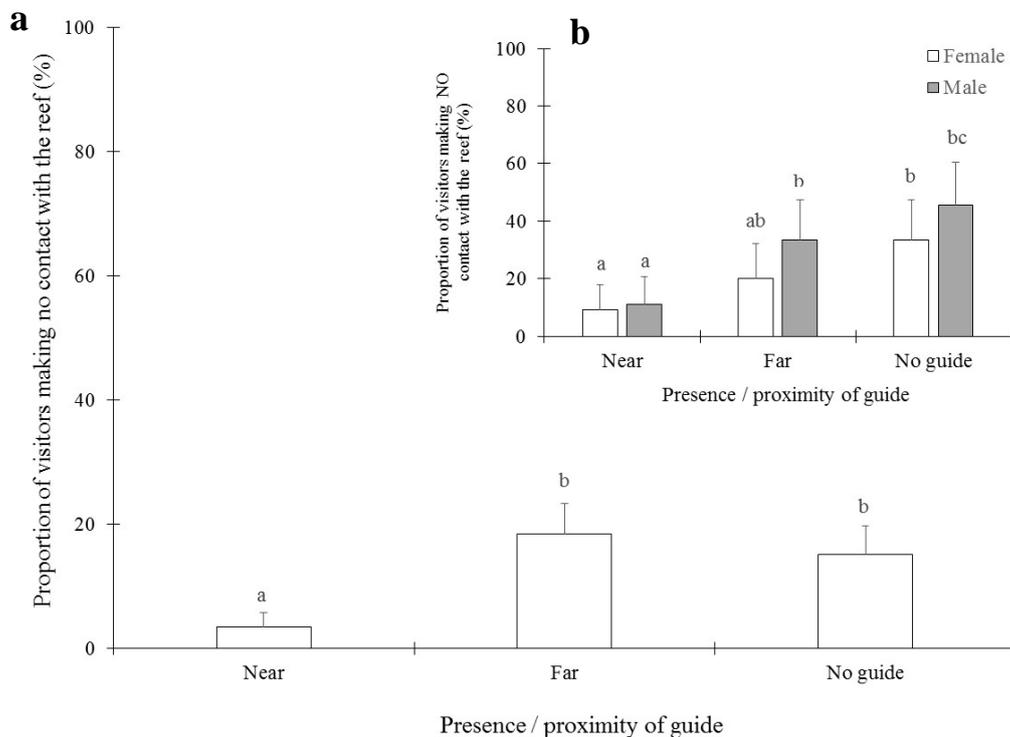
**Figure 3** (a) Mean contact rates for guides and the visitors under their immediate care (“Guided group”), and for visitors snorkelling alone, in pairs or larger groups near their guide (black bars), far from their guide (dark grey bars) and for visitors on tours with no guide (light grey bars). Error bars indicate standard error of the mean and letter symbols indicate rates that are statistically significantly different ( $p < 0.05$ ), with the same letters showing no difference in contact rate and (b) guide contact intensity vs visitor average contact rate independent of guide proximity or group size.

Contact rates of visitors observed near their guide ( $M = 0.18$ ,  $SD = 0.032$ ) did not differ from contact rates of the guided group ( $M = 0.17$ ,  $SD = 0.012$ ) but visitors with guides who contacted the reef more often had higher contact rates (see Figure 3b). No interaction was made with visitors or guides to establish their level of reef experience so it is difficult to determine, under the present study, if the visitors contacted the reef more often because they saw their (naive) guide contact the reef or because, as was heard on numerous occasions, the guide encouraged visitors to stand on the reef so he could more easily help.

There was no significant difference in contact rates between males ( $M = 0.09$  contacts  $\text{min}^{-1}$ ,  $SD = 0.04$ ) and females ( $M = 0.11$  contacts  $\text{min}^{-1}$ ,  $SD = 0.03$ ). Although factorial ANOVA showed no effect of group size on contact rate, an F-ratio of  $F(2, 171) = 13.01$ ,  $p < 0.001$

indicates a significant difference in the contact rate of snorkelers who stayed near the guide ( $M = 0.18$ ,  $SD = 0.032$ ) and snorkelers who stayed far from the guide ( $M = 0.07$ ,  $SD = 0.027$ ) or who had no guide at all ( $M = 0.09$ ,  $SD = 0.025$ ) - see Figure 3a. There was no interaction between presence/ proximity of the guide with group size on contact rate.

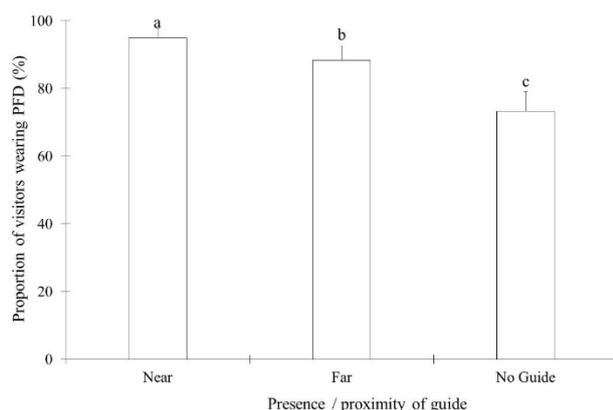
The proportion of visitors who made no contact with the reef was significantly higher in groups far from their guide and in groups with no guide (Figure 4a) and this was true for both males and females (Figure 4b). Whether this is because visitors far from their guide or who come on non-guided tours have more snorkelling experience or because they are beyond the influence of their guides who may encourage them to stand on the reef is difficult to determine given the objectives of this study.



**Figure 4** (a) The proportion of visitors (observed near their guide, far from their guide or with no guide) that made no contact with the reef and (b) The proportion of males and females that snorkel alone near their guide, far from their guide or with no guide who made no contact with the reef.

Error bars indicate standard error of the mean and letter symbols indicate proportions that are statistically significantly different ( $p < 0.05$ ), with the same letters showing no difference.

Visitors with no guides and visitors far from their guides were also significantly less likely to wear a PFD (Figure 5) and when comparing contact rates of visitors that snorkelled alone the contact rate for visitors that wore a PFD ( $M = 0.12 \text{ contacts min}^{-1}$ ,  $SD = 0.243$ ) was two times higher than the contact rate for visitors without a PFD ( $M = 0.06 \text{ contacts min}^{-1}$ ,  $SD = 0.167$ ) although the difference was not significant.



**Figure 5** The proportion of visitors that wore a personal flotation device (PFD) at Koh Sak. The different letter symbols indicate proportions that are statistically significantly different ( $p < 0.05$ ).

Studies investigating snorkeler's contact rates with the coral reef substratum are scarce in the literature; most studies instead focus on the overall impact of snorkelling. High-use reef sites experience more damage than low-use sites [19-21] showing that Koh Sak is no different to other reef sites around the world [12]. Contact rates in this study are lower than rates measured for snorkelers in Puerto Rico [22]; in that study, snorkelers contacted the reef at a rate of  $0.26 \text{ min}^{-1}$  but 39 % of contacts were made by snorkelers wearing fins suggesting that it was accidental contact. At Koh Sak, however, snorkelers do not wear fins and while only 29 % of snorkelers wore a PFD in the Puerto Rico study, compared to over 73 % in this study (Figure 5), the type of PFD in use at Koh Sak (high-visibility lifejackets) pushes wearers into an upright position (see Figure 2b) making it more likely that

intentional contact with the reef will occur. This may partly explain why > 95 % of contacts were made by visitors standing on the reef (unpublished preliminary investigations) compared to only 22 % of contacts made by visitors to the reefs of Puerto Rico [22].

Given that (i) a high proportion of guides contacted the reef and handled reef organisms within minutes of being in the water, (ii) only three guides did not contact the reef during observations, and (iii) visitors were more likely to contact the reef if they were near their guide, one must question the role that guides play at Koh Sak and at other reefs at other islands within Pattaya Bay. Guides do not show visitors how to properly fit and wear a mask before they get in the water and masks often flood, potentially reducing the visitors' enjoyment of the reef experience. Part of the role of a reef tour guide is to facilitate environmentally responsible behavior and to provide interpretation [23] of what visitors observe. This clearly is not the case at Koh Sak where guides play the role of "pathfinder" [24] leading people on the reef who "lack orientation"; visitors are not given even rudimentary information about coral reefs nor any advice on how to behave on the reef. Weblar and Jakubowski [22] recorded a five-fold decrease in the contact rate of snorkeling visitors after visitors first watched a short video encouraging pro-reef behavior while snorkelling, and then signing a pledge committing them to doing so. Similarly, an increase in positive behavior towards the reef was observed after local guides and boat crew were provided with simple training on reef biology and ecology which they could pass on to visitors. In turn visitors acknowledged that the informative input of the guides and crew added to their enjoyment of the experience [25].

Tour guides contacted the reef at a greater rate than visitors and it is evident that guides at Koh Sak lack training on proper reef etiquette

and environmentally responsible behavior. Programs such as Green Fins [26], which has established a code of conduct that tour providers and guides agree to abide by, are known to reduce contact rates [11]. Such an approach is needed at Koh Sak to establish a group of professional, well trained and knowledgeable guides with the skills and motivation to exhibit reef-friendly behavior and pass on reef-related knowledge to visitors.

### Conclusion

Contrary to expectations, visitors on guided tours who snorkelled near their guide were significantly more likely to exhibit reef-damaging behavior than visitors who came on non-guided tours or who snorkelled far from their guide. Guides had the highest rate of contact with the coral reef compared to visitors and actively encouraged negative behavior of nearby snorkelers under their control. Visitors who snorkelled far from their guide or who had no guide at all had lower contact rates. To decrease contact rates, prevent further damage to the reef and potential loss of tourism revenue it is essential to (i) redesign Personal Flotation Devices which at present push visitors into an upright position, making it more likely they contact the reef and (ii) provide training workshops for speedboat crew and tour guides so they can pass on information about coral reef biology and ecology and promote proper reef etiquette and behavior.

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