Environmental management of boating related impacts by commercial fishing, sailing and diving tour boat operators in Australia

Environmental Management by Fishing, Sailing and Diving Tour Boats

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4288 words

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Abstract

There are approximately 1500 commercial tour boat operators in Australia - the majority offer marine fishing, sailing or diving tours. Most of the fishing tour businesses employ fewer staff and use smaller boats than the dive and sail tours. Proportionately more of the sail and dive boats have basic environmental management measures such as ashtrays and garbage bins to reduce littering overboard, and sewage holding tanks with pump-out systems to reduce the impacts of human waste. In addition, more of the sail and dive tour operators are aware of their boat's environmental impacts and take steps to reduce or remediate them, including the use of environmental management guidelines. These differences in environmental management measures, however, are associated principally with patterns in vessel size, which affects both the practical and regulatory requirements. In addition, more of the dive tours operate in marine protected areas where regulations are more stringent. Once these factors are allowed for, environmental management by individual fishing tour operators is not significantly worse than by sail or dive operators.

Introduction

Controlling pollution from numerous diffuse and mobile sources is much more complex than managing discharges from small numbers of fixed identifiable point sources. From a regulatory perspective, the process involves at least seven distinct steps: (i) identifying and locating potential polluters; (ii) establishing the types, timing and levels of emissions; (iii) distinguishing their impacts from those of other potential pollution sources; (iv) establishing ambient quality targets for appropriate parameters; (v) establishing equitable emission controls to achieve those targets; (vi) establishing means to monitor the pollution measures concerned and the mechanisms which determine them; and, (vii) establishing effective and affordable social and institutional frameworks to ensure that individual polluters comply with controls. Where there are large numbers of intermittent pollution sources, the cost of ensuring compliance through publicly-funded patrols and enforcement is high, so governments can only obtain political support for this approach where the expected social and environmental benefits are equally significant.

Given these difficulties, governments are commonly keen to try out less costly approaches. In particular, where potential polluters are part of an industry rather than purely private citizens, one often-promoted approach is so-called self-regulation, where the individual industry members cooperate to establish and enforce their own environmental management measures (1, 2, 3). In some sectors, notably the chemical industry (4), it appears that this is merely a political tool to delay the introduction of government legislation. Likewise, it is not clear that the numerous ecocertification schemes in the tourism industry have actually improved aggregate environmental practices to any measurable degree (5).

Accordingly, here we set out specifically to examine environmental management practices in a highly diffuse industry sector - namely the commercial tour boat industry in Australia. This is a diverse and geographically diffuse sector with around 1500 individual members, some of them running highly professional and fully commercial tourism businesses and others scarcely distinct from the private recreational boating sector. GIS analysis indicates that half this industry operates in 7 locations (6), and this analysis focuses on those sites.

Tour boats produce a range of impacts in nearshore marine environments (7), and there are limited legal measures in place to address these. Regulatory requirements vary according to vessel size and place of use. Requirements to fit particular types of equipment, such as on-board toilets with holding tanks and pump-out facilities, can be policed to some degree through commercial licensing requirements. When and where mandatory equipment is actually used, however, and what additional equipment and practices are adopted voluntarily, are much more difficult to ascertain reliably.

Tourism interests often argue that the industry has an incentive to minimise its impacts so as to maintain the natural environment as a tourist attraction. Even if this is correct, however, it may not necessarily influence the behaviour of individual tour operators, firstly because of the asymmetry between public and private benefits, the tragedy of the commons; and secondly because individual entrepreneurs change their tourism products and buy and sell businesses at a shorter time scale than deterioration of the natural environment. Again, the Australian tour boat industry provides a good opportunity to put such assertions to the test.

Methods

We analysed environmental management technologies and practices in the Australian tour boat industry as follows. We defined tour boats as vessels of any size and hull configuration which are used to offer tours for purposes of leisure rather than transport. To restrict the study to the Australian industry, we considered only those vessels which are registered within Australia and which operate in Australian coastal territorial waters throughout the entire season. This excludes cruise ships, and expeditionary vessels which may pass through Australian waters but spend most of the year elsewhere. It also excludes vessels which may be physically identical to commercial tour boats, but which are used purely for private recreational purposes. This distinction is not always entirely clear-cut, since some commercially-registered vessels may in fact be used principally for private recreation or corporate promotions. Therefore, individual boats are only included where they are used to run routine commercial trips which are advertised publicly through channels readily accessible to tourists. We compiled a database of all such tour boat operators throughout Australia. For the purposes of this analysis we then excluded tours and vessels which operate in unusual circumstances, for example, those in inland waterways. We also removed those which, although still advertised, in fact seem to have ceased commercial operations.

We obtained data on characteristics of the tour businesses, the vessels, and environmental management practices for a sample of 145 tour operators, using a 20-item survey questionnaire. A randomly-selected 1-in-3 sample of about 700 operators at the 7 major sites was asked to complete the survey. Forty-eight completed responses were obtained using face-to-face interviews, and 97 using mailouts. Mail surveys followed best-practice approaches as specified by (8). Both subsamples were representative of the population under survey, and there were no statistically significant differences between the two sets, so they were combined for analysis. In addition, we carried out unannounced, incognito on-site audits for 27 of these 145 tours, to verify the accuracy of data provided by the tour operators.

Some of the survey questions referred to equipment fitted, such as: types of toilet and sewage holding and/or treatment systems, ashtrays and garbage bins, and antifouling and sacrificial anodes. Some referred to areas of operation, especially marine protected areas (MPAs). Some asked about environmental management practices such as identifying and remediating impacts, and adherence to environmental management guidelines such as those issued by (9). The remainder covered the characteristics of the vessel, the business, and they types of tour offered. Many operators were reluctant to provide any environmental information (6), and a total of more than 1000 telephone calls and 120 days in the field were required to compile the data set used here. Confidentiality has been maintained for individual responses, and respondents were advised of this.

Different vessels have different hull shapes and configurations, and some are multi-hulled. Since vessel size is a major constraint on the types of environmental management measure which are both feasible and expected, and in some cases required by law, a single measure of vessel size was needed in order to differentiate size-related effects from any potential effects due to factors such as area of use or type of tour. Accordingly, we calculated an effective size index as hull length x beam for both monohulls and multihulls. We tested that this measure applies accurately for both, by calculating log-log regressions of maximum legal (survey) passenger numbers for each vessel, against various size measures for monohulls and multihulls separately. More complex size indices were also examined, but did not improve predictive power.

Three main types of tour activity dominate the Australian industry numerically: diving (20%), fishing (37%), and sailing (43%). A number of the sailing tours, and a small proportion of fishing boats, are hired or chartered on a bareboat basis, but the majority are fully crewed and skippered. Depending on the precise tour and price range, the tour may or

may not be catered, and may or may not include the use of specialist navigational, fishing or diving equipment. Sample numbers were too small to draw any statistical distinctions on grounds such as these: for this analysis, all cases were classified simply as dive, fish or sail.

Most of the environmental management measures are dichotomous variables, such as presence or absence of a particular practice or piece of equipment. Some are independent from each other, whereas others are interrelated. For example, sewage holding tanks, macerators and crude sewage treatment systems are only relevant in vessels equipped with toilets. Three principal patterns were examined. First, we calculated aggregate frequencies for the various environmental management measures across the entire Australian tour boat industry. Second, we tested how the frequencies of each environmental management measure varied with vessel size, and (independently) whether they differed between the three main tour types. Finally and most critically, given that the distribution of vessel sizes differs between tour types, we tested whether each of the environmental management measures was more or less common in either fishing, sailing or diving tour boats after allowing for vessel size effects. For these analyses, to achieve sufficient statistical power we divided the vessel size index at the median to generate a dichotomous size variable, and tested for associations using logit analyses. All analyses were carried out using SPSS® version 14.0.

Some aspects of tour boat operations, such as hull speed and engine size, are determined by the design of the tour. They may have environmental implications, but the tour operator has little chance to change them except by offering a different tour. Some aspects of environmental management are set by regulations. Vessels over a certain size or passenger capacity, for example, or operating in particular areas such as marine parks, may be required to fit particular types of sewage treatment systems. In federated nations such as Australia, such regulations may differ between states. At the time of this study, regulations imposed on

the vessels themselves were few and lax in all states. Regulations applying to MPAs were more specific and stringent, but covered only a small proportion of each state.

Here, therefore, we focus on three aspects of environmental management which can be modified at the discretion of the tour operator, subject to any minimum standards set by regulation. The first is the use of garbage bins and ashtrays to discourage passengers from discarding litter overboard. The second is the use of various types of toilet, holding tank and sewage treatment systems to minimise the impacts of human waste on the marine environment. These two were tested through direct audits as well as survey responses. The third is the beliefs, attitudes and behaviour of the tour operators towards the environmental impacts of their boats, including any specific measures to reduce or remediate impacts, and the use of environmental management guidelines. For these factors, our data are derived only from surveys and interviews rather than direct observation. In addition, we compiled data for each tour operator on: the relative size of the tour business, measured by the number of employees; whether or not the business belongs to a relevant industry association; and what geographical areas and jurisdictions the tours use, and in particular whether or not they take place in marine protected areas.

One of the key issues from a management perspective is whether tours offering different activities demonstrate differentially better or worse environmental management performance. We hypothesize that diving tours should display the highest standards of environmental management, for three reasons. Firstly, they use the same sites repeatedly, and client satisfaction depends on the condition and appearance of those sites, so that either litter, eutrophication caused by sewage discharge, or other visitor impacts such as anchor damage, are likely to affect sales and profitability. Secondly, dive tourists use the marine environment in a non-consumptive manner, and hence may be more concerned about environmental

management, so tour operator practices may be expected to reflect those concerns. Thirdly, diving tours make particular use of marine protected areas, owing to their high density and diversity of marine organisms; but rules regarding environmental management equipment are stricter within MPAs than outside them.

We hypothesize that fishing tour operators may display the lowest standards, with anecdotal evidence suggesting a relatively low client interest in conservation, a focus on consumptive use of the natural environment, and the lack of any direct connection between the condition of the marine environment and the profitability of the tour as long as target fish species are still caught. Sailing tours, under these hypotheses, should be intermediate, with client satisfaction depending largely on above-water environment and social interactions, and use of the natural environment being non-consumptive but not dependent on underwater condition. Accordingly, the primary hypothesis tested here is that for each individual measure of environmental practice, performance and perception, dive tours have the highest standards, sail tours intermediate, and fishing tours the lowest.

Since at least some of the environmental management measures tested, however, are likely to depend on the size of the vessels used, for both practical and regulatory reasons, we tested whether the three types of tours use equal proportions of larger and smaller boats, and we examined differences in frequencies of each environmental management measure between larger and smaller vessels. To distinguish whether differences in environmental management measures between different tour types may be attributed solely to the size of the vessels used, we tested the effects of both factors jointly using logit analyses.

Results and Discussion

Boats and Businesses

Data are available for 145 vessels: 28 dive tour operators, 63 sail and 54 fishing tours (Table 1). The distribution of the sample is representative of the overall distribution of tour operators. Most (84%) of the fishing tours use boats smaller than the median size, whereas 71% of sailing tour boats and 65% of dive tour boats are larger than the median size. These differences are highly significant ($p < 0.001$). Most (87%) fishing tour businesses employ < 5 staff, significantly fewer ($p < 0.05$) than sail (70%) or dive (57%) businesses. Most (61%) smaller businesses use boats below the median size, whereas 83% of larger businesses (≥ 5 staff) use larger boats. Two-thirds of the tour operators belong to an industry association. For dive tour operators the proportion is four-fifths, but the difference is not statistically significant ($p > 0.05$). Operators using larger boats were also more likely to belong to an association ($p < 0.05$). One-third of the boats used were multihulls, almost entirely catamarans. Significantly more dive tours (82%) than sail (52%) or fishing tours (36%) operate in marine protected areas ($p < 0.01$), with no significant difference in the relative frequencies for boats of different sized categories.

Litter Control

The vast majority (93%) of sail and dive tour boats carried garbage bins. For fishing tours the proportion was slightly but significantly ($p < 0.05$) lower (76%). Garbage bins were carried by all the larger but only three-quarters of the smaller vessels ($p < 0.001$), however, and logit analysis indicates that there are no significant differences ($p > 0.05$) between tour types once vessel size differentials are taken into account. Fewer fishing tour boats than sail or dive tour boats carry ashtrays (41% *cf* 61%, $p < 0.025$ across all sizes jointly), but this

pattern is attributable to differences in frequencies between smaller and larger vessels (30% *cf* 74%, $p < 0.001$) with insignificant residual influence of tour type ($p > 0.05$).

Sewage Disposal

On all but the smallest boats and shortest tours, clients may need and expect toilet facilities. Under Australia's Uniform Shipping Laws Code (USL Code), larger commercial tour boats may be required to provide them. Tour boats operating in marine protected areas must generally be equipped with holding tanks so as to avoid any discharge inside the marine protected area itself. Some tourist ports and recreational marinas ban discharges within the marina itself, and provide facilities so that boats can pump out their holding tanks to onshore treatment facilities. In the State of Queensland, for example, the discharge of sewage into the waters of a marina has been prohibited since 1 January 2004. Larger boats which carry tourists on deck may be equipped with sewage macerators so that they discharge a uniform sludge without any identifiable items. This reduces aesthetic impacts for tourists and increases the breakdown rate of faecal material, but does not affect the ecological impacts through nutrients discharged.

Some boats have no toilets at all. Some have portable toilets which may be emptied either overboard or onshore. Some have either standard marine toilets (manually hand-pumped) or standard domestic toilets (gravity flush). Either of these types may be equipped with holding tanks, or may have macerators fitted between the toilet and the discharge point, or neither, or both; and they may be discharged either overboard or onshore. Because of the variety of different possible combinations, we tested the distributions of each component independently.

Data on toilet type and sewage treatment system are available for 140 of the 145 boats studied. Across all vessel sizes jointly, significantly more fishing tour boats (40%) than sail or dive boats (15%) carry a portable toilet or none at all ($p < 0.01$). There are no significant differences ($p > 0.05$) between tour types in the frequency of standard marine toilets, which are fitted in 25% of vessels overall. Electric macerator toilets, fitted in 29% overall, are significantly more frequent ($p < 0.05$) in sailing (40%) and fishing tours (26%) than in diving tours (11%). Standard domestic toilets, in contrast, are significantly ($p < 0.001$) more common in diving tours (43%), as compared to sailing (27%) or fishing tours (2%). Sewage treatment systems are relatively infrequent, installed in 14% of sail and 3.7% of fishing tour vessels, but no dive tour boats ($p < 0.05$).

The types of toilets and sewage treatment systems, however, are strongly related to vessel size. The 26 boats which carry no toilet at all are all small ($p < 0.001$). They include the 16 smallest vessels of all, and 25 of the 33 smallest. The seven boats which carry portable toilets are all smaller than the median size ($p < 0.02$). Of the 34 fitted with standard marine toilets, 19 are smaller than the median size and 15 larger ($p > 0.05$). For the 41 equipped with electric macerator toilets, 16 are in the smaller category and 26 in the larger, while all but one of the 28 boats with standard domestic toilets are larger than the median vessel size ($p < 0.001$).

Even once the effects of vessel size are taken into account, however, the differences between tour types remain statistically significant ($p < 0.05$) for the relative frequencies of standard domestic and electric macerator toilets, and for sewage treatment systems (Table 2).

There are several practical factors which are likely to contribute to these patterns. Firstly, the preferential use of marine toilets in sailing tour boats and domestic toilets in dive tour boats is

probably due simply to hull and power configuration. Monohull vessels under sail may heel considerably, and indeed marine toilets were first devised for historical sailing ships. It may also reflect the higher proportion of diving tour boats which are purpose-built for commercial tours of short duration, in contrast to sailing tours which use little-modified yachts built principally for long-distance private cruising.

Holding tanks with ultimate discharge overboard, outside marine parks and other areas where such discharges are prohibited, are proportionately more frequent in large vessels ($p < 0.001$) and in sail tours ($p < 0.01$), but with no significant residual differences ($p > 0.05$) between tour types once the effects of vessel size are taken into account. The most likely contributing factor is that almost all larger vessels are moored at permanent moorings when not in use, rather than hauled out onto a trailer, float or marina hardstand; and boats at permanent moorings are much more likely ($p < 0.001$) to be fitted with holding tanks, because of marina regulations.

Area and Perceptions

About half the 145 boat owners stated that in their view, their own vessel may produce adverse impacts on the natural environment. The proportions were slightly higher for larger than smaller vessels and for dive tours than sail or fishing tours, but the differences were not significant ($p > 0.05$).

Overall, 40% of tour boat operators claimed that they took steps to reduce the potential adverse environmental effects of their tours. The proportion was slightly but significantly ($p < 0.05$) higher for dive tours (54%) than fishing tours (28%), with sailing tours

intermediate and not significantly different ($p > 0.05$) from either. There were no significant differences ($p > 0.05$) between larger and smaller vessels.

Half of the tour boat owners claimed to use some form of environmental management guidelines in their day-to-day operations. The proportion was significantly higher ($p < 0.01$) for dive tours (71%) than fishing tours (33%), with sailing tours intermediate (52%) and not significantly different from either. This, however, may simply reflect the higher proportion in larger than smaller vessels (66% *cf* 33%, $p < 0.001$).

One reason advanced for not making use of environmental management guidelines was lack of information or availability. Almost 90% of tour boat operators, using both larger and smaller boats, claimed that they would use such guidelines if available. The proportion of operators who expressed no interest in using environmental management guidelines even if they were provided was slightly higher for fishing tour operators (20%) than sailing or dive tour (7%), and there were no significant differences ($p > 0.05$) between tours using larger than smaller vessels. The difference between tour types is marginally significant ($p < 0.05$) if tested *a priori*, but not significant ($0.1 < p < 0.05$) according to the two-factor logit analysis.

Onsite Audits

For the 27 boats and seven environmental management parameters where we obtained data from onsite audits as well as surveys, 27 (14%) of 189 individual data points differed at least slightly between survey and audit. This gives general confidence in the survey results. Where there were differences, however, tour operators consistently (24/27, $p < 0.001$) reported equipment or practices which audits indicated they did not actually have or use. The numbers are too low to indicate any significant patterns between tour types, vessel sizes or

environmental parameters, so the conclusion is simply that overall, environmental management performance in the Australian tour boat sector may be somewhat poorer than indicated by the survey responses above.

Conclusions

There are approximately 1500 commercial boat tour businesses in Australia, ranging in size from sole proprietor ships operating low-volume day trips with a single small boat, to large corporations with many staff and boats, and large vessels operating multi-day tours. The main activities offered are fishing, sailing and diving. By far the majority of tours operate along the coastline, with very few in inland lakes and waterways, and approximately half operate within marine protected areas.

The results presented above show that both basic environmental management measures such as litter control devices and low-impact toilet systems, as well as an awareness of environmental impacts and efforts to reduce them, are proportionately more common overall amongst tour boat operations that offer diving and sailing rather than those which offer fishing; but that the most parsimonious explanation for this pattern is that more of the fishing tours use smaller boats, and most of these measures are more common in larger vessels. Thus the empirical evidence does not indicate that fishing tour operators are any less well equipped to manage their environmental impacts than their counterparts in the sail or dive tour subsectors.

To quantify and compare the aggregate net environmental impacts of these and other subsectors of the marine tourism industry would require several additional steps. The results presented above demonstrate that larger boats generally have better environmental

management practices; but other things being equal, larger boats generally produce higher total impacts per boat, though not necessarily per passenger. The aggregate environmental impacts of any of these activity subsectors depends on the numbers and sizes of the vessels used, as well as the environmental management measures by vessels of different sizes. Effective environmental impacts also depend on the areas and ecosystems where each boat operates, and on the relative ecological significance and severity of the various components examined here.

In addition, the commercial boat tourism industry does not operate in isolation, but in the same areas as the private recreational boating industry. Some of the marine environments concerned are also subject to impacts unrelated to tourism, notably those of industrial and agricultural runoff and river plumes, and possibly also climate change. Data on the fine-scale geographical distribution of boats are indeed available through aerial surveillance of particular popular recreational areas, such as Moreton Bay near Brisbane (10). Limited data are also available on local biological indicators of sewage discharges, such as specific coprosterols (11). Environmental management guidelines for small-boat tours are in fact already widely available (e.g. 9).

Management agencies for particular marine protected areas, notably the Great Barrier Reef Marine Park, have adopted differential permitting strategies intended to encourage tour operators with high standards of environmental management (12). The data presented here generally support regulatory approaches which differentiate between vessels of different dimensions, rather than between tours offering different activities.

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Table 1 Key characteristics of tour boats.

Operator #	Primary Activity	Vessel Size	Vessel Length (m)	Company Size	Association Member	Hull Configuration	Garbage Bin	Ashtray	Holding Tank	Toilet Type	Treatment System	Sewage Management	Permanently Moored	Operate in MPAs	Acknowledge Impacts	Reduce Impacts	Use EMGs Now	Would use EMGs
1	D	Sm	6.1	Lg	Y	A	N	N	N	nt	N	1	N	Y	Y	Y	N	N
2	D	Sm	6.2	Sm	N	A	N	N	N	nt	N	1	N	N	N	N	N	Y
3	D	Sm	6.4	Sm	Y	A	Y	N	N	nt	N	1	Y	N	Y	Y	N	Y
4	D	Sm	7.5	Sm	N	A	Y	N	N	nt	N	1	N	Y	N	N	Y	Y
5	D	Sm	7.7	Sm	N	A	N	N	N	nt	N	1	Y	Y	N	N	Y	Y
6	D	Sm	7.8	Sm	Y	A	Y	Y	N	PT	N	2	N	Y	Y	Y	Y	Y
7	D	Sm	10.0	Lg	Y	A	Y	N	N	SM	N	5	Y	Y	Y	Y	N	Y
8	D	Sm	10.5	Sm	Y	A	Y	N	N	SM	N	5	Y	Y	Y	N	Y	Y
9	D	Sm	12.8	Sm	Y	A	Y	Y	N	SM	N	5	Y	Y	Y	Y	Y	Y
10	D	Lg	12.0	Lg	Y	B	Y	N	Y	SD	N	4	Y	Y	Y	Y	Y	Y
11	D	Lg	12.5	Sm	Y	B	Y	Y	N	EM	N	5	Y	Y	Y	Y	Y	Y
12	D	Lg	13.7	Sm	Y	A	Y	Y	N	SM	N	5	Y	N	N	N	Y	Y
13	D	Lg	15.8	Sm	Y	B	Y	Y	Y	SD	N	4	Y	Y	Y	Y	Y	Y
14	D	Lg	16.1	Lg	Y	A	Y	Y	N	SM	N	5	Y	Y	Y	Y	Y	Y
15	D	Lg	17.0	Lg	Y	A	Y	Y	Y	SD	N	4	Y	Y	Y	N	Y	Y
16	D	Lg	17.0	Sm	Y	A	Y	N	Y	SD	N	4	Y	Y	Y	Y	N	Y
17	D	Lg	17.0	Sm	N	B	Y	Y	Y	SD	N	4	Y	Y	Y	Y	Y	Y
18	D	Lg	17.0	Sm	Y	A	Y	N	N	SM	N	5	Y	Y	Y	N	N	Y
19	D	Lg	18.2	Lg	Y	A	Y	Y	N	EM	N	5	Y	N	N	N	Y	N
20	D	Lg	22.0	Lg	Y	A	Y	N	Y	SD	N	4	Y	N	N	N	Y	Y
21	D	Lg	23.0	Sm	Y	A	Y	N	Y	SD	N	4	Y	Y	Y	Y	Y	Y
22	D	Lg	24.0	Lg	Y	B	Y	Y	Y	SD	N	4	Y	Y	N	N	Y	Y
23	D	Lg	24.0	Lg	Y	A	Y	Y	Y	SD	N	4	Y	Y	Y	Y	Y	Y
24	D	Lg	25.0	Sm	Y	A	Y	Y	Y	EM	N	4	Y	Y	Y	Y	Y	Y
25	D	Lg	30.0	Lg	Y	B	Y	Y	Y	SD	N	4	Y	Y	N	N	Y	Y
26	D	Lg	30.0	Lg	Y	A	Y	Y	Y	SD	N	4	Y	Y	N	N	Y	Y
27	D	–	–	Sm	Y	–	Y	N	N	nt	N	1	–	Y	Y	Y	N	N
28	D	–	–	Lg	N	–	Y	N	N	SD	N	5	Y	Y	N	N	N	Y
29	F	Sm	3.4	Sm	N	A	N	N	N	nt	N	1	N	–	N	N	N	Y
30	F	Sm	3.7	Sm	N	A	N	N	N	nt	N	1	N	N	N	N	Y	Y
31	F	Sm	3.7	Sm	N	A	N	N	N	nt	N	1	N	–	N	N	N	N
32	F	Sm	3.7	Sm	Y	A	N	N	N	nt	N	1	N	N	N	N	N	Y
33	F	Sm	3.7	Sm	N	A	Y	N	N	nt	N	1	Y	N	Y	Y	N	Y
34	F	Sm	3.8	Sm	Y	A	N	N	N	nt	N	1	N	N	Y	Y	N	Y
35	F	Sm	3.8	Sm	N	A	Y	N	N	nt	N	1	N	Y	Y	Y	N	Y
36	F	Sm	3.9	Sm	N	A	Y	Y	N	nt	N	1	N	Y	N	N	Y	Y
37	F	Sm	4.2	Lg	Y	A	N	N	N	nt	N	1	–	Y	N	N	N	Y
38	F	Sm	4.5	Sm	N	A	N	N	N	nt	N	1	N	N	N	N	N	Y
39	F	Sm	4.6	Sm	N	A	N	N	N	nt	N	1	Y	Y	Y	N	N	Y
40	F	Sm	5.0	Sm	N	A	N	N	N	nt	N	1	N	Y	N	N	Y	Y
41	F	Sm	5.1	Sm	Y	A	Y	Y	N	nt	N	1	N	Y	Y	Y	Y	Y
42	F	Sm	5.1	Sm	Y	A	N	N	N	nt	N	1	N	N	Y	N	N	Y
43	F	Sm	6.0	Sm	Y	A	N	N	N	nt	N	1	N	N	N	N	Y	N
44	F	Sm	6.8	Sm	N	A	Y	Y	N	PT	N	2	N	N	N	N	N	Y
45	F	Sm	7.0	Sm	Y	B	Y	N	N	nt	N	1	N	–	N	N	Y	Y
46	F	Sm	7.0	Sm	Y	B	Y	Y	N	PT	N	2	N	N	N	N	Y	Y
47	F	Sm	7.0	Lg	Y	B	Y	Y	N	SM	N	5	Y	N	Y	Y	N	Y
48	F	Sm	7.5	Sm	N	A	Y	N	N	SM	N	5	Y	N	N	N	N	Y
49	F	Sm	7.6	Sm	Y	B	Y	Y	N	PT	N	2	Y	Y	N	N	N	N
50	F	Sm	8.5	Sm	N	A	Y	N	N	VT	N	5	Y	–	N	N	Y	Y
51	F	Sm	9.0	Sm	Y	B	Y	N	N	PT	N	2	N	Y	Y	Y	N	Y
52	F	Sm	9.3	Sm	Y	A	Y	Y	N	SM	N	5	Y	N	Y	Y	N	Y
53	F	Sm	9.6	Sm	N	A	Y	N	Y	SM	N	2	Y	N	N	N	Y	N
54	F	Sm	10.0	Sm	Y	A	Y	N	N	SM	N	5	Y	N	N	N	N	N
55	F	Sm	10.0	Sm	N	A	Y	Y	N	SM	N	5	Y	N	Y	Y	N	Y
56	F	Sm	10.1	Lg	Y	B	Y	N	N	EM	N	5	Y	N	N	N	N	Y
57	F	Sm	10.2	Sm	Y	A	N	N	N	PT	N	2	Y	N	N	N	N	Y
58	F	Sm	10.5	Sm	N	A	Y	Y	N	EM	Y	3	Y	N	Y	N	N	Y
59	F	Sm	10.6	Sm	Y	A	Y	Y	N	EM	N	5	Y	N	N	N	N	Y
60	F	Sm	11.0	Sm	Y	A	Y	N	Y	SM	N	2	Y	N	N	N	N	Y

Operator #	Primary Activity	Vessel Size	Vessel Length (m)	Company Size	Association Member	Hull Configuration	Garbage Bin	Ashtray	Holding Tank	Toilet Type	Treatment System	Sewage Management	Permanently Moored	Operate in MPAs	Acknowledge Impacts	Reduce Impacts	Use EMGs Now	Would use EMGs
61	F	Sm	11.0	Sm	Y	A	Y	N	N	EM	N	5	Y	N	Y	Y	N	N
62	F	Sm	11.0	Sm	Y	A	Y	N	N	SM	N	5	Y	Y	Y	Y	Y	Y
63	F	Sm	11.0	Sm	Y	A	Y	Y	Y	SM	N	4	Y	N	Y	Y	N	Y
64	F	Sm	11.3	Sm	N	A	Y	Y	N	SM	N	5	Y	Y	N	N	Y	Y
65	F	Sm	11.5	Sm	N	A	Y	N	N	SM	N	5	Y	N	N	N	N	N
66	F	Sm	11.6	Sm	Y	A	Y	Y	N	EM	N	5	Y	N	Y	Y	Y	N
67	F	Sm	11.7	Sm	Y	A	Y	Y	N	EM	N	5	Y	Y	N	N	N	Y
68	F	Sm	11.8	Sm	Y	A	Y	Y	N	EM	N	5	Y	Y	N	N	N	Y
69	F	Sm	12.0	Sm	Y	A	Y	N	Y	EM	N	4	Y	N	N	N	Y	Y
70	F	Sm	12.0	Sm	Y	A	Y	N	N	EM	Y	3	Y	N	N	N	N	Y
71	F	Sm	12.2	Sm	Y	A	Y	N	N	SM	N	5	Y	Y	Y	Y	N	Y
72	F	Lg	11.8	Sm	Y	A	Y	N	N	SM	N	5	Y	Y	Y	N	N	N
73	F	Lg	12.5	Sm	N	A	Y	Y	N	SM	N	5	Y	Y	Y	N	Y	N
74	F	Lg	12.8	Sm	Y	A	Y	N	N	EM	N	5	Y	N	N	N	N	Y
75	F	Lg	13.0	Lg	Y	A	Y	N	N	SM	N	5	Y	Y	Y	N	Y	Y
76	F	Lg	13.4	Lg	Y	A	Y	Y	Y	EM	N	4	Y	N	Y	N	Y	Y
77	F	Lg	14.0	Sm	N	B	Y	Y	Y	EM	N	4	Y	Y	N	N	Y	Y
78	F	Lg	14.6	Sm	N	A	Y	Y	N	EM	N	5	Y	N	Y	Y	N	Y
79	F	Lg	17.0	Lg	Y	B	Y	Y	Y	SD	N	4	Y	N	N	N	N	Y
80	F	–	–	Lg	N	A	N	N	N	SM	N	5	Y	N	Y	N	N	N
81	F	–	–	Sm	N	B	Y	N	N	SM	N	5	Y	N	Y	Y	Y	Y
82	F	–	–	Sm	Y	–	Y	N	Y	EM	N	4	Y	Y	N	N	N	Y
83	S	Sm	4.3	Sm	Y	B	N	N	N	nt	N	1	Y	Y	N	N	N	Y
84	S	Sm	4.5	Sm	N	A	Y	N	N	nt	N	1	Y	N	N	N	N	Y
85	S	Sm	6.0	Sm	N	B	Y	N	N	SM	N	5	Y	Y	N	N	N	Y
86	S	Sm	6.0	Sm	N	B	N	N	N	nt	N	1	Y	Y	Y	Y	Y	Y
87	S	Sm	6.0	Sm	N	B	Y	N	N	EM	N	5	Y	N	N	N	N	Y
88	S	Sm	6.5	Sm	N	B	Y	N	N	SM	N	5	Y	N	N	N	N	Y
89	S	Sm	6.5	Sm	N	A	Y	N	N	PT	N	2	N	N	Y	Y	N	Y
90	S	Sm	7.0	Sm	Y	A	N	N	N	nt	N	1	Y	Y	Y	Y	Y	Y
91	S	Sm	9.0	Sm	Y	A	Y	N	N	EM	Y	3	Y	N	Y	Y	N	Y
92	S	Sm	9.1	Sm	N	B	Y	Y	N	SD	N	5	Y	Y	Y	Y	N	Y
93	S	Sm	11.0	Sm	Y	A	Y	N	N	EM	N	5	Y	N	N	N	Y	Y
94	S	Sm	11.0	Sm	Y	A	Y	N	N	nt	N	1	Y	Y	N	N	Y	Y
95	S	Sm	11.6	Sm	Y	A	Y	N	N	SM	N	5	Y	–	Y	Y	N	Y
96	S	Sm	12.0	Lg	Y	A	Y	Y	N	SM	N	5	Y	Y	N	N	Y	Y
97	S	Sm	12.0	Sm	N	A	Y	Y	Y	EM	N	2	Y	N	Y	Y	N	Y
98	S	Sm	12.0	Sm	Y	A	Y	N	N	EM	Y	3	Y	Y	N	N	Y	Y
99	S	Sm	13.0	Sm	N	A	Y	N	Y	EM	N	2	Y	N	N	N	N	Y
100	S	Sm	15.0	Sm	N	A	Y	Y	Y	VT	N	2	Y	–	N	N	N	Y
101	S	Lg	10.0	Sm	N	B	Y	Y	N	EM	Y	3	Y	N	N	N	N	N
102	S	Lg	10.0	Sm	N	B	Y	Y	N	EM	Y	3	Y	N	N	N	N	N
103	S	Lg	10.1	Sm	Y	B	Y	N	N	EM	Y	3	Y	Y	N	N	N	Y
104	S	Lg	10.5	Lg	Y	B	Y	N	N	SM	N	5	Y	Y	Y	Y	Y	Y
105	S	Lg	11.8	Sm	N	B	Y	Y	N	SD	N	5	Y	N	Y	Y	N	Y
106	S	Lg	12.0	Sm	N	A	Y	Y	Y	EM	N	2	Y	N	N	N	Y	Y
107	S	Lg	12.2	Sm	Y	A	Y	Y	N	EM	N	5	N	–	N	N	N	Y
108	S	Lg	12.2	Lg	Y	B	Y	Y	Y	SD	N	4	Y	N	Y	Y	Y	Y
109	S	Lg	12.4	Sm	N	A	Y	Y	N	EM	N	5	Y	N	Y	Y	N	Y
110	S	Lg	12.5	Lg	Y	B	Y	Y	Y	EM	N	4	Y	Y	Y	Y	Y	Y
111	S	Lg	12.7	Sm	Y	A	Y	Y	N	EM	Y	3	Y	Y	Y	N	N	Y
112	S	Lg	13.0	Sm	Y	A	Y	Y	N	SM	N	5	Y	Y	Y	Y	Y	Y
113	S	Lg	13.0	Lg	Y	A	Y	N	Y	EM	N	4	Y	N	N	N	Y	Y
114	S	Lg	13.1	Sm	Y	A	Y	Y	Y	SD	N	2	Y	–	Y	Y	Y	Y
115	S	Lg	13.3	Sm	N	–	Y	N	Y	SM	N	4	Y	N	N	N	N	Y
116	S	Lg	14.5	Sm	Y	B	Y	Y	Y	–	N	2	Y	N	Y	Y	Y	Y
117	S	Lg	15.0	Lg	Y	B	Y	Y	Y	SD	N	4	Y	N	N	N	Y	Y
118	S	Lg	15.3	Lg	Y	A	Y	Y	Y	EM	N	4	Y	N	Y	N	Y	Y
119	S	Lg	15.5	Sm	Y	A	Y	Y	N	EM	N	5	Y	Y	N	N	Y	Y
120	S	Lg	16.0	Sm	N	A	Y	Y	Y	EM	N	2	Y	N	Y	Y	N	Y
121	S	Lg	16.6	Lg	Y	B	Y	N	N	SD	N	5	Y	Y	Y	Y	Y	Y
122	S	Lg	16.8	Sm	N	A	Y	Y	Y	SD	N	2	Y	N	N	N	N	Y
123	S	Lg	17.0	Sm	Y	A	Y	N	N	EM	N	5	Y	Y	N	N	Y	Y
124	S	Lg	17.0	Lg	Y	A	Y	Y	Y	SM	N	4	Y	Y	N	N	Y	Y

Operator #	Primary Activity	Vessel Size	Vessel Length (m)	Company Size	Association Member	Hull Configuration	Garbage Bin	Ashtray	Holding Tank	Toilet Type	Treatment System	Sewage Management	Permanently Moored	Operate in MPAs	Acknowledge Impacts	Reduce Impacts	Use EMGs Now	Would use EMGs
125	S	Lg	17.2	Sm	Y	A	Y	Y	N	SM	N	5	Y	Y	Y	Y	Y	Y
126	S	Lg	18.0	Sm	Y	A	Y	Y	Y	EM	Y	2	Y	N	Y	Y	Y	Y
127	S	Lg	18.0	Sm	N	A	Y	Y	Y	EM	N	2	Y	N	N	N	N	Y
128	S	Lg	18.3	Sm	Y	A	Y	N	N	EM	N	5	Y	Y	N	N	Y	N
129	S	Lg	18.8	Sm	Y	B	Y	Y	Y	SM	N	4	Y	Y	Y	Y	N	Y
130	S	Lg	19.0	Sm	Y	A	Y	N	N	EM	Y	3	Y	–	Y	Y	N	Y
131	S	Lg	20.0	Lg	Y	B	Y	Y	Y	SD	N	2	Y	N	N	N	Y	Y
132	S	Lg	20.2	Lg	N	A	Y	Y	N	SM	N	5	Y	N	Y	Y	Y	N
133	S	Lg	23.0	Sm	N	A	Y	Y	Y	SM	N	4	Y	Y	N	N	N	Y
134	S	Lg	24.0	Sm	N	B	Y	N	Y	SD	N	4	Y	N	N	N	N	Y
135	S	Lg	24.0	Lg	Y	A	Y	Y	Y	SD	N	2	Y	N	Y	Y	Y	Y
136	S	Lg	24.0	Lg	Y	B	Y	N	Y	SD	N	4	Y	Y	Y	Y	Y	Y
137	S	Lg	25.0	Sm	Y	A	Y	Y	N	SM	N	5	Y	N	Y	Y	N	Y
138	S	Lg	25.0	Lg	Y	B	Y	Y	N	EM	Y	3	Y	N	N	N	Y	Y
139	S	Lg	26.0	Lg	Y	A	Y	Y	Y	EM	N	4	Y	Y	N	N	Y	Y
140	S	Lg	26.0	Lg	Y	B	Y	Y	Y	SD	N	4	Y	Y	N	N	Y	Y
141	S	Lg	26.5	Lg	N	A	Y	Y	Y	SD	N	4	Y	Y	Y	Y	N	Y
142	S	Lg	26.8	Sm	Y	A	Y	Y	Y	VT	N	4	Y	N	Y	Y	Y	Y
143	S	Lg	27.0	Sm	Y	A	Y	Y	Y	SD	N	4	Y	Y	N	N	N	Y
144	S	Lg	30.0	Lg	Y	B	Y	Y	Y	SD	N	4	Y	Y	Y	Y	Y	Y
145	S	Lg	37.9	Lg	Y	B	Y	Y	Y	SD	N	4	Y	Y	N	N	Y	Y

LEGEND: – = no data; Y = Yes; N = No; **Primary Activity**:– D = Dive; F = Fish; S = Sail; **Vessel Size**:– Sm = Small (<median size); Lg = Large (>median size); **Company Size**:– Sm = Small (<5 employees); Lg = Large (≥ 5 employees); **Hull Configuration**:– A = Mono-Hull; B = Multi-Hull; **Toilet Type**:– nt = no toilet onboard; EM = Electric Macerator Toilet'; PT = Portable Toilet; SD = Standard Domestic Toilet; SM = Standard Marine Toilet; VT = Vacuum Toilet; **Sewage Management Measure**:– 1 = no toilet; 2 = toilet + holding tank/portable toilet + onshore pumpout; 3 = toilet + treatment system; 4 = toilet + holding tank + discharge overboard; 5 = toilet + discharge overboard.

Table 2 – Effects of vessel size and tour type

Environmental parameter	% all boats	Significant effect of:		
		boat size (alone)	tour type (alone)	tour type extra to boat size
garbage bin	87	***	*	ns
ashtray	50	***	ns	ns
toilet, any type	81	***	**	ns
portable toilet	05	**	ns	ns
standard marine toilet	25	ns	ns	ns
standard domestic toilet	20	***	***	*
electric macerator toilet	29	*	*	*
sewage holding tank	35	***	***	ns
sewage treatment system	08	ns	*	*
on-shore sewage disposal	14	ns	ns	ns
operate in MPAs	48	ns	***	ns
acknowledge impacts	49	ns	ns	ns
reduce impacts	40	ns	*	ns
use EMGs now	49	***	***	*
would use EMGs	88	ns	ns	ns

*, $p < 0.05$. **, $p < 0.01$. ***, $p < 0.001$. ns, $p > 0.05$