BOAT TOURISM AND GREENHOUSE GAS EMISSIONS: CONTRIBUTIONS FROM DOWNUNDER

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ABSTRACT

Transport to and between destinations by air, road and rail has been identified as tourism's major contributor to greenhouse gas (GHG) emissions. Travel by boat has received less attention, even though this form of transport, particularly at high speed, can be very energy intensive and could add a significant amount of GHG emissions to the overall energy budget of a holiday trip. Many destinations, especially in the mass tourism sector, are located in or near coastal environments, which provide opportunities for exploring adjacent waterways and marine environments. Recent trends in product diversification have helped to increase the demand for boat trips. The popularity of whale watching and dive tours are examples of the growth in this sector. Consequently, this paper tries to estimate the overall and per capita energy costs and GHG contributions associated with tourboat operations in Australia, a country with a 35 000 km coastline and world class marine attractions. Using a comprehensive database of Australian tourboat operators, 45 face-to-face interviews and 100 completed postal survey questionnaires, the overall GHG emissions for this industry sector was estimated conservatively at 70 000 tons CO_2-e or 0.1 percent of the transport sector in Australia, the fastest growing sector in terms of GHG outputs. On average, this consumption translated into an extra 61 kg CO_2-e per tourist if their travel itineraries included a trip on a boat with a diesel engine, or 27 kg CO_2-e for a trip on a boat with a petrol engine.

Information obtained from Australian tourboat operators, however, indicated a range of technical and operational opportunities for reducing GHG emissions. Some of the most promising solutions and their implementation are discussed in this paper.

KEYWORDS: *Boats, Tourism, Greenhouse gas, Tourboat operators*

INTRODUCTION

Marine transport, similar to air transport, has long been recognised as one of the major industry sectors responsible for producing large quantities of greenhouse gases (GHG) (1,2) and other air pollutants such as nitrous oxides (NO_x) and sulphate oxide (SO_2) (3,4). At the international level, emissions of GHG and pollutants from marine transport are largely associated with the use of large combustion (mostly diesel) engines operated on vessels navigating mostly in international waters. The release of air pollutants from these sources is currently being addressed by the International Maritime Organisation (IMO) under Annex IV of MARPOL 73/78, which is planned to come into force by 2005. However, GHG emissions have not yet been incorporated into this Annex.

At a national level in Australia, the increase in GHG emissions associated with transport is of major concern. Although the majority of these emissions across all types of GHGs (79.2 M tons CO_2-e or 14.4% the national budget) were associated with road transport (88%), marine transport or navigation contributed over-proportionally high amounts of CH_4, CO and SO_2 (5). Marine transport within Australian territorial waters includes shipping of raw materials, manufactured goods and products between major ports, commercial fishing operations, inner city public transport (river ferries), recreational activities, tourism, and a range of other minor activities. The contributions from each of these subsectors have not yet been quantified on a per sector basis. Of all the marine transport subsectors in Australia, tourism is likely to be one of the fastest growing—fuelled by a strong growth in numbers of both domestic and international visitors over the past ten years, and an ongoing diversification of Australia's tourism product. A good example of the more recently developed markets in the marine environment is the whale, dolphin and whale shark viewing sector with a growth rate of 23.5% between 2000 and 2003, generating 665 000 visitor nights in 2003 (6,7).

So far, there has been little interest in assessing the GHG emissions of the Australian tourboat industry. This lack of concern is somewhat surprising given that transport on water, particularly at high speeds, can be very energy intensive (8) and, therefore, has the potential to add a significant amount of GHG emissions to the overall energy budget of a holiday trip. Tourism is one of Australia's major export industries, and thus coastal and marine environments along its 35 000 km coastline provide key attractions for its tourism product. The only subsector of the tourism industry that has so far attracted more detailed attention in regard to climate change is Australia's ski industry (9,10). This particular interest has possibly originated from the fact that several Australian ski resorts were considered marginal in regard to their natural snow cover, and thus would face serious problems under the warmest climate change scenarios (9).

Another reason for the lack of data and research in regard to the tourboat industry may lie in the diversity of this sector and the corresponding difficulties associated with obtaining reliable information at reasonable costs. In theory, marine tours can include anything from hiring a surfboard to cruising onboard a major ocean liner (11). For this study, surfboards, windsurfers and kite surfers were excluded because they resemble sporting equipment rather than vessels. At the other extreme, ferries and ocean liners were excluded because their emissions were considered similar to large commercial vessels (except for solid wastes and sewage) that often operate in international waters as part of the major international shipping fleet and are, therefore, subject to treaties administered by IMO under MARPOL 73/78. Vessels used for ferry services as part of a regional public transport network were also excluded from the work presented here, even though many of these vessels are also popular with tourists (e.g. Sydney Harbour ferries, New York City ferries, Hong Kong ferries, etc.).

The main objectives for this research were: to characterise the types of small to medium size tourboat operations in Australia's coastal environment; to estimate the overall and per capita GHG emissions for this sector; and to ascertain perceptions of tourboat operators (TBOs) in regard to their contributions to GHG emissions in comparison to other impacts. Based on previous experiences with other small to medium size tourism enterprises (SMTEs) (12,13), information for this study was to be collected using a suite of methods ranging from face-to-face interviews, postal survey questionnaires and in-situ audits. Results from these investigations were to be used to highlight current problems with addressing GHG emissions in this industry sector, and to explore how existing policy frameworks could be improved to increase reductions in GHG emissions in the Australian tourboat industry.

METHODS

The general lack of comprehensive data for the Australian tourboat sector required the work for this study be broken up into a set of consecutive tasks and phases. The first phase involved establishing a reliable database for all (or most) TBOs in Australia. This database was used to identify hotspots of tourboat operations and allowed a random selection of TBOs for conducting initial face-to-face interviews and in-situ audits to fine tune and test the sampling instrument. The third and final phase involved the development and distribution of 750 postal survey questionnaires covering seven hotspot destinations in four Australian states (Qld, NSW, Vic., WA).

TBO database

Several online sources (*Yellow Pages, White Pages,* the *Australian Charter Guide,* etc.) were queried for the listing of potential TBO addresses and phone numbers using categories such as diving, snorkeling, fishing, boat hire, cruises, etc.. All entries in the resulting TBO database were standardized in regard to type and content of information provided in each field (e.g. street address, postcode, telephone number, etc.) and cross-checked for duplication of records. The remaining records were grouped by postcodes, geocoded to a current postcode layer available from CDATA 96 (14), and visually analysed for hotspots of tourboat activities.

Face-to-face interviews

Following a review of ship-sourced pollution legislation, and literature relating to impacts of boats and larger vessels in general (11,15), a questionnaire was prepared to establish current views and practices of Australian TBOs in regard to their business and tour operations, vessels in use, general environmental impacts, and aspects relating to GHG emissions. Following an initial small scale trial (16), 48 TBOs from within the seven study locations were randomly selected and asked to participate in a 20 minute interview to be conducted at a location dictated by the interviewee. Despite considerable investment in time and resources, the willingness to participate in this research exercise remained low (17).

Postal survey

The type and style of responses noted during face-to-face interviews were analysed and incorporated into a postal survey questionnaire reflecting the type of questions asked during face-to-face interviews. Wherever possible, operators were provided with tick boxes to facilitate providing information and to limit the time for completing the questionnaire to 25 minutes. The method used for the postal survey closely followed that outlined in Dillman (18), including the initial mailout (questionnaire, cover letter, contact details slip, etc.), a follow-up postcard, and (in case of a non-response) a follow-up letter three weeks after initial mail-out. Copies of the materials used for the survey questionnaire can be requested from the principal author.

Data compilation and analysis

Information from each business or operator was entered into a set of databases. Entries in each field had to be standardized in order to reduce the number of categories. For example, small open tinnies and trailerable half-cabin cruisers or any other similar vessel, according to its hull type and configuration, dimensions, means of propulsion, and engine details (inboard/outboard, two or four stroke, petrol or diesel) were amalgamated into one category named "tinnie/half-cabin". Similar amalgamations or condensations were applied to other fields such as principal type of activity (fishing, diving, etc.).

RESULTS

At first, 2998 business addresses of Australian TBOs were compiled from telephone directories and other databases. Based on the returns from 750 questionnaires allowing corrections for agents only or businesses that were no longer in operation, the number of TBOs operating one or more vessels in 2001 was estimated at 1476. Originally, 1505 TBOs were listed in the initial database for the seven study areas. Of these, 799 were sampled. Applying the same correction factor (49.2 % of actual TBOs in operation, see above) left approximately 400 TBOs that could be surveyed, or could have replied to the questionnaire. Overall, 145 operators responded to this study, either through participation in face-to-face interviews or a returned and, at least mostly, completed survey questionnaire. The overall response rate to the survey questionnaire and the face-to-face interviews was therefore estimated at 35%, which equated to approximately 10% of all TBOs in Australia.

Business characteristics

The majority (34.5%) of TBOs were, at the time of the study, in business for 5-10 years. Almost three quarters of operators considered their businesses to be small, employing usually one to five staff. Accordingly, 76 % of TBOs operated only one or two vessels. As expected, hire companies had relatively more vessels than other operators.

Data from this research also indicated that some operators preferred a certain vessel type based on their principal type of activity. For example, more than 65% of fishing tour operators (28 out of 43) used fly-bridge cruisers or fishing boats/cruisers for their businesses, whereas 62% of hire operators used tinnies/half-cabins or houseboats. The use of purpose-built tourism vessels, such as dive boats and hi-speed catamarans, was rare (i.e. only seven percent).

Tour characteristics

Given that purchasing and maintaining a tourism vessel in Australia is quite expensive, it was surprising to discover that 50% of all operators who provided information stated that their vessel was in operation for only 50 % of the year or less. Cruise/sail operators dominated this low use group.

The majority of tours conducted were half day (3 to 6 hrs) or full day (6 to12 hrs) trips. The most notable difference in trip duration for different types of tourboat activities were between fishing tours and cruises (sail or engine propelled). The majority of fishing trips lasted for between six to 12 hours, whereas cruises were usually less than 6 hours. The latter were also available for a more equal spread of passenger group sizes, whereas the number of customers on fishing trips rarely exceeded ten ($\chi^2 = 47.7$, 6 df, $p < 0.0001$ for primary activities with 'zero to five', 'five to ten' or 'more than ten' guests/trip, 'others' excluded) (Table 1).

Table 1: Trip characteristics of Australian tourboat operations

Tour Characteristics		Primary Activity Fishing	Cruise/sail	Hire	Dive/ snorkel	Other	Total
Boat Use	Total	**43**	**39**	**27**	**27**	**6**	**142**
(%/yr)	Mean	50	43	49.5	70.7	65.8	52.5
± 1 SE		4	4.28	5.32	5.35	17.09	2.41
No. Guests	Total	**43**	**38**	**24**	**27**	**6**	**138**
Per Average	Mean	8	31.3	7	21.6	59.7	19.2
Length Trip	± 1 SE	1	6.28	1.29	3.78	33.47	2.58
Time Average Length Trip (hrs/trip)							
0–3		1 (2%)	11 (30%)	8 (33%)	7 (25%)	2 (33%)	29 (21%)
3– <6		16 (39%)	16 (43%)	7 (29%)	8 (29%)	2 (33%)	49 (36%)
6– <12		24 (59%)	8 (22%)	5 (21%)	10 (36%)	2 (33%)	49 (36%)
≥12		0	2 (5%)	4 (17%)	3 (11%)	0	9 (7%)
Total		**41**	**37**	**24**	**28**	**6**	**136**
Mean		7	10.3	19.9	18.2	4.1	12.4
± 1 SE		0	5.09	7.26	7.68	1.1	2.48

Vessel characteristics

Most of the vessels used by TBOs in Australia were of a single hull configuration, on average 13 years old and 13 m in length overall (LOA) (Table 2 below). Smaller vessels (usually those less expensive and therefore less costly to replace) were not necessarily younger in age than the larger vessels. Tinnies and half-cabin cruisers, mostly around 5 m LOA, were on average 10 years old. Purpose-built tourism vessels, such as dive boats and hi-speed catamarans, on the other hand, were on average the largest and youngest vessels (Table 2)

Engine configuration on vessels used by Australian TBOs varied considerably. Overall, operators used engines from small two-stroke petrol outboard designs to large inbuilt, turbocharged two- and four-stroke diesel engines with claimed outputs of up to 1720 kW. Table 1 attempts to summarise the more general aspects of engine types fitted to tourism vessels. Most double-hulled vessels had two engines whereas 58% and 40% of all mono-hulls had a single or double engine configuration, respectively. Close to two thirds of all engines used by Australian TBOs were inboard four-stroke diesel engines, the remainder being mostly two- or four-stroke outboards. An additional type of engine, used on larger tourboats, was generators operated to provide electricity. However, due to low numbers, the emissions from these combustion engines were not considered any further.

Table 2: Vessel characteristics of Australian tourboat operators

Vessel Characteristic		**INS**	**Twin-Deck/Fly-Bridge Cruiser**	**Sail Boat**	**Tinny/Half-Cabin**	**Speed Boat**	**Fishing Boat/Cruiser/etc.**	**Dive Boat**	**Houseboat/BBQ Boat**	**Hi-Speed Cat**	**Other**	**Total***	**%**
Hull Configuration													
INS		4	–	–	–	–	–	–	–	–	–	4	2.8
Mono-Hull		9	31	15	16	10	12	6	2	–	1	102	70.3
Double-Hull		2	6	9	1	7	1	–	6	4	–	36	24.8
Tri-Hull		1	–	–	–	2	–	–	–	–	–	3	2.1
Total*		**16**	**37**	**24**	**17**	**19**	**13**	**6**	**8**	**4**	**1**	**145**	100.0
Length over	Total*	**13**	**36**	**24**	**17**	**18**	**13**	**6**	**8**	**4**	**1**	**140**	100.0
all (m)	Mean	11.5	13.7	14.9	4.9	12.5	15.4	18.8	10.7	27.2	25.0	13.2	–
± 1 SE		1.93	0.58	1.11	0.34	1.77	1.83	3.60	1.16	4.44	–	0.57	–
Vessel	Total*	**13**	**37**	**24**	**15**	**19**	**13**	**6**	**8**	**4**	**1**	**140**	100.0
age (yrs	*)*Mean	16.3	13.3	12.8	9.7	8.1	19.3	8.0	14.4	7.5	70.0	13.0	–
± 1 SE		3.18	1.23	2.30	1.19	1.25	5.61	3.29	2.58	3.28	–	0.96	–
Hull	*Engines*												
Mono-Hull	1	5	14	15	5	15	4	–	–	–	1	59	41.3
	2	4	17	–	5	1	8	2	4	–	–	41	28.7
	3	–	–	–	–	–	–	–	2	–	–	2	1.4
	Total*	**9**	**31**	**15**	**10**	**16**	**12**	**2**	**6**	**–**	**1**	**102**	71.3
Double-Hull	1	2	–	–	–	–	–	5	–	–	–	7	4.9
	2	–	6	8	7	1	1	1	–	4	–	28	19.6
	Total*	**2**	**6**	**8**	**7**	**1**	**1**	**6**	**–**	**4**	**–**	**35**	24.5
	Mean	1.3	1.6	1.3	1.6	1.1	1.7	1.4	2.3	2.0	1.0	1.5	–
	± 1 SE	0.13	0.08	0.10	0.11	0.08	0.13	0.18	0.21	0.00	–	0.04	–
Diesel		8	36	19	8	1	13	–	4	4	–	93	
Petrol		7	–	4	10	16	–	8	2	–	–	47	0.7
	Total*	**15**	**36**	**24**	**18**	**17**	**13**	**8**	**6**	**4**	**1**	**140**	100.0
Engine	Total*	**13**	**34**	**22**	**19**	**16**	**12**	**8**	**6**	**4**	**1**	**135**	100.0
Age (yrs)	Mean	14.4	10.4	9.0	3.7	6.4	12.2	4.1	4.3	3.5	70.0	8.9	–
	± 1 SE	4.83	1.29	1.56	0.41	0.80	2.58	0.90	0.92	1.19	–	0.85	–

NOTE: * = percentages of totals are given for the total number of responses for each variable measured

On average, marine engines used for propelling Australian tourism vessels were about 4 years younger than the hulls (Table 2) The highest turnover appeared to be with two-stroke (and to a lesser degree four-stroke) outboard engines. Many houseboats, tinnies/half-cabins and dive vessels (mostly semi-rigid inflatables) used outboard engines, which were on average younger than diesel engines in fly-bridge cruisers and sailboats (yachts). These results were not surprising as, from a technical and not uncommonly economical point of view, it is much easier to exchange an outboard engine compared to an inboard diesel engine. Further, changes to emission regulations for small spark ignition marine engines, under the U.S. *Clean Air Act* 1990 (as amended) (19), prompted engine manufacturers to develop more fuel efficient two-stroke and, ultimately, four-stroke outboard designs. According to feedback during interviews, several operators preferred the modern two-stroke and four-stroke designs, mainly for their greater reliability.

Calculations of GHG emissions

The results presented above, and further pattern analyses (results not shown here), of the dataset demonstrated that Australian TBOs could not be grouped into homogenous categories based on 'primary activity' type, vessel type or trip characteristics. Further, the relative proportion of different types of TBOs of the entire population of operators in Australia is unknown. Therefore, GHG emissions were estimated based on the following equations:

Equation 1

$$GHG_{fuel\ type}\ (CO_2e) = FC_{fuel\ type}\ (l\ h^{-1}) \times TD_{fuel\ type}\ (h) \times 0.6^{a} \times V/op_{fuel\ type} \times USE_{fuel\ type}\ (\% \times 0.01) \times 365 \times Ops_{fuel\ type}\ (\%\ sample \times 1476 \times 0.01) \times CR_{fuel\ type}\ (kg\ CO_2e\ l^{-1})$$

where

FC = average fuel consumption stated by operators

TD = average trip duration

V/op = average number of vessels per operator

USE = average percent use per annum

Ops = number of operators

CR = AGO conversion rate

NOTE: a = correction factor for turning off engines while stopped (or moored) at destination (one or several)

Equation 2

$$GHG\ TBOs_{Australia} = \sum GHG_{fuel\ type}$$

Based on these equations, the overall GHG emissions for the Australian tourboat industry sector was estimated conservatively at 70 000 tons CO_2-e or 0.1 percent of the transport sector in Australia, the fastest growing sector in terms of GHG outputs. Taking the average number of guests per trip into account, GHG emissions translated into an extra 61 kg CO_2-e per tourist if their travel itineraries included a trip on a boat with a diesel engine, or 27 kg CO_2-e for a boat with a petrol engine – the equivalent of a single person driving 140 km or 300 km, respectively, in a standard passenger vehicle

Reducing GHG emissions

When asked to consider the impacts of their vessel on coastal environments in an open-ended question, almost 75 % of operators were of the opinion that their activities caused no impact. Of those who were aware of their potential impacts, 27 out of 38 mentioned engine emissions, mostly in the form of small fuel spillages and oil leaks .

A slightly different picture could be obtained when operators where asked to rank the severity of potential impacts of different aspects of operating a vessel on a scale of one to ten (the latter representing the highest impact). Under these circumstances, TBOs ranked engine emissions second highest after impacts associated with the release of, until then, mostly untreated raw sewage from marine toilets and galleys (Table 3).

Table 3: Ranking of impacts of different boating aspects

	Primary Activity											
Boating Aspect	**Fishing**		**Cruise/ Sail**		**Hire**		**Dive/ Snorkel**		**Other**		**Total**	
	Mean ± 1 SE		Mean ± 1 SE		Mean ± 1 SE		Mean ± 1 SE		Mean ± 1 SE		Mean ± 1 SE	
Boat Sewage (n = 120)	4.5	*0.53*	6.6	*0.51*	7.6	*0.53*	6.1	*0.65*	3.9	*0.99*	5.9	*0.29*
Boat Engine Emissions (n = 122)	5.2	*0.53*	5.8	*0.53*	6.2	*0.56*	5.7	*0.49*	3.6	*1.17*	5.6	*0.26*
Antifouling Paints (n = 120)	4.4	*0.49*	6.0	*0.48*	5.1	*0.55*	5.7	*0.65*	3.6	*1.17*	5.2	*0.27*
Litter/Garbage (n = 123)	4.5	*0.64*	5.6	*0.66*	5.4	*0.66*	4.8	*0.64*	1.4	*0.52*	4.9	*0.32*
Physical Damage to Substrate (n = 121)	3.7	*0.42*	4.1	*0.57*	3.9	*0.61*	4.9	*0.66*	1.4	*0.53*	4.0	*0.27*
Wildlife Disturbance (n = 122)	2.8	*0.42*	4.4	*0.60*	3.3	*0.59*	3.7	*0.58*	1.3	*0.41*	3.4	*0.27*
Breakdown of Sacrif. Anodes (n = 122)	2.6	*0.34*	3.9	*0.48*	3.8	*0.59*	3.0	*0.41*	1.6	*0.38*	3.2	*0.22*

Both the survey questionnaire and the face-to-face interviews provided TBOs with an opportunity to comment on any aspect of their operations that they believed was of concern or should be addressed. None of these comments contained any remarks on GHG emissions or the potential effects of climate change on the day-to-day operations of TBOs in Australia.

DISCUSSION

Accuracy of CO_2-e emission estimates

All data obtained for this study were derived from operators, or the supply side of the tourboat market, and could not be verified against information collected from the demand side, i.e. the *International Visitor Survey* (IVS) or *National Visitor Survey* (NVS) conducted by the Australian Bureau of Tourism Research (BTR). The data collected by the BTR focus on activities (e.g. going fishing) and does not differentiate between ways in which this activity was conducted, for example fishing from the shore or beach versus fishing using a private vessel or a commercial tour. Another compounding factor associated with the BTR data is that many operators offered several activities on a single trip. Whale shark operators in Western Australia usually incorporated a guided dive tour, either after all their customers had been provided with the opportunity to swim with a whale shark, or, in case no whale sharks were spotted on that day, as an alternative program. Similar scenarios were observed for operators on the Great Barrier Reef, who often combined snorkelling and SCUBA dives in one trip.

It must be further acknowledged that the information provided by operators (notably with the questionnaire) was sometimes inconsistent or occasionally conflicting. For example, some operators considered themselves a small business and yet they indicated employing three staff, which was considered to be a medium-sized enterprise by other operators. Another potential source of error was the number of days or the time period that operators considered their vessel(s) to be out at sea and in use. Some may have taken adverse weather conditions or periods for maintenance into consideration, while others may have just reflected on their usual weekly business activities. A third factor limiting the accuracy of GHG emissions calculated for this study was the use of two-stroke diesel and petrol engines (no conversion factors could be obtained for predicting the amount of CO_2-e for these types of combustion engines).

Using data from fuel purchases at marinas and boat harbours would have quite possibly provided estimates with similar (if not greater) levels of uncertainties, as many TBOs share fuelling stations with other vessel operators (e.g. users of recreational vessels of similar size and commercial fishermen). TBOs with boats propelled by small outboard engines sometimes purchase fuel from road petrol stations to avoid additional charges or higher costs for fuel sold at marine refuelling stations. Again, the degree to which these practices exist among TBOs is currently unknown and would have caused estimates, based on fuel use, to be equally speculative.

Reduction of GHG emissions

Even though the actual overall amount of GHG emissions of Australian TBOs represents only 0.1 percent of emissions associated with transport activities across Australia, there appears to be a number of practices that lead to unnecessary wastes of non-renewable fossil fuels and emissions of GHGs. At the technical level, a comparison of engine specifications and combinations of hull and engine designs of individual operators revealed that a number of operators used old, and possibly outdated, engines or combinations of engine/hull designs. Using a vessel equipped with two 485 kW engines, an average fuel consumption of 300 l/hr and an average of no more than 11 passengers per trip should become a practice that is strongly discouraged.

Data from this study also indicated that the majority of Australian TBOs were ignorant regarding the potential for their operations to cause environmental impacts. Further, the idea that GHG emissions and climate change could affect day-to-day operations was non-existent among the operators surveyed for this study. This included larger companies which claimed to have internal environmental management systems in place and were accredited, or in the process of becoming accredited, as ecotour operators.

The lack of awareness about GHG emissions and climate change amongst Australian TBOs, and possibly most of their domestic clients could be the result of Australia's arid, hot climate and its history of sometimes drastic climate changes triggered by oscillations of surface water temperatures in the southern oceans (El Niño Southern Oscillation (ENSO) effects). Although this might need further research, the colloquial term of 'another stinking hot summer' indicates that Australians have learned to accept extremes. This not only includes heat waves and droughts but also rain events and flooding associated with tropical cyclones (particularly along the northern part of the continent anywhere between Perth and northern NSW (9)). Another difficulty with experiencing long-term changes in Australia's climate is that ENSO effects can be very localised and, therefore, allow only little or no direct comparison.

The following measures, all coordinated and facilitated by the Australian Greenhouse Office (AGO), could prevent many of the current ill-informed practices leading to the unnecessary use of non-renewable fossil fuels:

a) better communication of technical innovations/solutions between TBOs, naval architects and engineers,
b) introduction of a fuel consumption based excise on operator permits, and
c) small industry grants for upgrades of marine engines.

In summary, work from this project has provided some estimates for GHG emissions and contributions of Australian TBOs to global climate change. These results have also demonstrated that there is a considerable lack of awareness of impacts in general, and GHG emissions in particular, and that it would be prudent to assume that this level of information would be sufficient to design industry-specific measures for reducing fuel consumption and subsequently GHG emissions.

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