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INSHORE LEISURE CRAFT

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1. INTRODUCTION

Scarborough is a major seaside resort on the North Yorkshire coast, with a population of some 50,000, swollen by thousands of visitors every day in the summer. It is built around two wide bays, but with the bulk of the tourist facilities on the South Bay, while significant numbers of fishing boats and leisure craft operate from the harbour.

Jet-drive powerboats (jet-boats) are used to give passengers the thrill of high speed manoeuvring at sea. They are powered by an inboard engine, with impellers mounted in one or more tunnels below the hull which produce a jet of water to propel the craft - hence the name. In the boats under study, the engine exhaust was mounted in the stern board near to the waterline.

Personal Watercraft (PWC), commonly known by their Kawasaki trade name as Jet-Skis, are lightweight craft, in either two-seater or stand-up only versions, and are the nearest waterborne equivalents to the off-road motorcycle. The propulsion system is similar to that described above for jet-boats, only on a smaller scale.

Over recent years, a small number of complaints have been received regarding noise from PWC and jet-boats in the area (as well as regarding the manner of use of PWC). The feeling expressed in these complaints, and in informal conversations with members of the public, is that noise from both types of craft can be quite intrusive during outdoor leisure activities, possibly because of the continuous tone generated. Similar feelings were not expressed regarding traffic noise; although traffic in the areas under study were generally fairly light, overall noise levels from this source could often be greater than those from PWC or jet-boats. This may be because people are well used to traffic noise - in a recent large scale survey of noise exposure (1) traffic noise was audible at over 90% of sites in England and Wales.

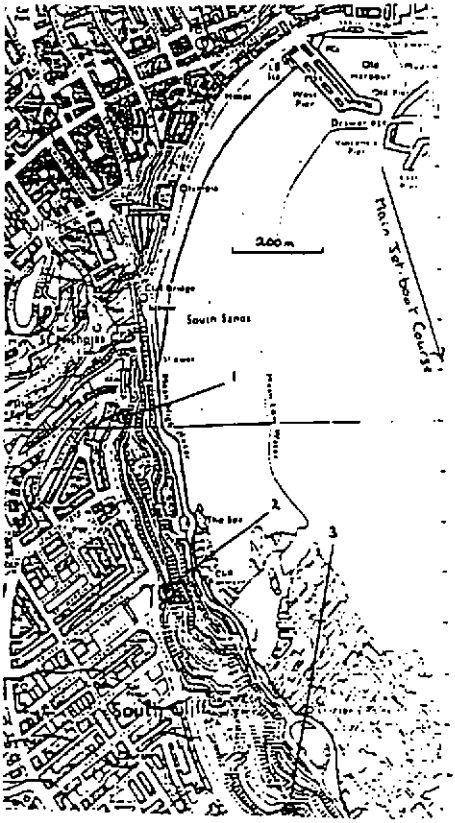
There has been very little published work on this area of noise complaint, so it was the aim of this study to make an initial assessment, by means of sound level measurements and noise rating for both types of craft, of the likelihood of such complaints being justifiable and also to suggest possible procedures for noise control (2).

2. METHODS

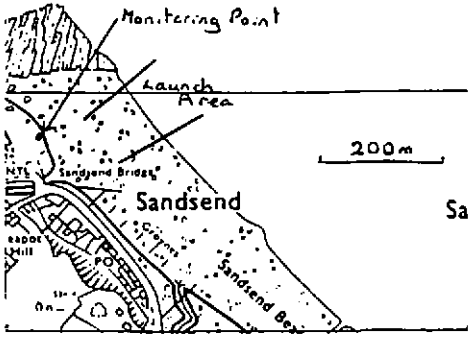
Octave band frequency spectra were obtained for both types of craft by means of L_{eq} measurements in the field with and without the craft of interest being audible. Following this, a series of sound level measurements were made from a number of locations to give the following sets of data (all values shown are dB re 2×10^{-5}Pa):

Jet-boats:	L_{Aeq}, L_{A90}, $L_{eq125Hz}$
PWC:	L_{Aeq}, L_{A90}, $L_{eq250Hz}$, $L_{eq500Hz}$

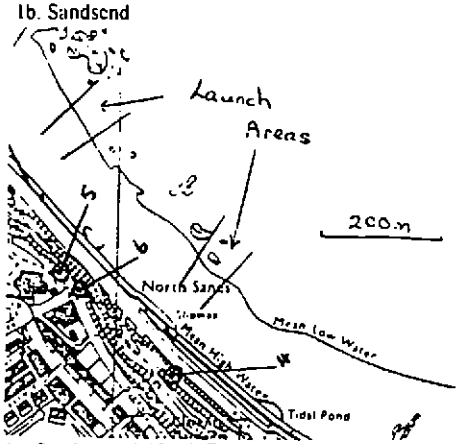
Figure 1: Monitoring Points in Relation to Craft Operating Areas



1a. Scarborough South Bay



1b. Sandsend

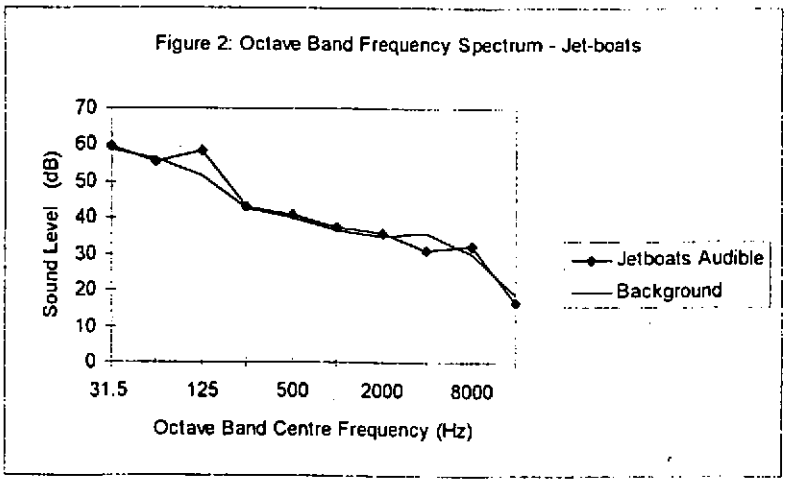


1c. Scarborough North Bay

Measurements were carried out using a Cirrus CRL236A precision integrating Sound Level Meter, which records sound levels as a series of 'short L_{eq}' values. For all of the work reported here, a 'short L_{eq}' setting of 0.125sec was used, while the measurement durations were all greater than 25sec for PWC (i.e. 200 'short L_{eq}'s) or 2min for jet-boats. So as to minimise the effects of wind speed and direction, measurements were only accepted if the average wind speed was less than 4m/s with gusts of less than about 6-7m/s.

3. JET BOATS

Three jet-boats were being operated from Scarborough Harbour. Sound Level measurements were made from three points on the cliffs above their usual course (Figure 1a). The distance from source to receiver varied from ~800m to ~2km, but all measurements were made at distances up to ~1200m, since the sound level was not measurable above background beyond this distance. Figure 2 shows the octave band frequency spectrum - note the tonal nature of the sound with a peak at 125Hz. No correction has been made for air attenuation or distance.



The principal contributor to background levels at sites 1 and 2 was traffic noise, since these sites were less than 3m from the kerb. Site 3 was deliberately chosen for low traffic noise levels, in an attempt to be more representative of rural locations further along the coast. Although three jet-boats were being operated, no more than two would be at sea at any one time, and usually only one of these was audible.

Table 1: Sound Pressure Level Measurements for Jet-Boats - dB(A)

Site	L_{Aeq} Jet-Boats Audible	L_{Aeq} Background	L_{A90}
1	60.7	66.1	57.5
2	61.8	61.4	59.1
3	45.2	46.2	40.1

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Although the jet-boats are clearly audible when operating, there is no sign of any change in the L_{Aeq} (Table 1) - the overall level of other noises in the background seems to be sufficient to mask the contribution of the jet-boats to the total. At 125 Hz, however (Table 2), a difference is obvious - 12.7 dB at one site, and an average of 5.6 dB across all readings.

Table 2 Sound Pressure Level Measurements for Jet-Boats - dB @ 125 Hz

Site	L_{eq} Jet-Boats Audible	L_{eq} Background	L_{90}
1	44.6	39.6	36.8
2	57.6	51.5	45.2
3	43.2	30.5	28.1

One point to note (especially as regards noise control) is that one of the jet-boats was of a different design to, and significantly quieter than the other two (Table 3).

Table 3. Comparative Sound Levels of Different Jet-boats

SPL	dB(A)	dB@125 Hz
Boat A	61.7	56.7
Boat B	62.2	56.2
Boat C	60.9	50.1

3. PERSONAL WATERCRAFT

PWC were being operated in two areas: mostly in the North Bay, but there was also some use off Sandsend, a small village about 35km up the coast. Sound level measurements were made from the sea wall at Sandsend (Figure 1b) and from three points on the slopes above North Bay (Figure 1c) while craft were within about 300m from shore (i.e. 100–400m from the measurement points). Beyond this distance, although they were audible, noise from PWC was indistinguishable from background.

Traffic and wave noise were approximately equal contributors to background noise levels at all sites, except Sandsend where traffic was much less significant. Varying numbers of PWC would be operating and audible during each measurement period, although no more than three tended to audible at the same time. At Sandsend, only one craft was operating during the whole period.

Figure 3: Octave Band Frequency Spectrum - PWC

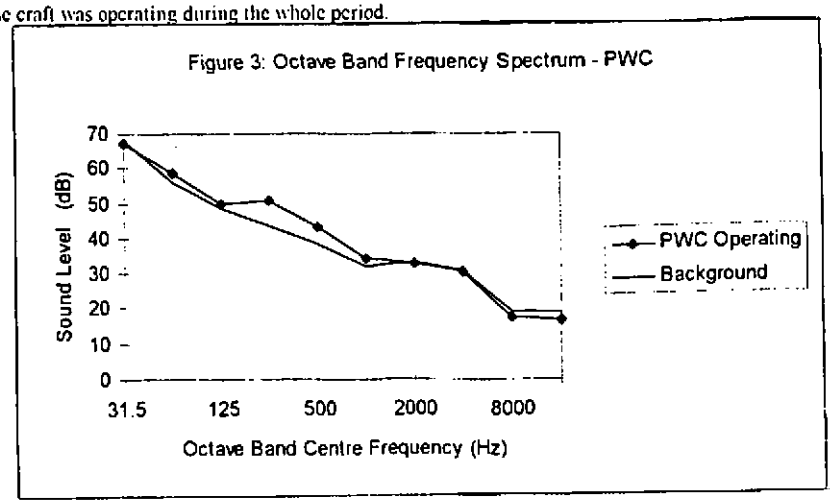

Figure 3 shows the octave band frequency spectrum for PWC. Note the broad peak compared to background around 250-500Hz. It is difficult to be more precise than this because measurements were made in the field, with moving sources and a variable background. The engine sound from these craft is tonal, but is not the only source of noise. Again, as with jet-boats (Figure 2) no correction has been made for air attenuation or distance.

Tables 4,5 and 6 show the results of sound level measurements carried out from the various sites for A-weighted SPL (L_A), and 250 Hz and 500 Hz octave bands respectively.

Table 4: Sound Pressure Level Measurements for PWC - dB(A)

Site	L_{Aeq} PWC Audible	L_{Aeq} Background	L_{A90}
4	60.7	56.9	53.7
5	56.3	54.7	50.6
6	58.8	57.5	54.4
Sandsend	58.8	56.6	45.2

Table 5: Sound Pressure Level Measurements for PWC - dB @ 250 Hz

Site	L_{eq} PWC Audible	L_{eq} Background	L_{90}
4	51.7	50.9	44.2
5	48.0	41.7	38.6
6	nr	nr	nr
Sandsend	nr	nr	nr

nr = no result

Table 6: Sound Pressure Level Measurements for PWC - dB(A) @ 500 Hz

Site	L_{eq} PWC Audible	L_{eq} Background	L_{90}
4	55.7	51.5	45.5
5	49.4	43.6	40.4
6	nr	nr	nr
Sandsend	nr	nr	nr

nr = no result

Unlike the situation for the jet-boats, an increase in Leq above that of background levels can be seen for all three sets of measurements - L_A, 250 Hz and 500 Hz - although these still tend to be fairly small. The actual differences depend in great part on the numbers of PWC operating, and how close inshore they came - the effective measurement distance could vary four-fold from ~100m to ~300-400m.

Sound levels also tended to be influenced by the type of PWC and the manner of use. All except one of the sit-down types observed were operated for hire, tending to be ridden by inexperienced users, who would drive somewhat less aggressively and keep further offshore. When driven hard and close inshore, they are quite capable of generating significant noise levels. However, one major source of higher noise levels from PWC is caused by 'wave-hopping', as the craft partially leaves the water and the engine races. This is more pronounced for stand-up types, since these are lighter craft than the sit-down. Indications that sit-down types could be more quiet than others would bear out the findings of a study by Lanpheer (3), which indicated a difference of approximately 3 dB on a standardised pattern test.

5. RATING AND ASSESSMENT OF NOISE LEVELS

5.1 Selection of Rating Method

Several methods of noise assessment were considered for this data, including BS4142:1990 (4), Noise Rating and Noise Criterion curves, general Environmental Noise Measurement (BS7445:1991) (5), and the use of narrow band (e.g. 125Hz octave band) assessment. Of these, only the last mentioned is likely to be of value, and then only in conjunction with another method such as BS4142:1990.

Although BS7445:1991 does describe suitable methods for carrying out environmental noise measurements, the assessment levels described in Part 2 of the standard are intended for general land use requirements, and so are designed to take account of all noise sources rather than any one in particular (unless that is a very dominant source). For Noise Rating (NR) or Noise Criterion curves, the minimum requirement is that data be obtained as at least octave band spectra for each assessment. This (unless a Real Time Analyser is available) would be very difficult to achieve given the variable nature of the sound sources and the background noise. Also, when the octave band spectra shown in Figs. 2 and 3 are plotted on NR curves (not shown), it would appear that any difference between NR levels for measurement and background is likely to be due to variations in background noise levels in the 4-8kHz octave bands, rather than due to differences in sound levels from the craft under study.

BS4142:1990 is intended for planning purposes in connection with industrial noise, but it is designed for use in assessing single noise sources or groups of similar sources. The principal methods of this standard are commonly used in complaints investigation by Environmental Health departments, and it does require only a precision integrating Sound Level Meter. It could also be appropriate to include an assessment of single octave band levels alongside the assessment level from BS4142:1990, in the form of a difference between L_{eq} values with and without the craft in question being audible (denoted D_{125}, D_{250}, etc.).

5.2 Assessment of Jet-Boats and PWC

Tables 7 and 8 show the assessment levels derived from BS4142:1990, and also L_{eq} difference values at the various sites for Jet-Boats and PWC respectively.

Table 7. Assessment of Jet-boats to BS4142:1990

Site	1	2	3
Specific Noise Measurement (L_{Aeq})	60.7	61.8	45.2
Specific Noise Level	57.7	58.8	43.2
Tonal Correction	+5	+5	+5
Rating Level (L_R)	62.7	63.8	48.2
Background Level (L_{A90})	57.5	59.1	40.8
Assessment Level (L_R - L_{A90})	5.2	4.7	7.4
D_{125}	5.0	6.1	12.7

It should be noted that the assessment levels derived for Jet boats by BS4142:1990 are due largely to the tonal correction, which may often be suspect. Overall, the assessment levels reflect background noise levels and distance from source. For example, at Sandsend and site 3, background levels (L_{A90})were significantly lower than at the other sites, whereas site 4 was somewhat closer to the shore, and thus to the PWC operating area, than were sites 5 and 6, and has a higher assessment level than either. The highest assessment level, 13.6 obtained at Sandsend, would tend to correlate to the known degree of annoyance in this area, although few formal complaints have been received. In BS4142:1990, an assessment level >10 indicates a strong likelihood of complaints arising. Given the limited number of actual complaints, it is not possible at this stage to fully assess the value of single band rating in this context.

Table 8. Assessment of PWC to BS4142:1990

Site	4	5	6	Sandsend
Specific Noise Measurement (L_{Aeq})	60.7	56.3	58.8	58.8
Specific Noise Level	59.7	54.3	56.8	58.8
Tonal Correction	0	0	0	0
Rating Level (L_R)	59.7	54.3	56.8	58.8
Background Level (L_{A90})	51.3	50.6	54.5	45.2
Assessment Level (L_R - L_{A90})	8.4	3.7	2.3	13.6
D_{250}	0.8	6.3	nr	nr
D_{500}	4.2	5.8	nr	nr

nr = no result

Since the main source of the tonal component is engine exhaust noise, it may be appropriate to seek absolute limits for this in these types of craft. Although no recommendation of a suitable level can be made at present, such a limit should include reference both to the tonal content and to broad band noise.

A further point to note is that the values for D_{250} and D_{500} for PWC do not correlate to the octave band spectra in Figure 3, which suggests that additional investigation is required in this area.

6. NOISE CONTROL

6.1 Jet-Boats

Individual craft can be readily identified and noise levels fairly easily monitored, since there are usually times when only one boat will be operating close enough to be audible above background. Enforcement of any requirements should also be relatively straightforward - the nuisance provisions of s80 of the Environmental Protection Act 1990 can be applied to vessels of all sizes, and these craft also usually require licensing by harbour authorities.

As can be seen from Table 3, one of the craft operating from Scarborough was noticeably quieter than the other two; this craft was newer, with a smaller engine, but still carried the same passenger load. Therefore, this would suggest that there are possibilities for noise control measures in the design and construction of such craft.

6.2 Personal Watercraft

The situation for these is much more complex than that for Jet-Boats. Apart from areas with very low background noise levels, it would seem that it is more the manner in which PWC are used than their basic noise level that causes most of the measurable problems (6). Also there is a cumulative effect, making it much harder to assign noise problems to any one craft, and added to this the problems of identifying individual craft and enforcing any requirements without an effective registration scheme. There was a registration scheme in place at the time of this study, but it was not enforced - none of the PWC observed carried any form of visible identification. This problem also applies to the simplest expedient, which is to require all PWC to operate more than e.g. 400m offshore (except for launching and landing) - how can craft which infringe this limit be positively identified?

6. CONCLUSION

Noise levels from PWC and Jet-Boats were measured, along with octave band frequency spectra showing the tonal nature of the sound, particularly from Jet-Boats. The principal reason for noise levels being above background in most circumstances arises from that tonal nature. Some possibilities for controlling noise levels

from both types of craft have been suggested but the difficulties facing enforcement on PWC are also recognised. However, further work is necessary to build up a database of complaints which can then be correlated to the various rating methods, so as to suggest a suitable system for consistent enforcement.

7. REFERENCES

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