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Sound generated by the oil/gas drilling rig in the Bay of Fundy

by

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Introduction

Drilling for oil in the oceans is becoming more frequent. The effect of this on fish is of concern to fishermen and biologists. One aspect of drilling that has received little attention is the noise generated at drilling sites, and its effect on fish movements, distribution and behaviour. The oil industry is aware of the concern of fishermen and has presented the view that fish in the Gulf of Mexico congregate at drilling and production sites (Brashear 1972). Noise could be one of the stimuli that leads to such congregations by attracting fish to the sites from long ranges. It is well known, however, that noise frightens certain species, especially pelagic species such as herring (Schubert 1950; Schärfe 1951). Herring is one of the major fisheries in the Bay of Fundy. Noise generated at a drilling site in this area may be of considerable interest to the fishery.

Recording

Underwater noise was recorded at a drilling site (Chinampas 0-37) in the Bay of Fundy. The site was located about 5 mi (9 km) east of the Wolves Islands at 44°56'53"N and 66°35' 17"W. The drilling barge was the *Sedco J*. It is a semi-submersible marine drilling unit constructed in a triangular plan form, 343 ft (105 m) long, 380 ft (116 m) wide with an overall height of 325 ft (99 m). The elevated deck at 146 ft (44 m) is stabilized by three vertical 35-ft (11-m) diameter caissons, one on each corner, under each of which is an independent footing structure 80 ft (24 m) in diameter. The centres of these footings form an equilateral triangle, 280 ft (85 m) along each side (*Sedco J*. Information Book). The unit was anchored in 208 ft (63 m) of water at mean low water depth. It was under contract to a Mobil-Gulf consortium.

Normal procedure is for a ship to stand by near the drilling site at all times. During the noise recordings the ship was the *Janie 'B'*. She is 185 ft (56 m) long, has twin variable pitch screws, and is powered by 5,280 horsepower. Her engine and screws were idling during most of the recording. Occasionally she added power to change position.

Recordings were made from the R. V. *Pandalus II*, a 50-ft (15-m) wooden stern trawler. She was tied to anchor buoy No. 3 of the drilling barge. The buoy was about 1,900 ft (580 m) off the starboard bow of the drilling barge. Recordings were made with the hydrophone below the *Pandalus* on the sea floor. All machinery on the *Pandalus* was shut off during the recording.

Recording was done on April 25, 1975, between about 10:00 and 11:30 a.m. Recording could be done only during the period of slack tide current because at other times the current caused the hydrophone cable to strum. The wind during the recording was calm; there were swells of about 4 ft (1.2 m) height.

The recording system consisted of a hydrophone, pre-amplifier, cable system (Clevite Corp.), a calibrated amplifier (Eastech Industries Ltd.) and an FM recorder reproducer (lockheed 417). The frequency response of the system was ±3 db from 3 Hz to 1,250 Hz. The sensitivity of the system was -35 dbv re 1 μbar.

Noise was recorded for two types of operation on the drilling barge. The first was an operation called 'tripping', during which they pull the drill pipe out of the hole, change drill bits and lower the pipe again. This is normally done after every 24-30 h of drilling. The time it takes depends on the depth of the hole. The second operation for which noise was recorded was the drilling. The depth of drilling was about 8,000 ft (2,440 m).

Analysis

The recordings were analysed in 24 third-octave frequency bands with centre frequencies from 3.15-630 Hz by a real-time spectrum analyser (Hewlett Packard 8054-A). The recordings were played back through the analyser. The drilling noise and 'tripping' noise spectra were each sampled ten times. During 'tripping' noise analysis, it was noted that there was a more or less constant noise level, but that every 2 or 3 min the noise level increased. This 'high level tripping noise" spectrum was sampled five times. During drilling noise analysis, it was noted that the noise changed whenever the *Janie 'B'* changed position. The *Janie 'B'* noise spectrum was sampled five times. The level of the spectrum samples from the analyser was converted from db re μvolt band level at 1,900 ft (580 m) from the source to db re μbar spectrum level (i.e. level in 1 Hz bandwidth) at 1 yd (.92 m) from the source. Inverse-square spreading was assumed (Urick 1967, p. 266).

Mean noise level spectra and their 95% confidence limits are shown in Table 1 and Fig. 1-4. Figures 1-4 also show the upper limit of prevailing ambient noise in the ocean (Wenz 1962).

Discussion

Hearing in fish is very sensitive. In gadoids, the sensitivity is limited by ambient noise levels in the sea (Buerkle 1968, 1969; Chapman 1973; Chapman and Hawkins 1973). Cod, for example, can detect noises that are about 10 db above ambient noise (Buerkle 1969). In herring the masking effect of ambient sea noise on hearing has not been reported. Enger (1967), however, reported a tentative audiogram for herring that shows a uniformly low threshold of -20 to -25 db re μbar for frequencies of 30-1200 Hz. This threshold is below the upper limit of ambient noise as described by Wenz (1962). If herring have a discrimination capacity similar to that of cod, they should be able to detect noises that are about 10 db above ambient noise. Figures 1-4 show that noises at the drilling site range from 73-83 db above the upper limit of ambient noise. By assuming inverse-square spreading losses, the ranges at which these noise levels could be detected can be calculated. Table 2 shows the detection range of the different noises when ambient sea noise is the prevailing maximum (Wenz 1962). These ranges apply when conditions for detection are most adverse.

When ambient sea noise is at lower levels, the detection range of course increases. An ambient sea noise level of -40 db, for example, is not uncommon (Piggott 1964; Wenz 1962). Drill rig detection ranges in -40 db ambient noise are shown in Table 3.

Detection ranges for noise produced at this drilling site are appreciable. Whether herring (or fish in general) change their behaviour to the detriment of fishermen is of course the real issue. Experiments to determine this would be costly and time consuming. They might become necessary if oil drilling operations along migration routes become extensive.

Acknowledgments

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Table 1. Mean levels and 95% confidence limits (db re 1 μbar) of four types of noise at an offshore oil drilling site (n = number of measurements).

Frequency (Hz)	Drilling n = 10			Tripping n = 10			High level tripping n = 5			*Janie 'B'* n = 5		
	-95%	mean	+95%	-95%	mean	+95%	-95%	mean	+95%	-95%	mean	+95%
3.15	48.4	52.2	56.0	51.6	55.9	60.2	43.1	52.8	62.5	63.5	68.4	73.3
4	43.7	45.7	47.7	48.6	52.7	56.8	44.6	52.0	59.4	52.0	56.6	61.2
5	45.9	48.0	50.1	47.4	49.4	51.4	48.2	51.6	55.0	55.0	59.0	63.0
6.3	40.9	43.5	56.1	43.4	46.0	48.6	45.8	50.6	55.4	43.3	50.2	57.1
8	41.1	43.7	56.3	41.7	42.7	43.7	42.9	46.2	49.5	39.8	44.2	48.6
10	40.2	43.3	56.4	41.3	42.7	44.1	41.7	45.6	49.5	41.9	44.8	47.7
12.5	49.7	51.3	52.9	45.6	46.6	47.6	55.6	49.8	54.0	51.0	51.6	52.2
16	61.9	62.4	62.9	56.6	57.6	58.6	56.4	58.6	60.8	61.8	63.6	65.4
20	46.5	48.9	51.3	45.7	47.4	49.1	46.8	51.0	55.2	44.6	48.2	51.8
25	46.0	48.0	50.0	48.5	49.2	49.9	48.8	55.0	61.2	51.9	54.0	56.1
31.5	51.6	52.9	54.0	53.4	54.6	55.8	52.6	56.6	60.6	52.0	55.6	59.2
40	51.3	52.7	54.1	55.6	56.7	57.8	56.4	59.2	62.0	52.6	58.8	65.0
50	54.3	55.9	57.5	57.0	57.6	58.2	57.4	61.6	65.8	56.0	59.6	63.2
63	56.6	57.6	58.6	59.5	59.9	60.3	59.6	64.2	68.8	57.0	60.4	63.8
80	53.5	54.1	54.7	53.3	54.6	55.9	58.4	62.8	67.2	52.8	57.2	61.6
100	52.7	54.0	55.3	58.8	59.5	60.2	61.0	65.2	69.5	56.6	58.8	61.0

Table 1. cont'd.

Frequency	Drilling			Tripping			High level tripping			*Janie 'B'*		
	n = 10			n = 10			n = 5			n = 5		
(Hz)	-95%	mean	+95%	-95%	mean	+95%	-95%	mean	+95%	-95%	mean	+95%
125	57.6	58.6	59.6	55.9	66.8	57.7	59.1	63.8	68.5	56.1	58.4	60.7
160	53.1	53.9	54.7	55.6	66.9	58.2	61.6	66.8	72.0	53.6	56.8	60.0
200	55.5	56.6	57.7	66.1	57.3	58.5	62.2	68.0	73.8	56.5	57.4	58.3
250	50.5	51.4	52.3	53.6	54.1	54.6	56.1	61.2	66.3	51.9	56.8	61.7
315	48.6	49.6	50.6	61.6	62.1	62.6	53.5	57.4	61.3	49.5	53.4	57.3
400	48.2	49.4	50.6	60.8	61.2	61.6	52.5	57.2	61.9	48.0	52.2	56.4
500	45.9	46.9	47.9	60.6	61.1	61.6	52.2	56.4	60.6	47.4	51.8	56.2
630	42.9	44.0	55.1	48.5	48.9	49.3	48.7	53.6	58.5	45.0	48.4	51.8

Table 2. Detection range of noises at an oil drilling site when ambient noise level is the upper prevailing ambient noise level.

Noise	Noise level db re 1 μbar	Ambient noise db re 1 μbar	Detection Range miles	km
Drilling	59	-14	.7	1.3
Tripping	62	-18	1.6	3.0
High level tripping	68	-15	2.2	4.1
Janie 'B'	58	-15	.7	1.3

Table 3. Detection range of noises at an oil drilling site when ambient noise level is -40 db re 1 μbar.

Noise	Noise level db re 1 μbar	Detection Range miles	km
Drilling	59	14	26
Tripping	62	20	37
High level tripping	68	40	74
Janie 'B'	58	13	23

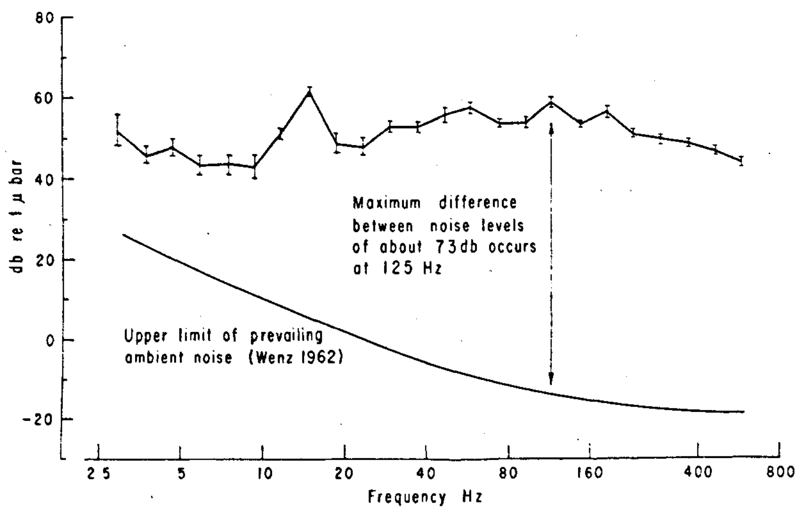

Figure 1. Drilling noise, average of 10 spectra, and 95% confidence limits.

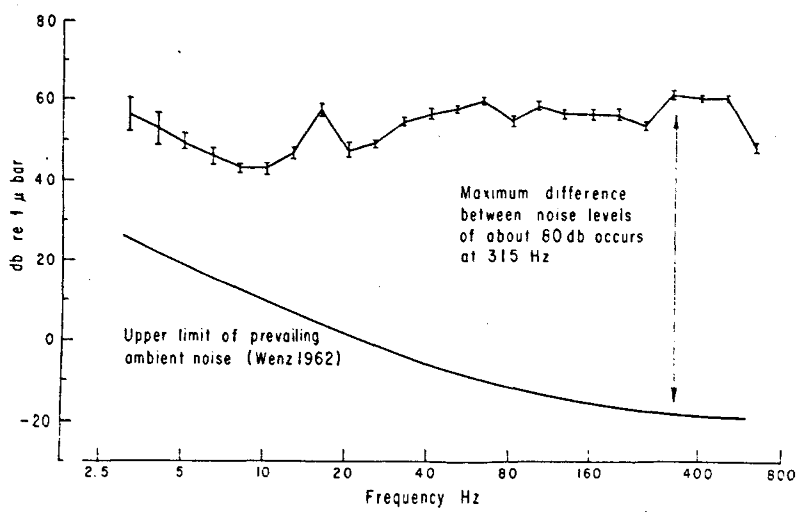

Figure 2. Tripping noise, average of 10 spectra, and 95% confidence limits.

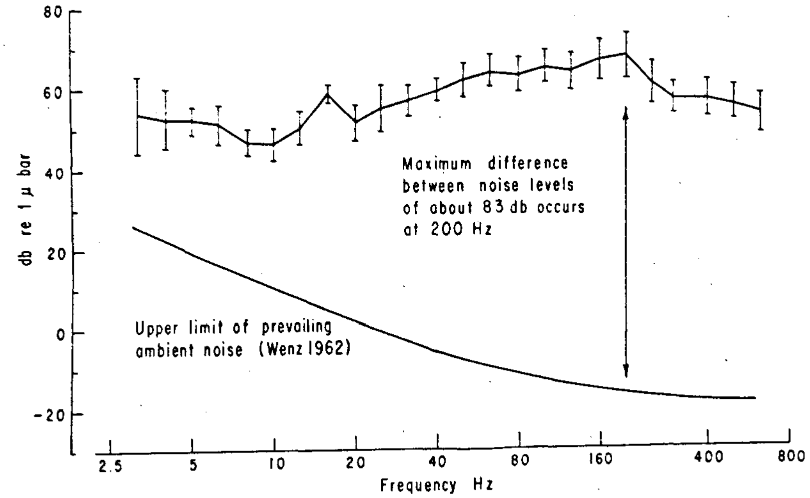

Figure 3. High level tripping noise, average of 5 spectra, and 95% confidence limits.

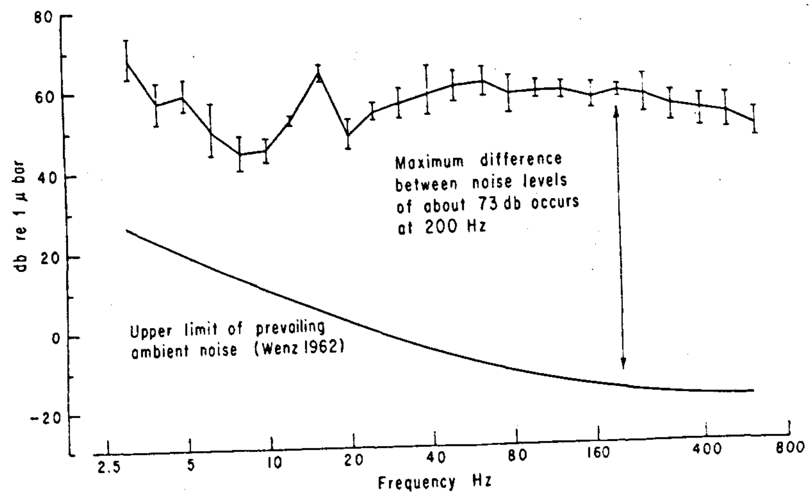

Figure 4. *Janie 'B'* noise, average of 5 spectra, and 95% confidence limits.