The Occurrence of Oily Pilchards in New South Wales Waters

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Summary

Efforts were made to check a hypothesis that pilchards are abundant below the surface and sufficiently fat to be profitably reduced into oil and fish meal in the summer months on the coast of New South Wales. Results obtained in January 1954 in the Port Stephens-Newcastle area were highly satisfactory. Although shoals were not seen at the surface they were readily detected in abundance by echosounding, and all samples taken by drift net consisted of fat fish. Oil content ranged from 11 to 17 per cent. by weight of raw fish (compared with 5 per cent. or less in the same region in winter), which would permit profitable reduction if sufficiently large and regular catches could be made.

I. INTRODUCTION

Occurrences of the unexploited pilchard, *Sardinops neopilchardus* (Steindachner), in New South Wales coastal waters have been described by Blackburn (1941, 1949, 1950) and Blackburn and Tubb (1950). Adult or near-adult pilchards, 5½-9 inches in total length, are common in shoals at the surface of the sea from about April to September, being then mostly in spawning or spent condition, lean, and of very low oil content. Immature pilchards, 3-5½ inches in total length, occur in similar shoals from about October to December, and their oil content likewise is low. Observed oil contents by weight in random samples of raw fish of these two seasonal groups have ranged from 0.3 to 5.1 per cent. (Blackburn 1950, Table 4). On the other hand, some shoals have been seen in summer, mainly in January, and a few samples taken in January 1940 consisted of plump adult pilchards with gonads in resting or early filling stages; oil content was determined for only one of these samples and was high, 14.0 per cent. by weight of raw fish.

These results, together with more extensive observations on overseas species of pilchards by other workers (e.g. Dill (1921), Clark (1928), Wagner and Ramalho (1936), and Hickling (1945), who all found the highest oil contents in adult pilchards between spawning seasons), suggested that oily pilchards could be expected to occur in the summer months, and then only, in New South Wales waters. Section II summarizes observations made in January 1954 to check this hypothesis.

II. OBSERVATIONS AT SEA

The F.R.V. *Derwent Hunter* reached Cape Howe, the southernmost point of the New South Wales coast, on January 3, 1954 and steamed

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north along the coast to reach Sydney on January 7. She left there on January 10 to look for pilchards further north in waters off Port Stephens, where F.R.V. *Warreen* had seen and caught pilchards in January of 1940, 1941, and 1942, and returned to Sydney on January 22. The ship left Sydney again on January 30 and followed the coast south to Twofold Bay. She then left the waters of New South Wales on January 31. Except for a few shoals which were detected by echosounding off Watamoli Head on January 30, there were no signs of pilchards south of Sydney, but such signs were plentiful from Sydney northwards.

The echosounder on the *Derwent Hunter* is a Kelvin Hughes MS24E operating on 14 kc/s giving 33⅓ soundings per minute on a basic scale of 160 fathoms. With this basic scale it is possible to scan at once the whole of any column of water over which the ship may pass anywhere on the continental shelf. The depth scale is too small for accuracy in depths shallower than five fathoms. In depths over five fathoms the definition of fish shoals on the echogram was very good. Fish were detected by this means, and this means only, on the passages between Sydney and Port Stephens.

Two traverses to the edge of the continental shelf and back to the coast, off Port Stephens and Broken Bay respectively, revealed no echo-traces of fish outside the 60-fathom line, so subsequent work was confined to shallower waters. At no time were any fish seen at the surface; a shoal of fish, assumed to be pilchards, was on one occasion seen passing under the ship while she was stationary, but this had first been detected by the echosounder. No shoals were detected by their luminescence at night, although most of those seen in the January surveys of 1940, 1941, and 1942 in the same area were found in this way; however, the moon was full on January 19, 1954, and the moonlight could have concealed the shoals.

The methods available on the *Derwent Hunter* for catching pilchards, which were required only in small samples for determination of oil content, were drift netting, explosives, and submarine lights. Drift nets were found to be most suitable for the purpose. Explosives cannot safely be used at night and were, in fact, used only once in this work; on that occasion birds took most of the fish which came to the surface. The submarine lamp was used, unsuccessfully, on only one occasion.

The drift nets used were of 1¼-in. mesh, 18 fathoms long by 9 fathoms deep; 20 were carried but the greatest number shot at any one time was 14, and most shots were made with only one net hauled every two hours.

Drift netting was begun on the night of January 13-14 off Broughton Island in a depth of 45 fathoms. A school of fish at five fathoms was selected with the echosounder and the nets were shot as nearly as could be judged into the thickest part of the school. During the set the ship drifted close to the net with the echosounder running continuously. What was assumed to be the original school of fish stayed in the vicinity of the net

until hauling was completed (Figs. 1 and 2). The nets were down for 4½ hours for a catch of almost a ton of pilchards, with a few mackerel, *Pneumatophorus australasicus* (Cuvier & Valenciennes), scattered at random throughout the haul. Most of the fish were in the bottom three

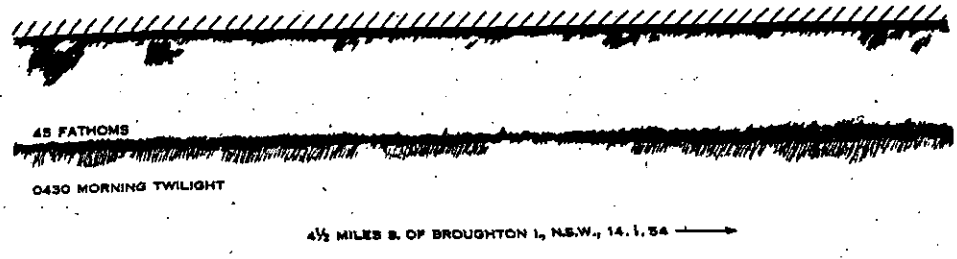

Fig. 1.—Echogram from Kelvin Hughes MS24E echosounder showing portion of a haul of drift nets in early morning daylight in the Port Stephens area. Note time scale (one stroke per min) above. The mid-water traces are pilchard shoals; the ship was stationary and the depth 45 fathoms.

fathoms of the net. The pilchards were very plump. This catch was a far larger sample than was actually needed and it was decided then that smaller nets hauled at frequent intervals would serve the purpose equally well.

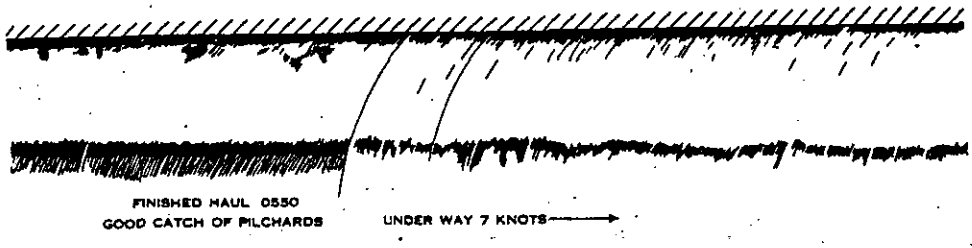

Fig. 2.—Continuation of the echogram of Figure 1, showing the end of the haul and subsequent steaming away at 7 knots; with corresponding change, from broad irregular to narrow plume-like marks, in the traces of pilchard shoals.

Subsequent night shots were made on echotraces of the same type, and all shots except one secured pilchards. A good deal of echosounding was done in the Port Stephens–Newcastle area, not as a systematic survey but in search for suitable places to set the nets. Mackerel were taken sparingly in most of the hauls and it is possible that some of the echosounder traces were due to their presence. The traces were of two distinct types: a dark firm mark which varied considerably in shape and depth (Figs. 1-4) and a lighter, more diffuse mark of the "layer" type (Figs. 3 and 4). From the drift net results it may reasonably be assumed that the dark firm marks were caused by pilchards; the best haul was made on traces of this nature. The light marks could have been caused by mackerel, too small to be taken by 1¼-in. mesh, but could also have been

caused by other species of small fish or even by plankton. It is also possible that the mackerel are few in number, mixed at random amongst the pilchards, and indistinguishable from them as a separate echogram trace.

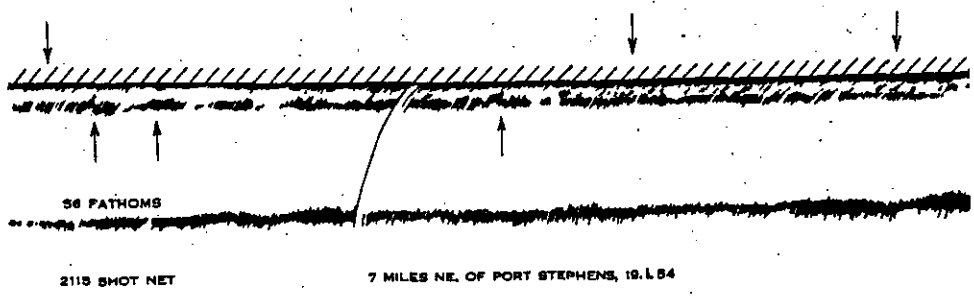

Fig. 3.—Echogram from Kelvin Hughes MS24E echosounder, showing portion of a haul of drift nets by night in the Port Stephens area. Note time scale (one stroke per min) above. The darker, firmer mid-water traces are pilchard shoals (see upward-pointing arrowheads) and the lighter, more diffuse, somewhat layered traces (see downward-pointing arrowheads) are possibly shoals of mackerel; the ship was stationary and the depth 56 fathoms.

Fish shoals of similar size cause larger echogram traces to be recorded when the observing ship is stationary or moving slowly than when she is moving fast. Figures 1 and 2, which record observations made when the ship was standing by and hauling drift nets and later when she was

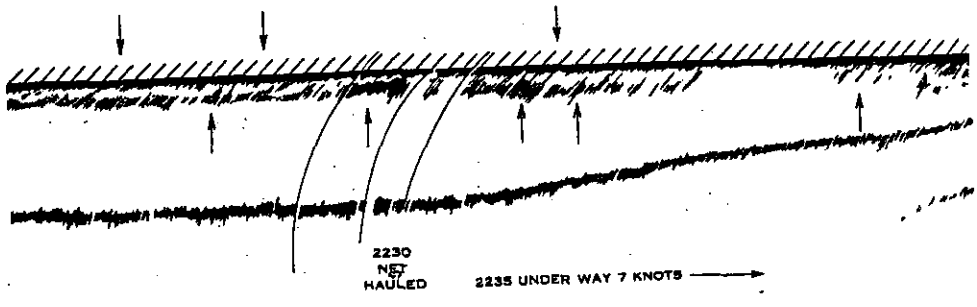

Fig. 4.—Continuation of the echogram of Figure 3, showing the end of the haul and subsequent steaming away at 7 knots; with corresponding change in the traces of pilchard shoals, as in Figure 2.

steaming off at 7 knots, show this quite clearly. In the first period the fish traces are mostly wide, one of them persisting for three minutes, and in the second period they are all narrow, of the "plume" type, mostly represented by three or four strokes of the stylus. Other plume-like traces

recorded off Port Stephens at a speed of 7 knots were about the same size, as shown for example on the right-hand side of Figure 4. All these are considered to represent pilchard shoals. It would be difficult to give more than a very rough estimate of the size of such shoals. A ship steaming at 7 knots would cover about 42 feet in the time between the formation of the first and last of three stylus marks made by the MS24E echosounder, and the breadth of the pilchard shoals could be of this order; the height of many of the shoals is probably about the same, as indicated in Figures 2 and 4.

Figures 2 and 4 give an idea of the frequency with which such shoals were encountered by the *Derwent Hunter* when steaming at 7 knots in the more productive parts of the Port Stephens area, both by day (Fig. 2) and by night (Fig. 4). The greatest number of shoals recorded on a long traverse was 68, on a single run of 22 miles from Port Stephens to Newcastle, in the daytime. Shoals were more often encountered between Newcastle and Broughton Island, the most northerly point reached by the ship on this cruise, than between Newcastle and Sydney, but more time was spent in the former area. In the latter area shoals recorded by three or more stylus marks were found in the following numbers: 38 between Newcastle and Norah Head, 2 off Broken Bay, and 6 off Sydney Heads; but a more systematic search in those areas might have revealed many more. It may be said in general that pilchard shoals were plentiful within the 60-fathom line (i.e. up to 10 miles offshore) between Norah Head and Broughton Island, by both day and night. The shoals were generally lying in the upper 15 fathoms of water.

The F.R.V. *Warreen* in January 1940, 1941, and 1942 found pilchard shoals in waters north of Sydney, mainly off Port Stephens, on an average of one day in every three (Blackburn and Tubb 1950, Table 4); she did not employ echosounding. The *Derwent Hunter*, using an echosounder, found some shoals every day.

III. Laboratory Observations

The pilchards taken by drift nets in January 1954 were fairly uniform in size; almost all of the several hundreds which were measured ranged from 6¾ to 7½ inches in total length. Their gonads were small (stage II, see Blackburn 1950) and hard to see because of the mass of mesenterial fat in the body cavity. The mackerel were about the same size as the pilchards.

Water and oil contents were determined as percentages by weight of seven samples of about six whole pilchards each from different drift-net catches. Each sample was minced and a subsample taken; this was weighed, dried to constant weight, reweighed, powdered, and Soxhlet-extracted with petroleum ether. The results are shown in Table 1.

These results are of the same order as the single result of 14.0 per cent. of oil (67.0 per cent. of water) obtained previously from material of

similar size and gonad condition taken in January 1940 in this region. The oil contents are much higher and the water contents lower than in all samples taken in New South Wales waters in the autumn, winter, and spring months, which contained 5 per cent. or less of oil and 72 per cent. or more of water.

TABLE 1
WATER AND OIL CONTENTS OF PILCHARD SAMPLES

Sample No.	Water (%)	Oil (%)
1	63.0	14.8
2	64.4	12.0
3	60.7	17.3
4	63.3	13.7
5	64.4	11.3
6	62.6	15.3
7	64.3	12.8

The estimated yield of oil per ton of 2240 lb of these pilchards ranges from 27.5 imp. gal. (sample 5) to 42.1 imp. gal. (sample 3), and averages 33.9 imp. gal.; these estimates are based on the assumption that all the available oil could be recovered.

IV. Economic Significance of Observations

These observations indicate that good quantities of pilchards, sufficiently oily to permit profitable reduction to oil and fish meal if other circumstances are favourable, are available in the Port Stephens–Newcastle area in the month of January. This is the first time (ignoring the single observation made in January 1940 and an isolated observation on Tasmanian sprats) that any such occurrence of any kind of fish has been identified in Australian waters. For a fish-reduction industry to develop, several circumstances must be favourable. Some of the more important are discussed below.

(*a*) *Oil Content of Fish*

Reference to the scattered literature and unpublished available information indicates that profitable reduction industries can operate on fish whose average oil content is 8 per cent. or more of the raw weight; the average seldom exceeds 18 per cent. (pilchard, herring, menhaden, maasbanker or jack-mackerel, etc., in United States of America, South Africa, Norway, etc.). The New South Wales pilchards described above, with an average oil content of 13.9 per cent., therefore leave little to be desired as far as quality is concerned.

(*b*) *Rate of Supply to Reduction Plants*

A substantial and regular supply of fish must be forthcoming to justify the outlay in buildings, machinery, and labour. In overseas reduction plants it generally averages over 100 long tons per day of the fishing season (see Section IV(*c*) for length of season), but operations have sometimes been profitable with a daily average intake as low as 15 tons when other circumstances were very favourable.

There is little doubt in the minds of the authors that catches of at least five tons of pilchards per boat per day could have been made by skilled fishermen with some type of pelagic seine (lampara, purse-lampara, purse-seine) or pelagic trawl in the area and at the time of the survey described above, using echosounders to detect the shoals. Much would depend on the amount of fish in the shoals, which could be determined only by fishing experiments. Fishing for pilchards in Australian waters has been persistently carried out only on the south coast of Western Australia, where the greatest single catch was 7½ tons (purse-seine, May 1952, in the daytime) and the average catch much less; but most of this fishing was done in the daytime, when pilchards tend to be wild, and the details of echogram traces given by Rapson (1953) suggest that most of the Western Australian shoals are smaller than those found by the *Derwent Hunter*. The largest recorded single catch of pilchards in any part of Australia was 9 tons, by purse-lampara in Port Phillip Bay, Victoria (June 1950, with attracting-lights at night; see Blackburn and Rayner 1951). If shoals such as those seen in January 1954 averaged five tons or more in weight there is little doubt that a skilled crew with suitable boat, fishing gear, and echosounder could deliver more than that amount on average per day of fishing season, as more than one set of gear can be made per day when conditions are suitable; if the shoals were smaller the gear would have to be set more often, but deliveries per boat probably could still average at least five tons a day.

(*c*) *Length of Season*

In established reduction industries this is generally three to five months and is rarely as low as two.

Nothing is known of pilchard occurrences in waters north of Sydney in the months of October, November, December, February, and March, but very little searching has been done in those months (Blackburn and Tubb 1950, Table 2) and none of it with the aid of echosounders. South of Sydney (Blackburn and Tubb 1950, Tables 7 and 11) shoals have been found in all these months, but most of those sampled before January consisted of small lean fish, and hardly any were sampled in January, February, and March. Shoals of larger (6-7 in.) pilchards were abundant in Jervis Bay in December 1944 and the few specimens obtained were described as "very fat". In late November and early December 1946 shoals

of similar-sized fish were seen in the same locality, and the specimens observed had conspicuous mesenterial fat. It is therefore possible that pilchards of the same quality (high oil content) as those taken in January are available in the same good quantity in other months from November to March (although probably not for all that period), not only in the Port Stephens area but on other parts of the New South Wales coast.

(*d*) *Price*

For reduction purposes overseas, the price paid to the catcher is always low. In 1950 it was about £4.10s. per long ton in South Africa, £7.10s. in Norway, and £10.10s. in England (all prices in sterling). Such low prices are unknown in the Australian fisheries, although they might be accepted if the catchers knew they could catch several tons per boat per day for one or two sets of gear, and that the buyers would unhesitatingly accept them.

The possibilities for canning these pilchards should not be overlooked, although reduction is usually more profitable. Generally speaking, fish of this kind for canning purposes need not be as oily as those needed for reduction, rate of supply need not be as great, and price need not be as low. Many established overseas reduction plants originally began as annexes to canneries, which doubtless helped to accustom the fishermen gradually to the more exacting requirements of the reduction industry. Downie (1949) and Blackburn and Rayner (1951) described a method of making small but regular catches of pilchards, more suited to cannery than reduction plant requirements, with small boat and lampara net in King George Sound, Western Australia.

It is worth noting that in the southern waters of Western Australia, where the pilchard spawning season, like that in New South Wales, is in late autumn and winter, there may likewise be a summer period of fatness. Percentage oil contents by weight of whole adult fish in samples taken in 1951 fell from 7.6 (average of 5 samples) in late March and early April to 6.0 (average of 6 samples) in late April, 5.2 (average of 4 samples) in May, and 1.2 (average of 2 samples) in June. Summer pilchards might be more oily than any of these. Pilchards found in February 1946 at Hopetoun, in stomachs of Australian salmon, were plump and rich in mesenterial fat. Few shoals have been seen in summer in that area, but little search has been made for them (Blackburn 1950). In Victorian waters the season for fat pilchards, if there is one, is probably in winter, as the fish spawn in summer and are then poor in oil; but little is known of winter occurrences. The position in South Australian waters is likely to be the same as in Victoria (Blackburn 1950).

V. Acknowledgments

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VI. References

Blackburn, M. (1941).—The economic biology of some Australian clupeoid fish. Coun. Sci. Industr. Res. Aust. Bull. No. 138.

Blackburn, M. (1949).—Age, rate of growth, and general life-history of the Australian pilchard (*Sardinops neopilchardus*) in New South Wales waters. C.S.I.R.O. Aust. Bull. No. 242.

Blackburn, M. (1950).—Studies on the age, growth, and life history of the pilchard, *Sardinops neopilchardus* (Steindachner), in southern and western Australia. *Aust. J. Mar. Freshw. Res.* 1: 221-58.

Blackburn, M., and Rayner, G. W. (1951).—Pelagic fishing experiments in Australian waters. C.S.I.R.O. Aust. Div. Fish. Tech. Pap. No. 1.

Blackburn, M., and Tubb, J. A. (1950).—Measures of abundance of certain pelagic fish in some south-eastern Australian waters. C.S.I.R.O. Aust. Bull. No. 251.

Clark, F. N. (1928).—The weight-length relationship of the California sardine (*Sardinia caerulea*) at San Pedro. Fish. Bull. Sacramento No. 12.

Dill, D. B. (1921).—A chemical study of the California sardine (*Sardinia caerulea*). *J. Biol. Chem.* 48: 93-103.

Downie, R. (1949).—How to use a lampara net. *Fish. News Lett. Aust.* 8 (7): 16.

Hickling, C. F. (1945).—The seasonal cycle in the Cornish pilchard, *Sardina pilchardus* Walbaum. *J. Mar. Biol. Ass. U.K.* 26: 115-38.

Rapson, A. M. (1953).—Pilchard shoals in south-west Australia. *Aust. J. Mar. Freshw. Res.* 4: 234-50.

Wagner, D., and Ramalho, A. (1936).—Estudos sôbre as conservas des sardinha portuguesas. Rev. Ass. Engen. Civ. Portug. No. 732 (also as Trav. Sta. Biol. Marit. Lisbonne No. 37).