# New Zealand Fish Oils

By F. B. Shorland

ALTHOUGH the fish life of New Zealand waters offers many interesting and unusual features, the study of the fish oils has, until quite recently, been practically neglected. The earlier work included an analysis of sting-ray liver oil by Donovan[1] and more extensive researches on the food values of New Zealand fish initiated by Malcolm in 1920. During the course of these investigations the oil content of the flesh from various fish was examined[2,3] and the fats of red cod (*Physiculus bachus*) in relation to its food were studied. The fat content was less in winter than in summer, indicating a depletion of reserves during the scanty winter feeding[4]. Although tarakihi (*Dactylopagrus macropterus*) flesh was found[5] to contain appreciable amounts of vitamin A, none could be detected either in the ether extract of this flesh or in the ether extracts from the flesh and liver of red cod[6].

Denz and Shorland[7] discovered in 1934 that the larger edible fish of Cook Strait, including ling, English hake and in particular groper and bass, yielded liver oils of much higher vitamin A potency than had generally been recorded in the case of North Sea fish. In contrast with the fish which had hitherto been examined by other investigators, the vitamin A content of ling liver was not found to exhibit any marked seasonal variation[8].

Lately, New Zealand freshwater eels, of which there are two species, *Anguilla aucklandii* and *A. australis*, have received considerable attention. It was found that the body oil (comprising so much as 20 per cent of the total weight of the fish) had a vitamin A potency approaching that of cod liver oil, while the traces of oil in the liver were extremely rich in this vitamin[7,9]. McIntosh and Shorland[9] established a general similarity between the composition of the component fatty acids of *A. aucklandii* and that of typical freshwater fats of the northern hemisphere analysed by Lovern[10], thus confirming the difference between the marine and freshwater types of fat. An examination of the $C_{18}$ unsaturated acids showed the presence of oleic and stearidonic acids. Neither linoleic nor linolenic acid could, however, be detected[9]. Edisbury, Lovern and Morton[11] showed that the ratio of non-liver vitamin A to liver vitamin A of *A. aucklandii* tended to increase with age, while the increased vitamin content of the body oil in the older fish was correlated with the oil content of the tissue.

CHARACTERISTICS OF SOME NEW ZEALAND AND OTHER FISH LIVER OILS

| | Species | Body weight | Liver weight | % Oil | Iodine value | Saponification value | % Unsap. matter | % Vitamin A ($\frac{E^{1\%}_{1cm}\ 328\ m\mu}{16}$) |
|---|---|---|---|---|---|---|---|---|
| New Zealand | Ling (*Genypterus blacodes*) | 20 lb. | 1 lb. 7 oz. | 35 | 137–153 | 183–189 | 2–4 | 0·6–0·7 (usually) |
| | English hake (*Merluccius gayi*) | 18 lb. | 1 lb. 6 oz. | 35 | 132–143 | 185–187 | 2–4 | 0·3–0·8 |
| | Groper (*Polyprion oxygeneios*) | 10 lb. | 6 oz. | 5–10 (usually) | 82–122 | 176–197 | 3–15 | 0·5–5·0 |
| | Bass (*Polyprion americanus*) | somewhat heavier than groper | 8 oz. | 5–10 | 78–131 | 175–191 | 4–16 | 1·0–4·5 |
| North Sea | Cod* (*Gadus morrhua*) | 17 lb. | 14 oz. | 60–70 | 140–180 | 180–190 | 1 | 0·01–0·05 |
| | Halibut* (*Hippoglossus vulgaris*) | 60 lb. | 1 lb. | 20 | 111–171 | 150–175 | 8–22 | 0·2–10 (usually 1–1·5) |
| | Hake[13] (*Merluccius merluccius*) | — | — | — | 149–159 | 184–186 | 0·9–1·7 | similar to cod liver oil |
| Chilean | [14] (*Merluccius gayi*) | — | — | — | 185 | 176 | 2·0 | similar to cod liver oil |
| | [14] *Genypterus blacodes* and *G. chilensis* | — | — | — | 169 | 188 | 0·2 | somewhat stronger than cod liver oil. |

* Typical values from the results of various investigators.

In many instances, fish oils of high vitamin A potency are also good sources of vitamin D. Cunningham[12] reported vitamin D values of 2,250 and 500 for groper and ling liver oils respectively, as compared with 100 international units per gram for good cod liver oil. Skate (*Raja nasuta*) liver oil and the body oil of freshwater eel gave, respectively, the lower values of 15 and 47.

The deep-sea fishing industry of Cook Strait, which provides the commercial liver oils, is rather limited on account of the small area of the banks. About 8,000 cwt. of groper and 2,000–4,000 cwt. of ling are caught annually, together with smaller quantities of English hake and bass. In other large centres such as Auckland, smaller fish, including snapper, tarakihi and flounders, predominate, and although some of these yield a small proportion of vitamin-rich oil the livers invariably weigh less than 2 oz.

Cook Strait elasmobranch liver oils are not rich in vitamin A. Skate (*Raja nasuta*) liver oil for example, is less potent than cod liver oil. Oils from individual livers are sometimes exceptionally potent. That from a bass contained 10 per cent vitamin A, while a swordfish from North Auckland yielded a liver oil with some 14 per cent of this vitamin.

An examination of the properties of the liver oils given in the accompanying table for the same or similar species inhabiting different waters suggests that the composition and vitamin A content are sometimes determined more by environment than by biological considerations of species.

Observations on the properties of groper liver oils, which will be published in detail elsewhere, show that the winter oils, especially during July and August, approach the upper limit given in the table as regards vitamin A content, iodine value, and percentage of unsaponifiable matter. During the intensive feeding of October and November, these values approach the lower limit and the livers become softer owing to the infiltration of fat, which in some instances increases the oil content to 20 per cent of the liver weight. The oil from *Sardinia neopilcharda*, a source of food at this time, gave no reaction for vitamin A. Seasonal changes in the properties of groper liver oils thus appear to be associated with alternate intensive feeding and relative starvation. The North Sea halibut affords an interesting contrast with groper in that the potency of the liver oil is lowest in winter but rises to a maximum during the seasonal increase of diatomaceous food in the spring[15]. Winter groper liver oil is exceptional in containing as much as 20 per cent phosphatide. An analysis of the component fatty acids of these oils is being made under the direction of Prof. T. P. Hilditch, of the University of Liverpool. Examination of other fat depots including the roe, head and stomach failed to reveal the presence of vitamin A except in the stomach oil.

Further work on ling liver oil at present in progress substantiates the lack of marked seasonal variation of vitamin A content or in yield of oil as determined by ether extraction. Of the total fat present in the fish, more than 96 per cent is concentrated in the liver, and during spawning less than 0·5 per cent of this fat is transferred to the roe. The ether extract from the ova gave no Carr-Price test, while that from the stomach showed a value of 800. Lack of seasonal variation in the vitamin A content during spawning seems to be explained by the fact that the production of ova requires an insignificant drain on the liver oil. Both cod and halibut appear to derive their vitamin-rich liver oils from food relatively deficient in this vitamin by a process of intensive storage[13,14] In these circumstances, it is not surprising to find that the livers from the older fish contain a higher concentration of vitamin A[15,17]. In the case of Cook Strait ling, however, the chief food is whiptail[8,18], which is rich in vitamin A (a specimen taken from a ling stomach, for example, yielded an oil giving a Carr-Price value of 75), so that relatively little storage is necessary to produce a vitamin-rich liver. In confirmation of this observation, the larger livers from the older fish have not been found to yield a more potent oil than the smaller livers.

Ling liver oil is distinguished from typical liver oils of the North Sea by the higher content of $C_{18}$ unsaturated acids (35–40 per cent as compared with 27–30 per cent) and the low proportions of palmitoleic acid (7–10 per cent as compared with 15–18 per cent). The ether extract from the roe contains about 56 per cent phosphatide. As in the case of animal fats, the phosphatide fraction is richer in $C_{20}$ and $C_{22}$ highly unsaturated acids than the glyceride fraction. The relative proportions of $C_{20}$ , $C_{22}$ acids in the liver, viscera, roe glyceride and roe phosphatide may be given approximately as 35, 45, 40 and 50 per cent respectively.

I wish to record my sincere appreciation and thanks to the directors of the British Drug Houses, Ltd., London, for generously placing their analytical laboratories at my disposal. Thanks are also due to Mr. T. T. Cocking of that laboratory for valuable advice, to Prof. T. P. Hilditch for his continued interest and to the Department of Scientific and Industrial Research, New Zealand, for a scholarship.

[1] Donovan, *Trans. N.Z. Inst.*, **52**, 29 (1920).
[2] Johnson, *ibid.*, **52**, 20 (1920).
[3] Johnson, *ibid.*, **53**, 472 (1921).
[4] Carter and Malcolm, *ibid.*, **56**, 647 (1926).
[5] Malcolm, *ibid.*, **57**, 879 (1926).
[6] Malcolm, *ibid.*, **56**, 650 (1926).
[7] Denz and Shorland, *N.Z. J. Sci. Tech.*, **15**, 327 (1934).
[8] Shorland, *ibid.*, **16**, 313 (1935).
[9] Shorland and McIntosh, *Biochem. J.*, **30**, 1775 (1936).
[10] Lovern, *ibid.*, **26**, 1978 (1932).
[11] Edisbury, Lovern and Morton, *ibid.*, **31**, 416 (1937).
[12] Cunningham, *N.Z. J. Sci. Tech.*, **17**, 563 (1935).
[13] Drummond and Hilditch, Empire Marketing Board Rep. No. 35 (1930).
[14] Pfister, *Pharm. Z.*, **81**, 933 (1936); *Chem. Abs.*, **30**, 7887 (1936).
[15] Lovern, Edisbury and Morton, *Biochem. J.*, **27**, 1461 (1933).
[16] Lovern and Sharp, *ibid.*, **27**, 1470 (1933).
[17] Macpherson, NATURE, **132**, 26 (1933).
[18] Phillipps, *Trans. N.Z. Inst.*, **56**, 525 (1926).