

ACTA ADRIATICA

INSTITUT ZA OCEANOGRFIJU I RIBARSTVO — SPLIT
FNR JUGOSLAVIJA

Vol. VIII. No. 13.

SOME ECOLOGICAL FACTORS CONDITIONING THE GROWTH OF THE LAMINARIACEAE AROUND SCOTLAND

NEKI EKOLOŠKI FAKTORI KOJI UTJEČU NA RASTENJE
LAMINARIJACEJA OKO ŠKOTSKE

Francis T. Walker



SPLIT 1958

ADULTS 1400-1700

ADULTS 1400-1700

ADULTS 1400-1700

SOME ECOLOGICAL FACTORS CONDITIONING THE GROWTH OF THE LAMINARIACEAE AROUND SCOTLAND

NEKI EKOLOŠKI FAKTORI KOJI UTJEČU NA RASTENJE LAMINARIJACEJA OKO ŠKOTSKE

Francis T. Walker

Institute of Seaweed Research, Edinburgh, Scotland

Submitted at the Symposium of Algologists, July 1957.

Institute of Oceanography and Fisheries, Split, Yugoslavia

Extensive sub-littoral surveys of the Laminariaceae growing around Scotland has shown the fresh weight and the area colonised decreases with increased depth of sea; that these two factors are related and that the decreases are exponential.

Seasonal variations are chiefly due to the winter storms removing plants from the seabed and the shedding of old laminae in the spring.

Perennial variations follow an eleven-year cycle in phase with the sun-spot cycle.

In 1944 it was decided to set up an organisation whose primary objectives were to survey the Laminarian resources of Scotland and the means of harvesting them; the former objective has been my concern.

Measurement of the Scottish marine coastline revealed a length of over 6,000 miles (10,000 km.), therefore, some means of eliminating unprofitable areas for surveys had to be found.

Chapman (1948) had shown that aerial photography could be used to map areas of laminarian growth.

It was therefore decided to collect data by detailed surveying from small motor fishing vessels, using calibrated spring grabs, submitting the data to continual statistical analysis and apply any found ecological law to areas of laminaria indicated by aerial photography.

By September 1945, exploratory tests were underway and trials initiated, the results of which were submitted for statistical analysis (Walker 1947). At this early stage, indications of an ecological law emerged, i.e.,

Fathom (1.85m.)	1	2	3	4	5	6	7	8	9
lb/sq.yd.	8.9	7.4	6.7	5.6	4.3	3.3	1.2	0.9	0.2
kg./m ²	4.8	4.0	3.6	3.0	2.3	1.8	0.6	0.5	0.1

An approximate straight-line relationship between depth and fresh weight of the Laminariaceae was found as follows:—

$$d = 10.2 - 1.15 f.$$

where d = density, fresh weight per unit area (lb./sq.yd.)

f = depth of quadrat (fathoms)

The first full scale detailed survey was carried out over 10 areas within Scapa Flow, Orkney, a group of islands off the north coast of the mainland of Scotland. The sampling was at fathom intervals along transects measured by range-finder. The combined results for the ten areas showed a straight-line relationship, similar to that above, namely, $d = 12.9 - 1.4 f$. It was found that the Laminariaceae worthy of record quantitatively were: *Laminaria cloustoni* (*L. hyperborea*), *L. digitata*, *L. saccharina* and *Saccorhiza bulbosa*. It was found that the nature of the substrata was related to the extent of the growth, i.e., with increasing rockiness of the substratum, the algal cover generally increased and also the dominance of *Laminaria cloustoni*, while with an increasing amount of sand, gravel or mud in the substrata of the seabed, the cover decreased and *Laminaria saccharina* became the dominant species. The cover and density (fresh weight/unit area) both decreased with increasing depth.

The second survey was carried out in the Bay of Firth, Orkney, over an area of 3,000 acres. The simple relationship between density and depth was not found in this area but one which included the cover, namely: $d/c = 3.90 + 0.20 f$, from 1–6 fathoms (L.W.M.O.S.T.).

This relationship (but with a negative sign) was subsequently found to hold in other extensive areas of Orkney, (Walker 1950), and further the level of the graph, $d/c = k - af$, was related to the rate of tidal stream operating during spring tides in the particular area. This relationship has held during the ten following years, for most of the other areas around Scotland. The values for k , against the tidal rate in the above formula, showed a different slope for areas, where *Laminaria cloustoni* dominated the flora, to those for areas, where *Laminaria saccharina* was the dominant species of the Laminariaceae, (Walker 1952).

The cumulative discovery of ecological laws governing the Laminariaceae enabled a preliminary assessment to be made in 1953 from aerial photographs covering the greater part of the Scottish coast, (Walker 1954). The result of this preliminary assessment was that over 5,300 miles of coastline representing 2 million acres, 10 million tons of Laminariaceae were growing (an average of 5 tons/acre or 12,500 kgm/hectare); 39 per cent of which occurred in quantity and concentration to be of economic value.

From 1946 to 1953, at all seasons, 59 detailed surveys, covering 80,000 acres had been completed. The combined data of the 59 surveys showed that the mean fresh weight per unit area of *Laminariaceae* in those quadrats which contained them at each fathom interval of depth, was proportional to the respective seaweed cover and that both fresh weight and cover decreased exponentially with increasing depth, (Walker 1954). This is not unexpected as the coefficient of extinction of light in water is also exponential.

During the later surveys plant weight and numbers were recorded and it was found that the decrease in algae density was more a result of a reduction in the number of plants per unit area rather than of the weight of individual plants.

Whether the above quantities have a permanency or not remained a question in 1951. It was decided therefore to complete a series of resurveys of selected areas *within one year* to record any significant seasonal variations. Three areas were chosen off the N.E., S.E. and S.W. of Scotland, where *Laminaria cloustoni* was known to be the dominant species. The general conclusion from these resurveys was that, within one year, the laminaria crop is fairly stable until the rough seas of the winter dislodge the plants from the sea-bed and until the plants shed their old laminae in the spring, (Walker and Richardson 1955).

This work was followed-up by further resurveys in the above three areas with the object of recording perennial changes.

Off the south-west, it was found that considerable loss of cover and density occurred from 1952 to 1953, both *Laminaria cloustoni* and *L. saccharina* decreased. Between 1953 and 1954, the cover showed a small gain while the density showed a small loss. Between 1954 and 1955 recolonisation was taking place.

Off the south-east, considerable loss in both cover and density occurred between 1949 and 1952 at all depths, but from 1952 to 1954 recovery had begun and continued in 1955.

Off the north-east, loss of both cover and density occurred from 1952 to 1953. From 1953 to 1954 recovery had taken place and was established by 1955, (Walker and Richardson 1957 (b)).

A similar pattern of perennial change was found in North Shapinsay, Orkney, between 1947 and 1955, and also around the Isle of Arran, Firth of Clyde, where *Laminaria saccharina* was the dominant species, (Walker and Richardson 1957 (a) (c)).

During the whole period of sub-littoral surveying, 1946-1955, over widely separated areas off Scotland, 100,000 quadrats have been measured from more than 27,000 hectares of the sea-bed at all times of the year.

It is now possible to indicate the trend of growth. By far the greater quantity of the Laminariaceae is found above 5 fathoms (9 metres) and consists of *Laminaria cloustoni* Edm., *L. Saccharina* Lamour and *L. digitata* Lamour.

Based on all quadrat values obtained from 86 surveys, the mean fresh weight per unit area of the three Laminariae, found between one and five fathoms (2-9m.) in each calendar year, 1946 until 1955, was:

1b./sq. yard (x 0.54 for kgm./sq. metre)

1946	9.1
1947	13.4
1948	11.2
1949	8.0
1950	5.0
1951	5.4
1952	3.7
1953	2.8
1954	3.4
1955	4.7

These values, when plotted logarithmically, show the trend over the past ten years and, when extrapolated backwards in time, give a trough in 1942 of the same level as 1953; and, when extrapolated forward in time, give a crest in 1958 of the same level as 1947. Ecological factors combining to produce an eleven year cycle would appear to be controlling the reproduction, colonisation and growth of the Laminariaceae around Scotland.

A surprising degree of correlation was found between the periodicity of the Laminarian crop and the sunspot activity, (Walker 1956).

It is not thought that the perennial periodicity of the crop of Laminariaceae is the direct consequence of sunspot activity but rather the indirect result of such activity producing meteorological conditions which in turn are reflected in the marine environment.

A continuation of such an ecological study would no doubt be rewarding.

REFERENCES

- Walker, F.T. 1947. Sublittoral Seaweed Survey; Part I, Development of the View Box-Spring Grab Technique for Sublittoral Seaweed Survey. Part II, Survey of Orknez, Scapa Flow. Part III, Survey of Orkney, Bay of Firth. Jour. Ecol., 35, 166-185.
- Walker, F.T. 1950. Sublittoral Seaweed Survey of the Orkney Islands. Jour. Ecol., 38, 139-165.
- Walker, F.T. 1952. Sublittoral Seaweed Survey; Dunbar to Fast Castle, East Scotland. Jour. Ecol., 40, 74-83.
- Walker, F.T. 1954 a. Distribution of Laminariaceae around Scotland. Jour. Cons. int. Explor. Mer., 20, 160-166.
- Walker, F.T. 1954 b. The Laminariaceae off North Shapinsay; Changes from 1947 to 1953. Ann. Bot., Lond., N.S., 18, 483-494.
- Walker, F.T. 1956. Periodicity of the Laminariaceae around Scotland. Nature, 177, 1246.
- Walker, F.T. and W.D. Richardson 1955. An Ecological Investigation of *Laminaria cloustoni* Edm. (*L. hyperborea* Fosl.) around Scotland. Jour. Ecol., 43, 26-38.
- Walker, F.T. and W.D. Richardson 1956. The Laminariaceae off North Shapinsay, Orkney Islands; Changes from 1947 to 1955. Jour. Mar. Res., 15, 123-133..
- Walker, F.T. and W.D. Richardson 1957 a. Perennial Changes of *Laminaria cloustoni* Edm. on the coasts of Scotland. Jour. Cons. int. Explor. Mer., 22, 300-310.
- Walker, F.T. and W.D. Richardson 1957 b. Survey of the Laminariaceae off the Island of Arran. Changes from 1952 to 1955. Jour. Ecol., 45, 225-232.

Received for publication February 5, 1958.

NEKI EKOLOŠKI FAKTORI KOJI UTJEČU NA RASTENJE LAMINARIJACEJA OKO ŠKOTSKE

Francis T. Walker

Institut za izučavanje morskog bilja, Edinburgh, Škotska

Referirano na sastanku algologa, jula 1957. Institut za oceanografiju i ribarstvo, Split

K r a t a k s a d r Ź a j

Ekstenzivna izučavanja sublitorolnih laminarijaceja na škotskim obalama su pokazala da masa svježih alga i areal njihove rasprostranjenosti opadaju s dubinom: ova dva faktora pokazuju pravilan odnos, i opadanje je eksponencijalno.

Na sezonska kolebanja utječu najviše zimske oluje.

Dugoročna kolebanja slijede jedanaestogodišnji ciklus, koji stoji u vezi sa sunčanim pjegama.

Tiskanje završeno 25. I. 1959.

Tisak: Novinsko-izdavačko poduzeće »Slobodna Dalmacija« — Split