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NOTE

A Computer Program, MAPP, for the Estimation of the Macroalgal Annual Production from Photosynthetic Rates and Biomass Changes

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광합성율과 생물량에 기초한 해조류의 년 생산량 계산 프로그램

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MAPP, a computer program, provides an estimate of the annual production of macroalgae. The calculation of the annual production is based on the Photosynthesis-Irradiance relationship under different temperature conditions and annual changes of algal biomass. The production in a given time was obtained from the multiplication of biomass by the production rate measured by *in situ* experiments. The annual production, P_{yr}, is calculated from $P_{yr}=\int_0^{yr} B_t \cdot P_t \, dt$, where, $P_t=f$ (T, L) and T, L$=f$ (t). The program is written in Pascal language to facilitate the usage with personal computers. The data of the photosynthetic rates and biomass of *Sargassum confusum* measured at Ohori, on the east coast of Korea, was used for an example.

이 컴퓨터 프로그램은 생물량의 변화와 광합성율로부터 해조류의 년 생산량을 계산하기 위해 작성한 것이다. 서로 다른 광도, 온도조건 아래서 측정된 해조류의 단위무게 당 광합성율을 광도, 수온의 년 변화와 연결시켜 광합성율의 년 변화를 계산하였다. 이 때 해조류의 광합성율을 1년간 짧은 시간간격으로 측정한다면 좀 더 정확한 값을 얻을 수 있을 것이다. 광합성율의 시간에 따른 변화를 생물량의 시간에 따른 변화와 연결시켜 년 총생산량을 계산하였다. 어느 주어진 시간에서의 생물량을 알고 이 때의 단위무게당 광합성율을 알면 이들 값을 곱하여 이 시간에서의 총 생산량을 알 수 있기 때문이었다. 프로그램은 개인용 컴퓨터를 이용하는데 편리하도록 파스칼 언어를 사용하였으며 계산결과를 데이터 베이스에 옮길 수 있도록 하여 다양한 프린터 사양을 가지게 한것도 하나의 특징이다. 강원도 고성군 오호리에 서식하는 알쏭이 모자반을 대상으로 측정한 생물량, 광합성율의 값들을 이 프로그램에서 예로 사용하였다.

OUTLINE OF THE PROGRAM

The primary goal of the program named MAPP (Macroalgal Annual Primary Production) is to compute the annual production of a given population from the standing stocks when the photosynthetic reaction rates per unit biomass are known. The population of *Sargassum confusum* was chosen for a sample in calculating the annual production. The detailed feature of the mathematical construction of the model used in the program was described by Koh and Joh (1991). The object here is therefore rather to summarize the model structure and essential techniques which all users need to have for practical use.

Before dealing systematically with data treatments, it is worth outlining the computation procedures which lead to the estimation of primary production for a given period. This involves first the measurements of biomass at appropriate time intervals and those of photosynthetic rates under different light and temperature conditions. Then, the production in terms of photosynthetic activity for a given biomass can be calculated by mutiplying the known photosynthetic rate in a given time (P_t) by the biomass (B_t). The production for a certain period, e.g. one year (P_{yr}), was therefore, $P_{yr} = \int_{0}^{yr} P_t \cdot B_t dt$.

The model calculates the total capacity of production by a given biomass. This capacity is the 'crop productivity' (Charles-Edwards, 1981). The difference between the estimate from the present model and the standing stock is the amount of organic materials produced through photosynthesis, but lost through exudation, shedding, and grazing, etc.. A closer spacing in time for the estimation of biomass and photosynthetic rates is needed for the accurate prediction by the present model, since B_t and P_t are used for the multipliers.

In the present model, P_t was written as a function of the temperature, and light intensity; $P_t = f(T, L)$. According to the *in situ* experiments performed at Ohori, on the east coast of Korea, the production rate of *Sargassum confusum* could be described by the hyperbolic tangent curves which reflect the non-photoinhibition (Jassby and Platt, 1976; Chalker, 1980). Temperature and light intensity were functions of time ($T, L = f(t)$), for these factors showed seasonal variations in the study site (Koh and Ahn, 1985). The detailed mathematical formulation of those functions can be found in Koh and Joh (1991).

The production model constructed in the present study have some limitations in estimating the annual production. Responses of the production rate to environmental conditions are not fully reflected in the model. Radiant environments in the algal community can change spatially and temporally. Great variations in water clarity which regulates the insolation at a given depth can be observed. Seasonal and diurnal fluctuations of the photosynthetic activity are physiological reactions to be considered in the model construction. To cover these deficiencies, experiments on photosynthetic rates at finer time intervals are necessary. Our model can easily be improved by modifying the algorithm, if we obtain the photosynthetic data through frequent in situ experimentations.

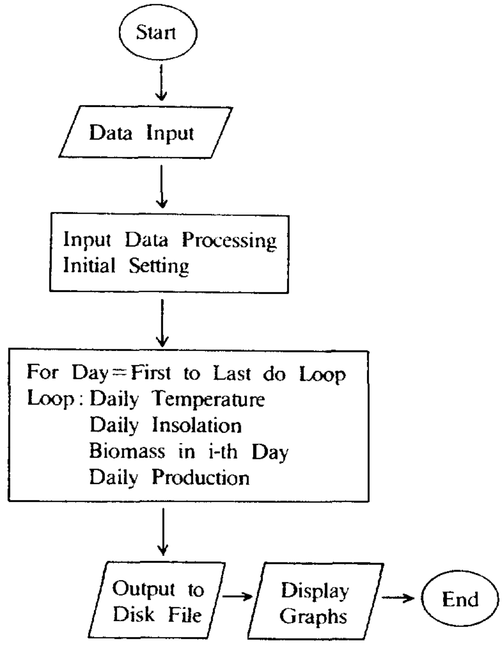

Fig. 1. Flow diagram of the programm, MAPP, calculating the annual production of *Sargassum confusum* from the annual change of water temperature, insolation, P-I parameters and biomass (units of parameters are described in Koh and Joh, 1991).

The protocol of this program is written in Pascal programming language especially in Turbo-Pascal (Borland Co., 1988) to facilitate the compiling process after user's program modifications. The compatible environment of IBM-PC/XT or AT is necessary to run the program. The source file is available on a 5.25" double density floppy diskette from the second author on requests.

DATA INPUT AND EXECUTION OF MAPP

Fig. 1 is a flow chart showing the logical structure of the programm, MAPP. After the initializing process involving the data input, several loops are set up so that the variations of temperature, light and biomass with time can be determined. The photosynthetic rates are recalculated at every time interval because the light and temperature condi-

Table 1. An example of input file for MAPP on P-I curves and biomass of *Sargassum comfusum* at Ohori, on the east coast of Korea.

Row No.	Input Data: Comments
(01)	10: Time interval of simulation (minute)
(02)	9: Number of data
(03)	27 3 1983 467.0: 1
(04)	16 4 1983 815.0: 2
(05)	26 5 1983 1045.0: 3
(06)	24 6 1983 1159.0: 4
(07)	1 9 1983 152.0: 5
(08)	20 10 1983 84.0: 6
(09)	21 12 1983 241.0: 7
(10)	23 2 1984 117.0: 8
(11)	16 3 1984 123.0: 9: dd-mm-yy & biomass (g-dry wt./m^2)
(12)	1.2: Photosynthetic Quotient (P.Q.)
(13)	23.0 7.18 2.56: Experimental-temp, MaxPn, Q10 of MaxPn
(14)	−1.28 4.28: Respiration-rate, alpha
(15)	36.333: Latitude
(16)	20 8 1983: dd-mm-yy of Maximum temperature
(17)	21.3 5.78: MaxT, MinT (℃)
(18)	23.4: Percent transmittance (%)
(19)	50.0: Fine day (%)
(20)	ALGAEØ.OUT: Output file name

tions change continuously with time. The annual production is computed in the last loop by the integration of the daily production over a year. The program is designed to write the results into disk files and to display graphs on the monitor.

For the data input, it is necessary to make an input data file in ASCII format. ALGAEØ.DAT in Table 1 is an example of the input file needed to initialize the program. The user can modify this file for the program operation by substituting the values of each row with their own. The first row (01) of ALGAEØ.DAT in Table 1 indicates an arbitrary interval of the loop calculation. The common divisor of integer 60 is recommended to diminish the round-off error. From the row of 03 to 11, the biomass values of *Sargassum confusum* determined from the study site and the sampling date are given. The rows of 13 and 14 contain the photosynthetic parameters which could be obtained from the experiments on P-I relationships of the object plant. Light and temperature conditions given on the rows of 15-19 describe the environment of the study site where the biomass and P-I curves were determined.

The program run will be invoked by typing the executable file name at the prompt sign in MS-DOS. If the user types MAPP ⟨Enter⟩, for the executable file is named with MAPP.EXE, then the program begins to run. Initializing the program is achieved by typing ALGAEØ.DAT ⟨Enter⟩ after MAPP ⟨Enter⟩. The program displays the content of the input file on the monitor for the verification of the input data. The user will thereafter have the opportunity of choosing the program run and termination by striking either ⟨Enter⟩ for the case of the continuous run, or ⟨Break⟩ if an alteration is required. After reading the ALGAEØ.DAT, the program computes the corresponding production values at 10 minute intervals. The results will be displayed as daily variation on the monitor and written simultaneously in the output file, ALGAEØ.OUT, assigned on the last line of ALGAEØ.DAT. Graphic displays of the output on the screen is provided when ⟨Enter⟩ is pressed.

The structure of the output file is so designed that the file is compatible with the well-known WORKSHEET softwares, e.g. LOTUS-123 and SYMPHONY etc.. It is of a great advantage and often desirable to process the output file in such a WORKSHEET software. The user can retrieve the output file by using the File Import function predefined in those softwares. These compatibilities allow the user to link the data sheets of results with the more detailed output functions including the Print Graphs available in the WORKSHEET softwares.

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REFERENCES

Borland International, 1988. Turbo pascal reference manual. Borland International, California, 376pp.

Chalker, B.E., 1980. Modelling light satuaration curves for photosynthesis: an exponential function. *J. Theor. Biol.*, **84**: 205-215.

Jassby, A.D. and T. Platt., 1976. Mathematical formulation of the relationship between photosynthesis and light for phytoplankton. *Limnol. and Oceanogr.*, **21**: 540-517.

Koh, C.-H. and I. Ahn. 1985. Community structure and productivity of phytobenthos in Juckdo (eastern coast of Korea) III. Growth pattern and productivity of *Sargassum confusum* (Phaeophyta). *Kor. J. Bot.*, **28**: 119-126 (in Korean).

Koh, C.-H. and S.-O Joh. 1991. The estimation of the annual production of *Sargassum confusum* by mathematical models based on photosynthetic rates and biomass changes. *J. Oceanogr. Soc. Korea*, **26**: 108-116.

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