THE DENSITY CURRENT PATTERNS IN SOUTH-CHINA SEA

Pham Van Huan

Faculty of Hydro Meteorology and Oceanography
College of Natural Sciences, Vietnam National University, Hanoi

Abstract: *The monthly averaged temperature and salinity fields are treated by geostrophic calculation formula to obtain the density current patterns in the South-china sea for all months of the year. The current patterns are compared to show the annual changes of the water circulation. Obtained values of water transport through the oceanographic sections across the Bashi and Formos entrances may be served as the data for the boundary conditions for the circulation models of this sea and other calculations and applications as well.*

The first information on the current fields in South-china Sea and adjacent waters was presented in [1,4]. In these reports the current maps of the South-china sea were drawn up based on the observed data that were usually rarely available at the moment they were built. Besides, there exist the current maps only for the surface of the sea. The current patterns of the South-china sea obtained with the application of numerical hydro dynamical models have the more detail on the structure of circulation of the sea. But the fact that in the realization of the numerical models one usually used the proposed boundary conditions because of the lack of the detailed current observations at the open boundaries of the computed domain makes these current maps of restricted accuracy and reliability.

Recently, the number of observed records on physical parameters of the water such as temperature, salinity for the regions of the South-china sea was growing up very fast and the different techniques for the data analysis were applied to obtain the detailed interpolization fields of these parameters for the whole sea [2,3]. This report presents the results of the geostrophic calculation with the objectively analyzed fields of the temperature and salinity of the South-china sea.

Suppose one have two oceanographic stations A and B on the isobars P_1 and P_2 (figure 1). Under the affecting of any external motive the water density on the vertical line AD may become less than that on the vertical line BC. And there will appear a horizontal gradient of the pressure in direction from A to B and the water particles tend to move in the same direction. However, the Coriolis force will deflect the movement to the right so that the pressure gradient of the direction from A to B will be balanced to the Coriolis force affecting in the inverse direction. This will happen when the current direction is perpendicular to the plane of the section from inside towards us.

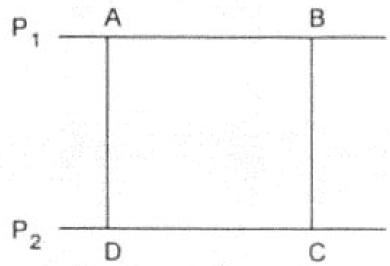


Figure 1. Oceanographic stations scheme

In this stable movement the work of the pressure force and that of Coriolis force on the exclusive line $ABCD$ are equal to each other

$$\oint_{ABCD} \alpha dP = -\int_{ABCD} 2\omega V \sin\phi dL, \tag{1}$$

where ω- the Earth rotation speed; ϕ the latitude; dL the element of the curve $ABCD$; α the specific volume of the sea water.

From the figure 1 we have

$$\oint_{ABCD} \alpha dP = \alpha_A(P_2 - P_1) - \alpha_B(P_2 - P_1) = D_A - D_B, \tag{2}$$

where D_A, D_B - the dynamical depth of the station A and B respectively, and

$$\oint_{ABCD} 2\omega V \sin\phi dL = 2\omega L \sin(V_1 - V_2), \tag{3}$$

where V_1, V_2 - the average current velocities on the isobar lines P_1 and P_2 respectively; L -the distance between stations A and B (the integrals along the fragments BC and DA are compensate).

Substitution (2) and (3) into (1) gives the geostrophic formula of the dynamical method for calculation of stable density current

$$V_1 - V_2 = \frac{D_A - D_B}{2\omega L \sin\phi}. \tag{4}$$

The dynamical depth D at the oceanographic station is computed after the specific volume of the sea water due to the formula

$$D = \int_P^{P_0} \alpha dP = \sum_P^{P_0} \alpha \Delta P = \sum_P^{P_0} V_{PST}.10^{-3}\Delta P + \sum_P^{P_0} 0,9\Delta P,$$

where V_{PTS} - the conventional specific volume of the sea water at the temperature T, salinity S and pressure P. When this dynamical depth D is used in formula (4) one can cancel the last constant term and the formula for computing D becomes simple

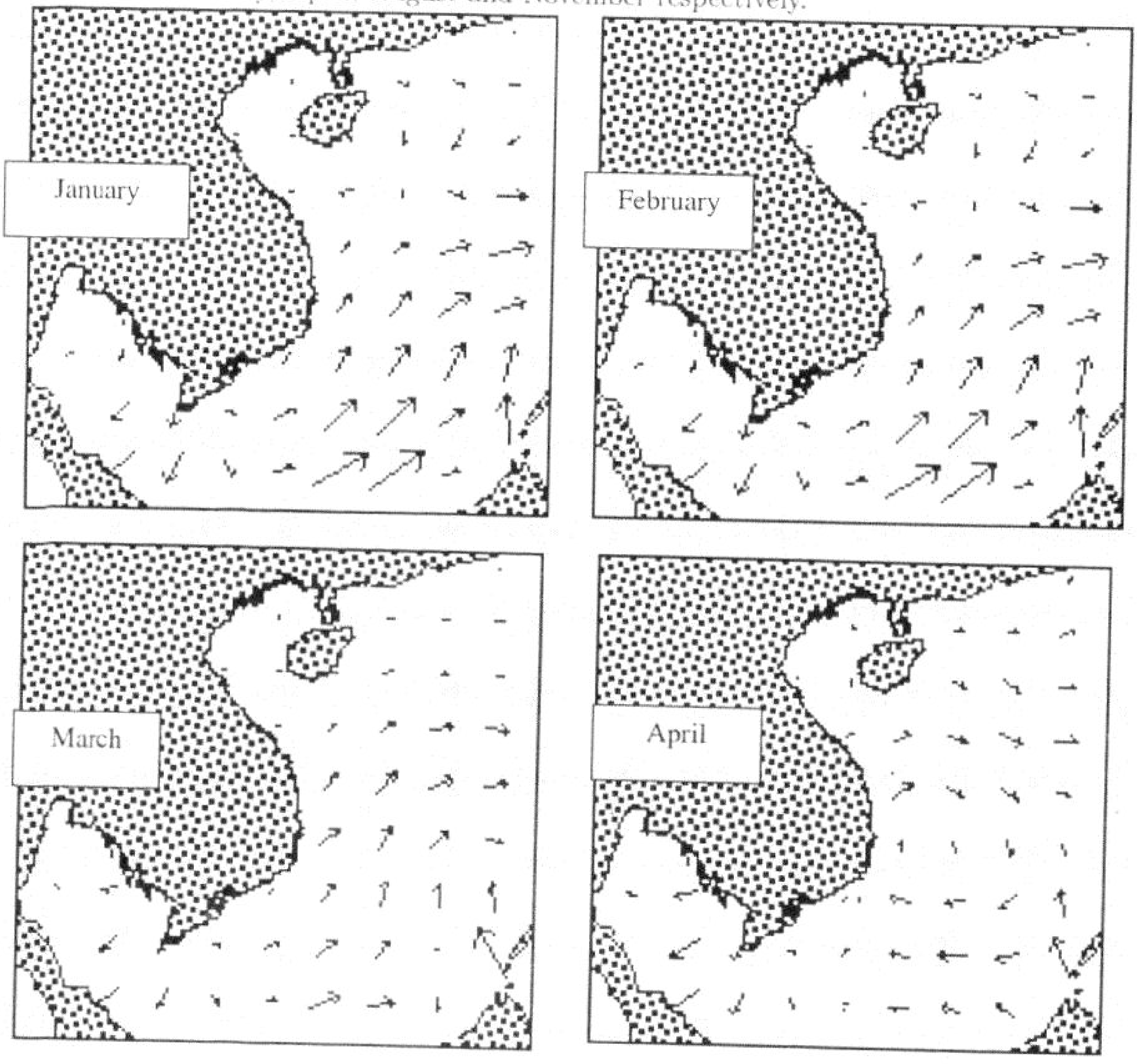
$$D = \sum_P^{P_0} V_{PTS}.10^{-3}\Delta P. \tag{5}$$

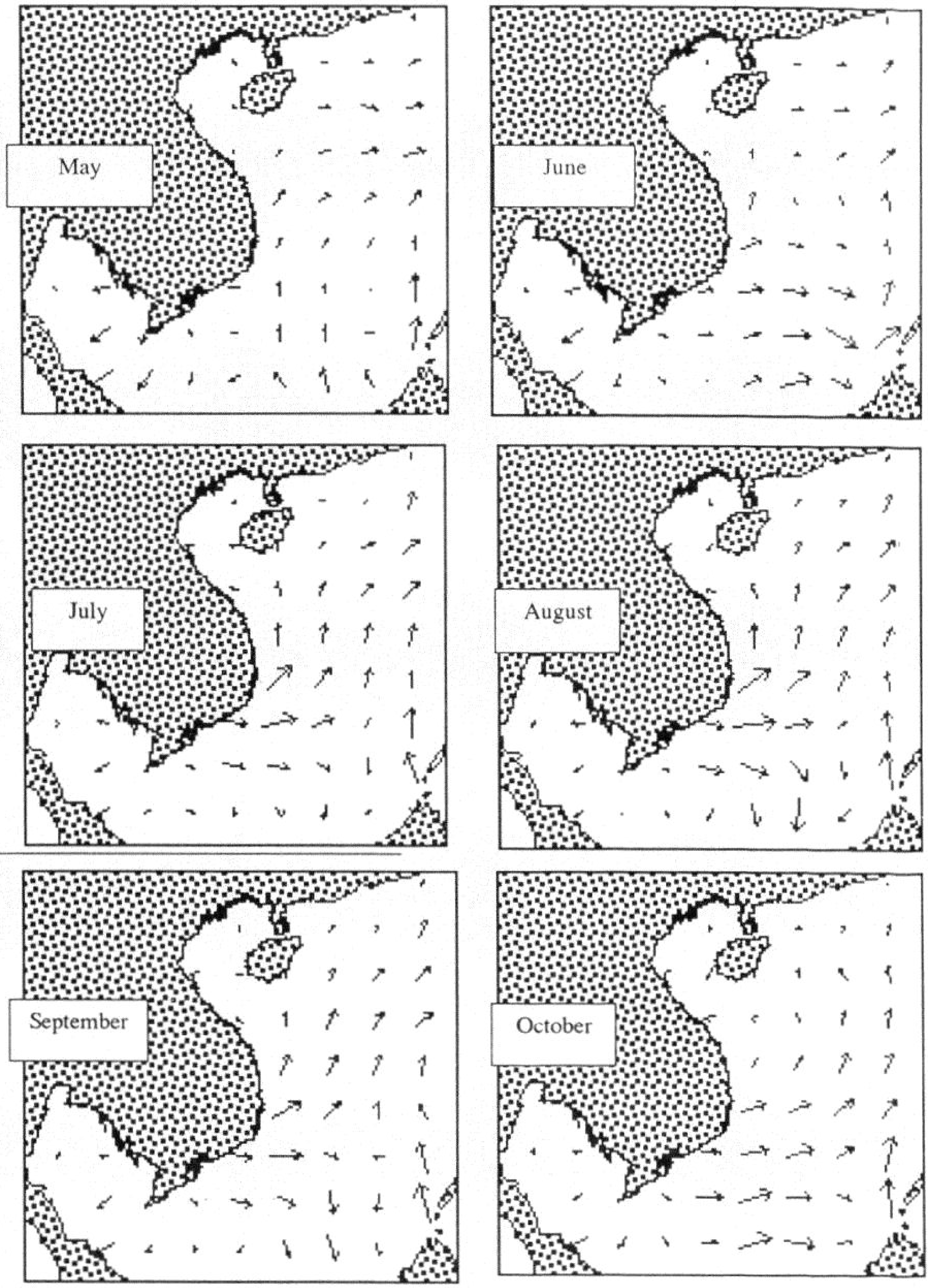
The formulae (4) and (5) serve as the main expressions for the treatment of the specific volume field to evaluate the density current field in the sea.

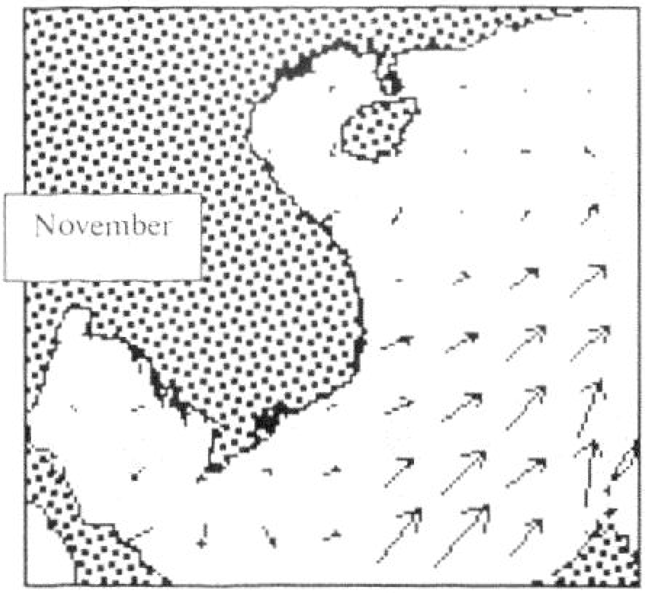
With this purpose we have collected the objectively analyzed data on the monthly averaged temperature and salinity for 17 levels from the surface up to the horizon 1000m for the whole South-china sea for all the months of the year. The specific volume of the sea water was determined due to the Bierknes expression. The dynamical heights (relatively to the sea bottom) were computed at grid points of the meshes of size 1^0 longitude and latitude. After that we have evaluated the eastward compound of current velocity at the meridian sides of each mesh and the northward compound - at the parallel sides. The resulting vector of the density current was assigned to the center of the meshes in the sea.

In the practical scheme of calculation the zero velocity (the zero dynamical plane) of the meshes in shallow water was accepted at the sea bed and for all other squares in deep region the velocity at level 1000m was accepted to be zero.

Thus, we have created 12 monthly averaged density current maps for the year. Figure 2 presents the average density current fields for the surface of the South-china sea for months January, April, August and November respectively.




May
June
July
August
September
October



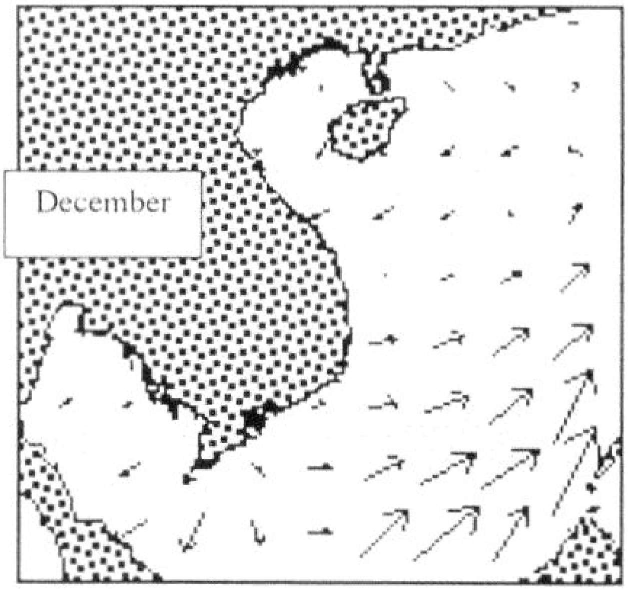


Figure 2. South-china sea density current patterns

The structure of the circulation in northeast entrances (table 1) appears to be complicated. The water from the Pacific ocean enters the South-china sea mainly through the Bashi entrance and it exits the sea through the Taiwan strait. The discharge of water through this narrow entrance is small in relation to the Bashi strait.

Table 1. Discharge through the Basi entrance 18°30'N-21°30'N, 121°E

Month	Bashi entrance (million m^3/s)			Taiwan strait (thousand m^3/s)		
	19°-20°	20°-2 1°	21°-22°	117°-118°	118°-119°	119°-120
January	-5.6	-3.2	-3.3	-0.9	-26.1	6.9
March	-4.5	-2.3	-2.6	2.7	-16.6	1616.6
May	-3.8	-2.3	-3.1	6.1	10.7	13.4
July	-3.9	-2.3	-2.5	2.0	5.3	34.9
September	-3.2	-1.3	-1.7	-4.6	9.7	21.8
November	-3.0	-1.5	-2.2	2.0	4.7	9.0

This work is a result of the theme 7.8.11 "The system of currents in the west of South-china sea and its impact on the natural conditions of Vietnam coastal" (Basic Research Program, The Earth Sciences 1999).

References

[1] Currents in the South China, Java, Celebes and Sulu seas. *The Hydrographic office United States Navy under the authority of the Secretary of the Navy,* Washington, 1945.

[2] S. R. Levitus. Burgett and T.P. Boyer. World Ocean Atlas 1994, Volume 3. Salinity. *NOAA Atlas NESDIS 3. U.S. Department of Commerce,* Washington, D.C. 99 pp.

[3] S. Levitus. and T.P. Boyer. 1994c. World Ocean Atlas 1994 Volume 4, Temperature. *NOAA Atlas NESDIS 4. U.S. Department of Commerce,* Washington, D.C. 117 pp.

[4] *The Encyclopedia of oceanography.* Reinhold publishing Corp., New York, 1966.

TẠP CHÍ KHOA HỌC ĐHQGHN, KHTN, t.XVII, n^{0}1 - 2001

CÁC SƠ ĐỒ DÒNG CHẢY MẬT ĐỘ ỔN ĐỊNH Ở BIỂN ĐÔNG

Phạm Văn Huấn
Khoa Khí tượng Thủy văn & Hải dương học
Đại học KH Tự nhiên - ĐHQG Hà Nội

Các trường nhiệt độ và độ muối trung bình tháng nhiều năm của biển Đông được xử lý bằng công thức địa chuyển và nhận được những sơ đồ dòng chảy mật độ ổn định cho tất cả các tháng trong năm. Khảo sát sự biến thiên năm của trường dòng chảy và tính toán một số đặc trưng vận chuyển nước qua mặt cắt phía đông bắc biển - eo Bashi. Những số liệu nhận được có thể dùng làm dữ liệu điều kiện biên cho các mô hình hoàn lưu biển Đông cũng như những tính toán và những ứng dụng khác.

A NEW METHOD FOR THE STUDY OF NUTRIENT TRANSLOCATION ALONG FUNGAL HYPHAE

Trinh Tam Kiet

The Centre of Biotechnoplogy - Vietnam National University, Hanoi

Abstract: *A method is described for study of nutrient translocation along fungal hyphae during suface cultivations. Labelled substances (sugars, amino acids) are translocated both in direction of growth and also oppositely. The translocation capacity appears as different in various parts of the mycelium. The hyphal tips display a particularly strong nutrient accumulation occurs when the fruit bodies are formed. The same applies to stipulae, primodia and their morphogenetic precursors.*

As compared with the higher plants possesing highly organized systems for water and nutrient distribution, the mycelium-forming fungi are believed to miss these specialized cellular funtions. Except for some *Thallophyta* such as brown algae, little information is available so far about nutrient translocation in multi-cellularly organized eukaryotic miroorganisms. Motility of the cytoplasm has been proposed as the main cause of nutrient translocation along fungal hyphae [2]. But a series of experimental results showed this suggestion to be at variance [20]. Several methods were developed aimed at investigations onto nutrient transport in the mycorrhizal [4, 17] and non-mycorrhizal filamentous fungi [18, 15, 21, 3]. But in general, the realibility of these results was hampered by the passive diffusion of the feeded radiolabelled substrates [9]. Hence improved methods for study of translocational features in fungal cultures are still of interest. Here we report on a new pulse-labelling method using U-^{14} C - nutrients for the characterization of substrate transport along the hyphae and accumulation in hyphae parts during the different developmental stages of the fungus.

1. Material and methods

The fungus *Lentinus tigrinus* FR. strain 9 was obtained from the strain collection of Prof.em. Dr. H.H. Handke, Martin-Luther-University Halle, Germany. Cultivation occurred as surface culture on a solid medium composed as follows (g/l): D-glucose 20.0, L-alanine 2.0, KH_2PO_4 1.0, a cocktail of KH_2PO_4 0.5, solution of trace elements 2 ml, agar - agar 30.0; pH after sterilisation 4.9.

For the investigation of nutrient translocation we used Petri dishes (20 cm diameter) with nutrient or water agar as a minimal medium. A piece of sterile aluminium sheet (0.3 mm thickness, size and form according to the aim of the investigation, see below) was applied either to the sterilized nutrient or minimal agar medium in 0.5 cm distance from the wall of the agar plate. Thereafter a nutrient agar piece (2.0 mm thickness) with the same form as the aluminium piece but small enough to have a distance of about 2 mm from the border of the alumina sheet was placed on its surface. Subsequently, we incubated the fungus on a solidified nutrient medium, in order to enable growth and fructification under optimal conditions. To study translocation within the mycelium we feeded the labelled compounds to the surface of the nutrient agar piece, preceding the growth of the hyphae tips towards the nutrient agar of the Petri dish. Befor the addition of labelled material to the fructifying system we had to obseve the appearance of primodiate, stipulae, young and fully developed fruit bodies. To determine the amount of label translocated from the origin (nutrient agar on the aluminium sheet) to the growing mycelium (along the hyphae and hyphal tips) and fruit bodies the labelled material was added at zero time to the nutrient agar piece on the aluminium sheet. After a given time intervall we cut wells of 10mm diameter in the agar by a driller. The circular mycelum disks thus obtained were extracted by ethanol (70% 2 ml) and the solution was evaporated. The residue was dissolved in dioxane containing POP and POPOP as liquid scintillation cocktail. To make sure that the full amount of radioactivity was recovered, the extracted residue was also suspended in dioxane containing the above liquid scintillation cocktail.

All measurements of radioactivity (in counts per minute; cpm) were carried out in the 4C-channel by a liquid scintillation counter (Tricarb, LKB, Bromma, Sweden.)

2. Chemicals

Labelled U-^{14} C - saccharose, U- ^{14} C - phenylalanine and U -^{14} C - α - aminosobutyric acid (specific activity 100 - 200mCi/mmole) were obtained from Lachena, Prague, Czech Republik and the feeded radioactivity for every Petri dish was 3.35 μCi (7.700.000) counts per minute; cpm) dissolved in 100 μl distilled water.

3. Results

Shown in Tab. 1 are the results of experiments investigating nutrient translocation along the growing fungal colony in direction of the hyphae development. Apperently, *Lentinus tigrinus* translocated U -^{14} C - sacharose rather quickly from the origin (the inoculum of the colony on the aluminium sheet) to the outgrown parts of mycelium.

Moreover, the total activity of the pertinent areas increased in the dependence of the feeding time of the labelled nutrients (2, 4, 8, 16 hours). At the beginning of cultivation a maximum activity was reconized near the origine, but after 8 to 16 hours it appeared at the front of the growing mycelium. This suggests that particularly high accumulation occurs at the growing hyphae tips and translocating activity is different in induvidual parts of the hyphae.

To investigate this phenomenon in detail we used a modified scheme (Fig.1) revealing that every parts of the surface culture contains different radioactivity. The original culture and the labelled material were placed on the middle of the Petri dishes, and the total activity along the line were measured. In this case , in 1 cm distance from the origine up to the hyphae tips the whole agar was cut out by the driller and combined for the measurements.

Tab. 1: Translocation of U -[14] C-saccharose in growth direction of *Lentinus tigrinus* in dependence of time after pulse - feeding. Values (in cpm) depending on the distance from the origin basis, middle of the plate, tip).

			area on the agar plate		
Time (hrs)	N.of petri		Basis	Middle	Tip
2	1		58	50	62
			110	61	99
			41	63	52
2	2		430	165	162
			850	891	227
			841	399	212
		average	366	271	135
4	1		247	191	54
			830	354	806
			4582	201	1554
4	2		1660	842	650
			926	502	897
			2284	167	614
		average	1402	376	762
8	1		534	125	1825
			1775	321	2216
			61	157	753
8	2		4045	515	4048
			614	799	4387
			404	386	1784
		average	1222	383	2504
16	1		1127	3012	3799
			1256	1350	2605
			308	2297	4748
16	2		719	822	3003
			2494	2684	5168
			630	1496	3017
		average	1085	1943	3723

In our next series of experiments we studied the transport of nutrients in the opposite direction, from the hyphal tips to the origin (Tab. 2). The mycelium front was grown towards the aluminium sheet containing non-inculated nutrient medium. If the hyphal tips reached the nutrient agar on the aluminium sheet the labelled materials was added.

After incubation for a given time the activity of the outside agar near the aluminium sheet ut to the growth origine was the measured.

Tab. 2: Translocation of U-^{14}C-saccharose opposite to growth direction by *Lentinus tigrinus* (N/N). cpm in 5 cm (10 cm) distance from the aluminium sheet toward the growth origine (inoculum).

time (hrs)	number of Petri dish	Basis	Tip
2	1	187 228 40.4	148 164 154
4	1	134 158 82	118 320 96
8	1	321 449 249	349 454 485
8	2	378 391 142	408 387 183
	average	321.6	377.6
16	1	378 391 438	428 507 452
16	2	397 261 398	596 428 469
	average	377.6	480

Tab. 2 showns that a remarkable activity is present outside the area of the aluminium sheet. This results reveals translocation of nutrients from the younger to the more differenttiated parts of the mycelium opposite to the growth direction but with a lower rate. As a conclusion we suggest that, in a first phase , there occurs a transports from the inoculation site (origin) to the tips along the growing hyphae and later in the backward direction, too.

Our next aim was to clarify whether the results obtained with U -^{14} C - sacharose could be relevant for other nutrients. U -^{14} C - L - phenylalanine and a weakly or non-manner as described above. The results revealed the same pattern of translocation for both amino acids (Fig. 2). But there was a difference in the amount and velocity of nutrients translocation. Thus, the U - ^{14} C - α - aminoisobutyric acid, U - ^{14} C - L phenylalanine and U -^{14} C - saccharose were transported with desreasing efficiency towards the mycelium front. This suggest that there are different transporting system in fungal nutrients translocations.

Subsequently we studied translocation of the same nutrients in a fruiting system of *Lentinus tigrinus*. In this case, feeding occurred in dependence of the developmental stage of the culture. Fig. 3, 4 and 5 show that fruit bodies are capable of attracting nutients in a particular manner.