ICCE 2018
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The State of the Art and Science of Coastal Engineering

Estimation of groundwater discharge in a sandy beach; An example of Fukiagehama, Kagoshima Prefecture, Japan

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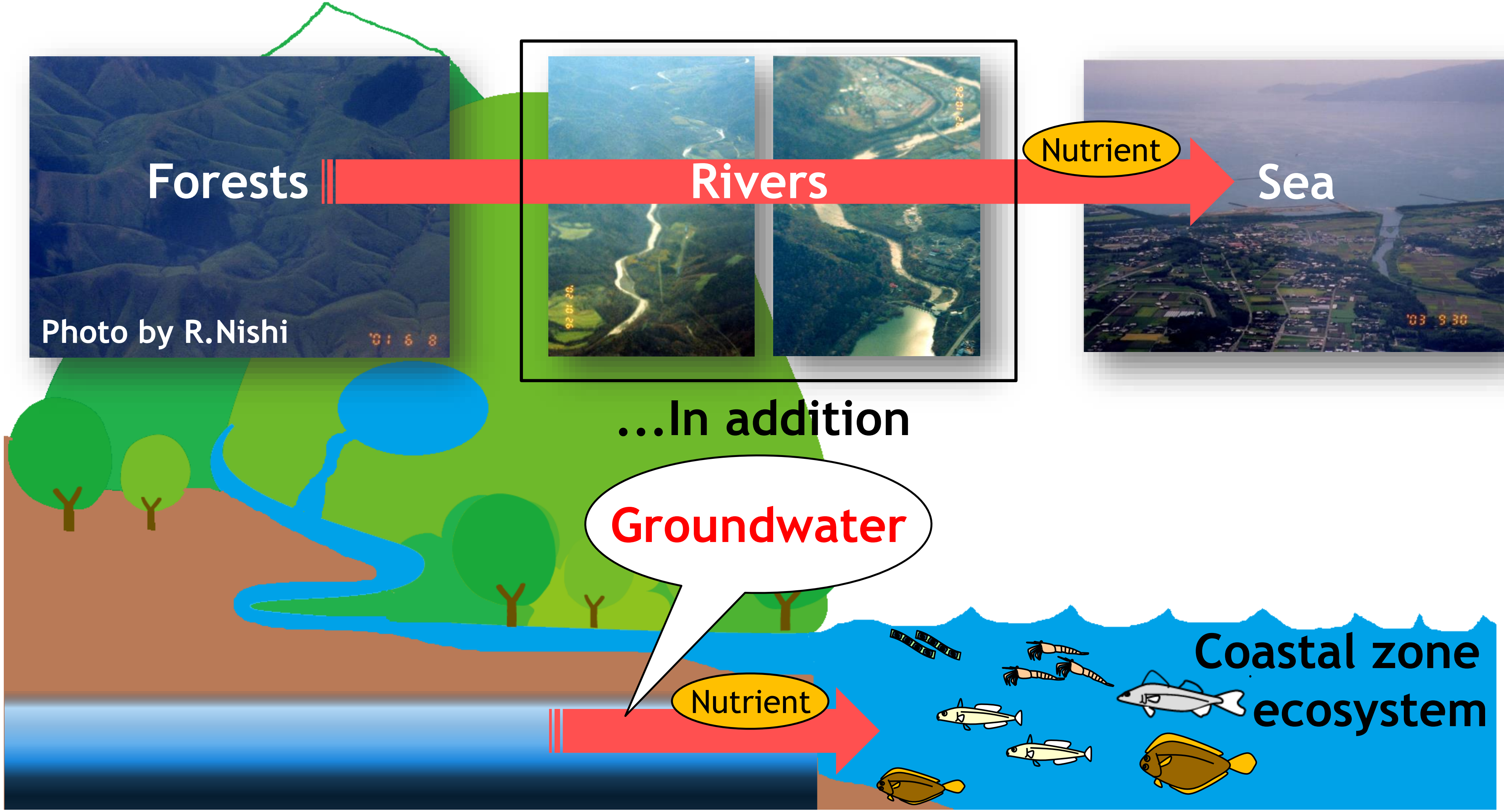
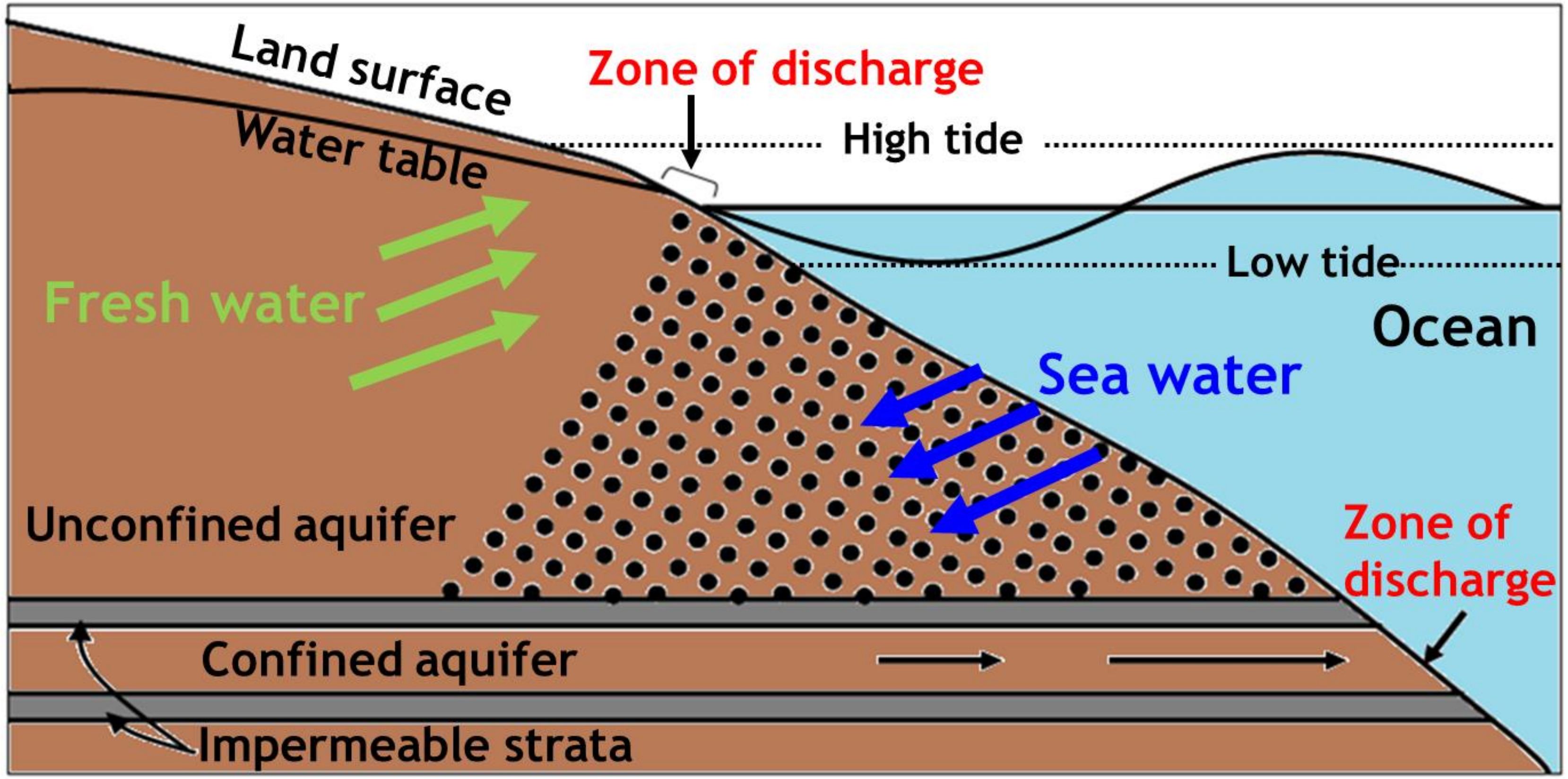
Background

Nutrient supply from land to the coastal zone



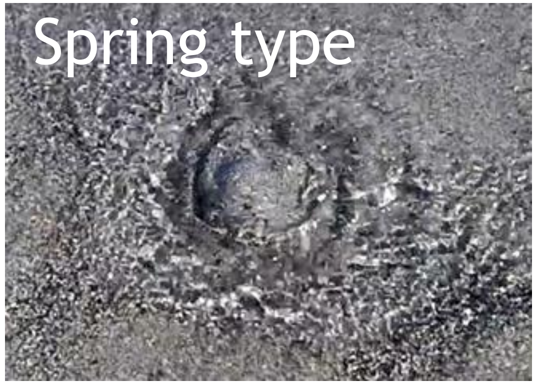
Background

SGD : Submarine Groundwater Discharge



Reference:Johannes(1980)

SGD



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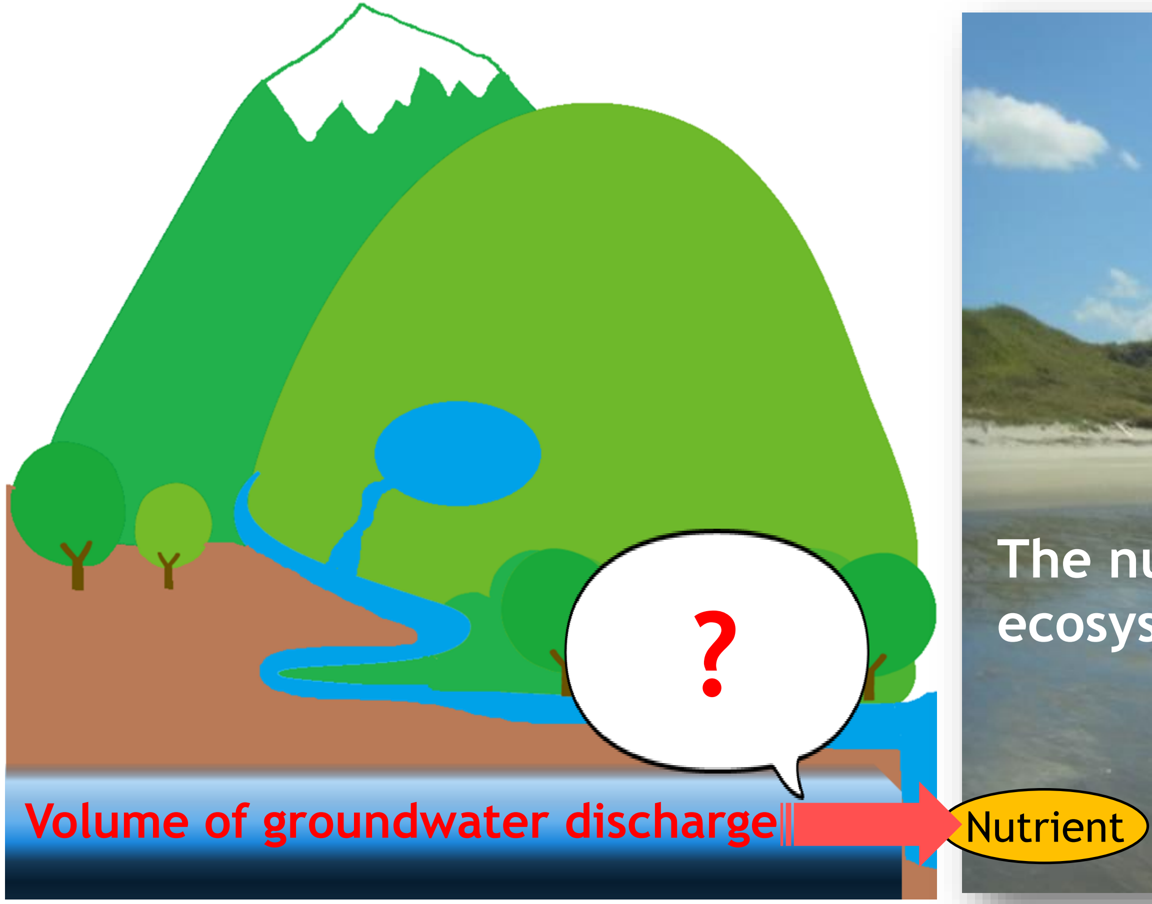
Purposes

ICCE 2018

Estimation of the groundwater discharge

✓ By using the water budget method(Macroscopic estimation)



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Study area ; Fukiagehama Beach

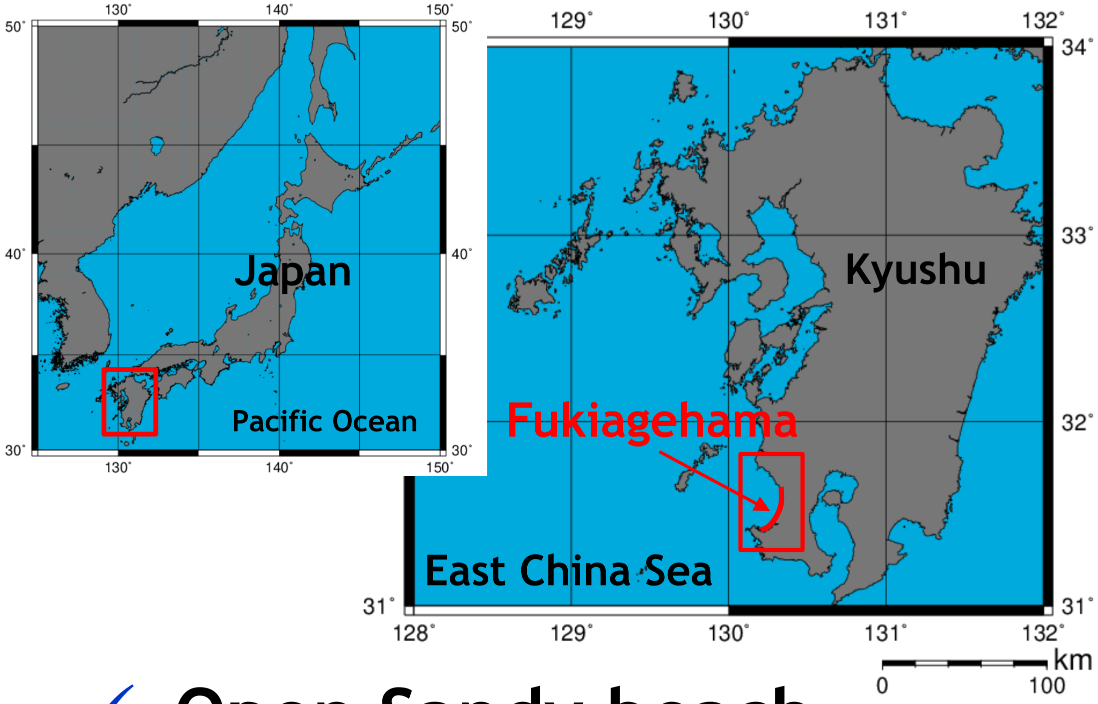



Photo by Y. Suda

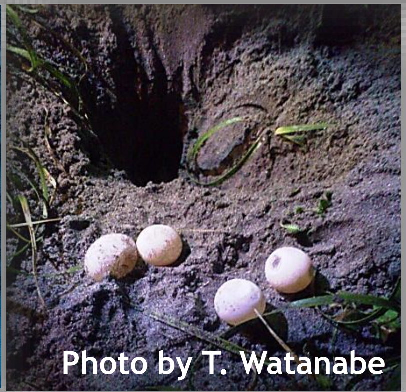
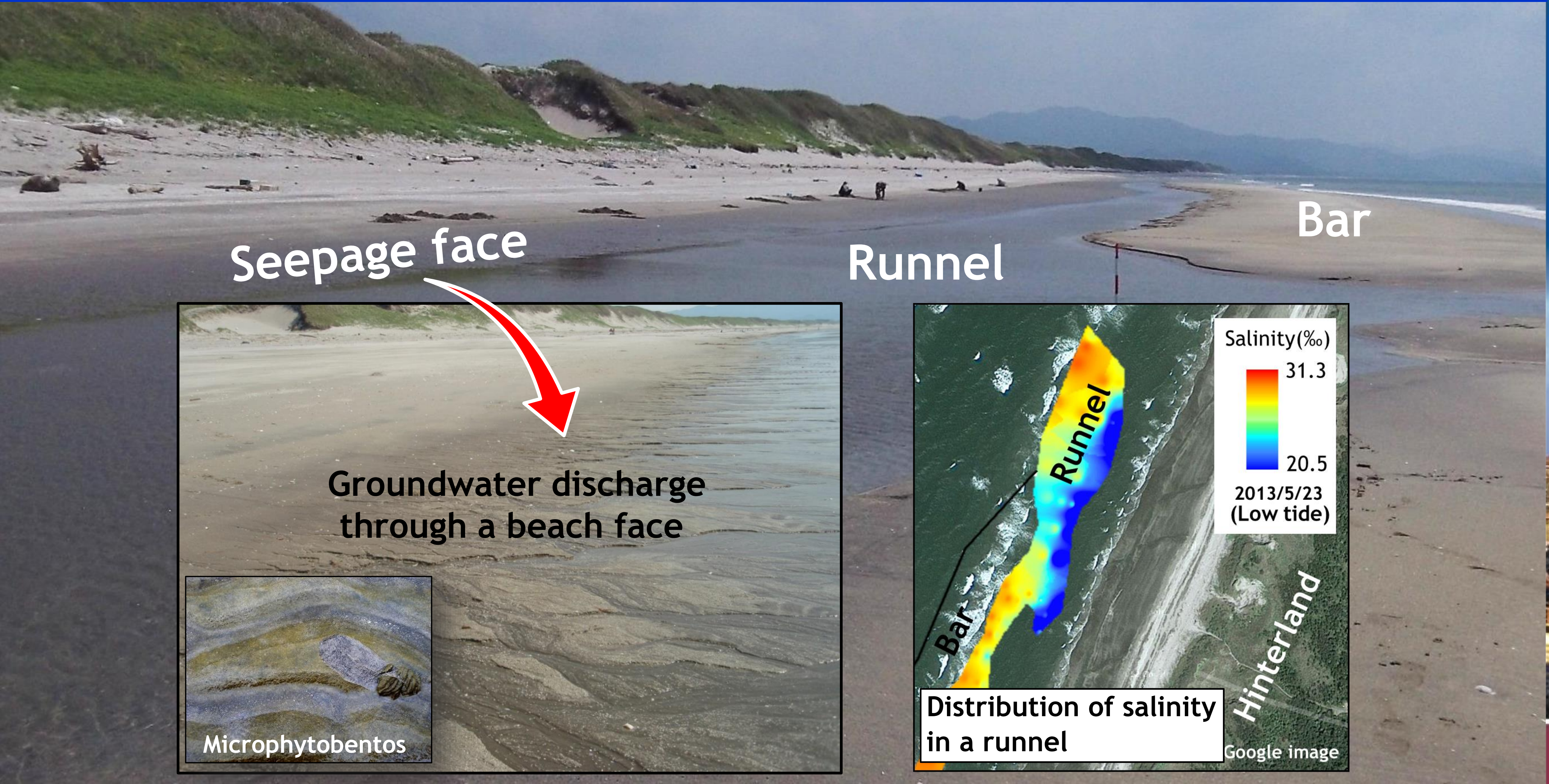


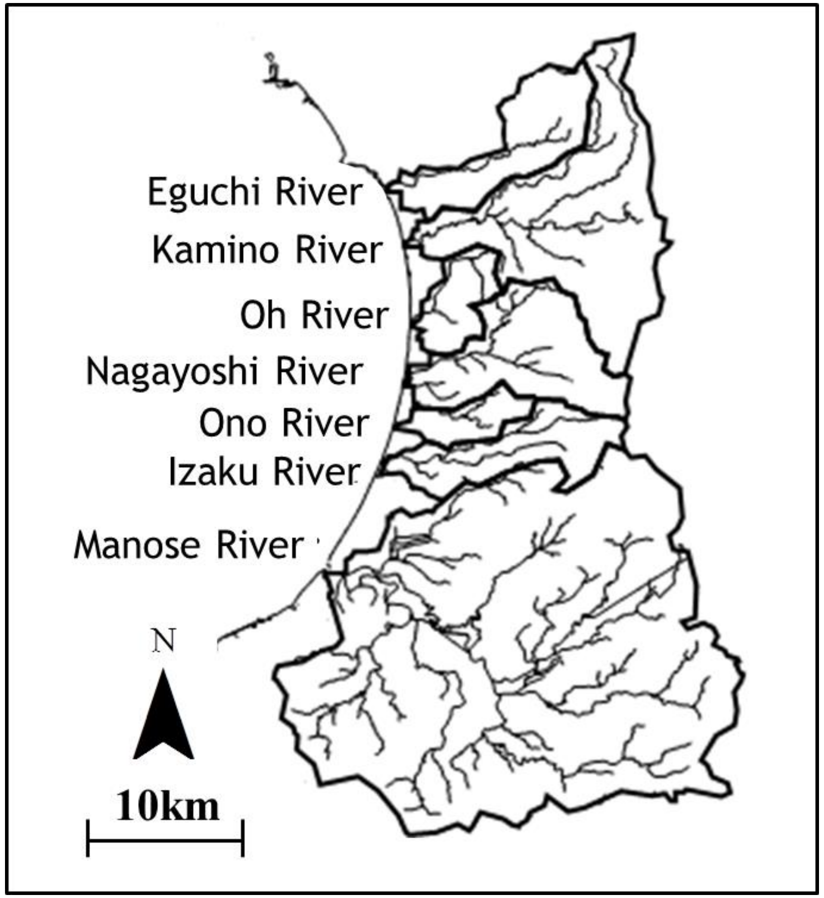
Photo by T. Watanabe

- ✓ Open Sandy beach
- ✓ Approximately 40km coastline
- ✓ One of the three major sand dunes in Japan
- ✓ Nesting place of loggerhead turtles
- ✓ Significant habitat for various juvenile fishes

Study area ; Fukiagehama Beach



Outline of Fukiagehama Basin (1)

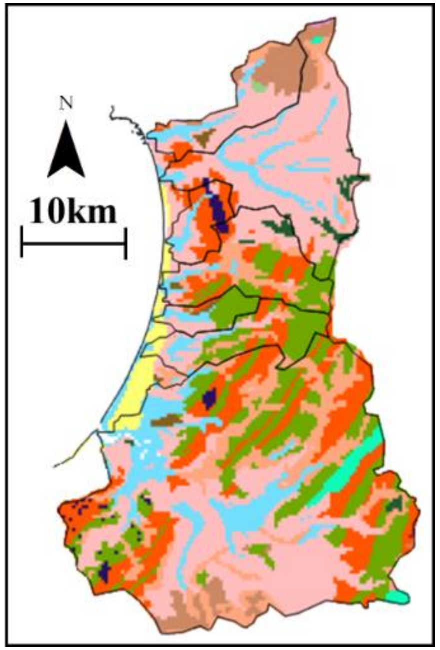


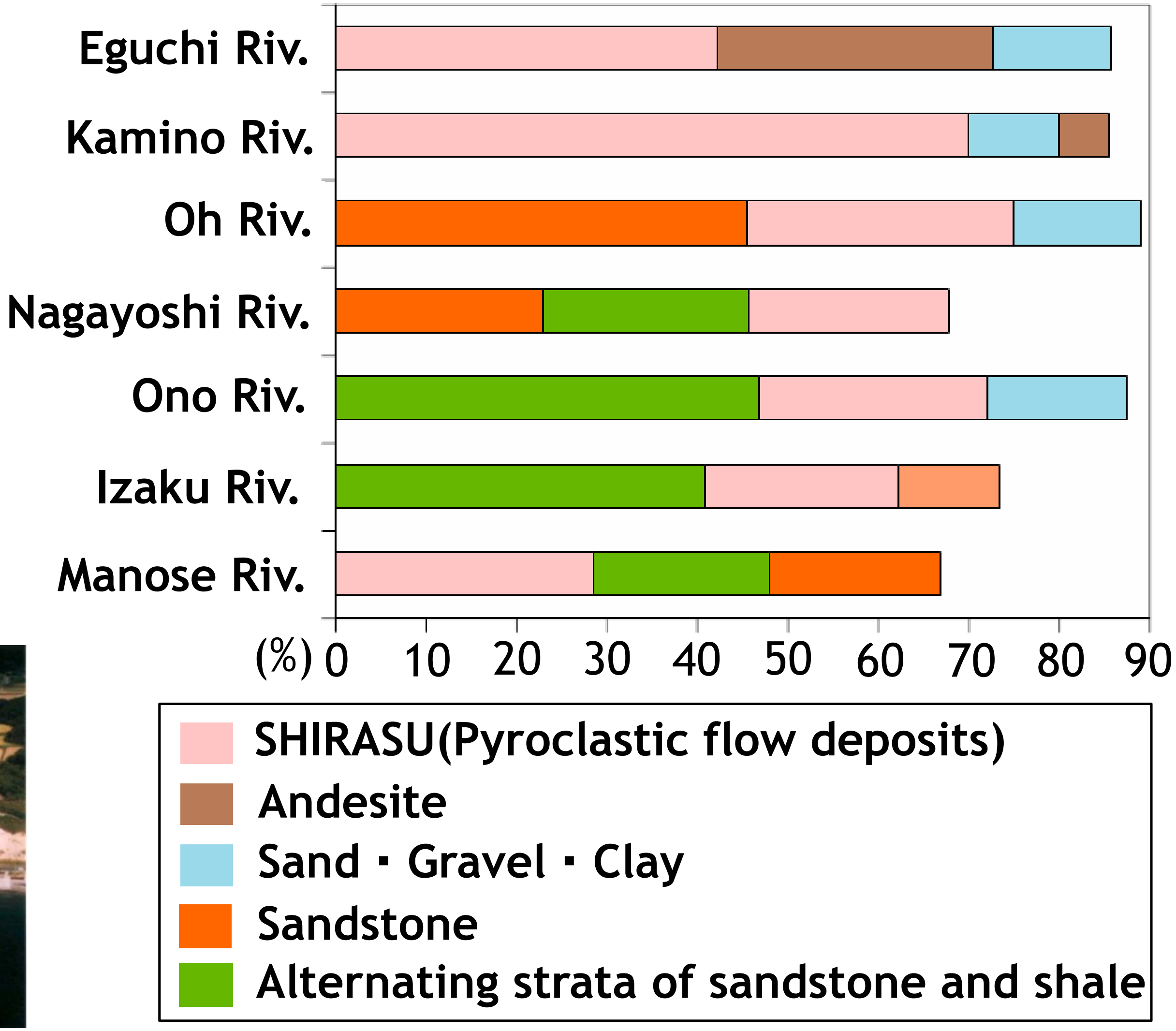
[km^2]

River	Basin area
Eguchi Riv.	22.9
Kamino Riv.	98.8
Oh Riv.	19.3
Nagayoshi Riv.	50.4
Ono Riv.	13.6
Izaku Riv.	38.9
Manose Riv.	372.3
Total	616.2

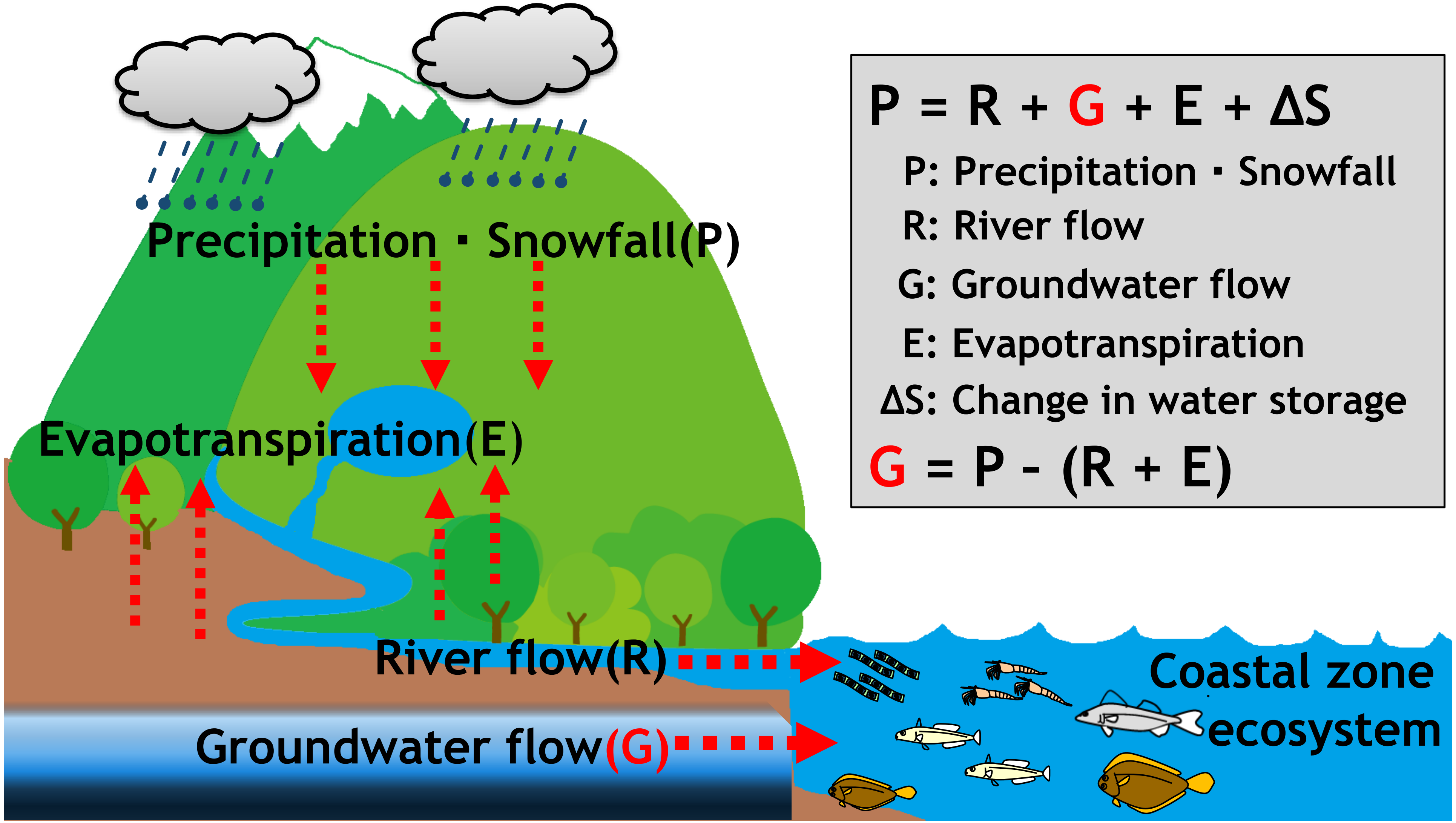
Outline of Fukiagehama Basin (2)

Ratio of subsurface geology (The top three items)





Outline of the water budget method



$$P = R + G + E + \Delta S$$

P: Precipitation・Snowfall

R: River flow

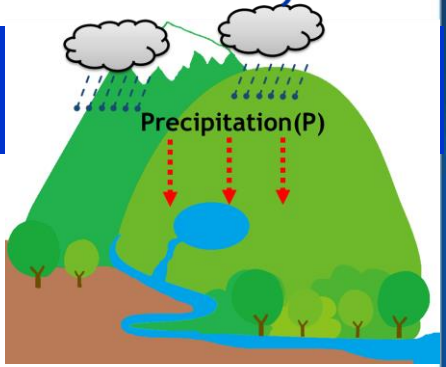
G: Groundwater flow

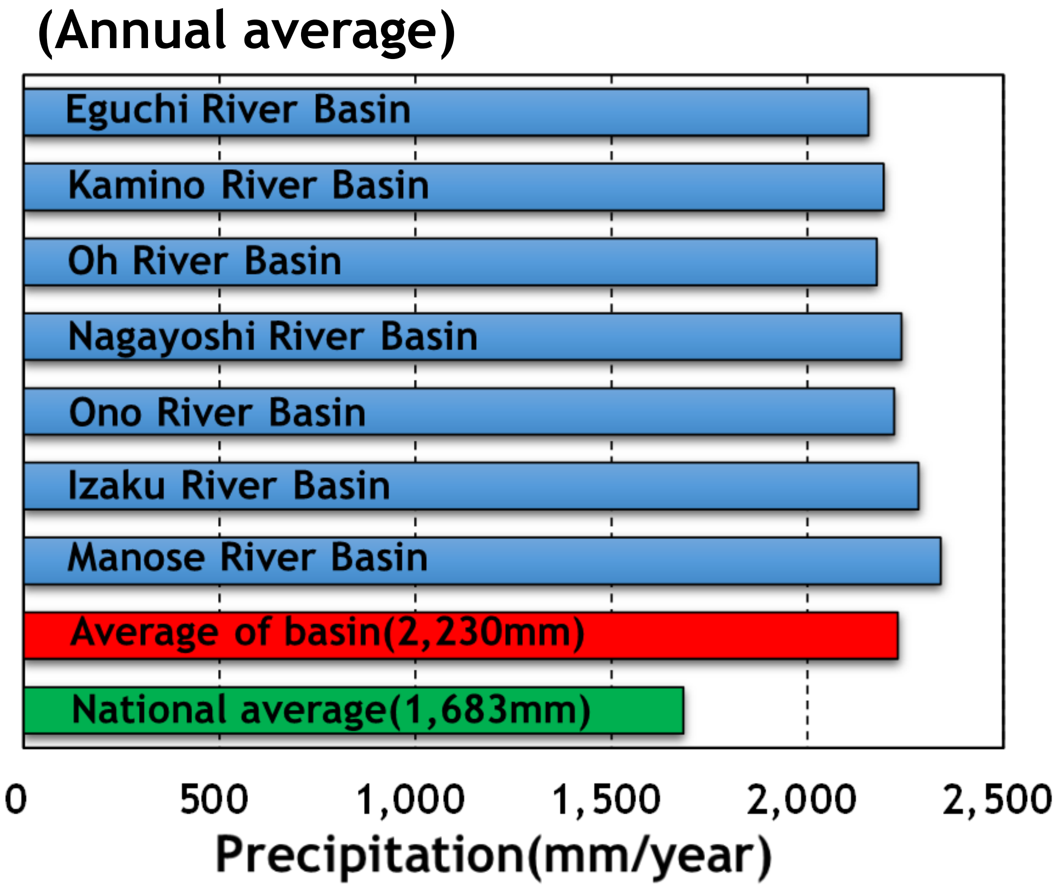
E: Evapotranspiration

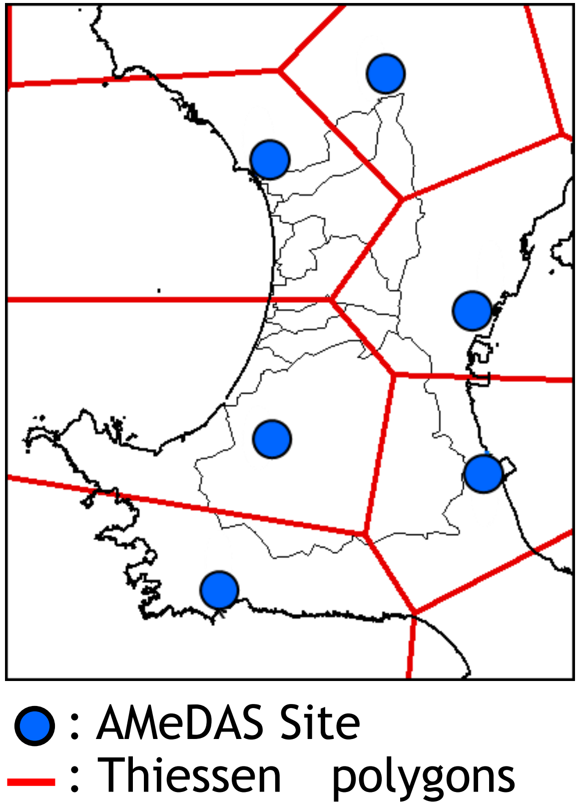
ΔS: Change in water storage

$$G = P - (R + E)$$

P : Precipitation

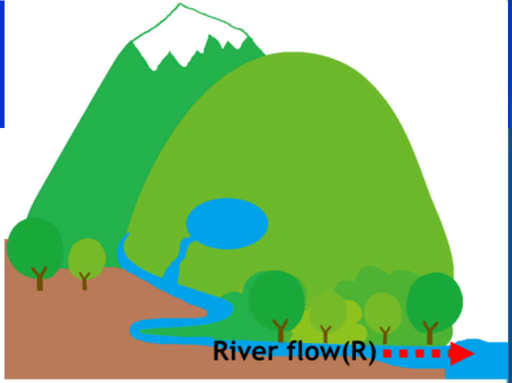




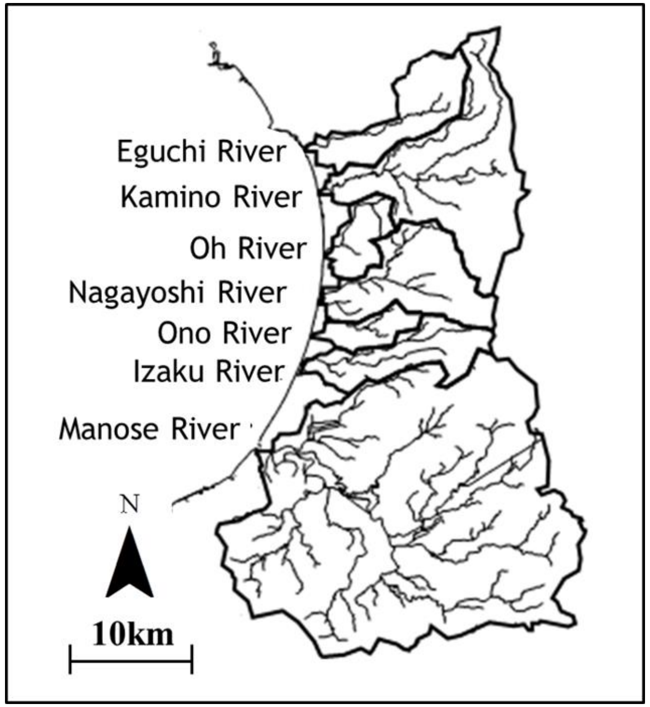


Data : AMeDAS precipitation data from the Japan Meteorological Agency(1992-2011)

R : River flow



River flow is observed by Kagoshima Prefecture.



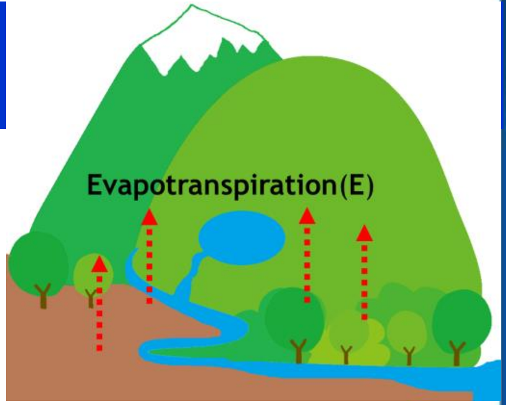
(Annual average) [m^3/s]

River	River flow
*Eguchi Riv.	0.32
Kamino Riv.	1.36
*Oh Riv.	0.27
*Nagayoshi Riv.	0.70
*Ono Riv.	0.38
Izaku Riv.	1.13
Manose Riv.	13.25

- ✓ Kamino River(1991-2011)
- ✓ Izaku River (1994-2011)
- ✓ Manose River(1991-2011)

- ✓ *Estimated river flow using specific discharge

E : Evapotranspiration



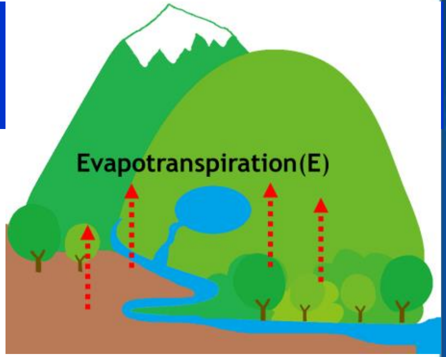
E = Potential evapotranspiration

× Evapotranspiration ratio

*Potential evapotranspiration

The potential evapotranspiration is the amount of evapotranspiration lost when a sufficient amount of water is supplied to a ground surface that is entirely covered by vegetation.

Potential evapotranspiration



The potential evapotranspiration was estimated by using Thornthwaite method and Hamon method, which can easily estimated the potential evapotranspiration from the monthly average temperature.

✓ Thornthwaite method(E_T)

$E_T = 16D_0(10T/I)^a$

D_0:Monthly average number of hours of possible sunshine

T :Monthly average temperature

$a= (492,390+17,920I-77.1I^2+0.675I^3)10^{-6}$

$I= \Sigma(T/5)^{1.514}$

✓ Hamon method(E_H)

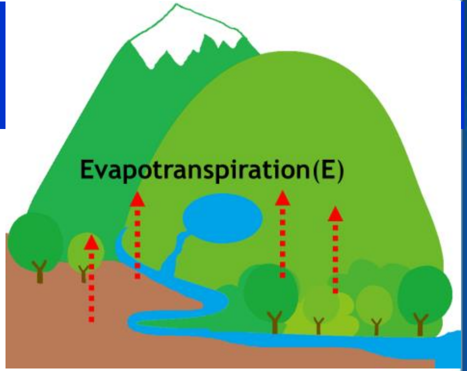
$E_H = 0.14D_0^2P_t$

D_0: D_0:Monthly average number of hours of possible sunshine

P_t : Absolute saturation humidity per monthly average temperature

Monthly average temperature : Japan Meteorological Agency(1992 -2011)

Evapotranspiration ratio



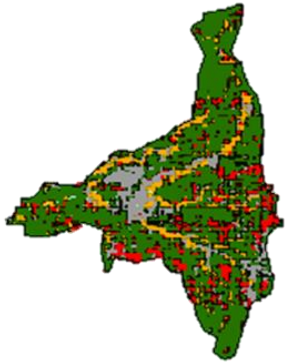
The evapotranspiration ratio was estimated by conducting land use classification by using ArcGIS 10.0(ESRI).

✓ Land use classification

Data : Land use subdivided mesh data from Nationl Land Numerical Information

Example

Land use ratio of Kamino river basin(%)



✓ Evapotranspiration ratio

Land use classification	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Paddy fields	0.45	0.45	0.55	0.60	1.00	1.05	1.25	1.30	1.30	1.20	0.70	0.55
Building sites/Roads/Railways	0.45	0.45	0.55	0.60	0.65	0.70	0.80	0.85	0.85	0.80	0.65	0.55
Forests/Wasteland	0.90	0.90	0.70	0.50	0.60	0.80	0.80	0.80	0.80	0.90	1.00	0.90
Agricultural land excluding paddy fields	0.85	0.75	0.80	1.65	0.70	0.75	0.70	0.75	0.90	1.00	1.00	1.00

Reference:Kaneko(1973)

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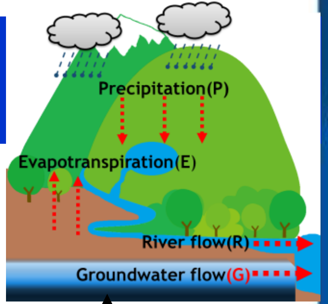
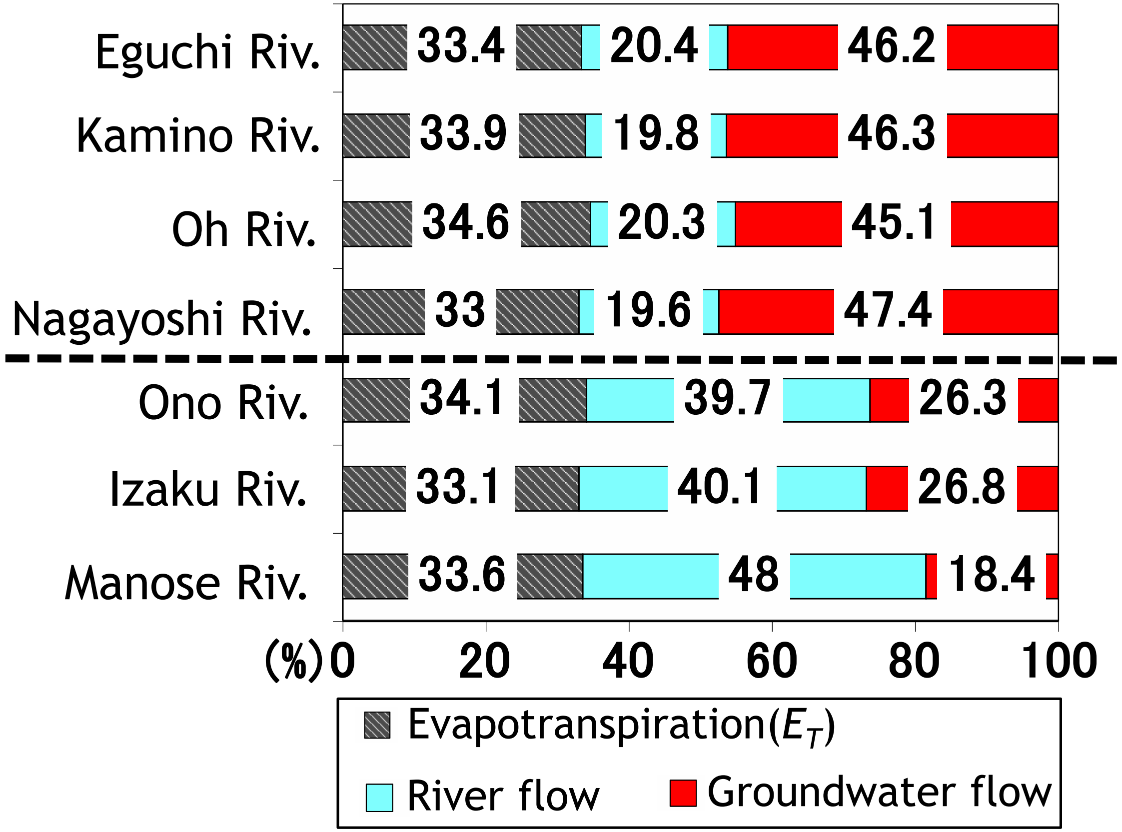
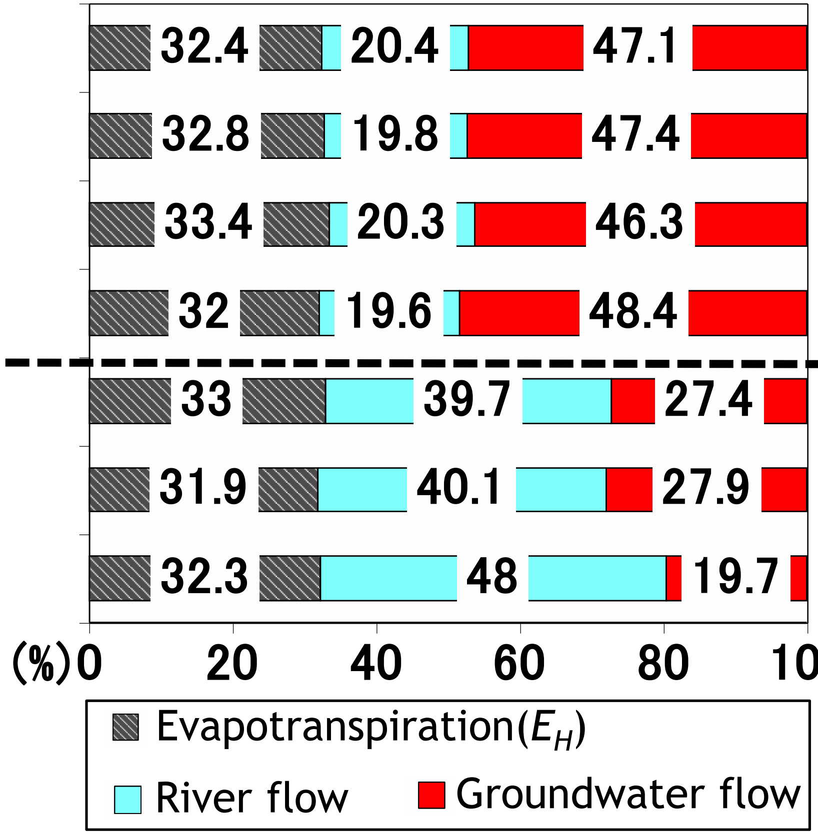
Ratio to total amount of precipitation



Thornthwaite method(E_T)



Hamon method(E_H)



North side

South side

	River flow	Groundwater flow
Average in the basin	29.7%	36.6～37.8%

$4.0 \times 10^8 m^3$/year
≒($12.7 m^3/s$)
Manose river: $13.3 m^3/s$

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Conclusions

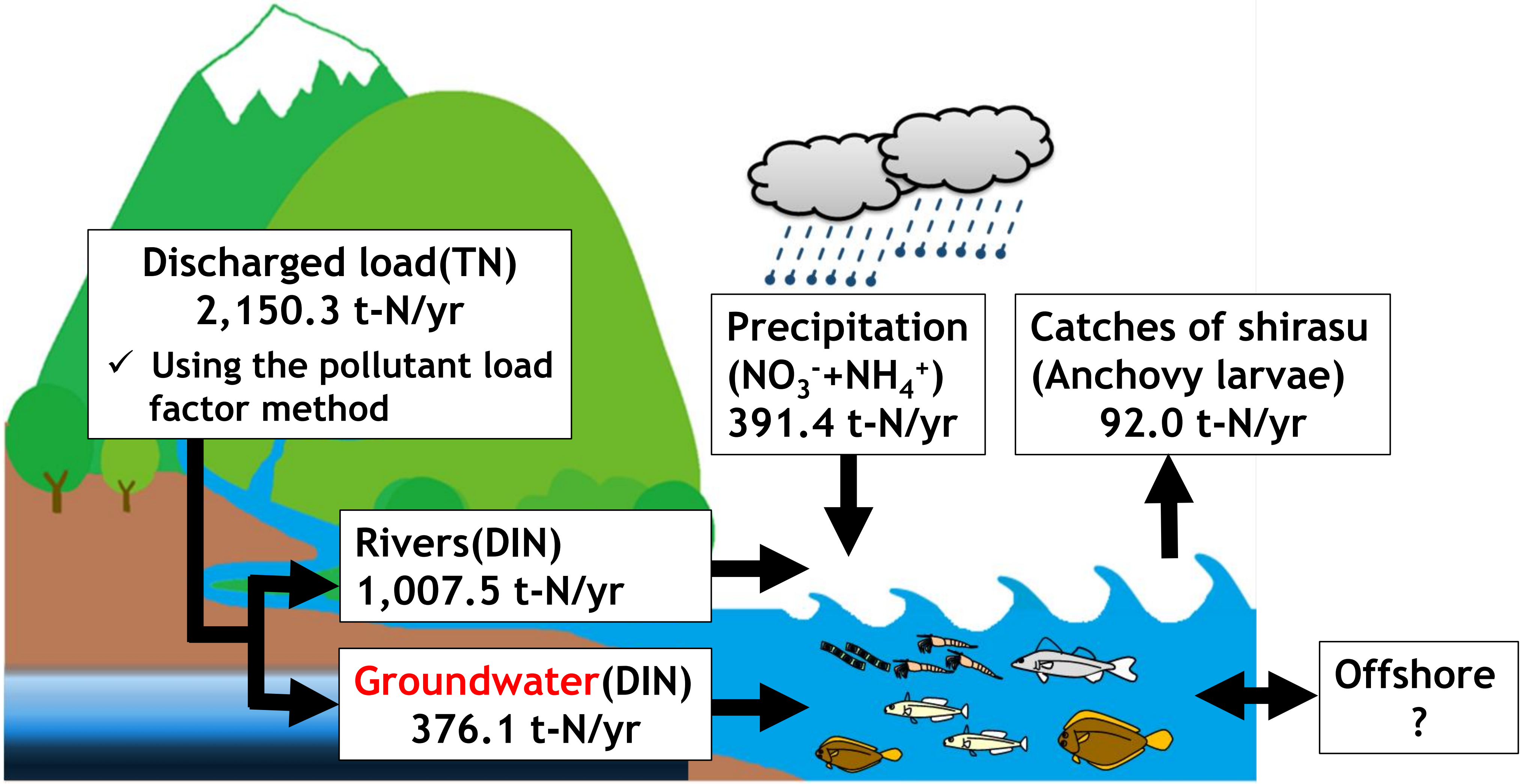
Major conclusions are as follows;

1) It is clarified that quantity of groundwater can be as large as 4.0×10^{8} m^3/year(12.7m^3/s), due to the large amount of precipitation and soil condition(much volcanic debris known as SHIRASU) for which permeability is high in general.

2) It is a macroscopic estimation using GIS, the groundwater flow is also important as a nutrient supply mechanism in the Fukiagehama basin.

Appendix

Nitrogen cycle in the coastal area of Fukiagehama



Thank you very much for your kind attention