Environmental damages valuation and I/O matrix

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1. Overview of the Nakhodka Oil Spill 1997 (By Kenji Katsuragi)

The oil-spill accident of Russian tanker "NAKHODKA" that occurred before dawn on January 2,1997 caused serious damages to the territory of the coastal region where the rights and interests were involved intricately. Moreover, the recovery operation was never adequate from the standpoint of ideal operation style and consideration to the environments.

A comprehensive assessment for the environmental impact due to the oil spill must be carried out to formulate the environmental policy or guideline for the future. The evaluation of the socio-economic damage from the oil spill is an especially important issue in order to decide how much resource should be devoted to protect the coastal environment against the oil spill.

The basic data from hearing research to fishery cooperative on fish and shellfish catch in recent years after the oil spill disaster in the market-based evaluation is as follows.

Table **Environmental Damages Valuation and I/O Matrix (Last page)**
(Proceeding of International Oil Spill Workshop on "Better Direction of Oil-Spill Warning and Restoration System in Japan",Feb.,2000,Kumagaya,Saitama p.146-7)

2. Measurement of the Environmental Value and Problems of Oiled Shoreline

2-1. Welfare Loss in Hegura-Jima Island Induced by the Nakhodka Oil Spill

(By Kazuyuki NAKAMURA)

(1) Introduction

In this paper, we estimate the damages to recreational activities from the Nakhodka oil spill in Hegura-Jima Island. Hegura-Jima Island, located about 50 km north of Noto Peninsula in the middle of Japan, is one of the best places for bird-watching in Japan, and is also a good place for recreational fishing. It draws more than 4 000 visitors in 1997, although the land area of the island is only 1.04 km^2. In the Nakhodka oil spill, the oil has come ashore on the northwest coast of the island. We can predict that the oil spill affect the demand for the natural resource based activities through a decrease in the environmental quality of the island.

We employ the travel cost method (TCM) to estimate welfare loss induced by the oil spill. The method estimates the demand for the site use from the data relating to the expenditures and behavior of visitors. The number of visits to a site serves as a proxy for the quantity variable, while the travel cost, which consists of monetary and opportunity cost, serves as a proxy for the price variable. The TCM is widely used for assessing the nonmarket user values of natural resource based activities such as bird-watching, recreational fishing and beach service.

As mentioned above, we must know both number and residence of visitors to apply the TCM. Fortunately, we can obtain both of them from the passengers list of Hegura-Kouro (Hegura Sea Line). Hegura Sea Line is the only one mode of access to Hegura-Jima Island. Thus we can apply the TCM for the whole visitors during the period to be estimated, which will lead us to an efficient estimation of the demand.[1)]

Furthermore, some of the difficulties with the TCM as pointed out in Randall (1994) are avoided in its application for Hegura-Jima Island. First, if an individual visits the several sites, then it will be difficult to allocate the total travel costs to the specific sites. This multiple visit journeys, however, may not be serious problem for applying the TCM to Hegura-Jima Island, because our interview survey reports that the 78% of visitors to the island is the single site visitor. Second, if some of the visitors have a substitute site for Hegura-Jima, then the TCM approach would yield incorrect results. However, this problem also may not be serious, because of uniqueness of Hegura-Jima Island. As the results, the simple TCM approach based on the partial equilibrium framework will be able to illustrate the good measurement of the damages to recreational activities from the Nakhodka oil spill in Hegura-Jima Island.

The rest of this paper is organized as follows. In section 2, we describe the analytical framework. We then show the demand function to be estimated. In section 3, we begin with discussing the data constructions and the econometric issues relating to functional form of the demand. We then estimate the demand function and the consumer surplus of the recreational activities in Hegura-Jima Island after the oil spill. In addition, we identify the damages to recreational activities in Hegura-Jima Island by the comparison between the number of visitors before and after the oil spill. Finally, we offer the concluding remarks in section 4.

(2) Analytical Framework

In this section, we describe a simple theoretical model to analyze the recreational demand. We assume that all consumers have the identical preferences. The consumers obtain their utility from site using recreational activities, other market goods and pure leisure. The utility function can be expressed by

$$u = u(x, z, q), \quad (1)$$

where x, z and q denote the recreational activity, the composite goods other than recreation and the pure leisure, respectively. The number of visit to the recreational site is used for measuring the consumption of recreational activity.

The welfare maximizing consumer subjects to two constraints: budget constraint and time constraint. The budget constraint for the consumer can be written as follows:

$$\pi + wl = px + z, \quad (2)$$

where π denotes the fixed non-labor income, w denotes wage rate, l is the time devoted to work. The monetary travel cost to the site is denoted by p. The price of composite goods is normalized by unity. For a given time endowment H, the time constraint of the consumer can be written as follows:

$$H = l + q + h(x), \quad (3)$$

where h(x) denotes the access hours to the site, which will include the loss of time due to fatigue caused by transportation.

Substituting (2) and (3) into (1), the optimization problem of the consumer becomes as follows:

$$\max_{x,l} u(x, \pi + wl - px, H - l - h(x)). \quad (4)$$

Solving this problem, we obtain the demand for the recreational activities as a function of prices and income as follows:

$$x = x(P, w, \pi). \quad (5)$$

In the above equation, P is the travel cost defined as $P \equiv p + wh'(x)$, which can be interpreted as the implicit price of recreation consisting of monetary travel cost and opportunity cost of scarce time.

Theoretically, TCM estimates the demand function described in (5). In the application stage, TCM is classified into two approaches: the zonal TCM (ZTCM) and the individual TCM (ITCM). Although the ITCM is a sophisticated method and consistent with the micro economic model discussed above, we employ the ZTCM because of data availability. The passengers list of Hegura Sea Line offers the complete information needed to apply the ZTCM. On the other hand, the ITCM requires additional information on the frequency of the visit by individuals, which will be obtained by interviews or mail survey of the limited visitors.

In the ZTCM, the demand equation to be estimated becomes as follows:

$$x^*_i(P_i, w_i, \pi_i) = X_i(P_i, w_i, \pi_i)/N_i, \quad (6)$$

where the subscripts i denotes the zone. The number of visitors from the ith zone and the number of population in the ith zone are represented by X_i and N_i, respectively.

From the demand function, we can calculate the net benefit of recreational activities in terms of consumer's utility. Consumer surplus represents the net benefit that individuals derive from the recreational activities in excess of their travel costs. The consumer surplus in the ith zone can be written as follows:

$$CS_i = N_i \int_{P_i}^{\hat{P}_i} x*_i(z, w_i, \pi_i)dz, \qquad x*_i(\hat{P}_i) = 0. \tag{8}$$

The consumer surplus in total is defined by $CS* = \sum_i CS_i$. Finally, the welfare loss induced by the oil spill is measured by comparing the consumer surplus before and after the oil spill

$$\Delta CS* = CS*_{AFTER} - CS*_{BEFORE}. \tag{9}$$

(3) Estimation

(3)-1 Data and definitions of variables

In order to estimate the demand equation, we compile the data for the number and residence of visitors from the passengers list of Hegura Sea Line during the period from January 1997 to October 1997. Table 1 presents the number of visitors by prefectures. The data does not include the visitors during the period from November to December. However, this lack of information does not become a serious problem, because the line is basically suspended in winter season. The passengers who live in Wajima-shi (Wajima City) are omitted from the sample, because they are regarded as the residents of the island or the visitors of business purpose. Thus 3,391 of 4,197 observations are used for the sample.

The length of trip is an important factor to be considered in the estimation of the demand function. However, we do not incorporate this factor into our estimation, because the difference of the length of trip among visitors is relative small. In fact, our interview survey reports that the 74.7 % of visitors stay one or two nights in Hegura-Jima Island

Prefectures are defined as the zone to calculate the visitor rate. The visitor rates are measured in per ten thousand of the population. The prefectures which do not have the visitors are excluded from the sample. Thus the sample zone is the 38 of 47 prefectures in Japan. The population by prefectures is obtained from 1997 Survey of the Resident Population by Ministry of Home Affairs (MHA).

We now turn to the travel cost. The travel cost consists of monetary travel cost and opportunity cost of scarce time. The monetary travel cost by prefectures is defined as the public transportation fares from the seat of the prefecutural office in each zone to Hegra-Jima Island. We assume that the visitors choose the least time consuming route.[2)] A number of visitors come to

Wajima City, where Hegura Sea Line leaves for Hegura-Jima Island, by using the automobile. However, at the equilibrium, the real travel costs will be the same between public transportation such as train and automobile.

The opportunity cost of scarce time is typically obtained from the travel time multiplied by time cost. Estimation of the time costs, however, is one of controversial issues in the TCM.[3] There is little agreement for the calculation of opportunity cost of time. In many applications, discounted wage rate is used for calculating the time cost. We estimate the demand functions based on three different opportunity cost of time: the time cost is evaluated at 50, 25, and 0 percent of the wage rate. The wage rate by prefectures is obtained from Basic Survey on Wage Structure 1997 by Ministry of Labor as $w_i = (C_i + B_i/12)/L_i$, where C_i and B_i denote the monthly scheduled cash earnings and the annual special cash earnings for male employees in the ith prefecture, respectively. The monthly work time in the ith prefecture is denoted by L_i. The travel cost in the ith prefecture is defined as follows:

$$P_i = m_i + kw_iT_i , \tag{10}$$

where m_i and T_i denote the monetary travel cost and the travel time from residence to Hegura-Jima Island in the ith prefecture. The discount rate of the time cost is represented by k (=0, 0.25, 0.5).

The other variable to be included in the demand function is the wage rate which can be interpreted as a proxy variable of the income or the price of pure leisure. We ignore the income factor except for the wage because of data availability. All price variables described above are adjusted by the regional difference index of consumer price 1997 reported in Annual Report on the Consumer Price Index by Management and Coordination Agency (MCA).

Table 2 presents the summary statistics of the variables. As discussed below, the coefficient of variance in the population, which is 0.867, suggests that we must take into account the heteroscedasticity in the estimation of the demand function.

(3)-2 Estimation procedure of demand function

To estimate the demand function, we have to specify the functional form. In addition, we must take into account the heteroscedasticity because we use the data aggregated by prefectures. Following Vaughan et al. (1982), we first estimate the following model of Box-Cox transformation with heteroscedasticity proposed by Lahiri and Egy (1981) :

$$x*_i^{(\lambda)} = \alpha_0 + \alpha_1 P_i^{(\lambda)} + \alpha_1 w_i^{(\lambda)} + \varepsilon_i , \tag{11}$$

$$\varepsilon_i \sim N(0, \sigma_i^2), \quad \sigma_i^2 = \sigma^2 N_i^{\delta} ,$$

$$z^{(\lambda)} = \begin{cases} \dfrac{z^{\lambda}-1}{\lambda}, & \lambda \neq 0 \\ \ln z, & \lambda = 0 \end{cases}, \quad z = x, P, w .$$

The set of parameters in (13), i.e. $(\alpha_0, \alpha_1, \alpha_2, \lambda, \delta, \sigma^2)$, is estimated by the maximum likelihood method, in which we use the iterative procedure called zigzag method as shown in Oberhofer and Kmenta (1979). At the same time, we estimate the equations in which some parameters are restricted as follows: log linear with homoscedasticitcity ($\lambda = \delta = 0$), log linear with heteroscedasticity ($\lambda = 0$), and Box-Cox with homoscedasticity ($\delta = 0$). Table 3 summarizes the estimation results in which only λ and δ relating to the next procedure are reported. Next, likelihood ratio test for these models is applied to specify the functional form. Table 4 summarizes the results. From table 4, we find the following facts: (i) log linear with hetero. is not rejected under 5% significance level; and (ii) other two models are rejected under 5% significance value. Therefore, we specify the demand function as follows:

$$\ln x^*_i = \alpha_0 + \alpha_1 \ln P_i + \alpha_1 \ln w_i + \varepsilon_i, \qquad (12)$$
$$\varepsilon_i \sim N(0, \sigma_i^2), \quad \sigma_i^2 = \sigma^2 N_i^{\delta} .$$

Table 5 shows the estimation results of (14). From table 5, we find that the coefficient on the travel cost, which is significantly different from zero, has negative sign. This indicates the downward sloping demand curve. On the other hand, the coefficient on the wage is not significantly different from zero except for the case of 50% discounted time cost.

(3)-3 Estimation of consumer surplus

We next turn to the estimation of the consumer surplus. The consumer surplus can be computed from the parameters estimated in the previous subsection. As pointed out in Stynes et al (1986), since our estimation is based on the log transformed function, we must take into account the log transformation bias; if the error term subjects to the normal distribution in log transformed function, then the retransformed function by taking anti logs used to estimate the consumer surplus subjects to the log normal distribution.[4)] Therefore the naive retransformation of the regression results yields an estimate of the conditional median function. If we intend to estimate the consumer surplus based on the conditional mean function, a modification of the naive retransformation is needed. There seems to be no consensus about which formula should be used for the TCM. Hence we calculate the consumer surplus according to the following formulas:

$$CS^*_M = -\frac{e^{\alpha_0}}{1+\alpha_1} \sum_i \left(P_i^{1+\alpha_1} w_i^{\alpha_2} N_i \right)$$

(13)

and

$$CS^*_E = -\frac{e^{\alpha_0}}{1+\alpha_1} \sum_i \left(e^{0.5\sigma^2 N_i^{\delta}} P_i^{1+\alpha_1} w_i^{\alpha_2} N_i \right)$$

(14)

where all parameters denote the estimated value in the previous subsection. Eq. (15) estimates the consumer surplus based on the conditional median value. On the other hand, Eq. (16), which follows (6) in Stynes et al. (1986), estimates the consumer surplus based on the conditional mean.

Table 6 represents the results of estimation. We find the consumer surplus within the range 5, 570 - 5,734 ten thousand of yen in conditional median case. In the conditional mean case, the estimated consumer surplus is within the range 3,973 - 4,248 ten thousands of yen. In the case of conditional median, table 7 represents the consumer surplus per ten thousand of population and its standard deviation evaluated at the weighted average of independent variables. The standard deviations are computed by using the Delta Method.[5)]

(3)-4 Loss of consumer surplus by the Nakhodka oil spill

The consumer surplus estimated in the previous section is that after the Nakhodka oil spill. We have to know the consumer surplus before the oil spill to consider the welfare loss due to the Nakhodka oil spill.

Fig. 1 shows the change in the number of visitors compared with the corresponding month a year earlier.[6)] We regard -0.9%, which is the average rate of change during the period from January 1995 to December 1996, as exogenous trend of the change in the number of visitors. After the oil spill, the number of visitors decreases 23% on average. Therefore we regard -22% as the decrease in the visitors caused by the oil spill. We assume that the number of visitors by prefectures decrease at the same rate. Under this assumption, the demand function before the oil spill is obtained by correcting the constant term of the demand function after the oil spill to upward by ln(1/0.78). Consequently, the loss of the consumer surplus is obtained by multiplying (0.22/0.78) to the consumer surplus estimated in the previous subsection.

Table 8 presents the loss of consumer surplus for six different cases. We can find that the loss of the consumer surplus is within the range 1,121 - 1,852 ten thousand of yen. It should be noted that the welfare loss estimated here is during the period form January to October in 1997. Further investigation into the number of visitors will allow us to identify the welfare loss from the oil spill in the long term.

(4). Concluding Remarks

In this paper, we consider the damages to recreational activities from the Nakhodka oil spill in Hegura-Jima Island. We show that the Nakhodka oil spill caused the welfare loss through the decreasing environmental quality in Hegura-Jima Island.

It should be noted that there are some limitations in our study. Our estimation does not reveal the comprehensive economic damages from the Nakhodka oil spill. From the definition of the TCM, we are only able to estimate the non market economic user value of the natural resource based activities in the Hegura-Jima Island. Therefore, the non market economic passive use values, which can be estimated by using the contingent valuation method (CVM), were not estimated. Furthermore, the oil spill has caused extensive damage on the shoreline of Hokuriku region. Then our estimation is only a small part of the welfare loss in total induced by the Nakhodka oil spill. Further research will be needed to asses the damages and to formulate the policy guidelines.

Notes

1). Sikida (1997) estimates the economic value of bird-watching in Hegura-Jima Island. He estimates the demand function based upon the interview survey.

2). In order to find the least time consuming route, we use the PC software "*Eki-spert*". This software is also used to calculate the transportation fares.

3). See, for example, Cesario (1976), Smith et al.(1983), and Shaw(1992).

4). See also Goldberger (1968).

5). See Greene (1997). It should be noted that, as pointed out in Krinsky and Robb (1986), the Delta Method may not provide a good approximation of the standard deviation.

6). In table 1, the residents of Wajima City are included in the number of visitors.

Table 1. The number of visitors to Hegura-Jima Island by prefectures (January - October, 1997)

Prefecture	visitors	Prefecture	visitors	Prefecture	visitors	Prefecture	visitors
Hokkaido	18	Kanagawa	81	Osaka	160	Fukuoka	20
Aomori	13	Niigata	26	Hyogo	108	Saga	0
Iwate	1	Toyama	440	Nara	19	Nagasaki	0
Miyagi	2	Ishikawa[a]	1,448	Wakayama	2	Kumamoto	4
Akita	0	Fukui	63	Tottori	2	Oita	0
Yamagata	15	Yamanashi	6	Shimane	0	Miyazaki	0
Fukushima	8	Nagano	94	Okayama	5	Kagoshima	1
Ibaraki	10	Gifu	32	Hiroshima	0	Okinawa	0

Tochigi	15	Sizuoka	73	Yamaguchi	2		
Gumma	29	Aichi	225	Tokushima	2	Wajima-Ci	805
Saitama	65	Mie	24	Kagawa	5	Unknown	1
Chiba	34	Shiga	20	Ehime	0		
Tokyo	218	Kyoto	100	Kochi	1	Total	4,197

a: Wajima City belongs to Ishikawa Prefecture. The number of visitors from Ishikawa does not include that of the residents of Wajima City.

Table 2. Summary statistics of variables

	maximum	minimum	average	coefficients of variation
visitor rates[a]	12.379	0.006	0.546	3.738
population of prefectures[b]	1154.915	61.938	295.041	0.864
monetary travel cost[c]	87.961	11.474	37.261	0.467
trip hours[d]	23.233	8.500	17.268	0.202
time costs[c]	55.669	19.361	40.773	0.202
hourly wage rate [c]	2.975	1.916	2.372	0.095
Travel cost in total [c]				
k=0	87.961	11.474	37.261	0.467
k=0.25	97.046	16.314	47.455	0.379
k=0.5	106.131	21.154	57.648	0.326

a: per ten thousands of population
b: in ten thousands
c: in thousands of yen
d: round trip to Hegura-Jima Island
All price variables are adjusted by regional difference index of consumer price

Table 3. Estimation results (1)

Model	②	[illegible]	Log Likelihood
k=0			
Box-Cox with heteroscedasticity	-0.089	-1.461	47.744
Log linear with homoscedasticity	0*	0*	42.466
Log linear with heteroscedasticity	0*	-1.509	46.868
Box-Cox with homoscedasticity	-0.099	0*	43.817
k=0.25			
Box-Cox with heteroscedasticity	-0.077	-1.485	48.670

Log linear with homoscedasticity	0*	0*	43.598
Log linear with heteroscedasticity	0*	-1.508	47.988
Box-Cox with homoscedasticity	-0.081	0*	44.527
k=0.5			
Box-Cox with heteroscedasticity	-0.067	-1.495	49.465
Log linear with homoscedasticity	0*	0*	44.552
Log linear with heteroscedasticity.	0*	-1.502	48.930
Box-Cox with homoscedasticity	-0.066	0*	45.185

* means subject to a priori restriction

Table 4. Model comparison

H_o	H_a	DF	$2\{L(H_a)-L(H_0)\}$	Critical χ^2, 5% level
k=0				
Log linear with	Box-Cox with	2	10.556	5.991
Log linear with	Box-Cox with	1	1.752	3.841
Box-Cox with	Box-Cox with	1	7.854	3.841
k=0.25				
Log linear with	Box-Cox with	2	10.144	5.991
Log linear with	Box-Cox with	1	1.365	3.841
Box-Cox with	Box-Cox with	1	8.287	3.841
k=0.5				
Log linear with	Box-Cox with	2	9.827	5.991
Log linear with	Box-Cox with	1	1.069	3.841
Box-Cox with	Box-Cox with	1	8.561	3.841

Table 5. Estimation results of the demand functions

	k=0	k=0.25	k=0.5
constant	14.498	16.301	17.942
	(2.227)	(2.535)	(2.810)
lnP	-2.058	-2.438	-2.761
	(6.602)	(6.967)	(7.277)
lnw	1.245	2.009	2.659
	(1.106)	(1.941)	(2.729)
δ	-1.509	-1.508	-1.502

	(4.898)	(4.895)	(4.875)
σ^2	2351.910	2205.391	2031.905
Log Liklihood	-46.945	-45.825	-44.882
N	38	38	38

Note: Parenthesized values are asymptotic t-values.

Table 6. Estimation of the consumer surplus (in yen)

	k=0	k=0.25	k=0.5
CS_M	39,728,503	40,513,564	42,480,149
per visitor	25,263	25,104	25,695
CS_E	56,074,346	55,707,565	57,337,179
per visitor	24,109	23,736	24,175

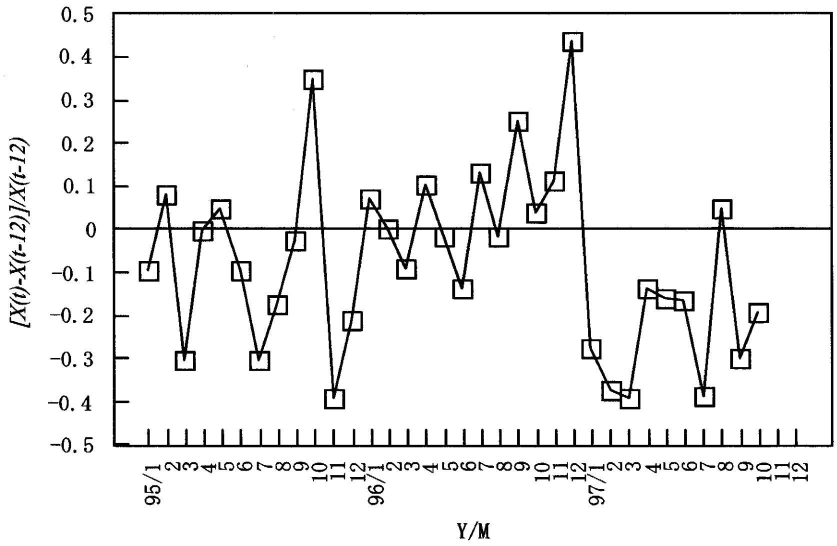
Note: Calculating the consumer surplus per visitor, we employ the estimated value from demand equation as the

Table 7. Consumer surplus per ten thousands of population evaluated at the weighted average

	k=0	k=0.25	k=0.5
CS_M	3368.90	3336.13	3408.84
Standard Deviation	1044.16	869.67	797.75
Weighted average values of variables			
Travel Cost	32504.91	43751.99	54835.84
Hourly wage rate	2558.68	2558.55	2557.75

Note: in yen.

Fig. 1. Change in the number of visitors to Hegura-Jima Island (with corresponding month a year earlier)



Source: Hergura-Kouro (Hegura Sea Line) passengers list

Table 8. Change in the consumer surplus (in yen)

	k=0	*k*=0. 25	*k*=0. 5
CS_M	−11, 205, 475	−11, 426, 903	−11, 981, 581
CS_E	−15, 815, 841	−15, 712, 390	−16, 172, 025

2-2. Review of environmental valuation at area, using the CVM: Design of environmental valuation methods: Research of Kaga-shoreline in Ishikawa Prefecture

(By Eiji OHNO)

Proposal for the new method to evaluate economic loss caused by an accident to the environment and resources around littoral regions

(1) Introduction

January 2nd in 1997, Russian tanker, Nakhodka, was wrecked around Okishima offshore and the oil spilled from it drifted to coastal areas along the Japan Sea. The accident gave serious contamination damaged to mainly Hokuriku region. As the result, the citizens came to know sharply seriousness of the marine contamination and difficulty of the coastal management. It is necessary to evaluate the monetary amount of damages for the mainly coastal management, but only the amount of physical damages has been focused so far. It seems insufficient in point of estimating environmental degradation.

There is an accumulation of researches of monetary evaluation for the environment. Usually, the CVM (contingent valuation method) is applied. In the CVM, environmental services are evaluated in the monetary value by asking directly to users their WTP (willingness to pay) or WTA (willingness to accept). It has been pointed early that answers are biased, that is, answers vary depending on questions. [Mitchell and Carson (1989)]. Further, the great deal of effort has been taken to develop research and analysis methods to avoid the bias.

Here, I want to raise a new question regarding the CVM. That is the validity of assessment of the environmental value by the WTP. By the way, in the WTA a result has a tendency of variation more than the WTP, so it is said that WTP is preferred to WTA. [Arrow et. Al. (1993)], WTA is not argued here.

One example is the problem of the sea-level rise caused by the global warming ［Ohno at al. (1996)］. Rising the sea-level is thought as serious environmental problem especially in the countries of the small islands, since it increases the high tide risk. However, these island countries are usually developing countries. The income levels are low, therefore, the WTP to restrain this problem is small, resulting in the conclusion of no countermeasure after the cost benefit analysis.

For the disaster restoration works in devastated areas in the event of Kobe Earthquake in 1995 and Nakhodka Oil Spill in 1997, many volunteer workers gathered and relief supplies and monetary donation were sent from the throughout the nation. In addition, at the event there were many voices heard to help restoration by labor not by money.

This research focuses on public awareness, including mental damage such as anxiety, caused by the oil spill, and suggests new approach, the WTW (willingness to work), to estimate the monetary value of volunteer works. The potential of the WTW will be studied through the estimation of the damages on seashore environment by Nakhodka Oil Spill.

(2) Difference between the WTP and the WTW

To present the difference between WTP and WTW in the environmental assessment, suppose the consumer's behavior as following.

$$\max_{\ell, x, y, z} \quad u[x, y, z;\ \varepsilon] \qquad \text{(1.a)}$$

$$s.t. \quad px + y \leq w\ell \qquad \text{(1.b)}$$

$$\ell + z = T \qquad \text{(1.c)}$$

here, $u[\,\cdot\,]$: utility function

x : amount of goods consumed

y : amount of numeraire goods consumed

z : leisure time

ε : the level of the environment

p : price of goods

w : rate of the wages
ℓ : labor hours
T : total hours

The formula (1.b) presents the budgetary constraint, and the formula (1.c) presents the time constraints. From those, the single formula for the constraint can be obtained by deleting labor hours, "ℓ".

$$s.t. \quad px + y \leq w(T - z) \qquad (1.d)$$

The Fig. 1 illustrates the question of the utility maximization of the formulas (1.a) and (1.d). If the utility function of Cobb-Douglas is given to the formula (1.a), isowelfare contour, v, in the illustration is shown in the indirect utility function as below.

$$v = v\left[\frac{wT}{p}, wT, T;\ \varepsilon\right] \qquad (2)$$

Next, in the case of the level of the utility is decreased, $(v^a \to v^b)$, because of the environmental deterioration, $\varepsilon^a \to \varepsilon^b$, with the conception of the compensatory vibration, CV, the deterioration is evaluated monetary in the WTP formulation.

$$v\left[\frac{w^b T}{p^b}, w^b T, T;\ \varepsilon^b\right] = v\left[\frac{w^a T - WTP}{p^a}, w^a T - WTP, T;\ \varepsilon^a\right] \qquad (3)$$

The figure 2 is the illustration of the formula (3).

In the meantime, the environmental deterioration is evaluated in terms of labor, not money, by the formulation of WTW as below.

$$v\left[\frac{w^b T}{p^b}, w^b T, T;\ \varepsilon^b\right] = v\left[\frac{w^a (T - WTW)}{p^a}, w^a (T - WTW), T - WTW;\ \varepsilon^a\right] \qquad (4)$$

The Fig. 3 is the illustration of the formulation (4). Now the relation of the WTP and the WTW can be presented as below, with the topology of the figure 2 and 3.

$$WTP \geq w^a \times WTW \qquad (5)$$

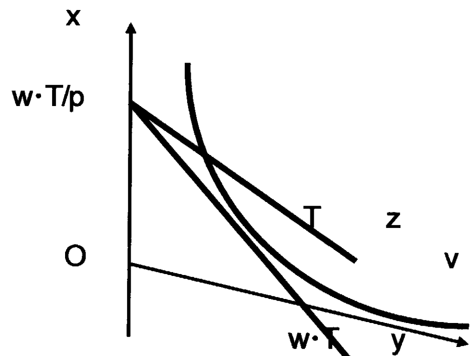


Fig 1　The question of the utility maximization

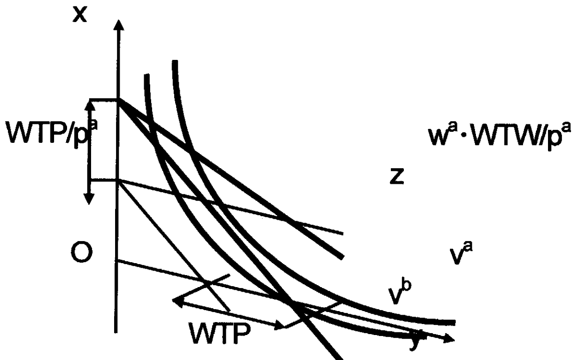


Fig. 2　WTP

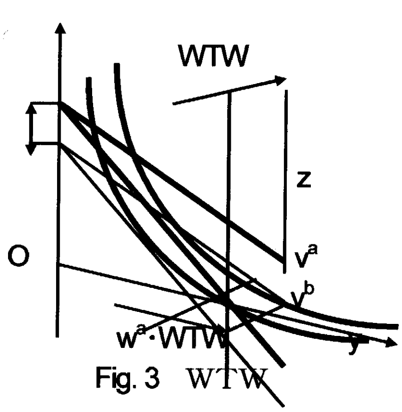


Fig. 3　WTW

(3) Estimation of the amount of the damages on seashore by the oil spill

3-1. Designing of the CVM survey

It has been pointed out that the variety of biases in the CVM assessment. To avoid them, an interview style survey is necessary for the CVM [Arrow et. Al. (1993)] ., In the research these 3 steps were taken because of the budgetary problem.

Step 1: Interview survey for affected people in the area (Kaga-city)

Step 2: Mailing style survey for affected people in the area (Kaga-city)

Step 3: Mailing style survey for people in the major cities in Japan

The aim of the step 1 and 2 is to examine the diremption between the assessment results of interview style and mailing style. The amount of the diremption is applied to the result of the step 3 to obtain the final result.

The outline of the CVM survey is listed in the table1, and questions are presented in the table 2 and 3.

Tab. 1　The outline of CVM survey

	Step 1	Step 2	Step 3
Month of survey	October, 1997	November, 1997	February, 1998
Area targeted	Kaga city	Kaga city	Major cities
Type	Interviewing	Mailing	Mailing

Number of postings	–	100	1,000
Number of collection	24	36	242

Tab. 2 Question regarding the WTP

*Q. Sea contamination caused by the Nakhodka Oil Spill accident gives serious damages to the scenery of fishing village and the ecosystem. Against any accident in the future in the coasts in Hokuriku Region to protect the costal environment as is presented in the picture, suppose that there is a plan to collect money as a contribution only one time this year for the restoration works. If the plan is carried out, the sea contamination will be restored soon after a accident, and consequently, there will be less damage ot the scenery of the fishing villages and the ecosystem. How much do you think is affordable to the plan?

1. ¥0 2. ¥100 3. ¥200 4. ¥300
5. ¥400 6. ¥500 7. ¥1,000 8. ¥2,000
9. ¥3,000 10. ¥4,000 11. ¥5,000 12. ¥10,000
13. ¥20,000 14. ¥30,000 15. ¥40,000
16. other (concretely : ¥)

Note 1) Please consider well that goods and services that you could buy will be decreased because of paying the contribution.
Note 2) According to the restoration works including collecting oil drifting offshore and reached on shore in Ishikawa prefecture, about ¥400 a household in whole Japan (It is converted to about ¥20,000 a household in only Ishikawa Prefecture) was estimated.

Note) In the survey of the affected area, WTP was answered.

Tab. 3 Questions regarding WTW

*Q. If you asked to join the restoration, as you see in the picture, n volunteer base, not to paying money, in order to protect the costal environment in the Hokuriku Region, presented in the picture, how many times can you join, and how many days can you work a time?

About ( ) time(s) ··· ( ) days per time

Note) In the survey of the affected area, hours to work was answered.

3-2. Estimation of the amount of damages

The table 4, 5, and 6 show the evaluation of damages on the costal environment by the CVM survey. Since there was a big distribution in the survey of each stage in the CVM surveys, the top10% and the lowest 10% were omitted from the samples for counting.

First, the table 4 shows the result of the WTP evaluation. As you see, the values from interviewing survey are bigger then ones of the mailing survey (about 1.17 time) and the values from the local survey are bigger than ones from major cities (about 2.63 times). The division of the former case seems to come form the difference in surveying methods. There are some reasons of this diivision: how much the questions are understood or whether surveyors have awareness well or not. When the deviance is applied to the value of the result from major cities, the amount of damages is ¥2,700 a person. On the other hand, it is considered a private passion to the coastal environment such as physical or mental distance to the affected areas causes the divisionof the latter case. Therefore, it needs to examine a factor distribution for the evaluation of total amount of damages as well as for the factor analysis for the WTP.

Next, the table 5 is the result of the WTW evaluation. You will understand that the values of interviewing survey are bigger than ones of the mailing survey (about 3.14 times) , and values from the local survey are bigger than one from major cities (about 8.09 times). These are similar to the result of the WTP evaluation.

The corresponding monetary values of the WTP and the WTW are listed in the table 6 As it shows, the values of the WTW are bigger than one of the WTP. The wage rate, formula (5), was applied to convert the WTW values to the monetary one. However, the magnitude relation has discrepancy from the formula (5). The possible reason is the difference between contribution (WTP) and volunteer works (WTW) regarding compassion. Compassion means here satisfaction obtained from social contributions. The respondents might answer in consideration of this satisfaction [Arrow et. Al. (1993).] If volunteer works have rather impression than monetary donation, the WTW must be bigger than the WTP. In addition, volunteer works on holidays or paid day-off or have small financial burden., so the WTW value will be much bigger. They are the point for the future research.

Meanwhile, if the deviance (about 3.14 times) between the interviewing survey and mailing one is applied to the value from major cities, the amount of damages will be about ¥100,000 a person. However, traveling costs to the affected area should be added, actually,. Therefore, especially the respondents in the remote places possibly undervalue.

Although the questions conform to the premise of " WTP OR WTW." there should be people who think both of "WTP AND WTW." This is an issue for the future. In addition, the correlation is presented in the table7. As you see, there is no relation between them

Tab. 4 The result of WTP (a person)

	Interviewing in the affected area	Mailing to the affected area	Mailing to the major cities
Average value	¥7,100	¥6,077	¥2,309
Standard deviation	¥8,385	¥5,892	¥2,548
Number of samples	20	28	194

note) The top 10% and the lower 10 % were excluded from the sample.

Tab. 5 The result of WTW (a person)

	Interviewing in the affected area	Mailing to the affected area	Mailing to the major cities
Average value	385.8 hours	123.0 hours	15.2 hours
Standard deviation	263.1 hours	150.9 hours	19.2 hours
Number of samples	20	28	194

Note1) The top 10% and the lower 10 % were excluded from the sample.
Note2) In the survey of the major cities in Japan, hours to work for a day was set as 8 hours.

Tab. 6 The result of the amount of damages (a person)

	Interviewing in the affected area	Mailing to the affected area	Mailing to the major cities
WTP	¥7,100	¥6,077	¥2,309
WTW	¥810,180	¥258,300	¥31,920
WTW/WTP	114.1	42.5	13.8

Tab. 7 Correlation of WTPとWTW

	Interviewing in the affected area	Mailing to the affected area	Mailing to the major cities
R^2	0.115	-0.071	0.144

(4) Conclusion

This research proposes the WTW evaluation in the CVM framework as a monetary evaluation, and applies to the estimation of loss of the environmental damages by Nakhodka Oil Spill to examine its potential. The results are:

① The evaluation of mailing survey < The evaluation of interviewing survey
②The evaluation of major cities < The evaluation of the locality
③WTP evaluation a parson : about ¥ 7,100 as the local average, and about ¥ 2,700 as the national average.
④WTW evaluation a parson : ¥ 810,000 as the local average, and about ¥ 100,000 as the national average.
⑤No relation between WTP evaluation and WTP evaluation.

Meantime, regarding the difference between WTP and WTW, theoretically (in the framework of the theory of the consumer s' behavior),

⑥WTP evaluation > WTW evaluation

However, this magnitude relation is reverse in the result . There is an inconsistency. It is thought that the difference between monetary donation and volunteer works may be the reason. The investigation into the cause is the research issue for the future.

3.Summary and Conclusions

The grounding of the NAKHODKA in Japan Sea unleashed a flurry of activity to contain and clean up the crude oil, rescue and rehabilitate affected animals (birds), and determine the impact of the spill on the environment.

A priority was to relieve the distress and suffering brought about by oil contamination to the area's wildlife.

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Of course, all remaining errors are responsible for the JST Project.

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Table Environmental Damages Valuation and I/O Matrix.

Shoreline area / Mesh No.	Item	(unit)	Mikuni Total	Shioya Total	Monzen Total	Wajima Total	Hegura·Nanatsu Is Total	Machino Total	Suzuhokubu Total	Noroshi Total	Takojima Total
Nature Account	invertebrate in shallows										
	a hardcoral (*Rhizopsammnia minuta mutuensis*)					1	1		1		
	a sea feather (*Cavernularia obesa*)										1
	a sea anemone (*Actinia equina*)				1				1		
	a snail (*Siphonaaria acmaeoides*)							1			
	a clam (*Pharaonella sieboldii*)										1
	a cowrie (*Palmadusta artuffeli*)									1	
	a cowrie (*Purpuradusta gracilis*)									1	
	Preserved rocky shores			1	1	1	1	1	1	1	1
	Preserved beach			1	1			1			1
	Preserved intertidal zone			1	1			1	1	1	
	Conserved coastal flora			1			1			1	1
	Breeding place of;										
	streaked shearwater (*Calonectris leucomelas*)						1				
	Shinhoe's storm-petrel (*Oceanodroma monorhis*)						1				
	Japanese murrelet (*Synthliboramphus umizusume*)						1				
	Temminck's cormorant (*Phalacrocorax capillatus*)						1				
	black-tailed gull (*Larus crassirostoris*)						1				
	Classificated by Cluster Analysis			A	A	B	C	A	B	D	D
Semi-Nature a/c	fixed shore net(trap)		1	1	11	5		5	5	6	7
	culture fisheries		0	0	0	1		0	0	1	4
	operating unit for collection of seaweed		164	0	128	121		42	60	75	36
	operating unit for shellfishery		162	0	0	115		58	102	80	0
	operating unit for gillnet fishery		0	10	104	194		66	81	102	41
	operating unit for squir jigger fishery		0	14	0	0		0	0	0	0
	operating unit for seine net fishery(on boat)		0	0	0	0		0	0	0	0
	operating unit for longline fishery		0	0	0	0		0	0	0	43
	operating unit for fishing			12	121	0		0	0	0	0
	other operating unit		174	0	0	0		0	0	0	0
	sport fishing guides	persons	23	21	2	0		0	0	1	0
	the total number of sport fishermen a year	hundred persons	472	66	56	53		13	51	53	45
	fishing spot										
	bird-watching spot										
Man-made a/c	fishing port		4	1	6	5		2	2	2	1
	fishing boats	the number of boats	185	22	246	529		119	170	156	142
	nonpowered boats	the number of boats	7	0	3	6		7	0	1	2
	outboard motor boats	the number of boats	104	4	173	177		96	138	100	60
	powered fishing boats	the number of boats	74	18	70	346		16	32	55	80
	park										
	beach										
	fishing village										
	Fisheries Cooperatives	number	2(2)	2(1)	0(1)	2(1)		3(0)	0(1)	0(3)	0(1)
	Fishery working Household	household	72	3	13	116		3	5	7	113
	members of fishery household	persons	1155	82	538	1968		320	463	471	772
	fisherman	persons	391	22	226	800		114	190	190	241
	fish market	number	1	1	0	1		0	0	0	1
	freezer and icebox factories	number	7	1	0	2		0	0	0	1
	marine product factories	number	8	0	2	19		0	0	0	3
	the total population	persons	23564	1899	10178	22906		7697	2021	2240	6876
	the total number of the household	household	6745	572	3419	7053		2229	625	713	1941
	main industry in zone		3rd	3rd	3rd	3rd	Agri.&Forestry	3rd	Agri.&Forestry	Agri.&Forestry	Agri.&Forestry
	weight of fisheries household	%	1.07	0.52	0.38	1.64		0.13	0.80	0.98	5.82
	weight of fisherman	%	1.66	1.16	2.22	3.49		1.48	9.40	8.48	3.50
	Total operating unit		253	18	176	342		72	129	125	96
	Avarage fishery catch per unit	ten thousand yen	582	479	138	1213		325	177	171	3861
	Total fishery catch	million yen	1,472	86	243	4,148		234	228	214	3,707

THE STATISTICAL ANALYSIS OF MANUAL REMOVAL OF STRANDED OIL SPILLS: LESSONS LEARNT FROM OIL SPILLS CAUSED BY RUSSIAN TANKER NAKHODKA

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ABSTRACT

In 1997, the Russian tanker Nakhodka, weighing 13,157 tons, sank off in the Japan Sea reportedly causing an oil spill. The oil spill had a serious impact on the shoreline environment. The purpose of this poster is to present the key to decide how many work force we need to prepare for shoreline cleaning-up process without decreasing its efficiency or redundancy. Therefore, this study aims to estimate the parameters of oil removable (the amount of oil that can be removed manually), and to explain the framework in which those parameters work. The result shows that the amount of oil removed on a day correlate with the cumulative amount of oil removed and the number of people engaged in cleaning up on that day. The equation predicting the amount of oil removed on sandy beach is:

$$S = 13.4827\,E - 0.03874\,C + 38458.1525$$

$$R^2=0.918,\quad F(2,34)=192.28,\ p<0.01$$

Where S=the amount of oil removed on a day (liter), E=the number of people engaged in cleaning up on a day, C=cumulative amount of oil removed (liter), R= correlation coefficient, F=degree of freedom.

It is possible to estimate the total amount of stranded oil that can be collected on a certain day and the number of people necessary to remove spilled oil at the most efficient rate. If we can use this equation, it is likely to calculate optimal number of work force.

INTRODUCTION

On the 2nd of January 1997, the Russian tanker Nakhodka, weighing 13,157 tons, sank off Oki Island in the Japan Sea reportedly causing an oil spill of 6,240 kiloliters. In spite of offshore oil collection attempts, and as a result of strong winds and rough winter weather, a large amount of spilled oil drifted into the Japan Sea. Consequently, vast amounts of this heavily emulsified oil washed up on the Japan Sea side shoreline of Ishikawa Prefecture. The oil spill had a serious impact both ecologically on the shoreline environment and economically on coastal activities such as fisheries and tourism.

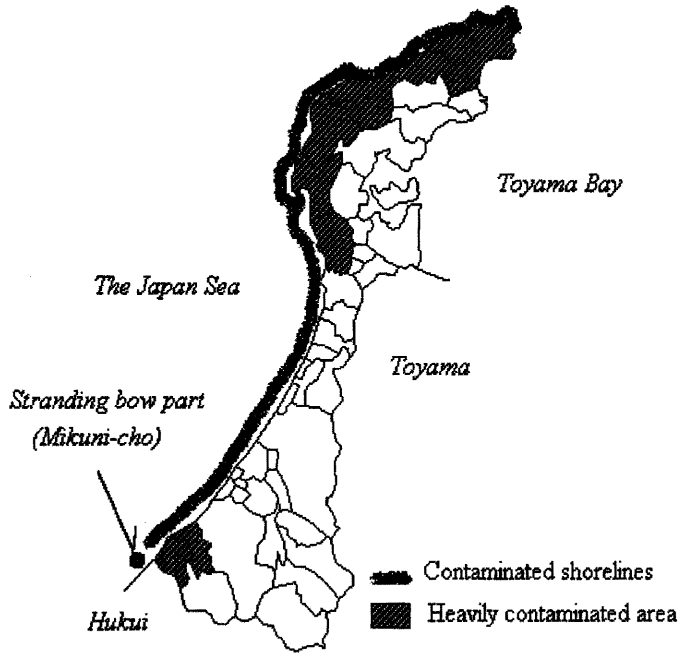

Figure 1 Geographic description of the Ishikawa Prefecture and the oil contaminated area

This study aims to estimate the parameters of oil removable (the amount of oil that can be removed manually), and to explain the framework in which those parameters work. The target area in this report is Ishikawa Prefecture where the official reports on shoreline cleaning-up process are available. The geographic description of the Ishikawa Prefecture and the oil contaminated area is shown in Figure 1.

METHOD

Sample description and experimental method

Data on manual oil recovery process are collected by way of on-site statistics form each municipalities in Ishikawa prefecture. The period of data collection for the analysis is from January 8, 2003 to March 30 when the organized oil recovery was terminated. The data for the estimation of parameter of multiple linear regression analysis were prepared from the first day to the end of manual recovery operation. Data of the day that the recovery operation was cancelled by the severe weather condition was excluded because the author observed that the amount of the stranded oil was unchanged unless the recovery operation progress. In addition, a multiple linear regression analysis was conducted for the data at sandy and rocky beaches separately because these are significant differences in geographical conditions between both beaches.

RESULTS

The on-site countermeasures were organized mainly by the municipal governments immediately after the oil stranding. The measurement actions were guided and directed by the prefectural government. However, the action seemed to be disorganized, because of the lack of sufficient information on oil spills. The main reason was that there had been no major oil spill in the area. Apparently, the lack of sufficient information combating oil spill caused disorder in the counter actions. This caused serious disorganized action on every oil contaminated shoreline.

Great efforts were made to clean up the shorelines, chiefly by manual removal of

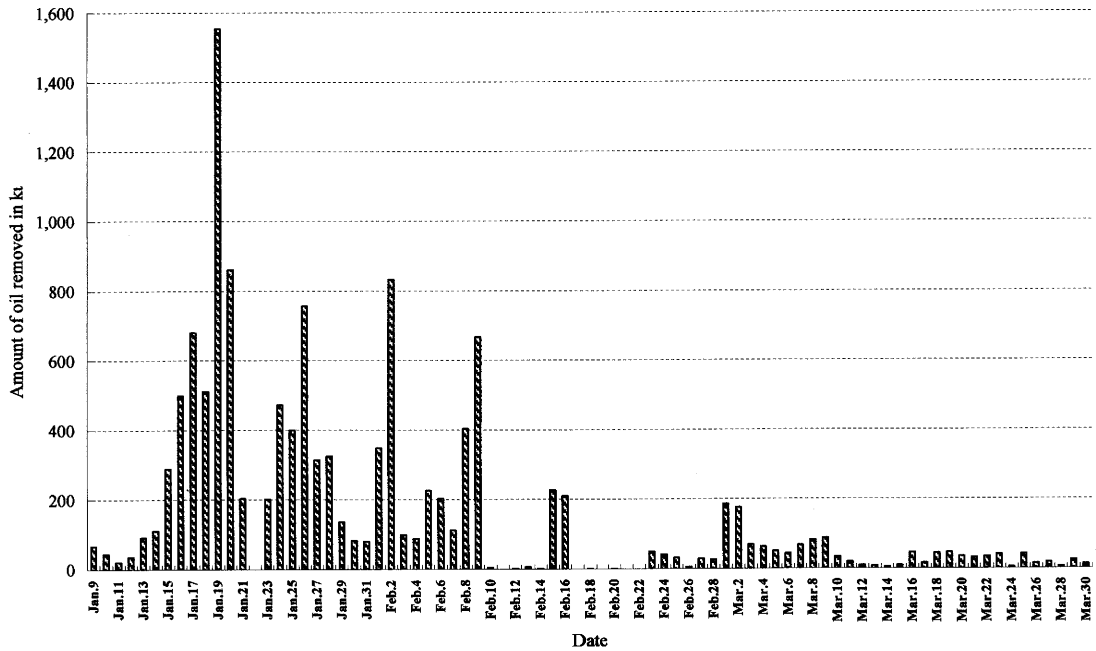

Figure 2 Observed changes in the amount of oil removed manually in Ishikawa Prefecture

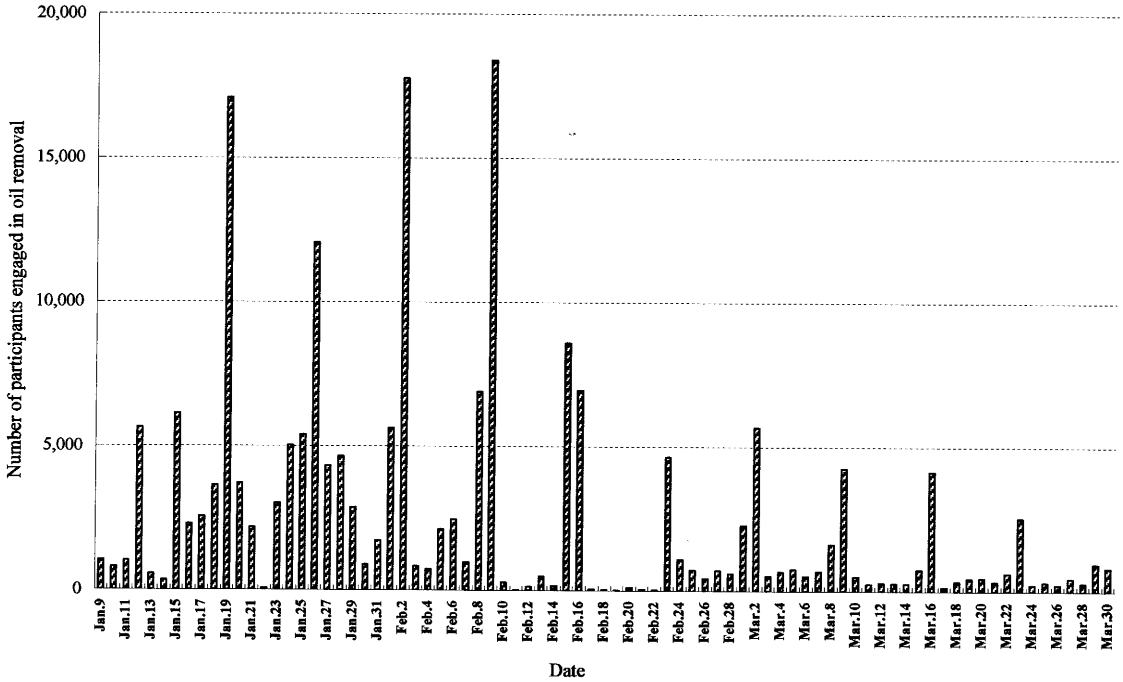

Figure 3 Observed changes in the number of participants engaged in manual oil removal in Ishikawa Prefecture

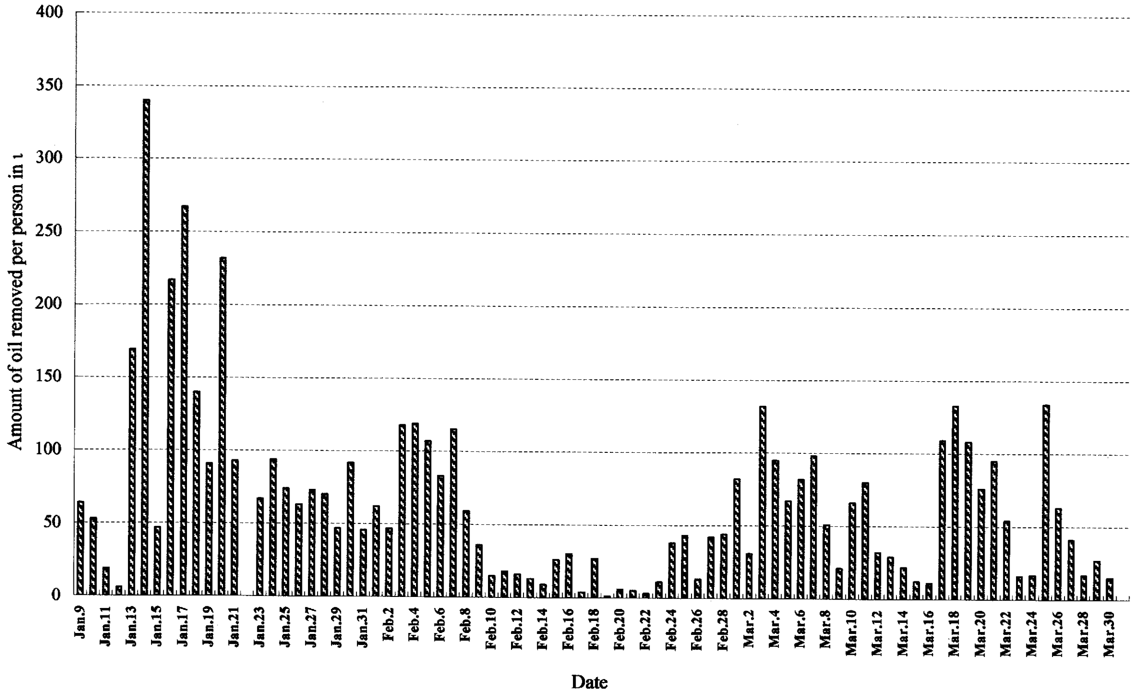

Figure 4 Observed changes in the amount of oil removed manually per person.

the spilled oil. In Ishikawa prefecture, located in the middle of the mainland of Japan, more than 200,000 local people, volunteers, public officials and self-defense force members participated in the cleaning of the polluted shorelines. However, in their haste to collect it quickly, there was little training and so the volunteers were not able to optimize their logistics and efforts.

Figure 2 describes observed changes in the amount of oil removed manually in Ishikawa Prefecture from the commencement of shoreline cleaning-up to the end of official oil recovery operation. The amount of oil collected increased until January 20, and decreased thereafter. The number of participants in manual oil removal showed no particular inclination except for marked rises (Figure 3). These drastic increases occurred on weekends.

In order to examine the day-to-day efficiency, the author calculated the amount of oil removed manually per person using the previously mentioned data. Figure 4 helps to define the daily change. The amount of removed oil per person decreased after January 14, 5 days after the commencement of official oil removal operation in Ishikawa Prefecture.

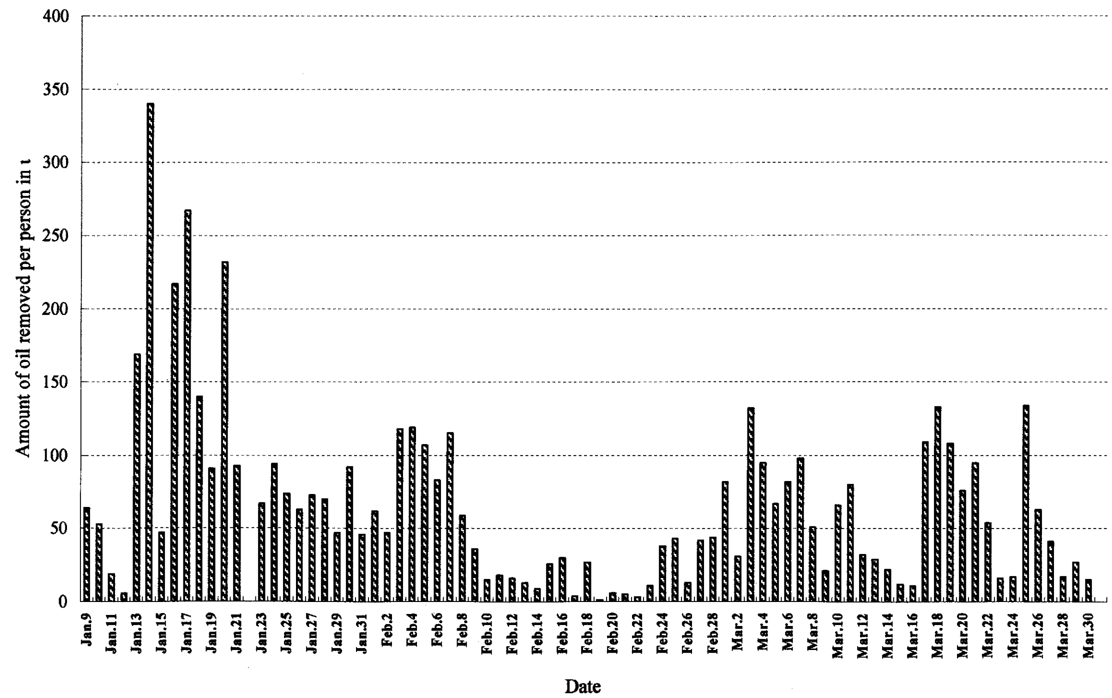

Figure 5 Comparison of observed amount of oil removed manually at sandy beaches in Ishikawa Prefecture, and amount estimated using model equation

DISCUSSION

The result shows that there is a significant correlation between the amount of oil removed on a day and, the cumulative amount of oil removed and the number of people engaged in cleaning up on that day. The equations predicting the amount of oil collected calculated from the data obtained from sandy and rocky beaches in Ishikawa Prefecture are:

Sandy Beach;
$S = 13.4827\,E - 0.03874\,C + 38458.1525$ $R^2=0.918$, $F\,(2,34) = 192.28$, $P<0.01$
Rocky beach;
$S = 104.0676E - 0.0267C + 225937.022$ $R^2= 0.776$、$F(2,50)=86.621$, $p<0.01$

Where S=the amount of oil removed on a day (liter), E=the number of people engaged in cleaning up on a day, C=cumulative amount of oil removed (liter), R= correlation coefficient, F=degree of freedom.

The above equation is likely to predict the amount of oil removed per day based on the number of participants and the cumulative amount of oil removed. Figure 5 shows the comparison of oil removed and estimated amount of oil at sandy beach using the above equation. As sketched here, the equation can well estimate the amount of oil removed on-site. The same can be said at rocky beach based on the equation.

Finally, it is suggested from the above equation that it is possible to estimate the total amount of oil on the beach that can be removed on a certain day, based on data collected on particular site. It is also possible from this to calculate the number of people necessary to remove the spilled oil at the most efficient rate. This will clearly be a great contribution to efficient manual removal of washed up oil spills in the future.

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HEAVY OIL SPILLED FROM RUSSIAN TANKER "*NAKHODKA*" IN 1997:Towards eco-responsibility, Earth Sense

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1997年，ロシア船籍タンカー「ナホトカ号」の重油流出事故：地球的視野に立った生態系への責任

田崎和江（編集）

金沢大学21世紀COEプログラム
環日本海域の環境計測と長期・短期変動予測
－モニタリングネットワークの構築と人為的影響の評価－
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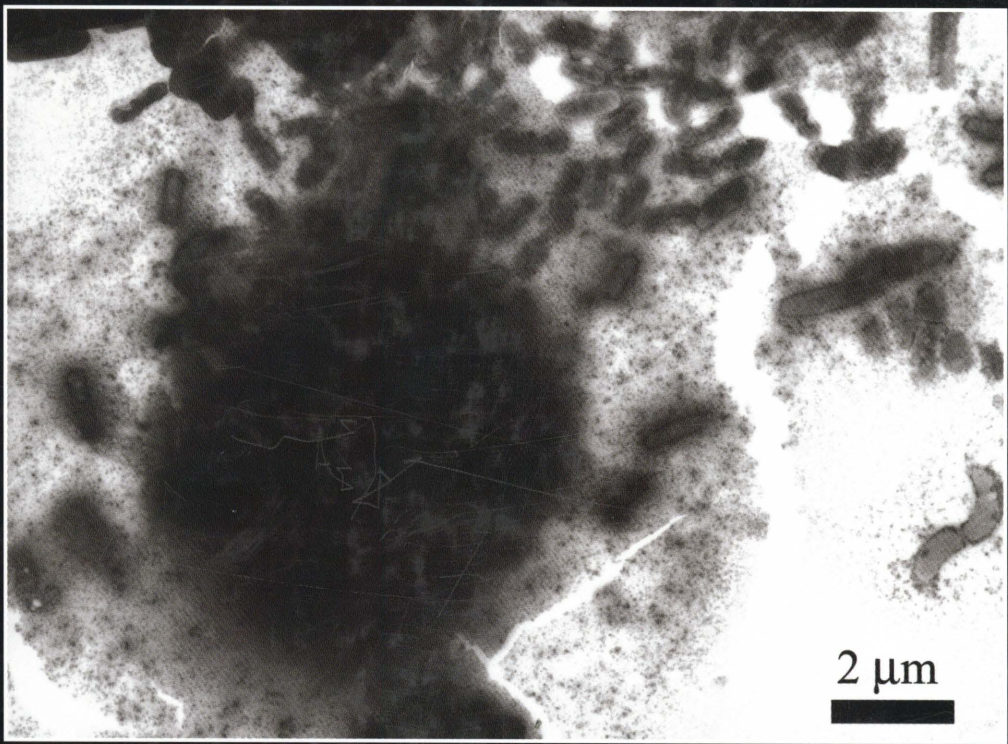
Cover : Local people, soldiers and volunteers worked to clean up oil stained beach on the coast of Mikuni, by using scoops, buckets, and hand-powered machines on January 10th 1997. (By Kazue Tazaki, Kanazawa University)

Back Cover : TEM microphotograph showing microorganisms habiting in the slick of the heavy oil which had been dropped on the seawater. Dark round area is a droplet of heavy oil. Small particles scattered in the slick are halite grains. (By Osamu Nishikawa, Kanazawa University)

表紙 ; 1997年1月10日，三国町安東における地域住民，自衛隊，ボランティアによる重油回収作業（田崎和江撮影）.

裏表紙 ; 油滴の周囲に生息する微生物の透過型電子顕微鏡写真（西川 治撮影）.



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