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Overwater Turbulence Intensity

Discovering Thoughts, Inventing Future

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Overwater Turbulence Intensity during Hurricane Katrina and Typhoon Russ

By Professor S. A. Hsu
Louisiana State University, USA

Abstract- When Hurricane Katrina was over the Gulf of Mexico in 2005 an unprecedented significant wave height ($\boldsymbol{H_s}$) of 17 m was measured at the National Data Buoy Center (NDBC) station 42040. Using this extreme $\boldsymbol{H_s}$ value and those from NDBC Buoy 42003 in the Gulf of Mexico during Katrina and Buoy 52009 during Typhoon Russ near Guam in the Pacific in 1990, it is found that approximately 85% of the variation in turbulence intensity (TI) over the wind seas can be explained by the variation in $\boldsymbol{H_s}$. Application of this relation between TI and $\boldsymbol{H_s}$ shows that the estimated drift velocity is in excellent(over 95%) agreement with that measured during Hurricane Ivan.

Keywords: hurricane katrina - power law wind profile - roughness length - turbulence intensity - typhoon russ.

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Overwater Turbulence Intensity during Hurricane Katrina and Typhoon Russ

Professor S. A. Hsu

Abstract- When Hurricane Katrina was over the Gulf of Mexico in 2005 an unprecedented significant wave height ($\boldsymbol{H_s}$) of 17 *m* was measured at the National Data Buoy Center (NDBC) station 42040. Using this extreme $\boldsymbol{H_s}$ value and those from NDBC Buoy 42003 in the Gulf of Mexico during Katrina and Buoy 52009 during Typhoon Russ near Guam in the Pacific in 1990, it is found that approximately 85% of the variation in turbulence intensity (TI) over the wind seas can be explained by the variation in $\boldsymbol{H_s}$. Application of this relation between TI and $\boldsymbol{H_s}$ shows that the estimated drift velocity is in excellent(over 95%) agreement with that measured during Hurricane Ivan.

Keywords: hurricane katrina - power law wind profile - roughness length - turbulence intensity - typhoon russ.

I. Introduction

According to Glickman (2000), turbulence intensity (TI) is the ratio of the root-mean-square of the eddy velocity to the mean wind speed. Following Panofsky and Dutton (1984), for strong winds, the power-law wind profile may be applied that,

$$\frac{U_2}{U_1} = \left(\frac{Z_2}{Z_1}\right)^p, \tag{1}$$

Where U_1 and U_2 are the wind speeds at height Z_1 and Z_2, respectively, and "*p*" is the exponent of the power law.

In addition, according to Hsu (1988, pp.199-200, and 2003), this exponent, *p*, is also related to the logarithmic wind profile law so that

$$p = 1/\ln\left(\frac{10}{Z_0}\right) = \left(\frac{U_*}{kU_{10}}\right), \tag{2}$$

Where *p* is named here as the turbulence intensity, Z_0 is the aerodynamic roughness length, U_* is the friction velocity, k (=0.4) is the von Karman constant, and U_{10} is the wind speed at 10 *m*.

Now, according to Taylor and Yelland (2001),

$$\frac{Z_0}{H_s} = 1200\left(\frac{H_s}{L_p}\right)^{4.5}, \tag{3}$$

And, for deep water waves,

$$L_p = \left(\frac{gT_p^2}{2\pi}\right), \tag{4}$$

Where H_s and L_p are significant wave height and peak wavelength for the combined sea and swell spectrum, respectively, and T_p is its corresponding wave period. Note that the parameter $(\frac{H_s}{L_p})$ is called wave steepness.

In order to minimize the swell effects, the criterion for the wave steepness as set forth by Drennan et al. (2005) is used such that, for the wind seas,

$$\frac{H_s}{L_p} \geq 0.020, \tag{5}$$

From Equations (2) and (3), it is clear that TI is related to the wave characteristics. Since H_s can be measured by remote sensing systems such as satellite altimetry (see, e.g., Wang and Oey, 2008), the purpose of this research note is to find a relation between TI and H_s, so that TI may be estimated from H_s, particularly during tropical cyclones.

II. Datasets and Analysis

Three datasets are employed in this study. They are based upon the measurements made by the National Data Buoy Center (see www.ndbc.noaa.gov) and all analyses are according to Equations (1) thru (5):

a) Typhoon Russ

According to the Joint Typhoon Warning Center (see http://www.usno.navy.mil/NOOC/nmfc-ph/ RSS/ jtwc/atcr/1990atcr.pdf). TyphoonRuss, the last western North Pacific tropical cyclone of 1990, was the most severe to strike Guam in 14 years. During the passage of Typhoon Russ in 1990, the U. S. National Data Buoy Center (NDBC) (see, www.ndbc.noaa.gov) owned and maintained a station near Guam, Buoy 52009, which measured Hs and Tp. The data are presented in Table 1, which will be incorporated into a much larger datasets during Hurricane Katrina over the Gulf of Mexico as provided in the next section.

Author: Louisiana State University, Baton Rouge, LA, USA.
e-mail: sahsu@lsu.edu

Table 1 : Measurements of significant wave height (Hs) and dominant wave period (Tp) at Buoy 52009 in December 1990 during Typhoon Russ (Data source: www.ndbc.noaa.gov).

Day	Hour, UTC	Hs, m	Tp, sec	Hs/Lp	Zo, m	1/Ln(10/Zo)
16	1	2.1	8.3	0.020	5.1E-05	0.08
16	3	2.2	7.7	0.024	1.3E-04	0.09
17	14	2.2	7.1	0.028	2.7E-04	0.10
17	15	2.2	7.1	0.028	2.7E-04	0.10
17	20	2.1	7.1	0.027	2.1E-04	0.09
17	21	2.3	7.7	0.025	1.7E-04	0.09
17	23	1.9	7.7	0.021	5.8E-05	0.08
18	0	2.1	7.1	0.027	2.1E-04	0.09
19	18	5.4	12.5	0.022	2.3E-04	0.09
19	21	5.5	10	0.035	1.9E-03	0.12
19	22	4.9	9.1	0.038	2.4E-03	0.12
19	23	5.3	10	0.034	1.6E-03	0.11
20	1	5.3	11.1	0.028	6.1E-04	0.10
20	3	5.6	12.5	0.023	2.8E-04	0.10
20	4	6.5	12.5	0.027	6.4E-04	0.10
20	5	6.3	12.5	0.026	5.4E-04	0.10
20	6	6.1	12.5	0.025	4.5E-04	0.10
20	8	6.3	14.3	0.020	1.6E-04	0.09
20	10	8.1	14.3	0.025	6.4E-04	0.10
20	13	7.8	14.3	0.024	5.2E-04	0.10
20	14	9.8	14.3	0.031	1.8E-03	0.12

b) Hurricane Katrina

Hurricane Katrina devastated north-central Gulf of Mexico and south-eastern coastal regions of Louisiana and Mississippi Gulf coast (see, e.g., Wang and Oey, 2008). For wind-wave interaction and other characteristics of Katrina, see Hsu (2015). Since the maximum $H_s$measured at the National Data Buoy Center (NDBC) station 42003 was approximately 11*m*before that buoy was capsized (see Table 2) and at Buoy 42040 was 17m (see Table 3)that is considered as an extreme significant wave height (www.ndbc.noaa.gov), these datasetsprovide us unique opportunity to investigate the relation betweenTI and H_s.

Table 2 : Measurements of significant wave height (Hs) and dominant wave period (Tp) at Buoy 42003 in August 2005 during Hurricane Katrina (Data source: www.ndbc.noaa.gov).

Day	Hour,UTC	Hs, m	Tp, sec	Hs/Lp	Zo, m	1/Ln(10/Zo)
26	4	0.69	4.55	0.021	2.5E-05	0.08
26	5	0.79	5	0.020	2.3E-05	0.08
26	6	0.89	5	0.023	4.4E-05	0.08
26	7	0.94	5.26	0.022	3.7E-05	0.08
26	8	1.04	5	0.027	1.0E-04	0.09
26	9	1.15	5.56	0.024	6.9E-05	0.08
26	10	1.15	5.56	0.024	6.9E-05	0.08
26	12	1.26	6.25	0.021	4.0E-05	0.08
26	13	1.25	5.88	0.023	6.6E-05	0.08
26	14	1.44	6.67	0.021	4.6E-05	0.08
26	15	1.5	6.67	0.022	5.8E-05	0.08
26	16	1.6	7.14	0.020	4.5E-05	0.08

26	17	1.73	7.14	0.022	6.9E-05	0.08
26	18	1.82	7.14	0.023	9.1E-05	0.09
26	19	1.91	7.69	0.021	6.1E-05	0.08
26	20	2.12	7.69	0.023	1.1E-04	0.09
26	21	2.11	7.14	0.027	2.0E-04	0.09
26	22	2.44	7.69	0.026	2.3E-04	0.09
26	23	2.61	8.33	0.024	1.6E-04	0.09
27	0	2.94	7.69	0.032	6.5E-04	0.10
27	1	2.94	7.69	0.032	6.5E-04	0.10
27	2	2.68	8.33	0.025	1.9E-04	0.09
27	3	3.44	10.81	0.019	7.2E-05	0.08
27	4	3.98	10.81	0.022	1.6E-04	0.09
27	5	4.45	10	0.029	6.0E-04	0.10
27	6	5.09	11.43	0.025	3.8E-04	0.10
27	7	5.2	11.43	0.026	4.2E-04	0.10
27	8	5.37	10.81	0.029	8.3E-04	0.11
27	9	5.68	12.12	0.025	4.1E-04	0.10
27	10	6.29	12.12	0.027	7.1E-04	0.10
27	11	5.67	12.12	0.025	4.0E-04	0.10
27	12	6.12	12.12	0.027	6.1E-04	0.10
27	13	6.32	12.12	0.028	7.3E-04	0.10
27	14	6.72	12.9	0.026	5.8E-04	0.10
27	15	7.35	12.12	0.032	1.7E-03	0.11
27	16	7.64	12.9	0.029	1.2E-03	0.11
27	17	7.15	12.9	0.028	8.2E-04	0.11
27	18	7.06	12.12	0.031	1.3E-03	0.11
27	19	7.81	12.9	0.030	1.3E-03	0.11
27	20	7.68	12.12	0.034	2.1E-03	0.12
27	21	6.85	12.9	0.026	6.5E-04	0.10
27	22	7.41	12.12	0.032	1.7E-03	0.12
27	23	7.48	12.9	0.029	1.1E-03	0.11
28	0	8.27	12.12	0.036	3.2E-03	0.12
28	1	9.26	12.9	0.036	3.4E-03	0.13
28	2	9.9	12.9	0.038	4.9E-03	0.13
28	3	10.28	13.79	0.035	3.3E-03	0.12
28	4	9.44	13.79	0.032	2.1E-03	0.12
28	5	10.57	12.9	0.041	7.0E-03	0.14

Table 3 : Measurements of significant wave height (Hs) and dominant wave period (Tp) at Buoy 42040 in August 2005 during Hurricane Katrina (Data source: www.ndbc.noaa.gov).

Day	Hour, UTC	Hs, m	Tp, sec	Hs/Lp	Zo, m	1/Ln(10/Zo)
27	2	1.43	6.67	0.021	4.4E-05	0.08
27	4	1.42	6.67	0.020	4.3E-05	0.08
27	6	1.46	6.67	0.021	5.0E-05	0.08
27	7	1.74	5.88	0.032	4.1E-04	0.10
27	8	1.85	6.67	0.027	1.8E-04	0.09

27	9	1.91	6.67	0.028	2.2E-04	0.09
27	10	2.04	7.14	0.026	1.7E-04	0.09
27	11	2.08	7.14	0.026	1.9E-04	0.09
27	12	1.91	6.67	0.028	2.2E-04	0.09
27	13	1.85	6.67	0.027	1.8E-04	0.09
27	14	2.06	7.69	0.022	9.2E-05	0.09
28	7	4.2	11.11	0.022	1.7E-04	0.09
28	11	4.66	11.11	0.024	3.0E-04	0.10
28	12	5.11	12.5	0.021	1.7E-04	0.09
28	13	4.76	11.11	0.025	3.4E-04	0.10
28	14	5.23	12.5	0.021	1.9E-04	0.09
28	15	5.03	11.11	0.026	4.5E-04	0.10
28	16	5.7	11.11	0.030	9.0E-04	0.11
28	17	6.34	11.11	0.033	1.6E-03	0.11
28	18	6.51	12.5	0.027	6.5E-04	0.10
28	19	7.36	12.5	0.030	1.3E-03	0.11
28	20	7.65	14.29	0.024	4.7E-04	0.10
28	21	7.63	14.29	0.024	4.7E-04	0.10
28	22	8.59	14.29	0.027	8.9E-04	0.11
28	23	9.4	14.29	0.030	1.5E-03	0.11
29	0	8.64	14.29	0.027	9.2E-04	0.11
29	1	9.05	14.29	0.028	1.2E-03	0.11
29	2	9.79	14.29	0.031	1.8E-03	0.12
29	3	9.97	14.29	0.031	2.0E-03	0.12
29	4	9.58	14.29	0.030	1.6E-03	0.11
29	5	11.61	12.5	0.048	1.6E-02	0.15
29	6	12.25	12.5	0.050	2.1E-02	0.16
29	7	11.26	12.5	0.046	1.3E-02	0.15
29	8	14.06	14.29	0.044	1.3E-02	0.15
29	9	14.04	14.29	0.044	1.3E-02	0.15
29	10	14.43	14.29	0.045	1.6E-02	0.15
29	11	16.91	14.29	0.053	3.7E-02	0.18
29	12	14.58	12.5	0.060	5.5E-02	0.19
29	13	15.67	14.29	0.049	2.4E-02	0.17
29	14	13.9	12.5	0.057	4.2E-02	0.18
29	15	10.7	12.5	0.044	1.0E-02	0.14
29	16	9.29	11.11	0.048	1.3E-02	0.15
29	17	8.24	11.11	0.043	6.9E-03	0.14
29	18	8.52	12.5	0.035	2.9E-03	0.12
29	19	7.34	11.11	0.038	3.6E-03	0.13
29	20	6.71	11.11	0.035	2.2E-03	0.12
29	21	6.33	12.5	0.026	5.6E-04	0.10
29	22	5.55	12.5	0.023	2.7E-04	0.10
29	23	5.17	11.11	0.027	5.3E-04	0.10
30	0	4.38	11.11	0.023	2.1E-04	0.09

30	1	4.23	11.11	0.022	1.8E-04	0.09
30	2	4.24	11.11	0.022	1.8E-04	0.09
30	3	3.9	10	0.025	2.9E-04	0.10
30	4	3.88	10	0.025	2.8E-04	0.10
30	5	3.36	9.09	0.026	3.0E-04	0.10
30	6	3.43	9.09	0.027	3.4E-04	0.10
30	7	3.1	8.33	0.029	4.2E-04	0.10
30	8	2.87	7.69	0.031	5.7E-04	0.10
30	9	2.62	8.33	0.024	1.7E-04	0.09
30	10	2.77	7.69	0.030	4.7E-04	0.10
30	11	2.71	7.14	0.034	8.1E-04	0.11
30	12	2.76	7.69	0.030	4.6E-04	0.10
30	13	2.3	6.67	0.033	6.1E-04	0.10
30	14	2.05	6.25	0.034	5.8E-04	0.10

III. Results

Our results are presented in Fig.1. Since the coefficient of determination, $R^2 = 0.85$ or the correlation coefficient $R = 0.92$, relation between TI and H_s does exist, so that,

$$p = 0.0003H_s^2 + 0.0018H_s + 0.0842, \qquad (6)$$

In order to validate this relation further, we employ the near-surface current measurements during Hurricane Ivan (Teague et al., 2007)in 2004. Since H_s=16 m(see www.ndbc.noaa.gov) and by substituting this value into Eq. (6), we get $p = 0.19$. Also, since $U_{10} =$ 48 ms^{-1} (seehttp://www.hwind.co/legacy_data/Products/PostAnalysis/2004/AL092004/AL092004_swath_max1minWind_ms.pdf), we have, from Eq. (2),

$$U_* = 0.4 \times 0.19 \times 48 = 3.65\ m\ s^{-1}.$$

According to Wu (1975) and Hsu (2003), the surface drift velocity, U_{sea}, is

$$U_{sea} = 0.55U_* = 2.0\ m\ s^{-1}.$$

This value is in excellent agreement (over 95 per cent) with the measured maximum near surface current of 2.1 $m\ s^{-1}$ (see Teague et al., 2007).

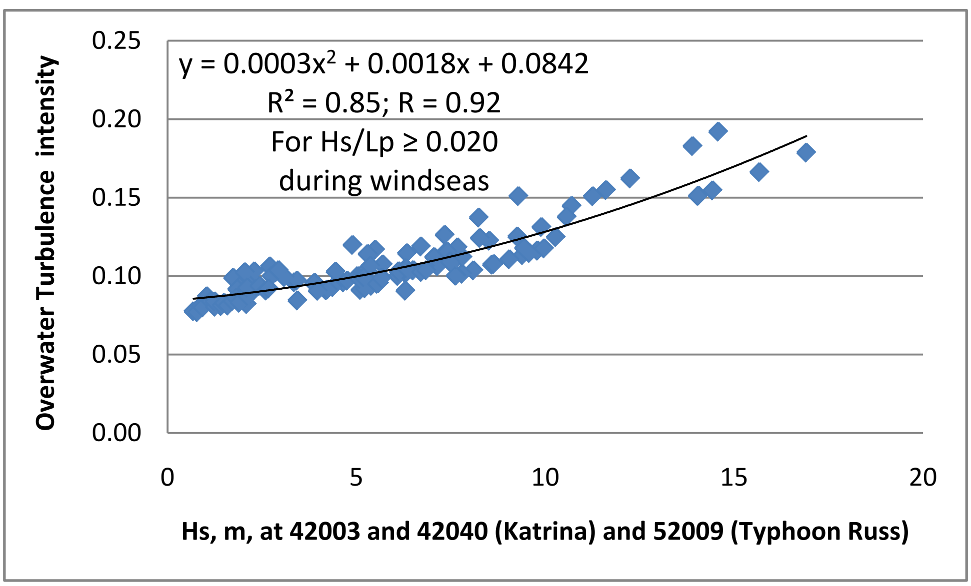

Figure 1 : Relation between overwater turbulence intensity and significant wave height during Typhoon Russ in 1990 near Guam and Hurricane Katrina in 2005 in the Gulf of Mexico

IV. Conclusions

On the basis of wave measurements during Typhoon Russ in 1990 and Hurricane Katrina in 2005, it is found that, during wind seas, overwater turbulence intensity and significant wave height are related through Equation (6)with a correlation coefficient as high as92 per cent. Application of this relation between TI and H_s shows that the estimated drift velocity is in excellent (over 95%) agreement with that measured during Hurricane Ivan.

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The Effect of Giving Dry Shrimp with Different Concentration on the Growth of Green Turtle Baby (Chelonia Mydas) in Sukamade Coastal Areas Meru Betiri National Park, Banyuwangi Regency, East Java

By Edi Wibowo. K & Suryono,Tri Saputra
Diponegoro University, Indonesia

Abstract- Turtle's exictence has long been threatened, either by nature or human eativities. The purpose of this research is to determine the effect of giving different feed concentration on the growth of green turtle baby (Chelonia mydas) at the age of 4 days for 5 week treatment period. This research uses experimental method. The material used is green turtle baby (Chelonia mydas) at the age of 4 days. The research was conducted at Sukamade Beach, Banyuwangi. The feed given is dry shrimp 3% and 8% of the weight of biomass. The results of the research indicate that the green turtle baby given dry shrimp with a concentration of 3% has a specific growth rate 1.429 ± 0.074 on average, less than the green turtle baby given dry shrimp with concentration of 8% which has a specific growth rate 1.630 ± 0.192.

Keywords: green turtle baby (chelonia mydas), growth, feed.

GJSFR-I Classification : FOR Code: 100104

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The Effect of Giving Dry Shrimp with Different Concentration on the Growth of Green Turtle Baby (Chelonia Mydas) in Sukamade Coastal Areas Meru Betiri National Park , Banyuwangi Regency, East Java

Edi Wibowo. K [α] & Suryono,Tri Saputra [σ]

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Keywords: green turtle baby (chelonia mydas), growth, feed.

I. Preface

Sea turtle is one of wildlife species in the spotlight due to a sharp population decline. Data from various sources indicate that the population of turtles in Indonesia dropped drastically in the last two decades. The observations of some researchers at several nesting sites indicate that the population decline could reach 80 (72% average) compared to the total population in the previos 15 years (Stringgel et al 2000: Suganuma et al, 1999). Continuous threats to the preservation of this endangered species can cause the extinction of this species, especially the types that the population is not much naturally (Suwelo and Somantri, 1990).

One of the problems faced is the number of green turtle baby that die after hatching. Green turtle baby receives less attention on the availability of feed and inadequate feed quality. After hatching, the green turtle baby is not given food for four days because green turtle baby still has food reserves in the form of egg yolk in his body. One of the nesting sites of green turtles is in Sukamade Beach, Meru Betiri National Park Area, Banyuwangi. According to the Meru Betiri National Park (1998), the area is known to be very productive for green turtle eggs due to many female green turtle land and nest in that area.

The newly hatched green turtle baby is very vulnerable to predators and disease. The green turtle baby is also not able to swim in balanced and to dive to avoid predators such as birds. Not all green turtle baby hatches in normal condition, some of them are defective. The defective green turtle must be separated from the normal one in order to be able to grow well (BKSDA East Java II, 1991).

II. Material and Methods

This research material uses 18 green turtle babies at the age of 4 days. They were divided into two treatments, three replications, and each of them consists of three green turtle babies. The babies were put in 6 plastic basins with 40 cm length, 30 cm width, and 10 cm height. The medium used is sea water that comes from Sukamade Beach which is usually used for breeding turtles in Meru Betiri National Park. The feed was given with 3% and 8% concentration of the biomass weight of the green turtle babies. The selection of 3% and 8% concentration refers to some researches that say that the optimal growth of green turtle baby with the concentration ranges between 5% and 10%. The choice of 3% feed concentration was to determine the growth of green turtle babies if the available natural feed is under normal condition and 8% concentration is selected when the available natural feed is in normal condition. Feeding is done twice a day in the morning at 09.99 and in the afternoon at 15.00 (Rihani, 2000 in Dawn, 2007).

The research method used is a laboratoty experimental method. Experimental obesrvation is an

Author α σ: Fisheries and Marine Sciences Faculty, Diponegoro University, Semarang. e-mail: ediwibowo1960@gmail.com

observation that is under artifical conditions (artifical condition) in which the condition is created and organized by researchers. Experimental research is research done by holding the manipulation of the object of the research (Nazir, 2005). This research uses a completely randomized design, the simplest kind of experimental design. Data analysis also uses proximate analysis to determine the nutrient content in dry shrimp, the feed of green turtle babies. Proximate analysis is a method of chemical analysis to identify the content nutrients such as protein, carbohydrate, fat and fiber in food substance (Hirth, 1991).

III. Results and Discussion

The weight growth of green turtle babies (Chelonia mydas) occurred in tih research varied in each treatment. The research shows that the growth of green turtle babies brought with 3% feed concentration did not increase very fast. While the growth of green turtle babies brought with 8% feed concentration was not stable at the beginning, but it increased rapidly in the last few weeks in line with the increase of maintenance time.

IV. Specific Growth Rate

The result of the specific growth rate of green turtle baby given dry shrimp feed with different concentration for 5 weeks is presented in Table 1.

Table 1 : The Average of Daily Specific Growth Rate of Green Turtle Baby (Chelonia mydas) during the Research

treatment	replay			Averages ± SD
	1	2	3	
Dry shrimp 3 %	1,375	1,399	1,514	1,429 ± 0,074
Dry shrimp 8 %	1,416	1,791	1,682	1,630 ± 0,192

The average result of the specific growth rate of green turtle baby given dry shrimp feed with different concentration has the highest average of specific growth rate, that is 1.630 ± 0.192% per day, while the lowest average of the specific growth rate is 1.492 ± 0.074% per day.

The analysis of variance test shows that the value of the specific growth rate using treatment of giving different feed concentration is F = 22.611, or (F > 0.05 or 0.01). It means that HO hypothesis is rejected and H1 hypothesis is accepted, which means that the specific growth rate of the green turtles baby given 3% and 8% feed concentration is significantly different.

a) *Feed Conversion Ratio (FCR)*

The result of feed conversion ratio of green turtle baby given dry shrimp feed with different concentration for 5 weeks is presented in Table 2.

Table 2 : The Conversion Ratio Value (g) of Green Turtle Baby (Chelonia mydas) Feed during the Research

Treatment	replay			Average± SD
	1	2	3	
Dry shrimp 3 %	4,080	3,947	3,791	3,940 ± 0,145
Dry shrimp 8 %	9,982	8,294	8,645	8,974 ± 0,891

The average result of the feed conversion ratio of green turtle baby given dry shrimp feed with different concentration has the highest average of feed conversion ratio, that is 8.974 ± 0.891 grams, while the lowest average of feed conversion ratio is 3.940 ± 0.145 grams. The result of variance test shows that the effect of giving different feed concentration to the feed conversion ratio is significantly different F count 23.893 > F table 0.01).

Table 3 : Nutrient Content of Dry Shrimp

No	kinds of Analysis	Levels 100% Gross weight
1.	Water Content	19,4916
2.	Ash content	32,8427
3.	Fat content	1,3266
4.	Fibre levels	1,5391
5.	Protein levels	58,1150

Feed is said to be useful if there is a positive effect on the growth of animals (Effendi, 2002). It has not been known so far how much protein is needed by green turtle baby to grow optimally. Bjorndal (1985) estimates that the low growth rate of the turtle is influenced by its nutrient rather than its genetic control.

The enduring ability of green turtle baby to consume feed that is given in the form of dry shrimp is great, it can be seen from the total consumption for every treatment. Based on the daily monitoring of food remain, the results indicates that the green turtle baby ate up all the feed given. The grwoth of the turtle kept in tub maintenance is greatly influenced by the amount and quality of the available food and on the condition of water temperature (Nuitja and Uchida, 1983).

b) The Growth Rate of Carapace Length

The result of the measurement during the resarch also got the result of the growth of the carapace length. The result of the observation on the growth of carapce length using different feed concentration is presented in Table 4.

Table 4 : The Growth of Carapace Length (mm) of Green Turtle Baby (Chelonia mydas) during the Research

Treatment	replay			Average± SD
	1	2	3	
Dry shrimp 3 %	53,427	53,088	51,753	52,756 ± 0,885
Dry shrimp 8 %	54,015	54,628	54,082	54,242 ± 0,337

The average result of carapace length of green turtle baby showed that the average length of carapace given 3% feed concentration reached 52.576 ± 0.885 mm, while the treatment using 8% feed concentration reached 54.242 ± 0.337 mm. Statistical analysis of variance test showed that the value of F = 22.664 > 7.44 or (F count > F table). It means that it can be proved that the growth of the carapace length of green turtle baby given 8% feed concentration is significantly different from that given 3% feed concentration, that is on the 0.01% and 0.05%.

c) The Growth Rate of Carapace Width

From the measurement results during the research, it was also obtained the growth rate of carapace width. The observation result on the growth rate of carapace width using different feed concentration is presented in Table 5.

Table 5 : The Growth of Carapace Width (mm) of Green Turtle Baby (Chelonia mydas) during the Research

Treatment	replay			Average± SD
	1	2	3	
Dry shrimp 3 %	45,915	45,798	44,905	45,539 ± 0,553
Dry shrimp 8 %	46,227	46,320	46,515	46,354 ± 0,147

The survival rate of green turtle baby in this research is high, it is 100% in all treatment. This is presumable due to the low density and good quality of water condition. Maintenance system affects the survival rate of green turtle baby much. The density of each container that is not too high, 3 babies per vessel, could be expected to prevent the competition for space and food. The competition for space and food can cause the green turtle baby fight and get injured. Besides that, the high survival rate of green turtle baby is also supported by the quality of water as the maintenance media that is relatively constant and also by the selection of green turtle babies that were healthy and not defect. The quality of water is maintained by 100% water change.

V. Conclusion

Gicing different feed concentration showed no real difference to the growth of green turtle baby. Feed with 8% concentration showed better and significant growth than the feed with 3% concentration.

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The Traffic Light Procedure for Decision Making: its Rapid Extension from Fisheries to other Sectors of the Economy

By John F. Caddy

Abstract- The Traffic Light approach as a technical procedure was first developed for monitoring the status and level of risk faced by a fish population from fishery-related, environmental, and economic variables (Caddy 1999a). It has also facilitated stock management and stock recovery, in both cases where supporting data series and stock assessment skills were limited. Nonetheless, since the early 2000's, the range of applications for this methodology have proliferated dramatically into most social and economic sectors, and after a description of the application of the traffic light procedure to fisheries, a second objective of this paper is to show some examples of the recent diffusion of this methodology to a much wider range of applications.

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Abstract- The Traffic Light approach as a technical procedure was first developed for monitoring the status and level of risk faced by a fish population from fishery-related, environmental, and economic variables (Caddy 1999a). It has also facilitated stock management and stock recovery, in both cases where supporting data series and stock assessment skills were limited. Nonetheless, since the early 2000's, the range of applications for this methodology have proliferated dramatically into most social and economic sectors, and after a description of the application of the traffic light procedure to fisheries, a second objective of this paper is to show some examples of the recent diffusion of this methodology to a much wider range of applications.

I. Introduction

The first objective of this paper, in part I, is to describe approaches used in the Traffic Light methodology in its earliest and most detailed application to fisheries and environmental assessment and management.

Since the Second World War, the science used in fisheries management has mainly relied on one or two mathematical frameworks and their diverse outgrowths: from the masterwork of Beverton and Holt (1957) which modeled life histories of exploited species using information on growth and mortality, and that of Schaefer (1954) who used the logistic function to model the effects of fishery exploitation. More recently, the trophic linkages in a food web have also been used, assuming that the relative abundance of predators and prey determines fishery productivity. However, these three assessment methodologies may have been less effective in considering the impact of social, economic, and overall climatic and environmental change, since they only deal with relatively few types of data. What seems to be needed in a situation of great uncertainty due to poor data and conflicting theories, is an easily understood empirical approach, where decision making is based on factual inputs.

While discussing multispecies management of fisheries, Longhurst (2010) wrote:

"One approach to management offers a way of integrating a highly diverse field of information into an informal model, thus bypassing the wholly impractical suggestions of holistic and numerical simulation of ecosystems and their socio-economic relations This is a system…based on Caddy's proposals for a 'traffic light' management approach….a wide range of variables could theoretically be integrated into an assessment of the risks associated with increasing or maintaining present (fishing) effort. Each indicator would be a three-level numeration of the variable by a single indicator. The original authors insisted that it would be of use in situations where management was committed to a set of decision control rules…" In a discussion on the precautionary approach, RAP (2000/02) concluded that the TL methodology is a potentially powerful tool for developing, displaying and integrating technical information for management planning.

We can consider this approach as the collective viewing of all time series of data relevant to a management objective before a decision is made on a research or management action. The annual data series are expressed in three (or more) color codes, showing where we currently are in relation to this objective. In simple terms, a data range can be assigned a green color representing a satisfactory/safe status, while data in a red zone represents a dangerous situation; these conditions being separated by intermediate values assigned a yellow/orange coloration which can be thought of as an unsatisfactory transitional condition between red and green. This simplification of the data series aids value judgments, and reduces data interpretation to a more manageable form, understandable to non-specialists. Mangel and Levin (2005) expressed this idea in the following way:

"Focusing on a variety of indicators will force us to embrace uncertainty and avoid false precision. This may require us to forgo the hope of finely-tuned management plans, opting instead for a series of indicators that can be broadly categorized. For example, Caddy (2002) described a 'basket' of indicators, each of one of which is associated with a yes/no question:

- is total mortality in excess of the optimal mortality for the stock?
- is spawning stock biomass less than 20% of the estimated value in the unfished case?
- is fishing mortality larger than a specified multiple of natural mortality?
- is recruitment much less than average recruitment? and:

Author: e-mail: jfcaddy1@yahoo.co.uk

- is fishing mortality more than 2/3 of F_{MSY} (or more than $F_{0.1}$)?

Each answer 'yes' produces a 'red' traffic light. The decision rule could be that five red lights lead to closure of the fishery, but 1–4 red lights lead to an open fishery with decreasing levels of fishing effort permitted (e.g., 75%, 60%, 40% and 20% of F_{MSY}). What is noteworthy here is that although the standard quantitative measures may still be evaluated, they are used in a non-standard way.

In a technical traffic light representation, a decision must also be made by the parties concerned as to which numerical values in the underlying data series the boundaries between color zones correspond. In fisheries management, these boundaries are often referred to as Target Reference Points (at the boundary between green and yellow), and as Limit Reference Points (between yellow and red) - (see e.g., Caddy and Mahon 1995; Caddy 1999b). Making a decision on the numerical value for these reference points may itself involve separate analysis and/or a Mensa-like discussion between those most knowledgeable in the question, but alternatively, precautionary values may be chosen, believed to be 'safe' measures, having a good chance of promoting stock recovery (e.g. Caddy and Agnew 20005).

a) *Origins of the TL approach*

Three main categories of traffic light (TL) application are considered here:

1) A simple descriptive approach that places on one graph time series of all relevant variables.
2) A scientific approach to a traffic light methodology in the field of fisheries and the marine environment can use numerical information. This approach stemmed from formulation of a new type of reference point, the Limit Reference Point agreed to under the 1995 UN Fish Stocks Agreement for precautionary management of marine fish resources. As noted by MacNeil (2013): "Under the Law of the Sea, the acceptable objective for fisheries had been the Maximum Sustainable Yield (MSY)...(but) the corresponding level of fishing effort for MSY is often overshot due to poor or non-existent controls on fishing capacity. Hence in the UN Fish Stock Agreement, a more precautionary Limit Reference Point (LRP) was instituted. This corresponds to a lower rate of exploitation and/or a higher fish stock biomass than at MSY (Caddy and Mahon 1995)". The two reference points (a LRP, which requires emergency measures if passed, and the MSY as a Target Reference Point), can be portrayed diagrammatically as specific values in a time series of biomass or fishing effort/mortality" (Fig 1). "These two reference points are separated by areas where the color (yellow) of the intermediate values for variables reflects an uncertain level of risk for the population".

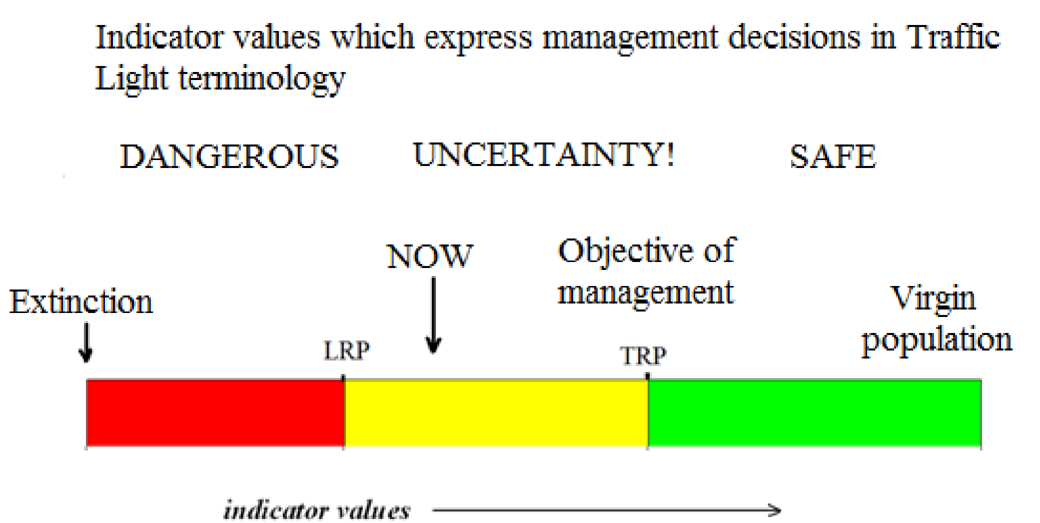

Fig 1 : The use of a traffic light colour code for illustrating the state of a resource in relation to optimal (e.g. Target Reference Points – TRPs), and precautionary states (i.e., above Limit Reference Points – LRPs). Judgement is based on biomass measures, or (in the reverse sense) on fishing effort or fishing mortality measures. This procedure identifies states of the resource that should not be infringed

3) A commercial approach to color coding of products by the food industry and other industrial sectors was developed, e.g. by Unilever (1998), in which fish and fish products are color-coded according to their freshness, quality, and method of harvesting and management. This approach was passed on to the Marine Stewardship Council (MSC) which may also use the Traffic Light approach through its independent evaluations of the relevant fishery and exploited resources. Similar applications are encountered in many other sectors of the economy and society and will be touched upon in Part II of the paper.

b) Locating applications of the TL procedure

In tracing past applications, three main sources of information were reviewed:

- A web search using 'traffic light' as the search criterion, supplemented by additional search criteria such as year of publication, 'procedure 'or 'method' and a range of supplementary criteria shown in Table 1.
- A search on the ASFA (Aquatic Sciences and Fisheries Abstracts) data base.
- Personal familiarity with the literature on scientific applications involving traffic light criteria.

Most TL applications are reported in sub-publications, the grey literature or on the Web, hence it is difficult to find them all, but searches of the internet using 'traffic light procedure' and 'traffic light method' resulted in increasing numbers of items being identified from 1998 onwards, but none for earlier dates. A search procedure using Google Scholar helped to identify items under these headings. The items identified were supplemented by a search of the ASFA data base for literature on biological research. It soon became evident that such searches would underestimate the number of items referring to a traffic light procedure, since this methodology would not necessarily be mentioned in the abstract, and relatively few references are made in later papers to earlier TL studies, especially in commercial or government applications. This makes their origins difficult to trace. Table1, later in the text therefore represents an underestimate of the number of mentions annually of the traffic light procedure. It seems very likely that such a bias will have become even more pronounced in recent years. Nonetheless, Table 1 seems a reasonable representation of the situation in the early years of application of this methodology. Further studies and a degree of standardization of search approaches seems called for.

c) What information is needed for judging the basic health of a fish stock?

Sustaining exploitation rates near the levels that produce MSY depends on active management if a continuously productive resource is to be maintained. Continually improving fleet technologies, high market demand, offshore operations and environmental fluctuations, make collection of data for management very difficult.

Achieving 'sustainability' is far from automatic! For example, my recent studies have demonstrated that:

a) North Atlantic landing trends for many species have shown 'boom and bust' characteristics (Caddy and Surette 2006);
b) Restoring depleted fish stocks is painful and costly. Successful restoration plans so far have been rendered difficult by the harvest needs of high capacity fleets (Caddy and Agnew 2005): i.e., stock depletion resulting from excess capacity is not going to be easily reversible. A science-based fisheries management system is information intensive – it must measure inputs (fishing effort or fishing mortality rate) to the fishery as well as outputs.

d) Establishing empirical traffic-light boundary values

Setting initial traffic light values can be problematic if we have no prior experience either from management, or a modeling context from which to define them. Yet, given a time series set of data, we often get a "feel" for which values are desirable and which are not. For instance, if we have a 30 year time series for landings we know from past experience which years were poor and which were plentiful and which were somewhere in the middle. In some situations, we would simply like to make qualitative or semi-quantitative comparisons between particular annual variables as part of an exploratory data analysis. From these notions we might formulate a few simple methods of transforming numerical data into the traffic light space. This method is not meant as a rigorous analysis of the data, but rather to provide a way of looking at high-dimensional data sets without premature modeling, or resorting to advanced statistical techniques before the critical variables have been identified.

Order statistics offer nonparametric (that is, distribution or model-free) ways of making inferences from our data. Here are suggested two approaches which arise naturally from either an equal range, or an equal probability assumption (Caddy and Surette 2006). If our data spans a long time series, we may wish to use absolute minima and maxima values to set traffic light intervals. For simplicity, we may set color intervals to be of equal range, requiring only that the number of categories be known. For example, if our indicator is a time series of landings and we have a fair number of data values, we simply take its minimum and maximum values and calculate traffic light boundaries so that they divide the interval evenly. Traffic light extreme values may also be set by the user on a subjective or theoretical basis. Landings for example, cannot go below zero and may have an upper limits set by theoretical limits stemming from management considerations or the carrying capacity of the ecosystem. Note that the two approaches may yield quite different results.

If a data set corresponds to an unknown model or distribution, we may nonetheless calculate percentiles at predefined probability levels. For instance, if we wish to divide an ordered data set into three parts of roughly equal range, we could use percentiles at the 33% and 66% levels as boundary values. We may then use the resulting intervals as traffic light intervals by assigning them color values, or we may wish to set different probability levels.

A word of caution: time series data are frequently autocorrelated, i.e. they do not constitute a random sample in the traditional sense. Secondly, the variances associated with proportional values are highest at the zero and unity probability levels, which are the minimum and maximum values respectively. The variance decreases with central percentile values, and its predicted minimum is found at the median value (0.5 probability level). Central values are actually more precise, but extreme values are more likely to influence the position of color boundaries. Thirdly, since 'equilibrium conditions' may not apply, factors influencing an indicator may change with time, and some inferences may only be appropriate for certain periods in the past, if at all.

Color boundaries in the TL system should ideally correspond to a limit (LIM) or precautionary (PA) reference point depending on whether the ICES convention (ICES 1997), or their equivalent in other terminologies is used. Later studies (e.g., Caddy et al. 2005), in the absence of reference points, showed that dividing the range of values in a time series (or their theoretical maximum range if this is known) into equal segments, will allow underlying changes in a large number of indicators to be compared visually. Of course when we begin statistical analysis of the data, this will often occur independently of color values.

Part I: A review of fisheries applications of the Traffic Light

The first proposal to use a traffic light methodology for technical analysis was in an assessment meeting of the North Atlantic Fisheries Organization (NAFO) in 1998, and was influenced by the impossibility of obtaining age-structured information for invertebrate resources (e.g., shrimp, crabs, lobsters) which is needed for applying conventional stock assessment models (Caddy 1999). In the TL approach, variables reflecting changes in environmental or economic influences over time, and any supplementary historical information, may be added to the multivariable TL display, to allow the environmental or socio-economic characteristics of the optimal yield to be identified. MacNeil (2013) noted: "The use of reference points has not been widely applied beyond fisheries but they have the potential for managing any resource in need of regulation." The collapse of some industrialized fisheries has brought limit reference points to the forefront of fisheries science, both for harvest regulation DFO (2004) and green certification schemes. Reference points are simply quantities related to the state of a resource for which management action is triggered or directed". Considering the state of the exploited resource as characterized by color values was a logical step after the formulation of two or more reference points, and stemmed from the use of questionnaires based on the Code of Conduct for Responsible Fisheries (FAO 1996).

The initial applications of the TL approach in fishery assessment and management identified the progressively greater risk of fish stock collapse associated with a movement from a green to a red category for the monitoring variables chosen. Supplementary empirical information on the ecosystem, or information based on the economic performance of the fleet, can also be expressed in color terms in a TL application.

a) *A basic feature of the TL method: color and information added to the graphical output*

We need an information basis for fisheries management that can use a wide variety of inputs, and can incorporate interdisciplinary information on the environment and socioeconomics, to be improved through experience. It should allow us to eliminate indicators that prove redundant, and provide the basis for likely research hypotheses. The traffic light displays time series in such a way that synchronous transitions in indicator values over a wide range of indicators can be readily appreciated visually prior to formal statistical analysis, and may provide clues as to the prevailing interrelationships. It is not a substitute for standard statistical procedures which should be performed in sequence on the original data set, but may point to likely interrelationships and sequences of events to be followed up using statistical methods. For example, cluster analysis may be a helpful adjunct in evaluating similarities between some time series that is evident from inspection of the colored bar charts.

The TL approach allows a system of indicators to be developed that is not 'modelconstrained', as opposed to a narrower model-driven approach to sampling and data collecting. In fact, when setting up any research-based information system there must be an initial phase when decisions are made on which indicators are important. At this point, a range of potential models relevant to the situation should be considered. This preliminary decision-making process is often neglected in favor of preconceptions as to the driving functions concerned. A narrowly focused data base will result from premature hypothesis formulation and will make it difficult later to consider other hypotheses. If later events suggest that other factors or constraints apply, the necessary data to test them will not have been collected. Hence, an initial phase of indicator selection is needed between the large range of possible or available indicators, based on the various considerations that earlier research suggest may be relevant. We should then allow the suite of indicators finally chosen to tell us about the situation as it develops. Also relevant at this stage is that the extra indicators considered may be relatively easy to obtain and not costly to assemble.

In the absence of existing values for limit and target reference points based on analysis, the traffic light convention used in Figure 1 follows that in Caddy et al. (2005) and Caddy and Surette (2005) by partitioning the observed range of landings by species over the period of available data into 3 or 4 intervals; coloured respectively red, yellow, green and blue, or red, yellow and green. This colour sequence either follows from the bottom to the top of the observed range, (as for landings where high values are favourable) or vice versa, where some stressor (such as fishing effort) has been suggested to be negative at high values. This allows a comparison of changes in the timing and trends in indicator fluctuations which are comparable for different data sets, irrespective of the absolute magnitude or units of measurement of the indicators in question.

b) Displaying time series of fisheries data in a traffic light format

While searching for examples of the traffic light approach in publication lists, automatic selection routines proved impossible since references to the performance or modeling of physical traffic lights in cities are also abundant in the literature. On this point it may be interesting to note that the first physical traffic light using gas lights was installed in the 1860's near the British Houses of Parliament. After only a month of use, the device exploded and injured the police officer who was operating it (see Wikipedia: 'History of Traffic Light').

The technical traffic light procedure originally proposed for fisheries management was a logical continuation of the use of target and limit reference points, whereby once an indicator of fishing pressure exceeded a safe limit called a limit reference point, it would register a red value. Similarly, if recruitment or biomass registered dangerously low values their indicators would also change to red. Later studies showed that in absence of formal reference points, dividing a time series into three equal segments of the observed range (or the theoretical maximum range if this is known), allows underlying changes in a large number of indicators to be compared visually, although in this case the color red indicates only that the red data points should be treated in a precautionary fashion.

Another traffic light approach that has been widely applied, again uses the three colour scheme to display verbal descriptions of safe, intermediate, and dangerous states of the situation under discussion. In such cases we may be dealing with policy recommendations, legal requirements, or mandatory actions given later in Part II of this paper. Here the characteristics corresponding to each colour are often verbal criteria.

c) The TL approach as an aid to hypothesis formulation

Criticisms have been made of the few data series collected for most fisheries, and that few of them incorporate key environmental or other forcing factors. The traffic light system used in fisheries (Caddy 1999, Koeller et al. 2000, Halliday et al. 2001) offers a framework for comparing multiple data series prior to deciding on the critical factors, and which relationships to incorporate into any model of the system being studied. A strategy which avoids building data collection around a specific model, and takes into account key information series outside the immediate area of concern, is less likely to incorporate misconceptions into an eventual management framework. It also should provide a way of confronting different indicator series, and comparing the relevance of a wide range of informational inputs to the management process. Finally, a system which displays contemporaneously a wide series of indicators is well adjusted for hypothesis formulation and is easily understood by non-technical audiences.

Halliday et al. (2001) produced a workbook supporting practical applications of the TL methodology, and described fishery system indicators that form the 'building blocks' for a TL analysis. They proposed that the TL methodology seen as a precautionary framework suitable for stock assessment of resources in situations where data is sparse, and reflect the underlying policy framework by:

- using multiple indicators of system status;
- classifying the current situation of the system using indicator colors;
- establish response rules which depend on an integration of the colors of the indicators.

Halliday et al. (2001) noted that the Canadian Fisheries Management Studies Working Group (FMSWG) had defined a management system embracing the precautionary approach as one with the following components:

- Management objectives are set:
- Strategies to achieve them are specified;
- Limit Reference Points defining the initiation of unacceptable outcomes are defined for the indicators;
- The indicators are monitored to determine system performance;

- Pre-agreement on corrective actions to take if limits are approached

In a practical application of this management system, ecosystem and socio-economic considerations may be taken into account by the definition of the appropriate indicators. An 'Objective-based Fisheries Management Approach' was defined by Canada's Department of Fisheries and Oceans in 2000, which had three objectives:

- Conservation;
- Orderly harvesting;
- Shared stewardship – the intention of this last objective being aimed at eventually giving the fishing industry authority and responsibility for fisheries management. To be consistent with the UN Fisheries Agreement, the management approach adopted should be ready to respond to two different phenomena:
  - Overfishing as judged by declines in resource productivity or ecosystem functioning;
  - Independently of the current rate of harvesting, a natural phenomenon may adversely affect resource productivity.

A signal that either of these phenomena may currently apply, should be evident from changes in the indicators used to monitor the exploited populations.

Halliday et al. (2001) suggested that the traffic light methodology provides a single framework for addressing these fisheries management issues while using a precautionary approach. Irrespective of whether the available data are extensive or limited, the basis for decision-making should be displayed in a way that gives weight to all available information. It can focus attention on biological aspects of the data and environmental and ecological information. Socio-economic inputs such as those provided by fishermen themselves through for example, interviews, are integral to the success of any co-management initiatives that may be in application.

Apart from monitoring the fishery and its physical, biological and socio-economic environment, the use of decision rules arrived at by consultation with the fishing industry, fits well into the TL framework, and will be discussed in a later section.

d) Alternative monitoring and management approaches

ICES and NAFO have also implemented precautionary management tactics, and it may be of interest to discuss briefly the models they use for the derivation of reference points based on MSY. These approaches are based on stocks for which there is substantial data; the assumption is required that recruitment is somehow dictated by spawning stock size. They are single species models that assume the environment and ecology remain stable over time; decision rules depend only on biomass and on fishing mortality estimates for the species under management, and the framework is specific to this species and not to the entire complex of fisheries in the area.

It is important to note however, that many elements of this conventional assessment approach can be integrated into a traffic light system, hence there is no reason why the information-gathering functions of an existing system should be discarded, although they may be somewhat amplified.

e) Description of the method

In his original description, Caddy (1999) made reference to a chart showing three components:

- A column of lights showing the most recent data point for its indicator, with the color showing its current status in relation to the limit reference point for that indicator;
- An integration algorithm for assembling the individual indicator values;
- A decision rule based on the final score for the most recent year.

In addition to the current year's data being evaluated, Koeller et al. (2000) drew upon a retrospective table of data which showed historical trends in the stock and other variables used in the TL. This stratagem appears to be a less rigorous approach, using historical data that Halliday et al. (2001) referred to as a 'TL stock status index', since it operates ostensibly independently of the approach described above, which they referred to as a 'TL Precautionary Management Framework'.

f) A limited selection of fisheries applications using the technical TL approach

In its simplest form, the Traffic Light (TL) methodology is a performance report in which time series of several indicators of stock health (not necessarily model-driven; they may be empirical, or based on historical data), are presented on a single chart.

The color boundaries in the TL system should ideally correspond to limit or precautionary RPs, but this is not always possible. Several brief examples follow of TL applications, notably in fisheries in the Black Sea and Atlantic, and fisheries for shrimp, snow crab, as well as the economic performance of Adriatic fisheries, and these may help illustrate possible procedures.

In his assessment of Atlantic herring in the Newfoundland region, Wheeler (2006) pointed to the limited data available, and in using the TL approach, noted that yellow meant 'uncertain', but was defined as 'uncertainty of an interpretation', rather than precautionary uncertainty.

1) The Black Sea; a method of displaying catch trends and environmental change

Historical information had been gathered on the landings of key species from the Black Sea (Prodanov et al. 1997), including estimates of the exploitation rate, from the early 1960's to the early 1990's. Fig 2 shows trends in landings for a key species, the turbot, *Psetta maeotica*. The annual bars of the landing histogram are colored yellow or green according to whether the annual fishing mortality rate was above or below $F_{0.1}$ (which is considered a limit reference point for safe exploitation - see Gulland and Boerema, 1973). The data series was colored yellow if the fishing mortality was above $F_{0.1}$ but below $1.5*F_{0.1}$, and red if it was above this last value. What emerges from this plot is that the increase in landings in 1992-95 was not due to a recovery in biomass, but to increased fishing effort: i.e., a decline in species abundance had occurred, in part due to overfishing, and in part due to eutrophication of the bottom waters (Zaitsev 1993).

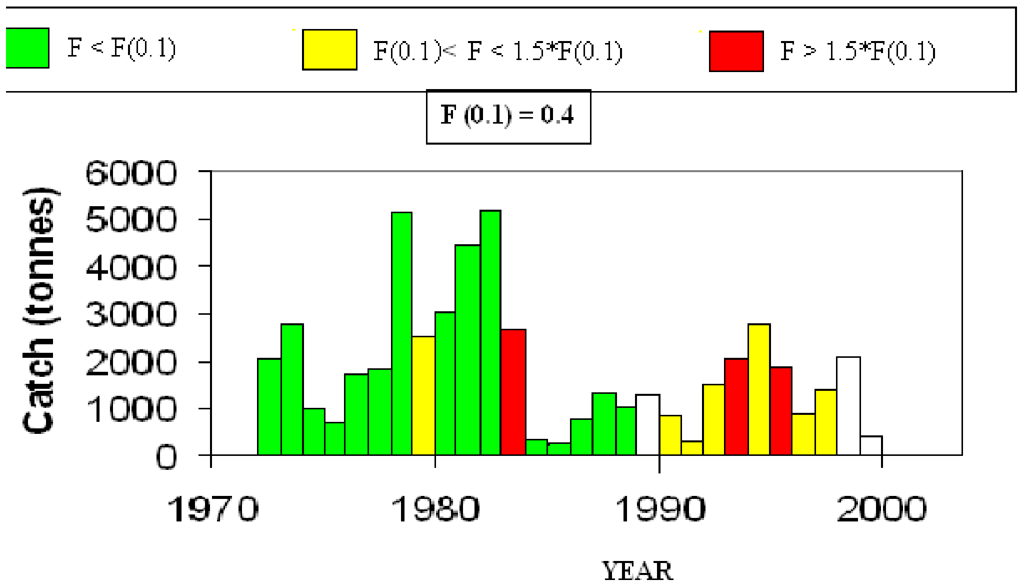

Fig 2 : The Traffic Light approach (here for turbot), provides a way of illustrating, changes in exploitation rate, simultaneously with catch trend. The Reference point $F_{0.1,}$ divides catches between safe (green) and uncertain (yellow). Dangerous (red) conditions were considered to arise when $F > 1.5F_{0.1.}$ (From Caddy et al. 2005)

The above graph combines two indicators, and offers a summary of the situation. This display could be more convincing when discussing research results with industry and non-technical fishery managers than mathematically more complex analyses. For example, it becomes evident from independent estimates of fishing mortality that the increase in landings of turbot in the 1990s was achieved only by exceeding a reference point for fishing mortality.

The same approach used for anchovy employs the natural mortality rate in defining the F criterion. When the current fishing mortality rate F remained below the natural mortality rate, M, the stock was considered to be in a safe (green) condition. When F exceeded 1.5M, overfishing was considered to be likely:

F<=M	M<F<1.5M	F>=1.5M
<=0.53	0.53-0.795	>=0.795
GREEN	YELLOW	RED

Changes in the Black Sea ecosystem over the last half century or more have been sudden and dramatic, making any single factor unlikely to fully explain events. The transition from a sea moving from moderate to more extreme eutrophication due to nutrient inputs from a large catchment basin (Caddy 2004, 2006) over the period, coincided with heavy fishing and the virtual elimination of larger predators. The invasion of the pelagic ecosystem by the alien Ctenophoran (jellyfish) *Mnemiopsis leydei* imported in ship's ballast tanks from the West Atlantic in 1988-92, This led to a major decline in small pelagic and migratory species, and caused a catastrophic ecosystem imbalance.

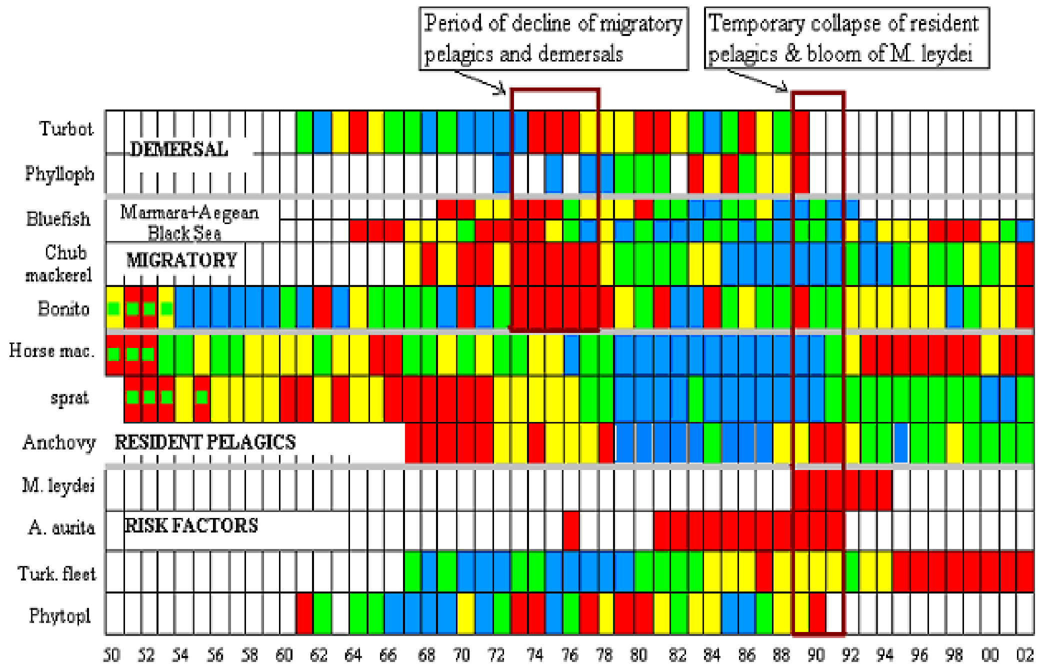

*Fig 3 : Traffic light display for Black Sea fisheries and other biological criteria. For commercial species, landings are used as indicators; fish catches and Phyllophora abundance decreasing from green to red. This 'arbitrarily scaled' traffic light plot should be used for seeing correspondences between indicators. Several postulated driving functions are grouped together at the bottom of the figure, including phytoplankton and annual estimates of Turkish fleet size (the largest fishing fleet). Unlike the indicators for species landings, for these, high values are shown as red; implying a dangerous state. An abundance of jelly predators is also colored 'red' where recorded. (i.e., Risk factors such as phytoplankton blooms, jelly predators, and Turkish fleet capacity all increase to red**):** (from Caddy 2006)*

The TL plot in Fig 3 is largely descriptive, but shows a number of features that can help generate hypotheses:

1) A key feature is the relationship between declines ìn pelagic fish abundance and outbreaks of *Mnemiopsis leydei*. Some fish stock recoveries came later, but pelagic predators such as bluefish, horse mackerel and bonito became uncommon in the northern Black Sea after the mid-1990's. The major increase in capacity of the Turkish fleet, fishing mainly for anchovy over this period, cannot be discounted either as a causative factor.
2) An inverse correspondence over time between turbot catches (red = low catches: blue = high), and the inverse trend in phytoplankton abundance (in this case, red = high) suggests a declining health of demersal habitats caused by hypoxia of bottom waters. Increased turbidity also negatively affected a species of bottom-dwelling red alga *Phyllophora sp*.

2) Recent changes in landings of Northwest Atlantic fish species

Fishery landing data from FAO records were expressed in TL colours for 73 species taken in the Northwest Atlantic over the last 50 years, and mapped on a single chart as a diagnostic of the overall state of fisheries (Fig 4 from Caddy and Surette 2005). This figure allows a discussion of the possible factors underlying the observed changes. Using such an empirical approach, indicators were incorporated onto a 'traffic light board' developed from the existing data series, which provides a summary of landing from the multispecies fishery. Although a comparable chart showing species biomass would be preferable, the data for biomass for all species is unavailable over the time span shown. However, this chart is easily understandable by managers and stakeholders, and indicates that several radical changes occurred in succession in the half century displayed. When considered together with ancillary data, it provides a broad background of information to evaluate the effectiveness of long-term fishery management decisions.

Debates on the state of production of world marine fisheries have a high public interest, but assessments of fish stocks are not always easily interpretable to nonspecialists in the proceedings of fisheries Commissions. Although total landings do not give a direct indication of exploitation rate (which requires age composition or biomass trends for the stocks), two indications can be drawn from Fig 4 for the NW Atlantic:

- A low level of landings and red coloration at the beginning of the time series indicates an initially low rate of fishing, and not a serious problem of conservation. To the contrary, red coloration at the end of the time series after a declining trend in landings, suggests a decline in abundance or a subsequent severe control on effort and landings to encourage stock recovery. (Low landings at the end of a time series are unlikely to reflect a lack of interest in a species, given generally rising prices for sea food in recent decades).
- The typical sequence of exploitation for most species is to initially pass through a low level of exploitation (red), then through a period of moderate (yellow) and high landings (green then blue), before landings decline again after a period of high landings and overfishing, to yellow, and even red. Typically the time series' rarely show sustainable production over decades, and often conclude in a red coloration, indicating that fisheries management (even if a recovery plan was being implemented) had problems in maintaining landings at a moderate level (Caddy and Agnew 2004).

Independent information suggested that environmental conditions may also have played some role here. Some exceptions to the declines noted were that invertebrate fisheries often appeared to be able to sustain moderate levels of landings over decades; perhaps in part due to a decline in predation rates from fish predators?

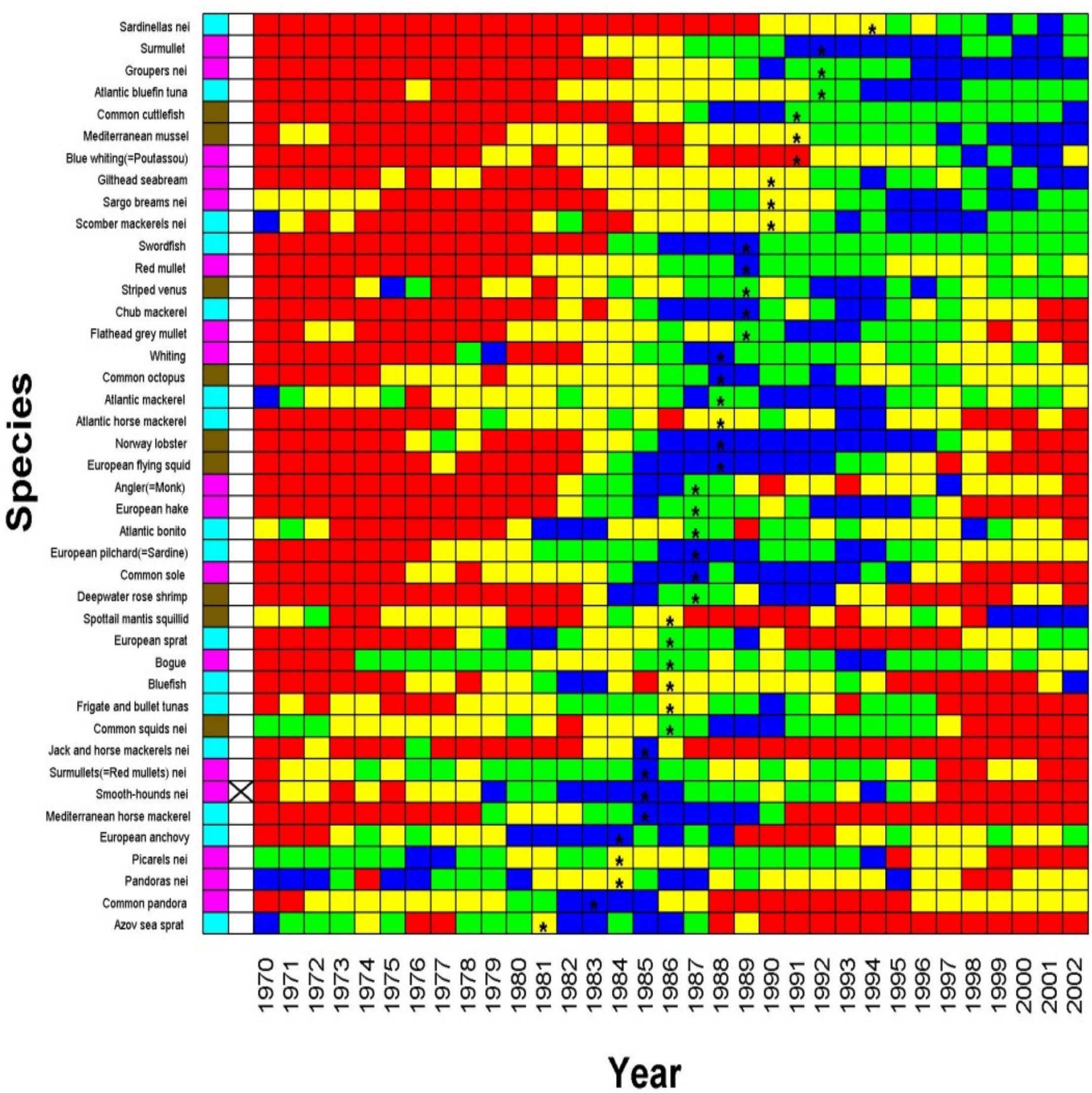

Fig 4 : Showing the range of landings in the Northwest Atlantic by 73 species from 1970-2002, as bar charts. Annual catch as a fraction of the maximum observed annual catch, is portrayed by quartiles from red (low) to blue (high). The black dots mark when the 50% point of total landings is reached over the whole period for each species. (From Caddy and Surette 2005

3) *Monitoring shrimp populations on the Nova Scotian shelf*

A traffic light system was used by Koeller et al. (2000) in producing assessment advice for shrimp populations on the Nova Scotian Shelf. In displaying multiple indicators for shrimp populations, a traffic light array was used to follow changes in population characteristics such as biomass or mortality, as well as predator abundance, recruitment and biomass. The TL display integrated annual values of 23 indicators describing the state of the physical environment, the fishery, and the relative and absolute shrimp abundance divided into three states (good, indifferent and bad).

Such an approach was referred to as a Traffic Light monitoring methodology (Halliday et al. 2001) as opposed to incorporating a fisheries management rule (Caddy 1999), although here the traffic light display was also used as a guide to quota setting based in part on the recurrence of conditions in earlier years. The objective was to display on a single graph a range of indicators allowing a comparative approach to investigating possible interrelationships between landing patterns for the resource and its environment.

4) *Management of Korean fisheries using the TL approach*

In assessing the effectiveness of improved fisheries management techniques, Park (2009) proposed a variant on the TL approach. For some time the Korean authorities had followed a structural adjustment policy in fisheries in the Yellow Sea, largely focusing on the buyback of fishing vessels. This policy significantly reduced the rate of decline of fisheries resources, and squid, Spanish mackerel and Jack mackerel are showing signs of recovery. Although many fishing vessels has been retired, the effective fishing capacity has tended to increase as increased engine power to a certain extent has replaced decommissioned vessels. This trade-off, often observed under buyback programs, was believed to be a result of ineffective institutional arrangements.

To make the buyback policy more effective, governments need to develop an integrated policy including buyback, resource enhancement, income promotion outside the fishery, a reorientation of fuel subsidies, and co-management programs. This will require far closer cooperative work among South/North Korea, China, and related international bodies exploiting the same resources. For the last three decades the Yellow Sea has suffered from severe overexploitation and pollution problems. Overexploitation has been intensified by capacity expansion of Korean and Chinese fleets, and there has been a continuous decline in fisheries resources since the mid 70's.

Traffic light displays classify the status of a resource into three stages and colors: green for safe, yellow intermediate, and red risky. For both relative stock size and relative fishing effort, the upper yellow rectangle in Fig 5 represents excessive fishing effort but a biomass still above the MSY level, while the lower yellow rectangle represents a low biomass but a moderate to safe level of exploitation. Evidently the graph is intended to guide the fishery to the management objective of a higher biomass than at MSY, being exploited at a fishing intensity somewhat below that which would yield MSY.

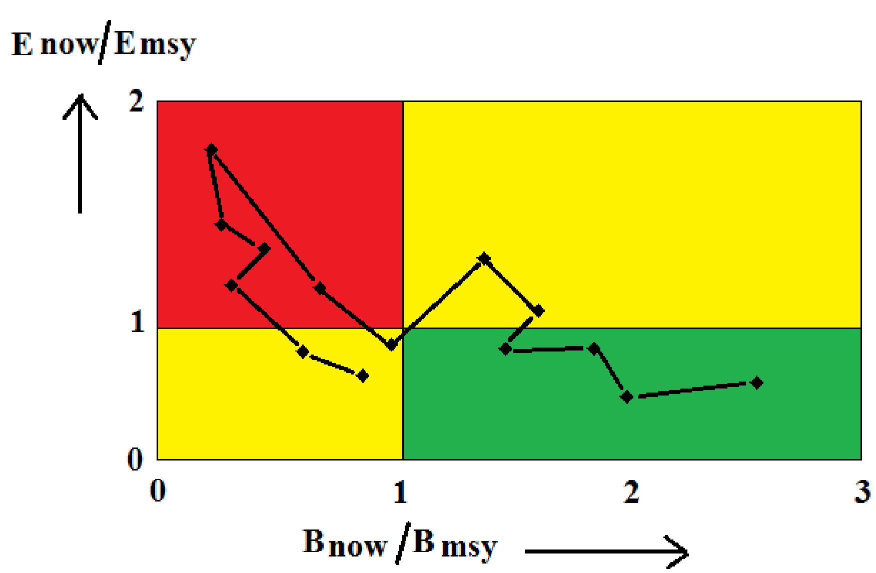

Fig 5 : Illustrating the type of TL diagram used to portray changes in exploitation in Korean fisheries management (redrafted after Park 2009)

5) Development of Yucatecan inshore fisheries

Detailed species data on quantity of landings was available for Yucatecan fisheries, together with some investment data (Seijo et al. 213). This showed the value of the TL approach for displaying data and obtaining a synoptic picture of the situation. In Fig 6, trends for landings of 10 shelf resources and two pelagic resources (sardines and tunas) were plotted together, using a traffic light convention which divided the landings into 4 equal ranges between the lowest and highest annual tonnage recorded. Except for the tunas (which are long exploited oceanic resources and show a widely different trajectory from shelf resources), the ranked series show close to synchronous colour changes for all coastal species over the period 1940 - 2001. Although the data set is strictly limited in terms of the information that can be extracted, one general conclusion is that all shelf resources, including sardines and other small pelagic fishes, have shown a parallel and closely coordinated evolution of catches since the 1940s. This conclusion would not have been so evident from the raw data set.

A reasonable conclusion from this observation would be that these time series reflect a programmed increase in fishing pressure over the time period that to some extent was independent of the fisheries for individual species, and probably reflected a period of slow fleet build up. An exception was that some species, for example 'mero'(grouper) 'algas' and 'sargazos' (algae and Sargasso weed) reached their highest landings early in the time series. Others (notably 'mojarra' (a small short-lived fish) and 'pulpo' (octopus), reached peak landings somewhat later. The apparent resistance of pulpo and mojarra to high fishing intensity is notable, and may reflect the high productivity characteristic of short-lived species. No information can be derived from this figure as to the optimum level of fishing for any resource. There do not appear to have been any major collapses or declines of resources, or a temporal differentiation between time series by species as occurred for the North Atlantic (e.g. Caddy and Surette 2006), and no landings descended into the 'red' category late in the time series. The main factor common to all species would seem to be an increase in fishing pressure over the entire time series, as suggested by the fishing effort data in figure 4.

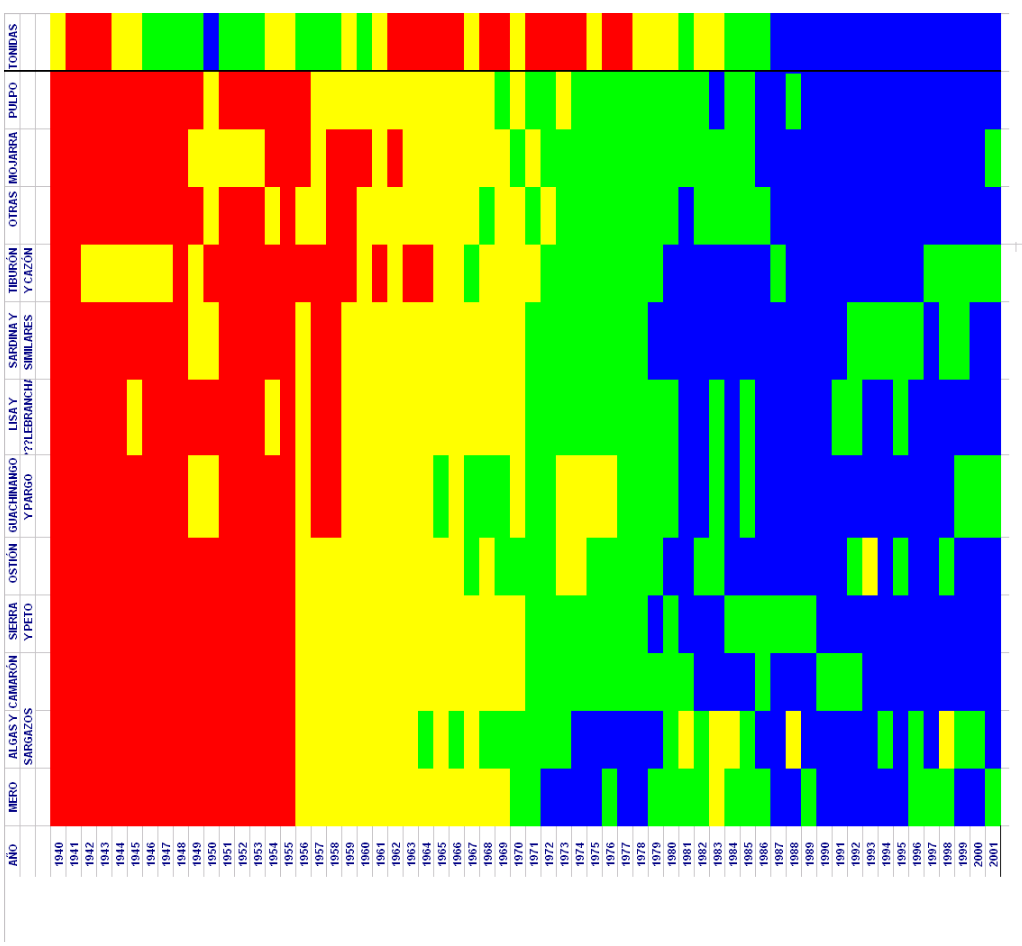

Fig 6 : National data sources on the trajectory of landings by 13 species divided into equal quartiles between the highest (blue) and lowest (red) annual landings observed for the Yucatàn region of Mexico (Seijo et al. 2013). The high seas tuna fishery (tonidas) with its anomalous landing trend differed from the series for shelf resources *g) A simple categorization of time series by cluster analysis*

The raw data series by resource shown in the traffic light chart in figure 1 was subject to hierarchical cluster analysis, using the Pearson correlation cluster method with nearest neighbor option, as given in the StatistXL software (Fig 7). Sardines and total catch were closely related, presumably since landings of this species outweigh the others. Tunas are also outriders. Bottom fishes tended to cluster together however, as did algae and oysters.

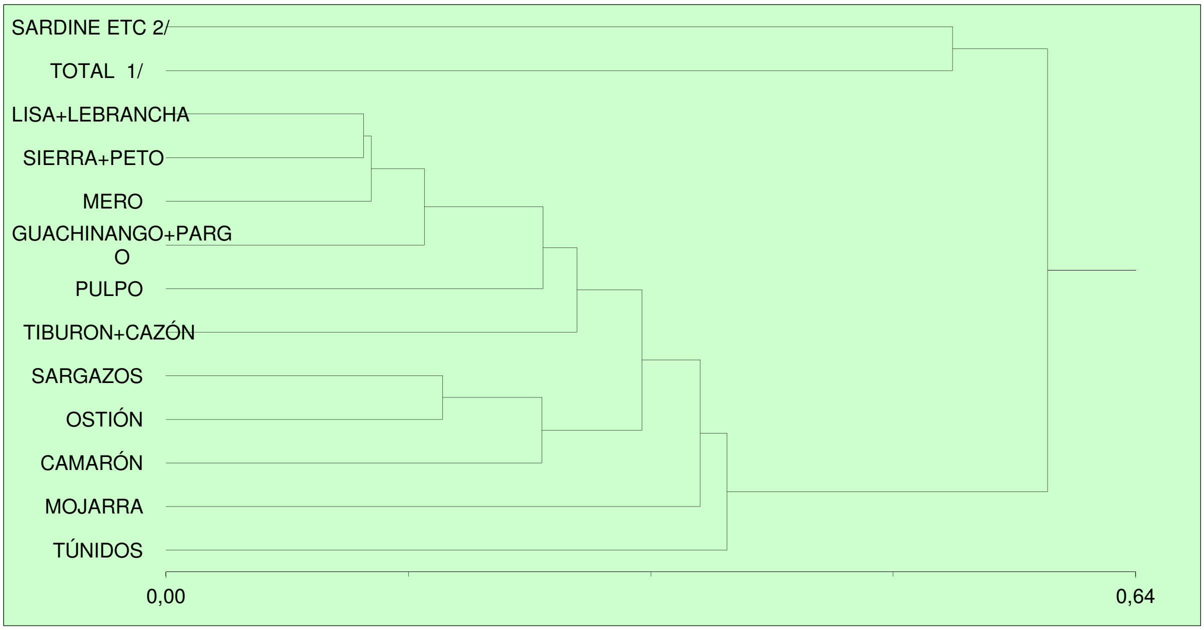

Fig 7 : *Results of cluster analysis of the data graphed in Fig 6. (From Seijo et al. 2013)*

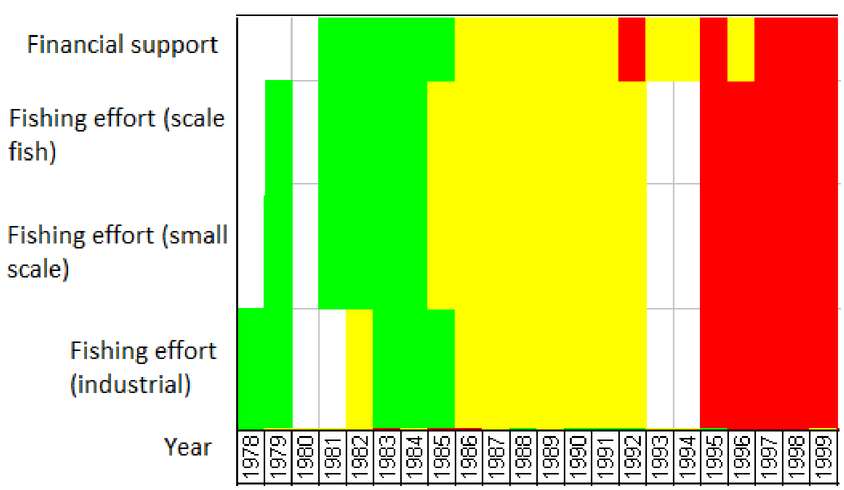

Fig 8 : *Financial support to the fishing industry and 3 sectorial measures of fishing effort over time (green low; red high) for Yucatecan fisheries .(From Seijo et al. 2013)*

In Fig 8, three separate series of fishing effort-related data are shown, plus a data set showing the overall financial support to the fishing industry. In this case a reverse coloration assumes that at a high level, both fishing effort and financial support to capacity building were colored red for precautionary reasons, since if excessive, this could prove negative for the resource and employment in the sector. This assumption of course provisional, even though one of the priorities in international fisheries of recent years has been an attempt to bring fleet capacity growth under control. However, this example is not intended to be a precise assessment; if it were, the yellow-red boundary on this chart would need to be set after independent bioeconomic analysis. What is interesting however is the close correspondence that emerges for these 4 independent data sets between the timing of the color transitions. This seems to confirm that there is a significant synergy between changes in fishing effort for small and large scale fisheries, and that these temporal changes reflect the degree of financial support received by the fisheries for all species. This supports the idea that restrictions on investment, rather than just on quotas or a control of days at sea, is likely to be the most effective measure for keeping total fishing effort or fishing mortality under control.

6) *Northern shrimp off Labrador and NE Newfoundland: are environmental or trophic influences more important?*

The paper described here investigated the feasibility of using the TL approach for monitoring shrimp (*Pandalus borealis*) stock status within northern Shrimp Fishing Areas (SFA) 5 and 6 off Labrador and Newfoundland. Two approaches were adopted: the first dependent on relatively short time series of large vessel (>500 t) commercial catch rates, while the latter used longer time series of total shrimp landings as the dependent variable.

The main objective was to review indicators used in the current assessment approach, develop a weighting scheme, and an objective approach to evaluating overall stock status. In trying to decide which variables to monitor in the Northern TL system for pink shrimp off Labrador and Newfoundland, papers in a recent symposium (Orr, (ed) 2004) were reviewed, and any mention of relevant variables, and observed or hypothesized interrelationships between them and shrimp production, was noted.

In summary, over recent years there has been a warming trend in the Arctic. In consequence a melting of Arctic Ocean/Greenland ice, and a southerly flow of cold low salinity water has intensified down to the Grand Banks. The increase in shrimp catch seems more likely to have been a consequence of changing flows of high salinity water off northeastern Canada than a consequence of a predator-prey upset, and Fig 9 seems to illustrate the potential error that may occur in premature modeling of ecosystem relationships.

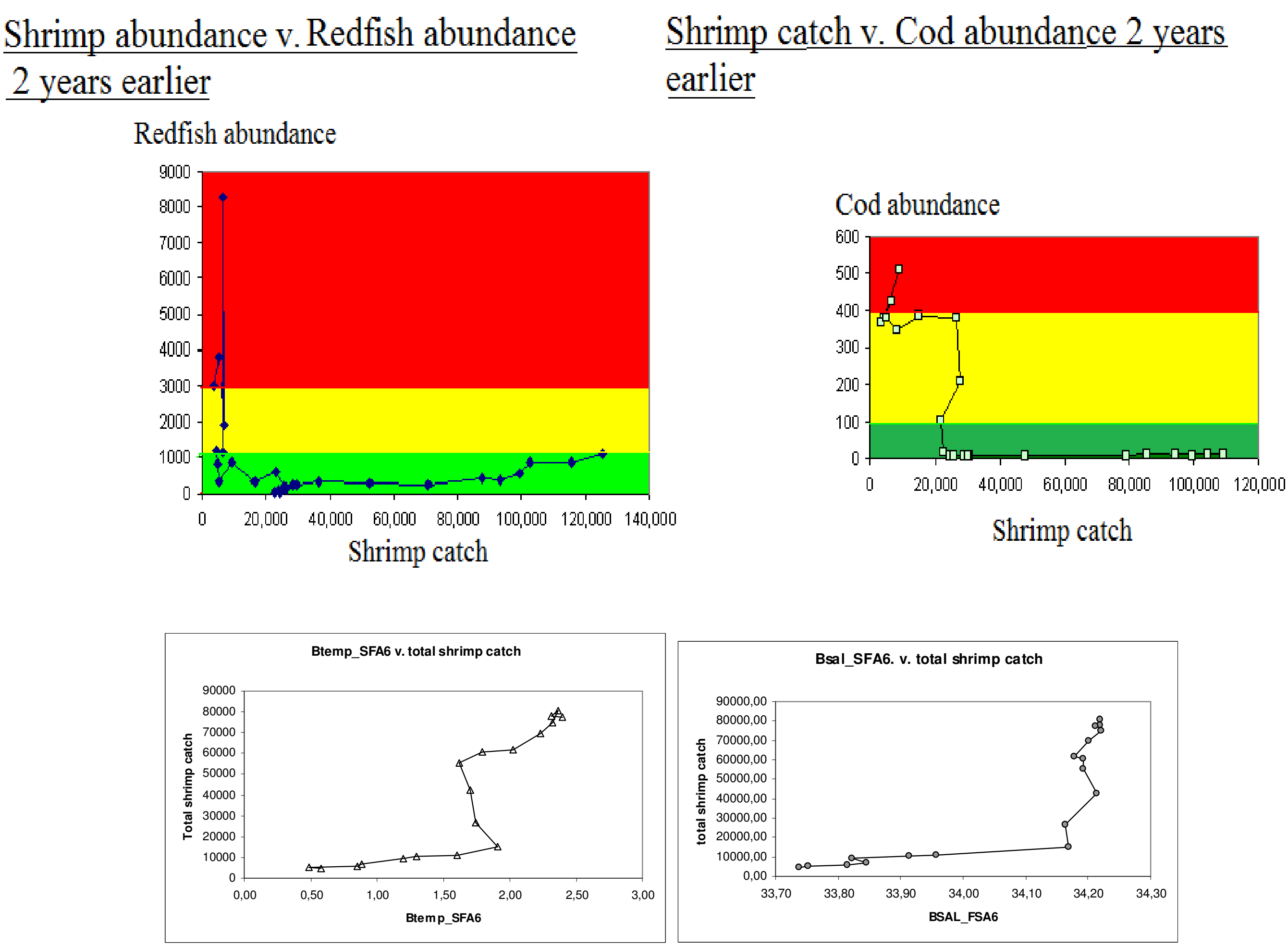

Fig 9 : (above) Smoothed data series (1983-2006) of annual catches in shrimp fishing area 6 of Pandalus shrimp plotted against smoothed catches of two of their predators, redfish and cod; (below) of shrimp catch against local prevailing salinity and temperature. (Data from CSAS 2007)

One of the more serious errors that can arise using conventional assessment methods based on relatively few variables, is the assumption that equilibrium environmental conditions have persisted, such that when a change in relative abundance of predators and prey occurs, a change in trophic conditions is assumed to be responsible. Thus, in Fig 9, high catches of a pandalid shrimp seem to reflect declines in two of its key predators, seals and cod. These dramatic changes are illustrated in two-variable plots of smoothed annual data series (Vn +Vn+1 +Vn+2)/3, such that an apparent dependence of high shrimp catches on a low abundance of predators seems to emerge. However, when changes in the ambient temperatures and salinities are included in the picture, it seems clear that a fairly rapid switch in the physical environmental regime favors shrimp abundance but not the abundance of its predators. Therefore changes in the physical environment may in part be responsible for the dramatic changes in relative abundances that were observed. This misinterpretation was more likely to have occurred if a traffic light figure incorporating all of the above parameters, had not been created.

The relevance of this example to all annual 'assessments' is clear. As Koeller et al. (2000) noted, conventional assessments using only one or two indicators are usually associated with high variances. This makes for uncertainty as to what an observed change means relative to stock status. Adding more indicators coming from independent observations will tend to reflect better the true state of the stock and its likely trend in the near future.

The traffic light approach has been proposed for monitoring shrimp fisheries in the *Southern Fishing Areas* (SFAs) off Newfoundland and Labrador, because it allows the consideration of a wide range of potential driving functions in a situation where:

1. There are uncertainties in age reading in establishing year class strength, but where dramatic increases in shrimp biomass suggest conditions have recently been favorable to recruitment and population growth;
2. A regime shift occurred during the late 1990's which has led to significant changes in indicators of sea ice cover, salinity and temperature;
3. Recruitment is believed to be largely environmentally-driven;
4. Shrimp stocks are relatively resilient to overfishing, but are not believed to be heavily exploited, hence population changes may not be reflecting solely fishing pressure;
5. There is limited dynamic range in many of the conventional fishery indicators (e.g., effort, catch per unit effort) that have been used to describe changes in northern shrimp populations off Newfoundland and Labrador;
6. Shrimp are recognized to be important forage items for several commercially important groundfish, invertebrates and marine mammals therefore fishing mortality has purposefully been kept at conservative levels;
7. At the same time, the predators potentially affecting shrimp biomass (groundfish, seals) have shown dramatic changes in abundance over the last decade, which could have affected shrimp biomass, and hence cannot be ignored in any system for monitoring shrimp productivity;
8. Because of the lack of age composition data, the relatively low level of exploitation indices (e.g., catch/biomass), and the non-equilibrium conditions that currently prevail, it has not been possible to detect fishery impacts upon shrimp within the study area;
9. Attempts to use assessment methodologies that assume a constant natural mortality rate (such as virtual population analyses - VPA) or constant productivity (such as surplus production models) appear inappropriate here, given the changing productivity of the stock;
10. Unlike a complete reliance on classical stock assessment models, (which of course can also be applied in parallel), traffic light displays are not structured around a limited number of data series and hence will allow a more flexible response to underlying changes in the environment and ecosystem.

7) Tunas and the "Traffic-Light" Approach

The use of empirical indicators will need to be tested both in simulation and in practice in order to detect and overcome possible problems of practical implementation. However, empirical-based approaches were presented to SCTB 17 meeting, held August 2004 in Majuro, Marshall Islands.

Performance measures and related reference points may lack the theoretical rigor usually associated with the more familiar model-based reference points, (but) initial results indicate the utility of this approach (Hilborn 2002). Furthermore, the use of such indicators may best be applied using a "basket" of empirical measures, each derived from fundamentally different data sources in a 'traffic-light' mode, where the nature of the management response is based on the number of reference points which have turned from green to either yellow or red. Due to the inherent uncertainty associated with any individual indicator, a range of indicators will be evaluated in parallel. The number of green, yellow and red light indicators will then be tallied and used to evaluate the likelihood of 'real' changes in the fishery, and then used as the basis for decision rules. An ideal management strategy should include multiple indicators, each derived from independent data, with trigger reference points corresponding roughly to the same level of exploitation or risk. Finally, as the history of their model-based counterparts indicates, such reference points will likely need to be subject to some 'fine-tuning' as part of a fishery management system, ie. they will probably have to be modified in the light of practical experience.

8) Trends in abundance of snow crabs in the Gulf of St Lawrence

The traffic light approach can provide useful results, especially in following trends in recruitment and abundance of life history stages, as illustrated for the snow crab (*Chionoecetes opilio*) population in the Gulf of St Lawrence. In the absence of age data, the identifiable stages of snow crab biology were sampled annually for abundance (Fig 10), and placed in sequence by age (Caddy et al. 2005).

Fig. 10 : Unlagged traffic light series for recruitment abundance indicators in 2003. The relative abundance of a recruitment indicator shows up as a diagonal band of color, as sequential life history stages pass through the population (from Caddy et al.2005)

Assuming in Fig 11 that the diagonal bands represent year class and their relative strength, this graph can be lagged so that good and poor cohorts passing through the population show up as vertical color bands. If this interpretation of the identities of life history stages is correct, this modified plot (Fig 11) could also provide a rough forecast of future yields, given that some periodicity in the abundance of life history stages in the population may be showing up.

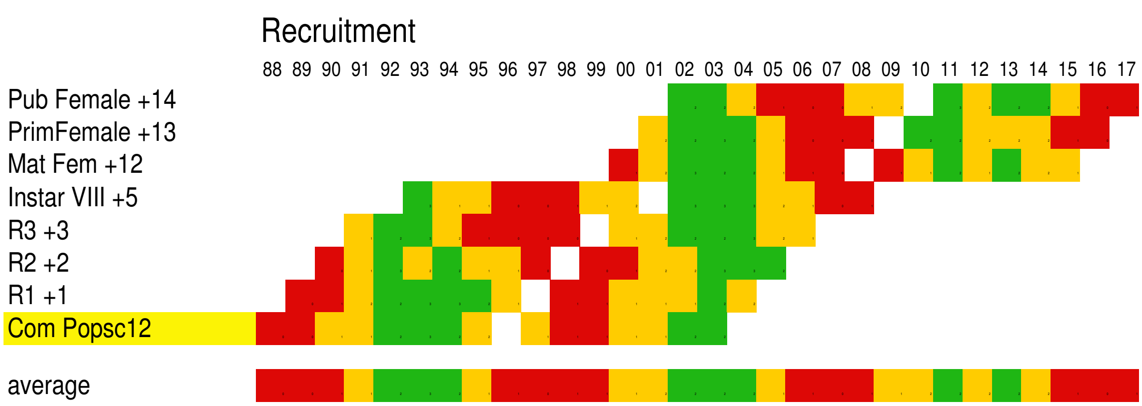

Fig. 11 : Recruitment indicators lagged so that good and poor cohorts passing through the population show up as vertical bands of homogenous color (From Caddy et al. 2005)

If used on a data set including categories related to age, a TL procedure may then lead to a degree of forecasting ability. For example, the temporal changes of a wide range of indicators in the snow crab (*Chionoectes opilio*) fishery over a series of years, including data on abundance of life history stages, fishing success, and environmental change, meant that even though age reading is impossible for crabs, the traffic light approach seemed to provide a reliable indication of the passage of year classes through the fishery. It was proposed therefore, to make provisional forecasts of the condition of the fishery several years ahead based on this data set.

The following general conclusions may be drawn from these last few examples:

Changes in environmental variables such as sea temperature are likely to become more important with climate change. The technical applications of the TL approach are also useful for empirically describing ecosystem interactions between species or habitat characteristics, but without having to assume any prior mechanism or interelationship.

- The snow crab and shrimp reports made use of three colors; red (indicator values potentially of concern), yellow (intermediate values) and green (positive conditions for production), in which past experience with the fishery, biological information, and the precautionary approach were used in setting color boundaries.
- The relative abundance of a life history stage in the annual trawl survey can be interpreted, since good and poor year classes remain visible as diagonal strips of green and red color respectively in sequential years (Fig 11).
- The abundance of adults (Com Popsc) tends to coincide with poor recruitment of very small crabs (Pub Females), and the apparent regularity of this density dependence seems to offer some limited forecasting capability.

9) A TL application based on the economics of a fishery

The economic performance of the Adriatic trawl fishery (Accadia and Spagnolo 2006) highlighted the presence of a negative trend throughout the period under investigation, judging from economic and social indicators. The worst economic performance was in 1999 and 2002-2003, while an improvement in the fisheries was registered in 2004.

The negative trend in economic performance over the period 2002-2003 was mainly due to reduced physical productivity and increased costs, but the lowest value for the economic sustainability indicator was registered in 1999. This was mainly due to the effects of the Balkan War, which led to a significant decrease in number of days at sea for the demersal fleet, and to a decrease in profitability. The average salary per man employed also declined, as did the social sustainability indicator. Relevant here, the opinions of stakeholders in the fishery can also be represented in the TL chart.

The economic indicators used were:

- Fuel cost for each day at sea of a vessel;
- Maintenance cost per vessel;
- The average market price of landings.

Social indicators used were:

- The average production (weight of landings) for each man employed;
- Revenue per crew, in terms of market value for each man employed;
- Number of people employed in the fishery;
- The average income for each man employed.

10) Management by a 'fisheries management plan' formulating 'fisheries control rules'

The TL methodology was intended as an empirical approach to evaluating the status of a fishery. Instead of conventional assessment procedures which usually employ the few data series needed to fit a specific model (typically catch, effort, biomass, or population age structure), the use of a TL approach as a preliminary assessment with all relevant time series, allows an evaluation through visual inspection and statistical procedures of the most suitable data sources for informal assessment or modeling of the population. The method may also incorporate the results of decision-making procedures, such as cooperation with stakeholders in deciding when critical conditions have been reached, or decision criteria can be incorporated into a fishery control law to guide future decisions.

A Fisheries Control Law incorporating the Traffic Light procedure allows more explicit decision-making and precautionary regulation (Fig 12). Such a specific fishery rule may be formulated where species are characterized by the change in abundance in successive years, placing them into one of three categories: declining, stable, or recovering, for each of the variables: including commercial catch rates, survey catch rates, mortality estimates, and/or effort units exerted. A weighted overall mean can be calculated, whereby if the score is <1, fishing effort is reduced next year. Management options are also spelled out in Fig 12.

INDICATORS OF ENVIRON-MENT AND ECOSYSTEM	STOCK CONDITION (based on annual surveys)		
	Healthy stock condition	Biomass below Bopt	Biomass below Blim
Habitat/ Environment satisfactory	May increase capacity moderately	Maintain capacity constant	Close the fishery in this area
Deteriorating Productivity	Maintain capacity constant	Reduce capacity or days fished	Close the fishery in this area
Habitat/Environ-mental conditions unsatisfactory	Reduce capacity or days fished	Close the fishery in this area	Close the fishery in this area

Fig 12 : One hypothetical design for a Science-Management nterface. The fishery scientists responsible for assessment should assign the current state of the resource into one of 9 boxes based on technical criteria. The fishery control rule gives managers some limited discretion as to how they implement the advice in the appropriate box

An alternative framework is suggested based on the hypothetical TL approach is shown here:

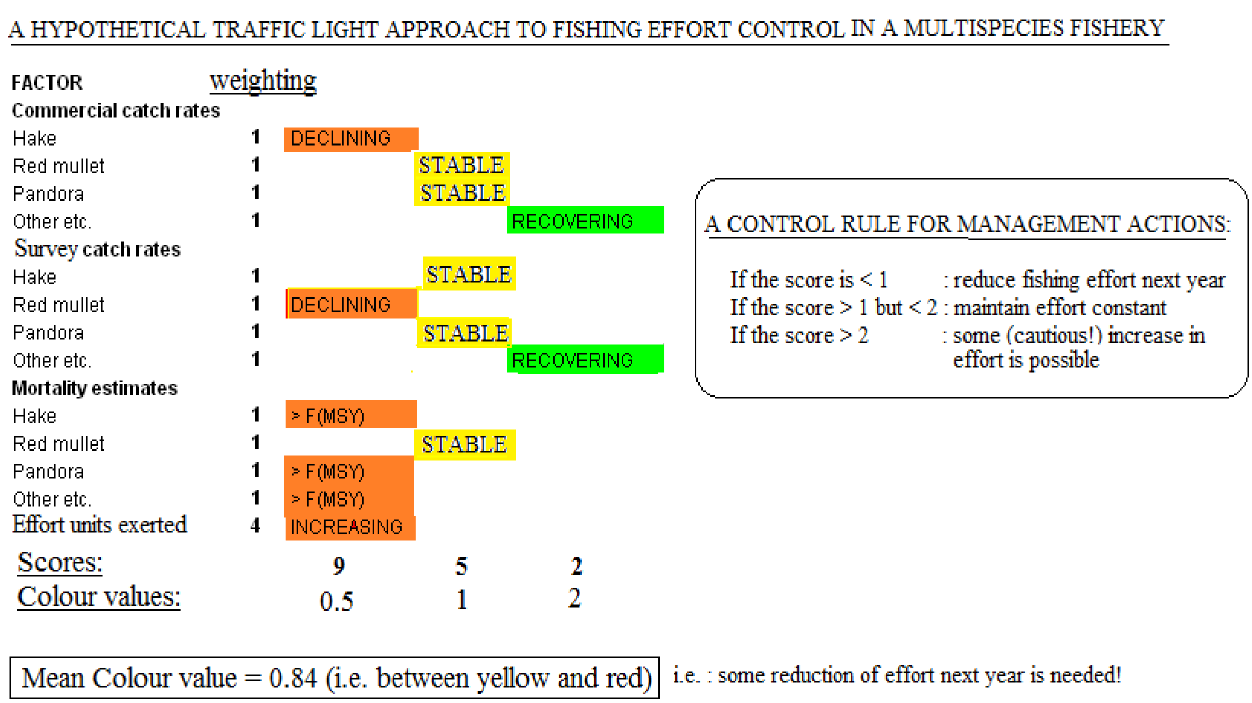

Fig 12 : A hypothetical traffic light approach to fishing effort control in a multispecies fishery, showing options for fishing strategy next year

h) Comments on fishery control laws

Fisheries control laws are usually based on pre-established reference points for the species being measured (Fig 13), which unfortunately, often are indicated by different symbols used in different fisheries commissions.

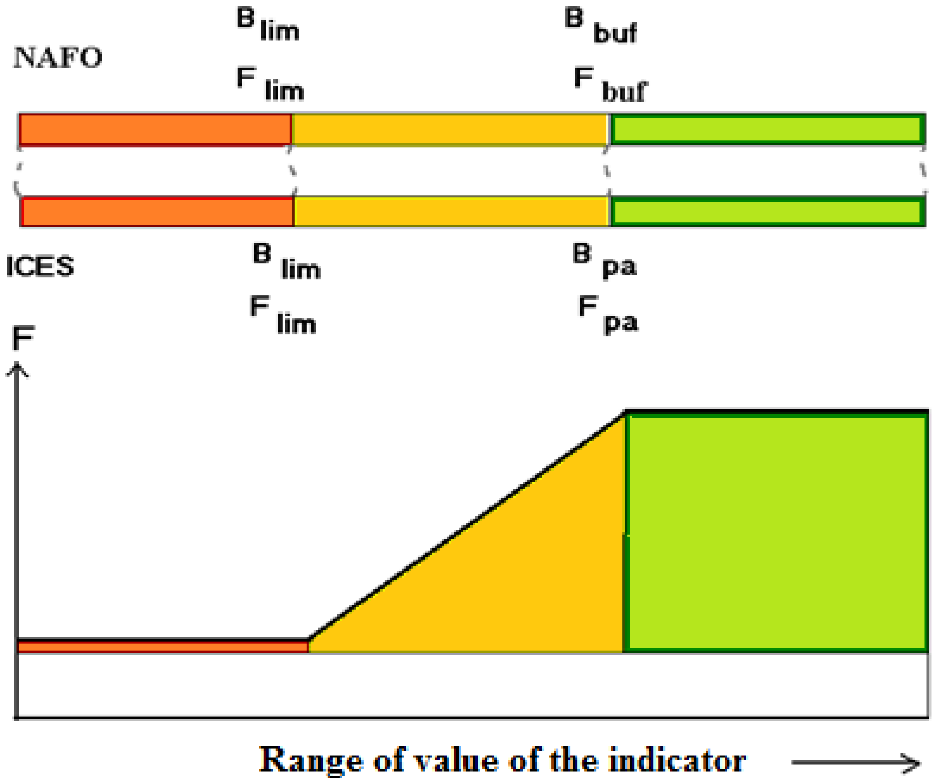

Fig 13 : Approaches to deciding on fisheries control laws used in ICES and NAFO commissions, expressed in traffic light form

With the agreement of the fishing industry, a fisheries management control law aims to develop the industrial fishing enterprise, and establish rules for its operation, as follows:

- A Fisheries Control Rule may be a component of an established Fisheries Management Plan, and as such, allows the Management Plan to be more easily modified without changing its broad legal framework.
- The Limit and Target reference points referred to may be obtained by calculation, but it is important that there is general agreement that the LRP values are precautionary, since actions required if they are encountered will be painful!
- Annual performance reports must be prepared, using agreed metrics when determining what actions to take in response to between-indicator changes in color.
- A management plan framed as a legal document may be difficult to change, if after adequate experience it proves technically faulty, but if it incorporates a stock rebuilding plan based on responses to a LRP, actions can be taken rapidly.
- Once the LRP is triggered, a stock rebuilding plan should be initiated immediately.

In the absence of limit reference points for the indicators selected, several other approaches to setting color boundaries may be used. Two representations of hypothetical stock rebuilding plans are shown in Figs 13 and 14.

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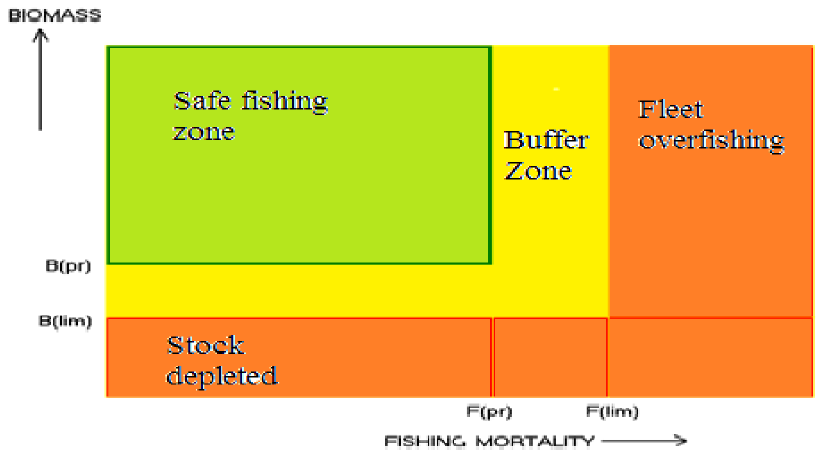

Fig 14 : *Visualization of a management control law based on preset values for indicators of spawning biomass and fishing mortality. When either (spawning) biomass and/or fishing mortality rate move from the 'yellow' to the 'red' zones, a fisheries recovery plan is automatically initiated until an agreed safe target biomass is restored. (FPR and BPR are levels of fishing mortality and biomass respectively, where there is a low probability of exceeding the respective limit reference points FLIM and BLIM). (Redrawn from Caddy and Agnew 2004)*

i) Conclusions on the application of a technical traffic light approach in fisheries

Conventional assessment models assume that the key variable affecting the managed population is the rate of exploitation, and generally ignore other factors. While this assumption may sometimes be necessary, the decisions of the management body (a Fishery Commission for international resources, or a Fisheries Ministry for national resources), are also affected by social and economic factors, the current level of investment in the fishery, as well as by ecological and/or environmental change. Given the complexity of the exploited resources and the harvesting pressures, decisionmaking aimed at a single optimum agreed to by all parties is not easy to resolve, and climate change won't make it any easier. In these circumstances, it is highly desirable that the data series' used to arrive at decisions are displayed in an unambiguous fashion, so that management decision-making can make use of historical information, employing management rules based on earlier experience. It is also important that a wide range of information be used, gathered not only from scientific investigations, but also by the fishing industry itself. It must be understood that decisions taken by fisheries management bodies do not issue forth from an equation or from applied mathematicians alone, but are arrived at by a process of consultation between interested parties, that may be compared with the Mensa approach. Providing the needed data for such a process should be aided by the Traffic Light procedure.

The rapid expansion of applications of the 'Traffic Light Procedure' as an aid to hypothesis formulation and decision-making in a wide range of applications, will be briefly summarized in part II of this report.

Part II: Developing applications of the traffic light approach in other sectors

An increasing frequency of traffic light applications has occurred over the last decade, and the simplest way to access these is over the Web. The approach described here does not claim to be foolproof or comprehensive. What has been attempted is to show the general trend in utility of the TL approach over the last few decades, in a wide range of applications.

The point could be made that the expression 'to give the green (or the red) light' to an action long precedes development of a 'traffic light procedure' as described in earlier sections. Simpler applications that literally reflect the 'go/pause/stop' sequence of a physical traffic light are commonly-used in all socio-economic sectors, but strictly speaking, they do not constitute a traffic light procedure involving numerical data. Perhaps a good example of these was the development of yellow and red cards by soccer referee Ken Aston in 1970, to signify caution and expulsion from the game. The fishery control rules described in part I also resembled this simple example, in reflecting that once a decision has been reached using a numerical traffic light, the number of cells of the traffic light can be reduced to a limited number containing diagnostic statements on management measures based on earlier unreported analyses. It seems quite likely that a number of applications mentioned here that appear similar to this typology, may in fact reflect conclusions reached on the basis of unreported numerical analysis.

With respect to applications of a traffic light methodology, military procedures incorporating this type of procedure may exist, but are not usually available in civilian literature and hence are not referred to here, and a TL portrayal of trends is occasionally used in stock market reports and decisions. Other areas where a traffic light approach has been attempted, is in the monitoring and (hopefully) management of climate change (Bowes-Larkin 2014). For example, the 2° climate warming 'goal' (not to be exceeded) may be seen as the limit reference point between acceptable and dangerous climate change.

It is possible, or even probable, that more than one TL procedure described here will have been reinvented; for example, some medical applications. Nonetheless, with respect to possible reinventions of the TL method, it was soon recognized, in searching for applications, that commercial or institutional applications of traffic light procedures rarely provide an exact date of origin, or a reference to earlier applications. Also, the date of the web pages chosen here may have been inserted after the method was already underway. Nonetheless, the 115 TL applications located, suggest that we are dealing with the widespread adoption of a specific type of procedure over a short period of time. From evidence given on the web, the apparent origin was in the late 1990's, but the use of the TL procedure has proliferated greatly since then. It seems likely that the beginnings of the data base on TL applications initiated here will be expanded by new items added in the near future, (and in all probability by some older ones).

The following short summaries, (expressed in their original form with slight modifications) do not enter into a full diagnosis of the features they exemplify: they are introduced with the main objective of showing the wide range of applications now existing, and as useful references for more detailed investigation. Although rarely specified in the web descriptions accessed, an information-collecting function is presumed to underlie the traffic light applications presented in Part II. Though specific reference points are rarely mentioned, in place of these, written criteria decided by some decision-making function or body must exist.

Some 29 examples follow of activities involving the traffic light approach with a brief summary for each of their key features:

1) *University of Western Australia 2014. Safety and Health*

The Traffic Light system offered an opportunity for integration of senior management into a measurement and evaluation process with outcomes which help demonstrate involvement and due diligence. The University is required to have adequate systems, processes, structures, resources, procedures and reporting approaches in order to be compliant with health and safety legislation (The Work Health and Safety Act). This level of monitoring provides a method of measuring key elements of health and safety management which can be used to highlight overall performance in all parts of the University. Its collated data presents an Executive Overview to assist in identifying and acknowledging areas where greater focus is required, in respect of work health and safety. This enables the University to direct and better utilize resources to assist in implementation of corrective measures. The Traffic Light System is to be used on a biannual basis and demonstrates a proactive determination to monitor and continually implement safety improvements.

2) *Protection of North Atlantic Right Whales from shipping and noise during wind farm construction offshore*

'This morning, together with the National Wildlife Federation and Conservation Law Foundation, we announced an agreement with Deepwater Wind, a major offshore wind developer, to safeguard North Atlantic Right Whales during the initial phases of development off southern New England. The agreement provides more protection than the administration has required thus far, and right whales are very much in need of protection'.

Right Whales got their name because they were deemed the "right whale" to hunt, and were driven to near-extinction by whaling. It's been almost eighty years since they were legally killed, but they remain critically endangered in the Atlantic. Right whales are highly vulnerable to collision with ships when they feed on copepods just below the water's surface, where they can be struck but not seen. They also have a terrible history of entanglement in fishing gear. Underwater noise from shipping and industrial activity also disrupts their behavior and destroys their ability to communicate, and pollution is degrading their habitat. The wind development areas off Rhode Island and Massachusetts are in whale habitat. The largest right whale feeding aggregations ever seen have occurred in Rhode Island Sound—more than 100 animals.

At the heart of the agreement is a traffic-light system of red, yellow, and green periods. Pile-driving and sub-bottom profiling are prohibited during the red period, when right whales are most likely to be in the area; and mitigation measures apply during the yellow months, when right whales are less likely to occur. Some measures would run throughout the year when the light is green, since right whale occurrence always remains a possibility.

3) *Soil: This project specifically addresses Theme 1 of the Soil Biology Initiative - Monitoring soil quality for better decision-making*

Growers need monitoring tools that directly measure soil biology (or provide a reasonable surrogate measure) so they know they are heading in the right direction with their systems and practices. These measures need to be regionally relevant, land use and soil type specific, and able to be related to crop performance measures. As part of the *www.soilquality.org.au* monitoring program, growers can access regionally specific data on soil biological, chemical and physical constraints on production. This information is provided in a number of formats including a 'traffic light' snapshot that highlights the main issues for concern in a region. The traffic light system is based on expert panel recommendations for critical values for each indicator housed in the web site. A grower can also benchmark their own data against grower group and regional averages. Together with tailored soil health workshops and computer training, this empowers growers to make better informed management decisions with respect to production and longer-term soil sustainability. The soil quality data on the web site is supported with information fact sheets and calculators which enable 'what if' scenarios to be tested so as to highlight favorable soil quality management decisions. To date the soil quality data sets are Western Australian focused. The main objective of this project is to develop this monitoring and web site approach as a national platform to aid the Australian grains industry with better management decisions and to provide the necessary data/information on soil biology (in association with soil chemical and physical data).

4) *Grains research and the development corporation*

As part of the *www.soilquality.org.au* monitoring program, growers will be able to access regionally-specific data on soil biological, chemical and physical constraints to production. This information is provided in a number of formats including a traffic light that highlights the main issues of concern in a region. This traffic light system is based on expert panel recommendations for critical values and is housed on the website.

5) *Singapore Sustainable Seafood Festival (8-15 June 2014)*

WWF recognizes the following types of seafood as “sustainable”:

1. Marine Stewardship Council (MSC) certified seafood;
2. Aquaculture Stewardship Council (ASC) certified seafood;
3. Seafood listed on the green list on the WWF Singapore Seafood Guide.

Based on an internationally accepted methodology the guide summarizes a selection of 46 commonly-found seafood in Singapore, into three categories using a traffic light system:

Green (Recommended): Seafood in this category come from well-managed, sustainable stocks which are not considered to be over-exploited. This seafood is the preferred eating choice.

Yellow (Think Twice): Seafood in this category comes from fisheries that are at risk of becoming unsustainable due to poor management and environmental or stock health issues. This seafood should only be eaten occasionally and preferably only when recommended options are not available.

Red (Avoid): Seafood in this category comes from fisheries considered to be overexploited and unsustainable. Consumers should avoid eating fish from these overfished and poorly managed fisheries at present.

6) *South African Sustainable Seafood Initiative (SASSI)*

In 2004, the World Wide Fund for Nature (WWF) established the South African Sustainable Seafood Initiative (SASSI) to inform and educate all participants in the seafood trade, from wholesalers to restaurateurs through to seafood lovers, about sustainable seafood. By using a "traffic light" system, the color-coded SASSI list categorizes selected South African and imported seafood species according to their conservation status.

Green: This is the group from which consumers are encouraged to choose, as it contains the most sustainable choices from the healthiest and most well-managed populations. These species can handle current fishing pressure.

Orange: This group includes species that have associated reasons for concern, either because the species is depleted as a result of overfishing and cannot sustain current fishing pressure, or the fishery that catches them may cause particularly severe environmental damage, and/or has high by catch, or the lifestyle of the species makes it vulnerable to high fishing pressure. Consumers are encouraged to think twice and consider the implications of these choices.

Red: This group includes both unsustainable species, which are from collapsed populations or have extreme environmental concerns and/or lack appropriate management, and species that are illegal to buy or sell in South Africa (no-sale species). These species should never be bought by consumers. Fish highlighted in bold in this category are illegal to sell in South Africa.

7) *Government of Canada: Color Coding for Ice Charts*

Colors are used to enhance ice charts for presentations and briefings. The codes allow users to make a quick assessment of the general ice conditions and to visually follow trends. It is important to remember that the colors alone cannot be used for navigation decisions and that more detailed ice information is contained within the Egg Code. There are four color codes in use at CIS, since each code displays the ice in different ways.

Standard CIS Color Code or ISS Color Code:

The Standard CIS Color code is intended to assist navigation decisions in ice-infested waters. It represents the severity of the ice conditions and is somewhat similar to a traffic light. Colors are used to identify concentrations of significant ice. Blue and Green represent relatively easy conditions; Yellow and Orange indicate caution is needed. Red and Purple indicate the more dangerous ice conditions.

8) *Integrating indigenous livelihood and lifestyle objectives into managing a natural resource*

The impact of alternative management strategies is evaluated using triple-bottom line sustainability objectives, namely impacts on social and cultural outcomes, economic profitability, and resource status (via a traffic-light display where for a particular performance indicator, **red** implies "**worse off**," **amber** means "**same state**," and **green** means "**better off**").

9) *Government consultations on new sustainable development indicators*

When changes in the indicator measures are small, it can be difficult to judge whether they are sufficient to indicate that there has been clear improvement or deterioration. For this reason each measure has been assessed using a set of "traffic lights". These do not show whether the measure has reached any published or implied targets; rather, they show whether changes in the trends are showing a clear improvement or a deterioration.

The traffic lights are determined by identifying a period over which to assess change, and comparing the value of the measure in the base or start year with the value in the end year. Where data are available, two assessment periods have been used:

Long-term – an assessment of change since the earliest date for which data are available (usually back to 1990). If the earliest data available is after 2000, no long term assessment is made.

Short-term – an assessment of change is made for the last five year period.

The traffic lights only reflect the overall change in the measure from the base to the latest year, and do not reflect fluctuations during intervening years. The individual measures also have a third marker which shows the direction of change between the two most recent data points. This period is too short for a meaningful assessment. However, when it exceeds a one percentage point threshold, the direction of change is given as an acknowledgement of very recent trends, and as a possible early sign of emerging trends. The traffic light assessments are:

Green: Improving;

Yellow: Little or no overall change;

Red: deteriorating.

10) *Microbial risk classifications for recreational waters and applications to the Swan and Canning Rivers in Western Australia*

In accordance with established Guidelines, a traffic light system of green, amber and red was devised to monitor 27 aquatic sites more effectively for the WA public. Green represents the safer areas for swimming, and red, areas of higher recreational risk. In the absence of definitions for each risk classification in the Guidelines, generic definitions were developed and assigned a color corresponding to the perceived risk.

Abbott, B., R. Lugg, B. Devine, A. Cook and P. Weinstein 2001 Journal of Water and Health (09.1).

11) *Project/program monitoring and evaluation (M&E) guide*

One way chosen to highlight key data in presentations, is through a "traffic light" approach that rates data by either: 1) **green** for '**on track against target**', 2) **orange/amber** for '**slightly off track but likely to meet the target**', and 3) **red** for '**off target and unlikely to meet target**'.

Int'l Federation of the Red Cross and Red Cross societies, 2011.

12) *Science for Environment Policy*

The *Viswijzer (fish guide/handbook/advisory body)* was set up in 2004 by the North Sea Foundation (NSF) to independently assess stocks of the most popular commercial fish species. The primary consumer tool produced by the *Viswijzer* is a small walletsized card which indicates the sustainability status of different species with a traffic light system (red = overexploited, green = environmentally sustainable). The card is now reportedly used by 25% of all Dutch consumers.

DG News Alert Service; European Commission

13) *Traffic Light Labeling is the Best Way to Reach Consumers*

How food labeling regulations should be designed remains a subject of controversy. There are two models to choose from: the EU Commission prefers a system in which the recommended daily values for each dietary component are indicated as a percentage, without a color-coded classification system. By contrast, consumer and health care organizations prefer a traffic light model, with red, yellow, and green lights to indicate nutrient levels in a particular food.

(*Soon to be published) - Kornelia Hagen. Nutritional Information: in DIW Weekly Report No. 19.*

14) *The emergence and effectiveness of the Marine Stewardship Council*

A consumer-based approach has been introduced to improve fisheries governance, and develop seafood-ranking guides to help consumers choose fish from sustainably managed fisheries. The Audubon Seafood wallet card is intended to guide customers when ordering seafood in restaurants and buying fish in supermarkets. It identifies seafood choices according to traffic-light colors, green, yellow and red.

Lars H. Gulbrandsen Fridtjof Nansen Institute, P.O. Box 326, 1326 Lysaker, Norway. (Forthcoming in Marine Policy vol. 33, 2009).

15) *Policy on Non-Timber Forest Products*

The Forestry Commission for Scotland is keen to support and encourage the development of the NTFP (Non-Timber Forest Product) sector in a way which allows continued access to the resource, but ensures that harvesting is carried out in a sustainable and responsible way. A new Access Behavior Code has been developed to provide guidance to FCS staff and stakeholders. This sets out how the relevant legislation applies to forest users, and provides a traffic light system to indicate what activities are acceptable, which will be subject to advice, or in the worst case, criminal proceedings. ***Scottish Government Policy***.

16) *Development and Use of Reference Points*

Fishing mortality and stock size reference points synthesize much information into a few numbers (e.g., *F*MSY, BMSY), while index-based reference points are generally for individual data sets. Thus, the utility of index-based reference points is improved with the addition of more data sources. One method uses a 'traffic light approach' (see Caddy's Traffic Light Approach). In this type of management régime, abundance, recruitment, age structure, and other fishery-independent or – dependent information, is used to assess the current status of the stock. In utilizing multiple sources of information, indicators of stock status may be more informative when compared with reference points or methods based on a single data source.

McKown, K., S. Correia & M. Cieri. (2008). The Assessment Science Committee; Atlantic States Marine Fisheries Commission.

17) *Halliday et al. (2001) proposed that decision rules be based on the integrated score of indicator values measuring at least three characteristics (abundance, production, and fishing mortality)*

A gradation of responses is likely to occur, since individual indicators of characteristics may not be triggered simultaneously. This may provide some redundancy and smoothing if the proportion of indicators triggered determines the degree of management response. On this point, Prager (1994) and Prager et al. (2003) argued for the advantages of using normalizing time series, or expressing indicators in dimensionless form; such as the ratio of current value to the 'optimal' value. This puts all the indicators on the same scale, though it might be advisable to use standard deviation units (Z transformed) to also eliminate differences in variability.

18) *A bio-economic indicators suite for the appraisal of the demersal trawl fishery in the Southern Adriatic Sea (Central Mediterranean).*

Biological indicators were applied for "single-species" (*Eledone cirrhosa, E. moschata, Illex coindetti, Merluccius merluccius, Mullus barbatus, Nephrops norvegicus, Parapenaeus longirostris, Raja clavata, Zeus faber*), and for "multispecies" analysis. Economic indicators describing economic performance, productivity, costs and prices, and the overall economic sustainability of fishery were estimated. Social indicators and a general indicator summarizing social sustainability were also considered. Indicator values were displayed using the Traffic Light system. Both fishery-independent and fishery-dependent indicators highlighted a progressive decline of the trawl fishery system in area GSA 18. This decline was mainly related to ongoing depletion of the traditional fishery target species (mostly long-living, latematuring species), which were partially replaced by an increase of traditional accessory species (generally short-lived species), as well as by the reduction of productivity and increasing costs. The whole procedure was proposed as a contribution to the identification and applicability of bio-economic indicators for fishery management purposes. ***Ceriola L., P. Accadia, P. Mannini, F. Massa, N. Milone, N. Ungaro. (2008).Fish. Res., vol. 92, no. 2, pp. 255-267***.

19) *CEFAS: Potential reference points, precautionary management frameworks and harvest control rules for UK shellfish species*

Traffic light systems, primarily used in data-poor situations, allow the synthesis of signals from a range of sometimes-empirical indices and indicators. They use scoring systems to combine metrics of different scales or units and provide an overall indication of stock or fishery health. Scoring systems can include fuzzy logic and ramp functions, but the selection and weighting of indices to be used in the synthesis is crucial to the overall score. Traffic light (TL) systems can, and preferably should be extended to include Harvest Control Rules (HCRs), thereby acting as a precautionary management framework, rather than simply as a combined index. Traffic light systems have been criticized for a lack of scientific rigor. Nonetheless, they have been quite widely used in Canada, particularly for crustacean stocks, but have not been applied to any significant extent in Europe.

Many stocks are taken as by-catch and are very data-poor. In these instances simpler approaches may be required. At many levels of complexity there may be advantage in utilizing several independent indicators and taking environmental conditions into account. Traffic light approaches can provide a suitable means to automate and formalize data synthesis as well as the framework for making consequent management decisions. ***Report commissioned by the Shellfish Association of Great Britain (SAGB) and the Marine Stewardship Council (MSC) by M.T. Smith 2008.***

20) *A critical review of approaches to aquatic environmental assessment*

The traffic light approach was adapted for the Charting Progress report (DEFRA, 2005) to indicate whether the current environmental status is 'acceptable', 'unacceptable' or if there is 'room for improvement'. These are subjective estimates based on available evidence, reached in consultation with experts. Color coding is useful for showing trends, but interpretation is generally subjective and can be influenced by the selection of components and/or the number and ranges of color categories chosen. Computer modeling systems are used by some authors.

Foden, J., S. I. Rogers, A. P. Jones (2008).Mar. Poll. Bull. 56; pp.1825–1833.

21) *Charting Progress: an integrated assessment of the state of UK seas*

Key principles for the assessment process: For some components it was straightforward to decide on the extent of problems within a Region. For example, the eutrophication assessment showed that in some Regions, eutrophication only occurred in several small estuaries. These areas constitute less than 0.2% of each Region (and less than 0.003% overall), so their eutrophication status was represented by a green traffic light denoting 'few or no problems'. However, for the habitats and species components it has sometimes been more difficult. The assessments address the number of pressures exerted on it, or the impacts it receives, or a combination of the two. For example, the intertidal rock habitat in Region 5 is affected by rising sea levels and climate change, and this has led to changes in a number of rocky shore communities. Even though the extent of the rocky shore habitat is small, within the context of Region 5 as a whole it is significant, so it was decided to allocate this component an amber status within Region 5, thus denoting 'some problems'. Although we have used all the evidence available, not all aspects have been covered, so we have had to rely on expert judgment in assigning 'traffic light' status to some of the components.

Department for the Environment, Food and Rural Affairs, Defra, 2005. PB 9911. 120pp. (http://www.defra.gov.uk/environment/water/marine/uk/stateofsea/index.htm).

22) *The OECD Environmental Outlook to 2030*

The report 'Key Messages': is based on projections of economic and environmental trends to 2030. The key environmental challenges for the future are presented according to a "traffic light" system. The *Outlook* also presents simulations of policy actions to address the key challenges, including their potential environmental, economic and social impacts. Classified by a traffic light approach are aspects of climate change, biodiversity & renewable natural resources, water, air quality and waste & hazardous chemicals.

A Green light = well-managed environmental issues, or where there have been significant improvements in management in recent years.

A Yellow light = environmental issues which remain a challenge, where management is improving, where the current state is uncertain, or which were well managed in the past but less so now.

A Red light = environmental issues which are not well managed, are in a bad or worsening state, and which require urgent attention. All trends are global, unless otherwise specified.

Action is affordable: policy scenarios and costs

The *Outlook* highlights some "red light" issues that need to be addressed urgently. The policy scenarios in this *Outlook* indicate that policies and technologies to address the challenges are available and affordable. Ambitious policy actions to protect the environment can increase the efficiency of the economy and reduce health costs. In the long term, the benefits of early action on many environmental environmental challenges are likely to outweigh the costs.

23) *Guidance for methane and carbon dioxide emissions during construction*

The Traffic Lights approach details what protection measures should be installed to adequately protect a residential development against emergence of ground gases. Attention is paid to current best practice in use throughout industry and to site characterization techniques for improving risk assessment accuracy. Risk assessment and its role in site development is introduced, and various methods of determining risk are presented. A key element is the reduction of ambiguity in the choice and installation of ground gas protection measures. A set of 'Traffic Lights' are proposed where if specified methane and carbon dioxide concentrations exceed Typical Maximum Concentrations, further evaluation of flow rates is required. (***NHBC/RSK).***

24) *Sustainability criteria for fisheries subsidies: Options for the WTO*

Benchmarks for Rapid Overall Evaluations. A "condensed questionnaire" was prepared to establish the state of management and exploitation of marine resources as a basis for further development. Although exact criteria were not proposed, if scored impartially by persons familiar with the fishery traffic light criteria, it should return a high percentage of 'Green' responses if the fishery is properly managed. A proportion of 'Yellow' responses can be accepted, but any 'Red' responses should be seen as the basis for urgent improvements. ***UNEP/WWF report: by David K. Schorr and John F. Caddy.***

25) *Great Barrier Reef (GBR) Marine Park Authority: Indicators; their application for marine protected area management*

A *'Traffic light'* approach is satisfactory for simple depiction of the status of the GBR, using standard indicators. What does an indicator need to be?

- Representative?: is it representative of the GBR as a whole, or an issue?
- Responsive?: will it change according to changes in the health of the GBR?
- Scientific merit?: can it be measured accurately and relatively simply?
- Meaningful?: especially to managers & the community.
- Threshold?: is there a level at which concern will be raised in time to take action?
- Ecologically, socially & economically relevant?
- Indicators must reflect changes at spatial and temporal scales of relevance to management and what needs to be measured;

Suggested criteria:

- You need differing indicators for site level and system level;
- Think of your audience when developing an indicator;
- Ecological goals, socio-economic and governance goals are not mutually exclusive; but they do need different evaluation criteria/indicators.

World Heritage Workshop, Paris, Jan. 2007.

26) *Charting Progress: An Integrated Assessment of the State of UK Seas*

This is the first integrated assessment of the state of UK seas used a "traffic light" system to indicate whether progress is acceptable, unacceptable, or has room for improvement. Assessments apply both to fauna/flora (fish and other biota), marine mammals, sea birds, environmental quality, and climate change. The evidence is capable of differing interpretations, (but) the judgments expressed were reached in consultation with experts. Assessment criteria used in an example of the traffic light categories for fish stocks, follows:

RED: Stocks suffering from reduced reproductive capacity

YELLOW 1: Stocks which are at risk of suffering reduced reproductive capacity

YELLOW 2: Stocks at full reproductive capacity but are harvested unsustainably

RED: Stocks at full reproductive capacity and being harvested sustainably

WHITE: No assessment done (either no data, unfished, or species not present).

The multi-indicator system and the TL methodology are illustrated as a means of following changes within the changes in the stock, to provide useful information for the assessment of the resource. *www.defra.gov.uk.*

27) *Draft Bering Sea & Aleutian Is. King and Tanner Crab Plan. (Addendum to King and Tanner Crab Plan Team Meeting Minutes, 4 October 2003)*

Additional elements were proposed to be included in an amendment of the Plan:

- 'A Limit Reference Point [LRP] System [Caddy 1998] is needed for gauging the annual status of the stocks.
- Caddy's 'Traffic Light System' for identifying and enumerating meaningful indices of stock status evaluated annually, so as to derive an aggregate index of stock health. This method was proposed to replace the current simple determination as to where current stock biomass is relative to a single level'.

28) *Fishing for the Future: Unilever's Fish Sustainability Initiative (FSI)*

Unilever was the company that in 1998 began to apply a traffic light approach to the fish products they offered for sale. Their brochure described this event as follows: 'In 1996 we started by engaging with our fish suppliers to encourage them to adopt sustainable fishing practices. That year we wrote to all our suppliers asking them to confirm that their fish were legally caught in specified FAO catch areas and that they were not involved in species threatened with extinction. We stopped doing business with those suppliers who could not offer confirmation. We then developed a method to assess our suppliers. In 1996, we began working with the international conservation organization WWF, to help establish an independent certification programme for sustainable fisheries – known as the Marine Stewardship Council (MSC)'.

.Our sustainability assessment tool: Conserving biodiversity and the sustainable use of biological resources– as set out in the United Nations Convention on Biological Diversity – are at the core of our fish sustainability initiative. We have developed what we call a traffic light system to assess the sustainability of fisheries, based on the 1995 FAO Code of Conduct for Responsible Fisheries. Our dedicated sustainability manager assesses each fishery against five indicators: fisheries research; quota system; regulatory tools; control systems; long-term management plan. The effect of fishing on marine ecosystems is also taken into account. We grade the assessment results into three colors – red, green and yellow (see below). A fishery that gets an all green coloration is deemed ***sustainable*** and we encourage them to seek certification to the Marine Stewardship Council (MSC) Standard. Those that show a mix of green and yellow are deemed ***managed and progressing***, and those that get one or more red color, ***poorly managed***. We categorize a fishery as ***unmanaged*** if it scores red against all five indicators. We no longer source from fisheries that are unmanaged, and continue

to support those that are making good progress towards sustainability. In 1998 we started to use our traffic light system to assess our whitefish (groundfish) suppliers. We have now reached the stage where the checks and re-checks are continual. In practice, for each fishery, four indicators were set up by color as to whether the fishery was satisfactory in the following functions:

INDICATOR 1: Fisheries research

INDICATOR 2 : Quota system

INDICATOR 3: Regulatory tools

INDICATOR 4: Control systems

INDICATOR 5: Long-term management plan

Depending on the response to these individual indicators, the fishery was categorized as follows:

ALL GREEN: Sustainable

MIX OF GREEN AND YELLOW: Managed and progressing

ONE OR MORE RED: Poorly managed

ALL RED: Unmanaged

29) 'A food labeling row shows no signs of abating' (UK)

The centre of the controversy is the traffic light system, which allocates red, yellow and green colors for total fat, salt, saturated fat, sugar and calories per 100g/ml, in an attempt to provide an easy visual system for assessing the nutritional properties of a particular food prior to buying it in the supermarket.

When the scheme was introduced last summer, a Member of Parliament reportedly argued that traffic light labeling should be made mandatory across Europe. After only a few months of implementation, the impression was that this outcome was being achieved through a voluntary scheme. However, during the last Agriculture and Fisheries Council of 2013, several national delegations presented their concerns on this scheme, arguing that it had the potential to affect the free movement of goods and harm traditional regional food products. On that occasion, concerns were played down by highlighting that the UK scheme introduced is voluntary, and the possibility was mentioned of preparing a report on all labeling systems in place by Member States. Nonetheless, a comprehensive briefing was presented urging the Commission to assess its effects on the internal market; the competitiveness of the European food industry; the provision of correct health information to consumers; and the safeguard of traditional regional food products.

Table 1 : Observed frequencies of traffic light applications located in different sectors

Key: *FI:* Fishery Assessment/Management *AQ:* Aquaculture /Agriculture

ENV: Environmental/Ecosystem Issues *MED:* Medical/issues/Food/ Health/Safety

CON: Wildlife) Conservation/Forestry *DEV:* Sustainable/Project Development

Year	FI	AQ	ENV	MED	CON	DEV	TOTAL
1998	1			1			2
1999	2						2
2000	1						1
2001	3						3
2002	1	3	2				6
2003	5	1					6
2004	10					1	11
2005	9		2				11
2006	3	1					4
2007	9				1		11
2008	7		8				16
2009	1				1	1	3
2010	1	1		2			4
2011	5		1	1		3	10
2012							0
2013	1		1	2		1	5
2014	1	1		8	1		11

A preliminary review of traffic light applications present on the WEB and in publication sources, as judged by key words, is shown in Table 1. The Fisheries Assessment and Management category is dominant and apparently an early application, initiated in 1998. The diffusion of the methodology/terminology to other sectors is indicated in Table 1 and the preceding brief descriptive texts.

II. Discussion and Conclusions

Many TL applications found on the Web outside the fisheries sector seem to show that policy applications may utilize TL methodologies, even though the contents of the traffic light table used for technical analysis are not always numerical data, but may be textual corresponding to legislative criteria. The contents may consist either of the diagnosis, or the actions to be taken, should specific conditions be met. In some cases, the diagnoses in color form are a measure of the current state of the issue in question: in others they indicate dynamic changes that have occurred over the recent time horizon, since the last event mentioned (e.g., improving; static; deteriorating).

- Regardless of the metrics used, the TL trends for multiple indicators can be clearly presented on a single page. This is an aid to hypothesis formulation in situations of uncertainty.
- The traffic light report is suited for combining quantitative or semi-quantitative data in different units of measurement.
- Data from the natural world do not exist 'at equilibrium', nor are they usually treated as single, or simple, variables in a computer model. Using a broad range of indicators offers more opportunities to pick up changes in critical factors over time, such as regime shifts or changes in ecosystem components (Caddy, 2005). Thus the method provides a multidisciplinary display of information for deciding which questions should be addressed in statistical models, and whether the appropriate data exist to do so.
- The graphic presentation that results is easy for non-technical audiences to understand, and may be used as a precautionary framework that will lead to the development of new limit reference points as experience and data accumulates.
- To create an integrated management framework for fisheries applications, performance reports can be linked to simple regulatory control rules, that in some circumstances may be established by participants in the activity.
- In decision-making, the TL approach brings into play data from a wide variety of monitoring approaches, including the results of traditional assessment or evaluation methodologies, but also anecdotal and political/economic considerations which may critically affect management decisions.

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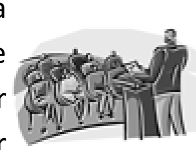

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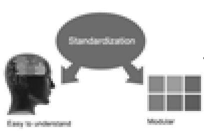

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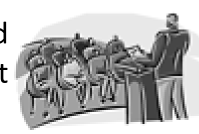

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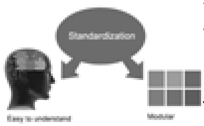

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- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
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Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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