Trophic status of water from selected sites in the Les Cheneaux Islands.

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Summary.

This report provides results from our first season of water trophic analysis from ten sites located from the West Entrance to the East Entrance of the Les Cheneaux Islands. It was an effort to develop baseline data to monitor trends in the aesthetic attributes of local waters. Our intent is to protect and preserve our presently desirable aquatic environment.

Findings suggest that algal biomass and nutrient levels within the Les Cheneaux Islands correspond with the distance of any given sample sites from the open waters of Lake Huron. From a trophic, or nutrient, viewpoint the Islands can be divided into lower nutrient outer channel and higher nutrient inner channel zones.

Results from this Island-wide survey agree with findings from another recent study of three local bays suggested that the water chemistry of those bays varied from good to excellent (Grant, 1994, 2001a; Smith 2001). Data further indicated that nutrients known to promote algae and weed growth accumulate in areas where water exchange with the lower nutrient level waters of L. Huron is minimal (Smith 2001).

Based on chlorophyll-a and phosphorus Trophic Status Index (TSI) calculations, the waters in the Les Cheneaux Island area are only moderately productive and do not support an excessively large standing crop of algae and other phytoplankton communities. The rate of organic matter accumulation is apparently not excessive, thereby avoiding premature aging of the nearshore waters.

We have learned a lot about the impact of organic nutrients throughout the Les Cheneaux channels from just a partial season of data from ten sites: (1) the channels can be categorized into inner and outer zones based upon nutrient availability; (2) the relative stability of algal populations in areas such as Marquette Bay and East McKay Bay and (3) nutrient flow from Cedarville Bay to Scammons Harbor. Confirmation of findings from the 2001 season will allow tracking of the TSI for extended periods and could reveal patterns of more intense algal growth that may need special management considerations in the future.

Data from the summer of 2001 provide a valuable comparison for the general water quality throughout the LCI. Additional data collected during the next five years will provide important trend information to serve as a basis for managing our local waters. These data not only provide a comparison of sites throughout the LCI but, through time, will provide a look at how individual sample sites change. The TSI database will serve as a basis for action by local groups and by the Eastern Upper Peninsula Watershed Management Group for protection and preservation of LCI water quality.

Introduction.

This report summarizes a technical report submitted by Michael Grant of Aqua-Terra Labs on the Trophic Status Index of samples from ten sites taken within the Les Cheneaux Islands during 2001. A copy of his report can be obtained for those interested by contacting Bob Smith or Mark Engle.

A project to expand sampling of LCI waters grew out of water chemistry studies of three local bays (Grant 1994, 2001a; Smith 2001). As lakes and waterways are impacted by human activities, organic matter begins to accumulate at accelerating rates, altering the trophic level of the lake. Energy flows in the system are disrupted or diverted which can lead to increased phytoplankton, primarily algae, as well as higher densities of water weeds and a general decline in water quality from a recreational use standpoint.

The term "trophic" refers to the ability of a body of water to support plant and animal growth. A lake with a high trophic level, able to sustain large plant and animal communities, is said to be eutrophic (Welch,1952). An oligotrophic lake will have minimal nutrients required for plant and animal metabolism. It will have little plant growth with sparse animal communities. Mesotrophic waters are intermediate in their productivity, or nutritive attributes, between the oligotrophic and eutrophic. The natural progression is for an oligotrophic lake to become eutrophic as it ages.

A Trophic Status Index (TSI) is a more definitive means of assigning the nutritive, or life sustaining, capacity of a lake or body of water. In the late 1970's Robert Carlson (Carlson, 1977) developed a lake classification system that is widely used today. The underlying principal in his model is that phytoplankton, most notably algae, respond rapidly to variations in water conditions. Algal populations can be measured by three independent methods: water transparency, chlorophyll-a, and total phosphorus. These methods allow for rapid assessment of productivity changes and, because they are independent measurements, they also serve to cross check each other. A series of three empirically derived equations link water transparency, chlorophyll-a and total phosphorus values to an index referred to as the Trophic Status Index (TSI). The index in an integer value ranging from 1 to 100. The productivity of a lake can be located along a continuum with smaller index values indicating lower productivity. Productivity is a term that refers to nutritive level. A highly productive lake contains nutrients sufficient to sustain large plant and animal populations it should be noted that the index is a metric and ranks lakes along a productivity continuum, it does not represent a true trophic measure of a lake.

TSI values, however, are not the same as a water quality index. Determinations of trophic state are made from examination of several diverse criteria such as the shape of the oxygen curve, species composition of the bottom fauna or of the phytoplankton, concentrations of nutrients and various measures of biomass or production. Although each changes from oligotrophy to eutrophy, the changes do not occur at sharply defined places, nor do they all occur at the same place or at the same rate. Some lakes may be considered oligotrophic by one criterion and eutrophic by another. This problem is sometimes circumvented by classifying lakes that show characteristics of both oligotrophy and eutrophy as mesotrophic.

In the case of chlorophyll-a measurements, a TSI increase of 10 points approximates a doubling of algal biomass (Carlson 1977). Values obtained from TSI analysis can not be averaged. TSI values lower than 30 can be correlated with the classical oligotrophic condition as having minimal nutrients to support plant and animal growth. TSI values in the 30 to 50 range compare to mesotrophy and TSI index values from 50 to 70 are in the eutrophy category.

Methods.

During the 2001 field season, May through Sep, an assessment of the spatial and temporal variation in the TSI was made at ten locations throughout the Les Cheneaux Islands ranging from the West Entrance to the East Entrance as shown in Fig. 1.

Sample sites were regularly tested for water transparency using a Secchi disk, and water samples were collected for chlorophyll-a analysis. In May and Sep samples were obtained for total phosphorus analysis. All samples were stored frozen until analyzed. Samples were collected by a group of area volunteers, including M. Engle, E. Engle, P. Carr, K Serretz, B. Smith, and F. Moore with R. Smith as coordinator. Samples were taken weekday mornings during the same time frame when boat traffic was minimal and light conditions as similar levels. Secchi disk readings were taken from the shaded side of the boat. Sample site locations were referenced by compass triangulation fix and by GPS coordinates. M. Grant of Aqua-Terra Labs analyzed phosphorus and chlorophyll samples (Grant 2001b).

Results and Discussion.

TSI values for Secchi disk data show little variation throughout the sampling period. Measurements appear to divide the region into two broad areas that can be referred to as "inner" and "outer" channel areas. Sites TS2 through TS6 represent the inner channel while sites TS1 and TS7-9 describe the outer channel (Fig. 1). Secchi TSI values suggest that water in the outer channel is less productive that that of the inner channel, most likely due to more efficient mixing with unproductive waters from L. Huron.

For the dates sampled, turbidity readings measured by Secchi disk for the Sep sampling were generally lower at all sites as a result of algal growth. Secchi disk readings, although useful for monitoring clarity of a specific site, should not be compared between or among sample sites due to depth variations at the respective sites.

It is reported that Secchi disk measurements are the least reliable for predicting the trophic status index of a lake and should only be used if no other means is available (Wetzel, 2001). The reasons for this include the difficulty in making accurate observations and that Secchi disk values are easily influenced by nonalgal turbidity.

Raw data from the 2001 Island-wide TSI survey are shown in Table 1. Temperature at the May sampling ranged from 50°F at the east end of McKay Bay and the Strongs Island-Boot Island Channel to 60°F in Cedarville Bay. Highest temperatures were recorded in July. The lowest maximum temperature of 64°F was found in east McKay Bay, the Strongs-Boot Channel and in Marquette Bay. Snows Channel, Muskie Bay and Cedarville Bay all had Jul highs of 72°F. Site TS4A, a cove on the west end of Muskie Bay had the highest recorded Jul temperature of 74°F. Observed temperatures reflected the inner and outer channel concept.

Total phosphorus data are most useful for detecting nutrient levels in the spring and fall; therefore they were taken only during the first and last sampling trips. Phosphorus concentrations are useful for determining nutrient levels and, therefore, predicting the intensity of expected algal blooms or weed growth.

Fig. 1. shows the location of Les Cheneaux sample sites for TSI analysis in 2001. Fig. 2 compares total phosphorus and chlorophyll Sep readings at each site. Except for the Strongs-Boot Channel, TS-8, phosphorus index values were all lower than chlorophyll values, as is expected when phosphorus is a limiting nutrient. With this limited data it is presently impractical to dwell on the TS-8 anomaly. Interpretation can be meaningful as data points from future sampling become available.

Otherwise, the phosphorus and chlorophyll concentrations reflect the proximity of each sample station to the open waters of Lake Huron. Highest phosphorus values were recorded for Cedarville Bay, which is most distant from L. Huron. Marquette Bay, Hessel Bay, Strongs-Boot Channel and east McKay Bay sites are directly exposed to L. Huron and also had lowest phosphorus and chlorophyll levels due, in part, to mixing of their waters with the nutrient poor water of L. Huron. Given the exposure of Muskie Bay to the Middle Entrance the phosphorus and chlorophyll levels were higher than expected. It is possible that the higher phosphorus and chlorophyll levels from these sites are due to a combination of human activity in the Snows Channel and Muskie Bay area coupled with the relatively narrow and shallow Middle Entrance Channel that would restrict water exchange with L. Huron.

Total chlorophyll, or chlorophyll-a reflects the planktonic algal biomass in the surface water at the time of sampling. Since algal blooms are a prime and reliable indicator of nutrient loading and availability, the dynamics of algae growth from May through Sep 2001 were recorded for each sample station and is depicted in Figs 3-5. Total chlorophyll provides an estimate of algal biomass at the time each sample was taken. Algal biomass is a key descriptor because it can be quantified and because the public can easily detect algal blooms. Algal blooms commonly follow increases in phosphorus, a common limiting nutrient for algal growth.

Based on chlorophyll-a values, three outer channel sites: Marquette Bay, Strongs-Boot Channel, and east McKay Bay, TS-1, TS8 and TS-9 respectively, had lowest algal populations with minimal fluctuation in those populations throughout the recording period. These areas are considered to have the lowest biological productivity (nutrient loading) of the sites measured.

Three inner channel sites were amazingly similar in their 2001 algal dynamics. Snows Channel (TS-3), Muskie Bay (TS-4) and the Muskie Bay cove (TS-4a) each had similar algal biomass concentrations as well as similar time frames for population increases (Fig 4). The chlorophyll TSI values for all three sites doubled between May and Jun and doubled again between Jun and Jul. Biomass decreased somewhat for all three sites by Sep due possibly to nutrient limitation, water temperature decrease or a combination of these or other factors.

A classical progression of algal growth was observed for Cedarville Bay (TS-5), Government Bay (TS-6) and for Scammons Harbor (TS-7) (Fig. 5). The shallow, nutrient rich water from Cedarville Bay is moved slowly eastward by prevailing westerlies into the deeper and cooler Government Bay which, in turn, flowed into the yet cooler and deeper Scammons Harbor.

Fig. 5 shows that Cedarville Bay algal populations increased by a factor of two from May to Jun, decreased from Jun to Jul and again doubled between Jul and Sep. It is possible that the high weed population in Cedarville Bay was growing exponentially due to warmer water in Jun and Jul, therefore limiting algal growth by successfully competing for nutrients. Following the burst of weed growth nutrients would again become available for algal growth, reflected by the Jul to Sep increase in algal chlorophyll.

Government Bay (TS-6) appears to have completed a bloom in the May-Jun timeframe and then began a continuous growth mode from Jun to Sep (Fig. 5). A flow of nutrients from Cedarville Bay and an increase in water temperature are likely explanations for algal biomass dynamics observed for Government Bay.

Scammons Harbor (TS-7) is cooler and deeper than Government Bay. The chlorophyll level was initially low in Scammons Harbor but steadily increased throughout the season as the waters warmed and nutrients flowed into it from Cedarville Bay through Government Bay (Fig. 5).

Perspective.

Just how we are to interpret and act on findings from this report and the report published on the water condition for three local bays remains to be seen. In the Grant report from 1994 several "pollution tolerant" invertebrates and diatoms were identified as present in Cedarville Bay. Present water chemistry values for Cedarville Bay tell us the water is of good quality. Therefore, during the seven years between surveys, not withstanding that about one ton of extra nutrients in the form of phosphorus has been dumped into Cedarville Bay, the water itself is in the lower mesotrophic, or good to excellent, range. It appears that nutrients are rapidly consumed either by algae or by weed metabolism in Cedarville Bay resulting in analytical values for phosphorus and chlorophyll levels in the water that do not appear excessive.

What are we missing in assessing water quality of the channels? The TSI is an excellent survey tool that provides an overall picture of water condition but it is only one of several parameters, as mentioned earlier, used to determine total water quality. We should continue to conduct TSI surveys. However, we still must deal with good water chemistry results for Cedarville Bay while looking at huge mats of weeds float on the surface each day during the summer after having been chopped off by passing boats. Moreover, at least a foot of silt covers the bottom of Cedarville Bay and extends to Government Bay. Contrast this situation with the recovery of more perch skeins in the Cedarville Bay area than anywhere else in the Islands during the past several years.

The fact is that algae, perch, weeds and silt have been part of Cedarville Bay for over fifty years. Are we seeing species shift to more pollution-tolerant forms? Possibly. Until the aquatic dynamics of Cedarville Bay and the Les Cheneaux chain is better defined it is our best interest to err on the cautious side. We can begin by controlling known contributors to premature aging of waterways such as the continued dumping of phosphorus via Pearson Creek. As more is learned about our Les Cheneaux waterway ecology more precise, better defined steps can be taken to preserve our unique and desirable ecosystem.

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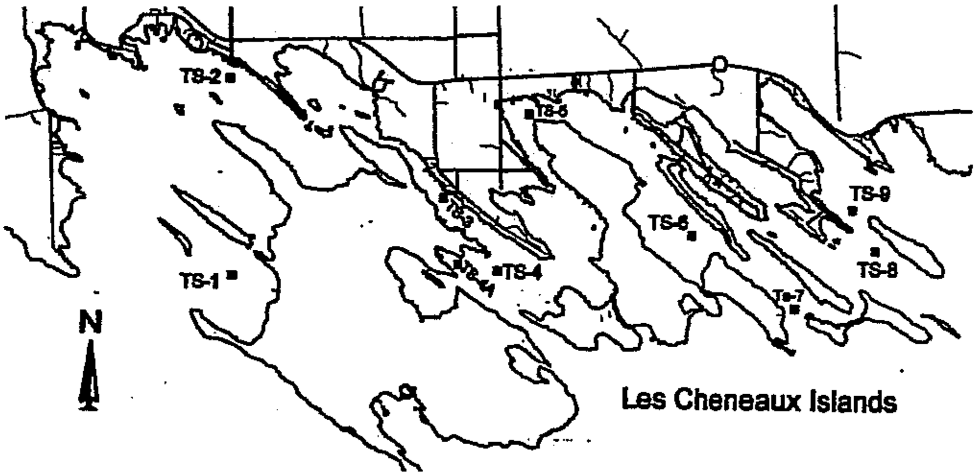


Fig. 1. Trophic Status Index (TSI) sites for Les Cheneaux area in 2001 with site locations listed below

Site	Location
TS1	Marquette Bay
TS2	Hessel Bay
TS3	Snows Channel
TS4	Muskie Bay
TS4A	Cove at NW side of Muskie Bay
TS5	Cedarville Bay
TS6	Government Bay
TS7	Scammons Harbor
TS8	Strongs-Boot Channel
TS9	East end of McKay Bay

Table 1. Raw data for TSI samples taken from representative inner and outer channel sites in the Les Cheneaux Islands during 2001.

Site No.	Site description	Month	Site depth (feet)	Temp (C/F)	Secchi reading (feet)	Total phosphorus (ppb)	Total chlorophyll (ppb)
TS1	Marquette Bay	May	35	13 / 56	21	3.5	0.31
		Jun		17 / 63	20	NS	0.52
		Jul		17 / 64	27	NS	0.38
		Sep		16 / 62	18	2.2	0.62
TS2	Hessel Bay	May	12	14 / 58	10	2.6	0.68
		Jun		19 / 66	12	NS	0.45
		Jul		20 / 68	9.0	NS	2.13
		Sep		19 / 66	7.0	2.9	0.74
TS3	Snows Channel	May	8.5	15 / 59	6.5	2.9	0.35
		Jun		21 / 70	8.5	NS	0.72
		Jul		22 / 72	8.0	NS	1.58
		Sep		19 / 67	6.0	3.5	1.33
TS4	Muskie Bay	May	14	15 / 59	6.0	3.5	0.46
		Jun		22 / 72	8.0	NS	0.86
		Jul		22 / 72	9.0	NS	2.19
		Sep		19 / 66	6.0	5.1	1.63
TS4A	Muskie Bay Cove	May	8.0	15 / 59	6.0	4.2	0.43
		Jun		23 / 74	7.0	NS	1.03
		Jul		23 / 73	7.0	NS	1.45
		Sep		NS	NS	NS	NS
TS5	Cedarville Bay	May	5.5	15 / 60	3.0	3.2	0.45
		Jun		21 / 70	4.5	NS	1.31
		Jul		22 / 72	5.5	NS	0.86
		Sep		20 / 68	5.5	6.4	3.26
TS6	Government Bay	May	22	12 / 54	14	1.6	0.61
		Jun		17 / 64	14	NS	0.48
		Jul		19 / 68	12	NS	1.42
		Sep		17 / 64	8.5	5.4	2.17
TS7	Scammons Harbor	May	25	11 / 53	20	3.8	0.3
		Jun		15 / 60	20	NS	0.56
		Jul		17 / 64	22	NS	0.7
		Sep		15 / 60	12	4.8	1.14
TS8	Strongs - Boot Channel	May	30	10 / 50	20	1.3	0.36
		Jun		14 / 58	20	NS	0.57
		Jul		17 / 64	28	NS	0.47
		Sep		15 / 60	14	6.4	0.76
TS9	E. end McKay Bay	May	20	10 / 50	15	1	0.43
		Jun		16 / 59	18	NS	0.56
		Jul		17 / 64	17	NS	0.53
		Sep		15 / 60	14	3.2	0.71
	NS = no sample taken						
	rawdat2001						

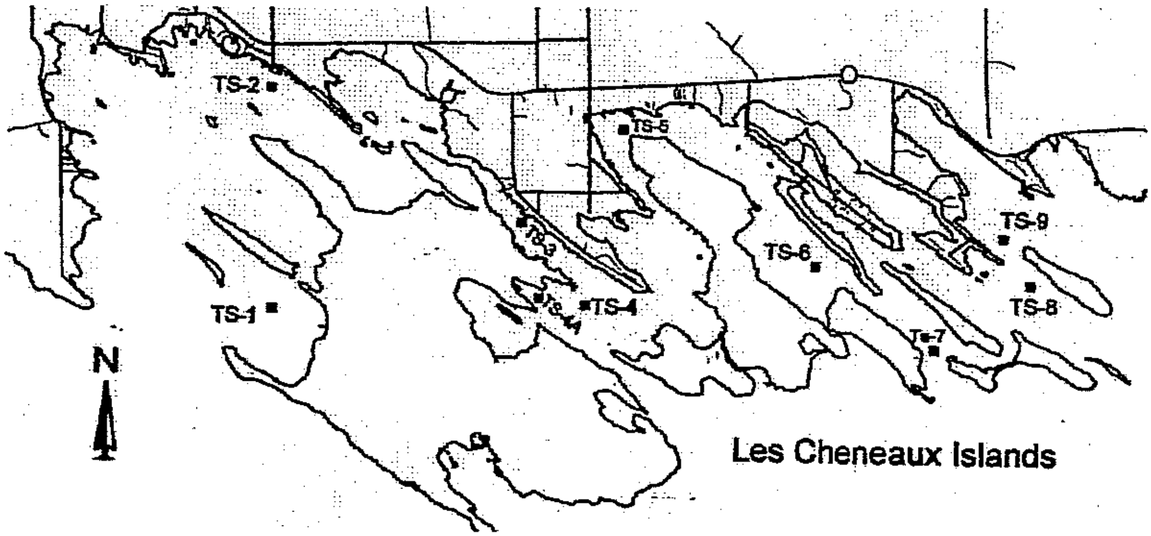
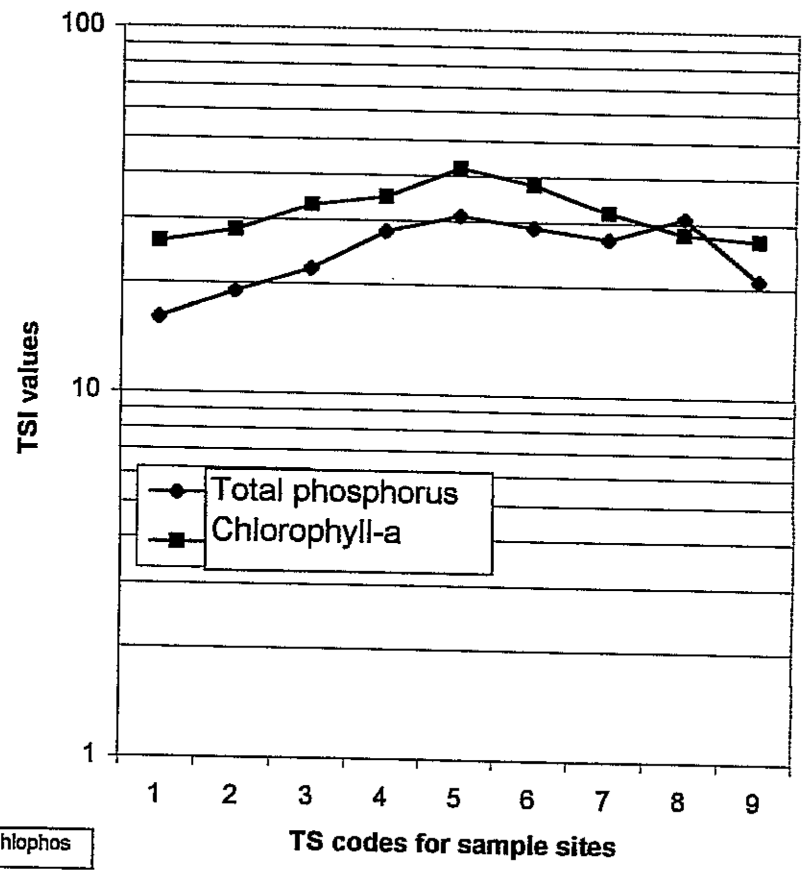


Fig. 2. Comparison of total phosphorus and chlorophyll-a TSI values for Sep, 2001 samples at nine Les Cheneaux locations.



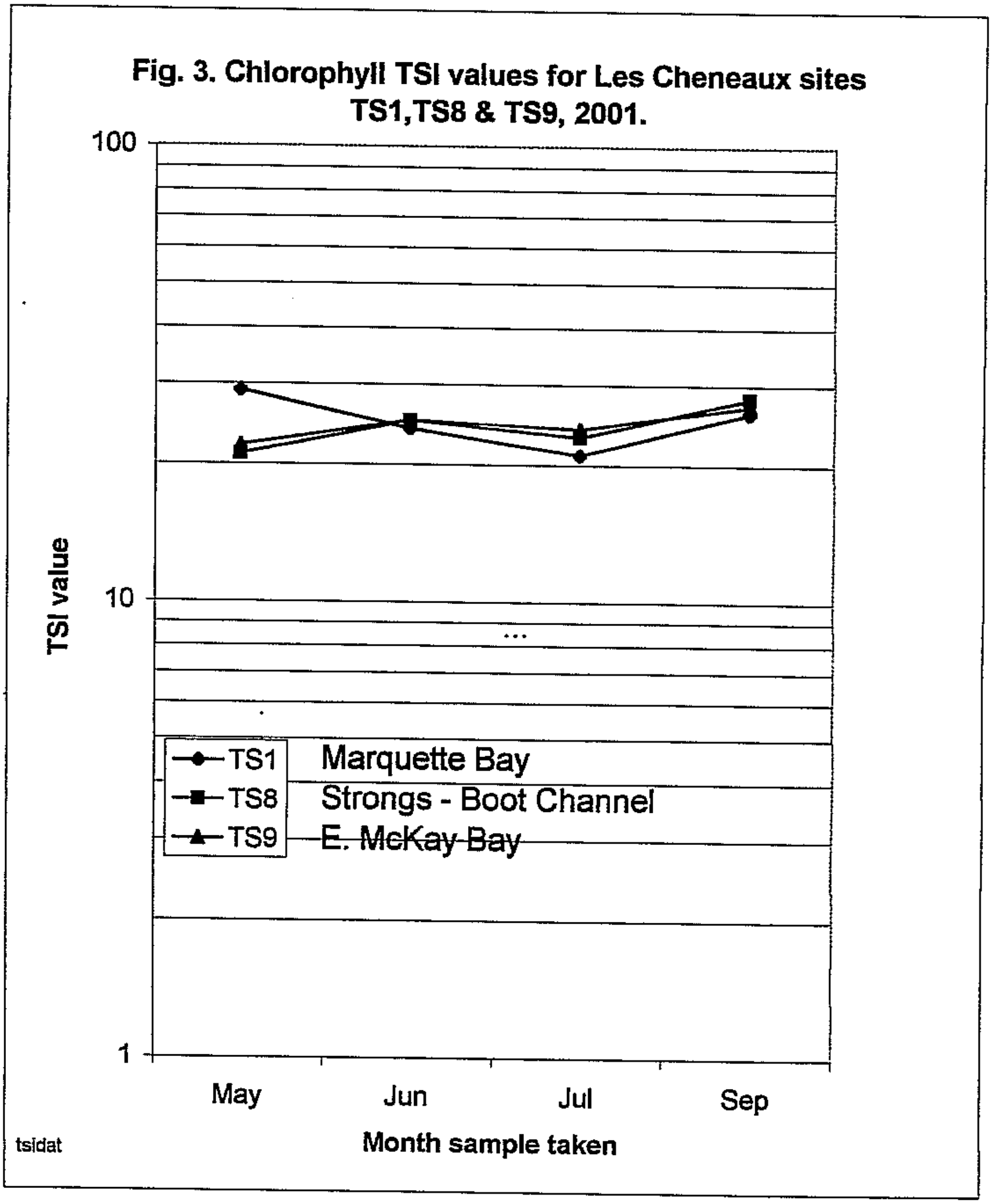


Fig. 3. Chlorophyll TSI values for Les Cheneaux sites
TS1,TS8 & TS9, 2001.
100
10
1
TSI value
TS1 Marquette Bay
TS8 Strongs - Boot Channel
TS9 E. McKay Bay
May
Jun
Jul
Sep
Month sample taken
tsidat

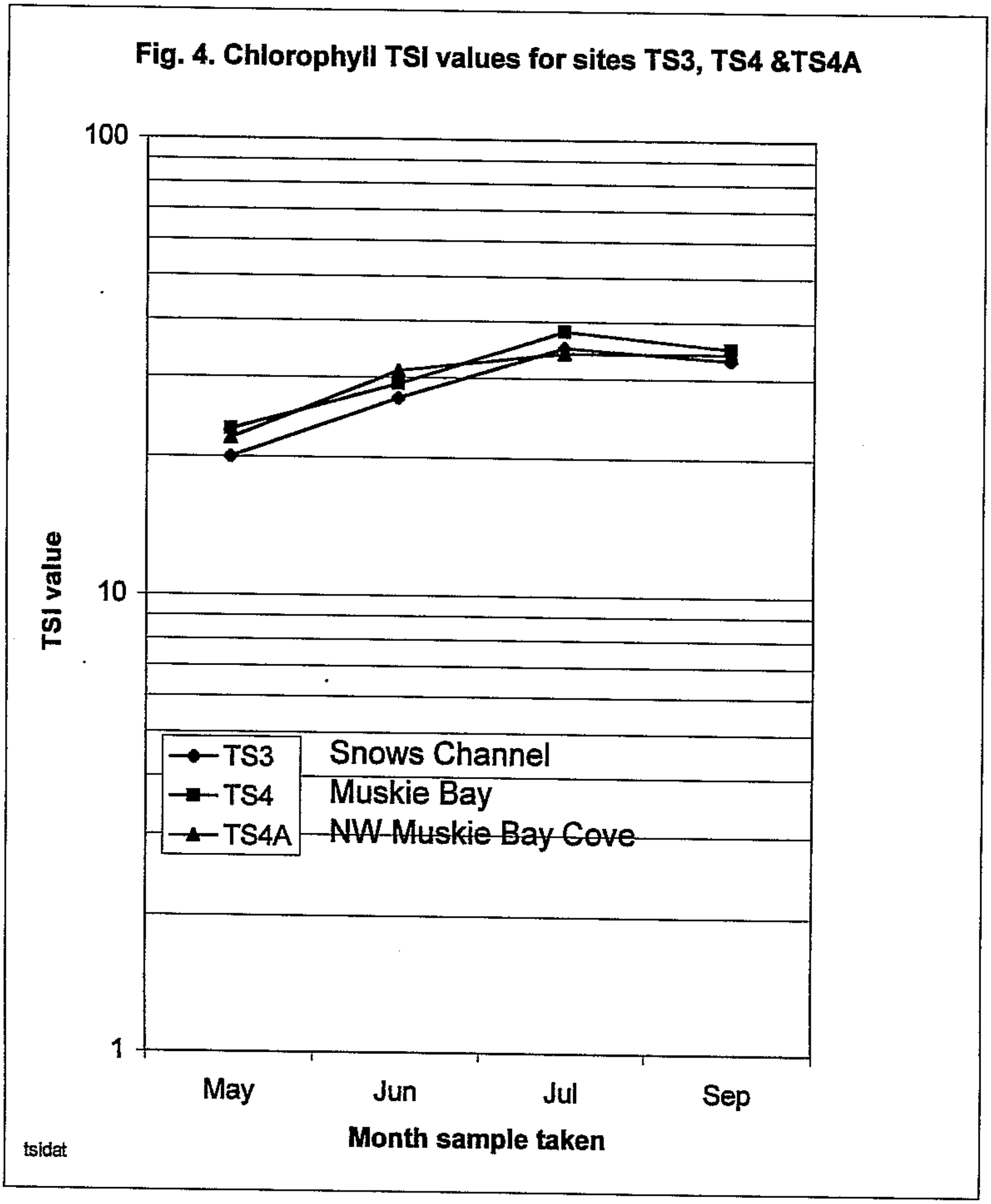


Fig. 4. Chlorophyll TSI values for sites TS3, TS4 &TS4A
100
10
1
TSI value
TS3
TS4
TS4A
Snows Channel
Muskie Bay
NW Muskie Bay Cove
May
Jun
Jul
Sep
Month sample taken
tsidat

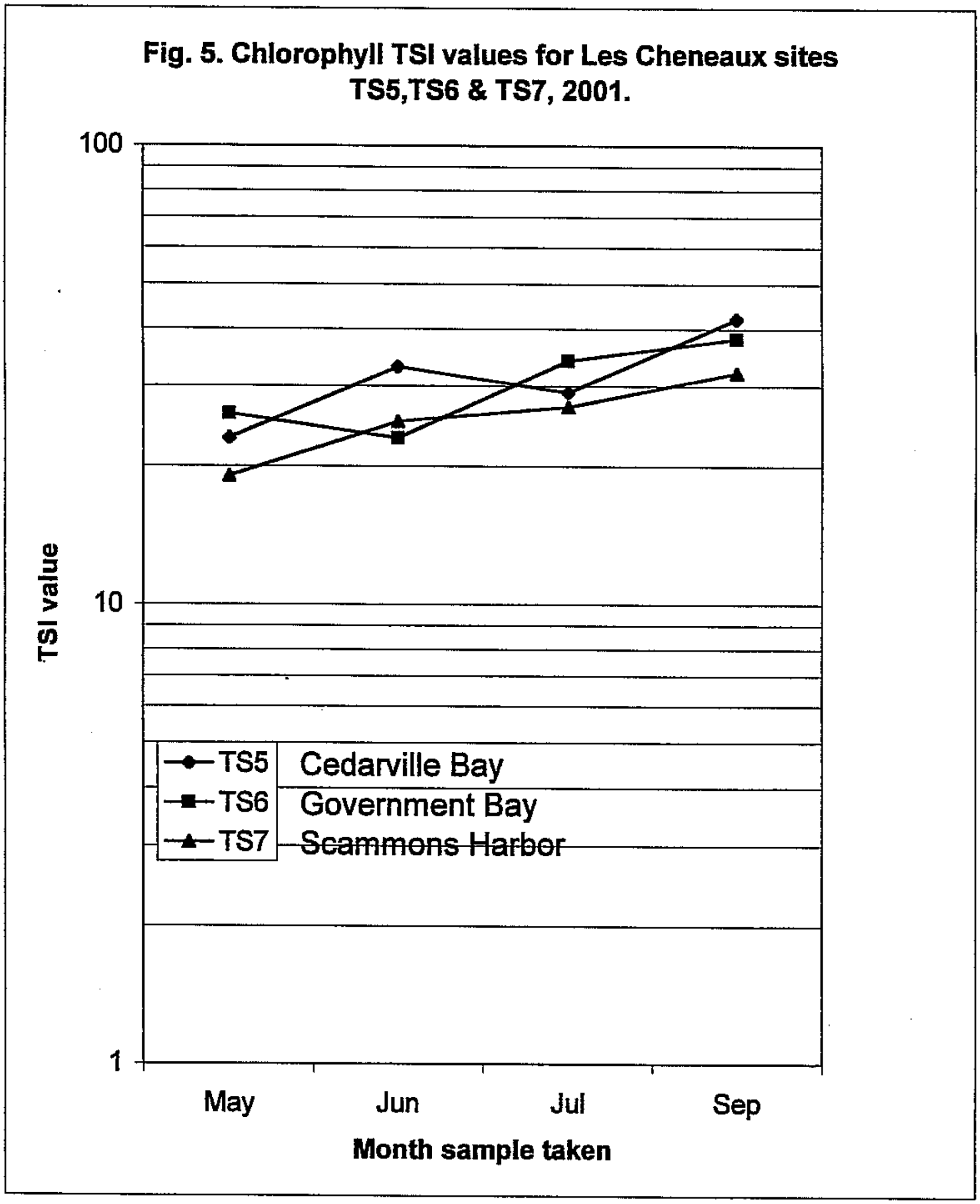


Fig. 5. Chlorophyll TSI values for Les Cheneaux sites
TS5,TS6 & TS7, 2001.
100
10
1
TSI value
TS5 Cedarville Bay
TS6 Government Bay
TS7 Scammons Harbor
May
Jun
Jul
Sep
Month sample taken