POTENTIAL USE OF LOW-ALTITUDE AERIAL PHOTOGRAPHY TO IDENTIFY SUBMERSED MACROPHYTES

Donald W. Schloesser and Bruce A. Manny

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Great Lakes Fishery Laboratory

1451 Green Road

Ann Arbor, Michigan 48105

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Abstract

To demonstrate the feasibility of using low-altitude aerial photography to identify submersed macrophytes, we obtained aerial color transparencies and collateral ground survey information about submersed macrophyte beds at 10 sites in the St. Clair-Detroit River system in September 1978. Using transparencies and ground survey information, we developed a dichotomous key for the identification of macrophyte beds visible on the transparencies. The key and 17 transparencies with 20 delineated areas were used to determine whether test subjects could accurately identify macrophyte beds. One pair of test subjects was trained in the interpretation of a variety of aerial photos, a second pair had field experience in the collection and identification of submersed macrophytes in the river system, and a third pair had neither training in the interpretation of aerial photos or field experience. The criteria that we developed were applied equally well by the subjects, regardless of their training or experience; 68% of the beds of submersed macrophytes were identified correctly. The percentages of macrophyte beds of five genera that were correctly identified were Heteranthera, 50; Potamogeton, 54; Chara, 58; Vallisneria, 83; and Myriophyllum, 86. We believe that low-altitude aerial photography, together with limited amounts of collateral ground survey information, can be used to economically identify submersed macrophyte beds in the St. Clair-Detroit River system.

Introduction

Submersed macrophytes are a prominent feature of littoral waters that border the more than 600 km of shoreline in the St. Clair-Detroit River system between Lakes Huron and Erie. Identification of submersed macrophytes throughout the St. Clair-Detroit River system by conventional ground survey techniques is costly (Schloesser and Manny 1982). Examination of the literature indicated that low-altitude aerial photography may be an economical and reliable method for determining the identity of submersed macrophyte beds (Wile 1973; Markham et al. 1977; Avery 1977). To test the feasibility of this approach, we obtained color aerial photographs (i.e., transparencies) of submersed macrophyte beds at 10 sites in the St. Clair-Detroit River system in September 1978 (Figure 1) and collected collateral ground survey information.

Methods

A review of aerial photographs on file with the Environmental Research Institute of Michigan, Ann Arbor, revealed that the resolution of aerial photographs taken from an altitude of 1829 m (6000 ft) was adequate to show beds of submersed macrophytes. On September 26, 1978, we obtained 17 vertical, true-color, positive transparencies, 23 cm (9 in) square, from an altitude of 914 m (3000 ft) above mean sea level over 10 sites throughout the St. Clair-Detroit River system. Photos were taken during periods of minimal cloud cover between mid-morning (1030 h) and early afternoon (1300 h) to reduce sun glare. We used a grapnel hook and Ponar grab sampler to collect collateral ground survey

information on the taxonomic composition of submersed macrophyte beds at the 10 sites, September 25-29, 1978.

Transparencies were obtained by exposure of Kodak Ektachrome MS aerographic (type 2448) film [1/] in a Wild Heerbrug RC-5 camera with a 15.24-cm (6-in) focal length at f5.6 for 1/300 second. Resulting transparencies (e.g. Figure 2) had a nominal photo scale of about 1:5000. Locations of transparency coverage were indexed on 1:15,000 scale NOAA charts by reference to landmarks visible on both the transparencies and charts (Appendix I). Transparencies covered an area about 1143 m (3750 ft) square with a minimum resolution of 1.5 m (5 ft).

The dichotomous key we developed to identify submersed macrophyte beds visible on transparencies (Appendix II) was the elimination type described by Avery (1977). Diagnostic features used in the key included differences in plant habit (i.e., floating or not floating) and the color and texture of beds visible on transparencies. Instructions, the key answer sheet, and 17 transparencies with a total of 20 delineated areas on them were provided to three pairs of test subjects; one pair was trained in the interpretation of a variety of aerial photos, one pair had field experience with submersed macrophytes in the river system, and one pair had neither such training or experience. Photos were examined with the aid of a translucent light table. The applicability of our key was determined by measuring the accuracy with which the test subjects

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[1/] Mention of brand names does not imply endorsement by the U.S. Government.

correctly identified submersed macrophyte beds visible on transparencies. Correct answers were determined on the basis of ground survey information. Differences in the number of correct and incorrect answers between identifications of taxa and between the three pairs of test subjects were tested for significance by using 2 x 2 and 2 x 3 Chi-square contingency tables, respectively (Snedecor and Cochran 1967).

Results

Tests using the dichotomous key to identify submersed macrophyte beds visible on transparencies revealed that test subjects could correctly identify macrophyte beds 68% of the time (Table 1). The range of correct test scores was 55 to 75% among the three pairs of test subjects, but the differences were not significant ($P > 0.05$).

Heteranthera, Potamogeton, Chara, Vallisneria, and Myriophyllum were the taxa visible on aerial transparencies; they were correctly identified 50, 54, 58, 83, and 86% of the time, respectively (Table 2). An area of sand bottom was correctly identified 100% of the time. Chi-square tests ($P < 0.01$) indicated that sand bottom was identified correctly more often than beds of Potamogeton and Heteranthera, and that beds of Myriophyllum were identified correctly more often than beds of Chara, Potamogeton, and Heteranthera.

Of the 20 delineated areas identified by each of the six test subjects, the numbers of incorrect identifications were as follows: zero to three for

13 transparencies, two for 3, and four to six for 4 (Table 3). Of the 20 delineated areas on aerial photographs, 4 (i.e., 3718-1, 3729-2, 3733-1, and 3743-2) accounted for 21 of 39 (54%) of the incorrect identifications of submersed macrophyte beds.

Discussion

The similarity between test scores of the three pairs of test subjects is partly attributed to our use of color transparencies as a photographic medium. This medium does not require complex interpretation and shows differences in color tones and texture more clearly than panchromatic or infrared photographs, which have been used in wetland surveys (Wile 1973; Caron et al. 1976).

Subtle differences in color tone and texture visible on the transparencies were important characteristics used in the dichotomous key for identification of beds of submersed macrophytes. For example, Potamogeton along river channels (e.g., 3733-1 and 3743-2; Table 3) showed a uniform color and no texture, whereas Potamogeton at the head of islands (e.g., 3748-1 and 3758-1) was non-uniform in color and rough in texture. These differences in the appearance of Potamogeton on aerial photographs resulted in incorrect identification in 11 of 12 times for beds located adjacent to river channels but in none of 12 times for beds located at the heads of islands. Additional aerial photographs and collateral ground survey information would be needed to improve our key and to increase the accuracy with which interpreters identify submersed macrophyte beds visible on aerial photographs.

Other investigators have attempted to map and identify beds of submersed macrophytes by aerial photography. Markham et al. (1977) and Wile (1973) reported that submersed macrophyte beds could be delineated but not identified in inland lakes because of such variables as cloud cover, and depth and clarity of water. Haegele (1978), who took aerial photographs of beds of macroscopic algae in littoral marine waters off British Columbia, using nearly the same techniques we used--at nearly the same altitude and the same film/filter combinations--determined that the algae beds visible on the aerial photographs could be identified 60% of the time. Macomber and Fenwick (1979), who took aerial photographs of submersed macrophyte beds in Chesapeake Bay, using essentially the same film, filter, and altitude combination that we used, together with ground survey information, correctly identified the taxonomic composition of plant beds 70% of the time. These percentages of correct identifications are similar to that (68%) in our study.

The greatest potential advantage of low-altitude aerial photography, compared with manual methods deployed from a boat, to identify beds of submersed macrophytes throughout a large body of water, is the saving of time: an aerial survey of the St. Clair-Detroit River system would take 1 or 2 days to complete, whereas a boat survey would require 2 months (Schloesser and Manny 1982). An additional advantage is that the criteria we developed to identify submersed macrophytes were applied equally well by test subjects, regardless of their previous training and experience. Therefore, much of the identifications of submersed macrophytes could be done by persons having no specialized training in identifying submersed macrophytes, either in photos or in the field.

Additional tests and modifications of the dichotomous key using aerial photographs other than those from which the key was developed would be the next step to further test the validity of using aerial photography for identifying beds of submersed macrophytes. Although the original intent of this study was to obtain additional photographs and collateral ground survey information on submersed macrophytes, funding needed to continue this work was not secured. We believe that additional research on the methodology used in the present study would result in improved accuracy and usefulness of low-altitude aerial photography in identifying submersed macrophyte beds.

We believe this study demonstrated that low-altitude aerial photography, together with limited amounts of collateral ground survey data, is potentially useful in the rapid identification of submersed macrophyte beds in littoral waters similar to those in the St. Clair-Detroit River system.

Acknowledgements

We thank Norman Roller of the Environmental Research Institute of Michigan, Robert Macomber of Aero-Eco, Inc., and Charles L. Brown of this laboratory for technical advice and encouragement throughout this study.

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Snedecor, G. W., and W. G. Cochran, 1967. Statistical methods, 6th ed. Iowa State Univ. Press, Ames, Iowa.

Wile, I., 1973. Use of remote sensing for mapping of aquatic vegetation in the Kawartha Lakes. Pages 331-340 In Proc. Conf. Remote Sensing and Water Resources Management, Am. Water Resour. Assoc., Urbana, Ill.

Table 1. Percentage of correct identifications of submersed macrophyte beds made by three pairs of test subjects, using 17 transparencies of 10 sites in the St. Clair-Detroit River system taken September 26, 1978.

Test Subject Pair and Subject Identification (A or B)	Percent Correct
Trained in photo interpretation	
A	65
B	70
With field experience in identifying submersed macrophytes	
A	70
B	75
Untrained and no field experience	
A	70
B	55
Mean	68

Table 2. Contingency table compiled from identifications made by test subjects who examined beds of five macrophyte taxa and one substrate delineated on aerial transparencies of 10 sites in the St. Clair-Detroit River system taken September 26, 1978. Answers in the diagonal box represent agreement between identifications made by test subjects and ground survey information; answers not on the diagonal are incorrect identifications.

Identifications made by test subjects	Identity from ground survey information					
	Heteranthera	Potamogeton	Chara	Vallisneria	Myriophyllum	Sand
Heteranthera	12	1	0	0	0	0
Potamogeton	8	13	3	0	1	0
Chara	0	2	14	1	3	0
Vallisneria	0	0	3	5	0	0
Myriophyllum	3	8	4	0	31	0
Sand	1	0	0	0	1	6
Percentage identified correctly	50	54	58	83	86	100

a/

b/

Table 3. Ground truth survey identifications and photo identifications (C=correct, I=incorrect) of 20 delineated areas on 17 aerial transparencies of 10 sites in the St. Clair-Detroit River system taken September 26, 1978.

Transparency number[a] and number of delineated area	Site[b]	Ground truth identification	Pair of Test Subjects: Trained in photo interpretation — Test Subject A	Trained in photo interpretation — Test Subject B	Field experience with macrophytes — Test Subject A	Field experience with macrophytes — Test Subject B	No training or field experience — Test Subject A	No training or field experience — Test Subject B	Number Incorrect
3716-1	1	Heteranthera	I	I	C	C	C	C	2
3717-1	2	Heteranthera	I	I	C	I	C	C	3
3718-1	2	Heteranthera	I	I	I	I	C	I	5
3720-1	2	Heteranthera	I	C	C	C	I	C	2
3721-1	3	Myriophyllum	C	C	C	C	C	C	0
3729-1	3	Myriophyllum	C	C	C	C	C	I	1
3729-2	3	Chara	C	I	I	I	I	I	5
3733-1	4	Potamogeton	I	I	I	C	I	I	5
3733-2	4	Myriophyllum	C	C	I	C	C	C	1
3737-1	4	Sand	C	C	C	C	C	C	0
3740-1	4	Chara	C	C	C	I	I	C	2
3743-1	6	Myriophyllum	I	C	I	C	C	I	3
3743-2	6	Potamogeton	I	I	I	I	I	I	6
3745-1	7	Myriophyllum	C	C	C	C	C	C	0
3748-1	8	Potamogeton	C	C	C	C	C	C	0
3749-1	8	Chara	C	C	C	C	I	I	2
3753-1	9	Myriophyllum	C	C	C	C	C	C	0
3758-1	10	Potamogeton	C	C	C	C	C	C	0
3759-1	10	Chara	C	C	C	C	C	I	1
3765-1	5	Vallisneria	C	C	C	C	C	I	1

[a] Location of each transparency is shown in Appendix I.

[b] Approximate location of each site is shown in Figure 1.

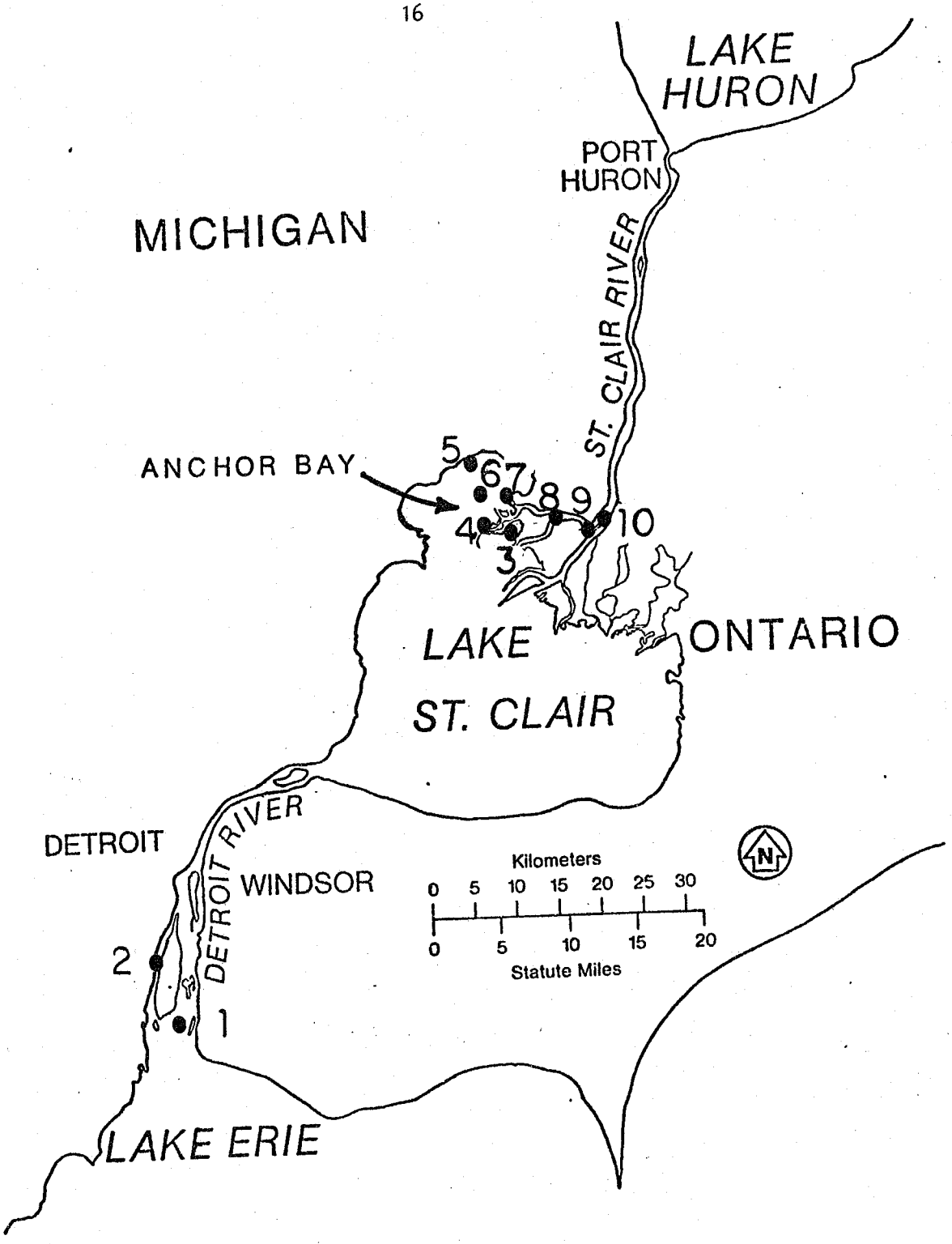
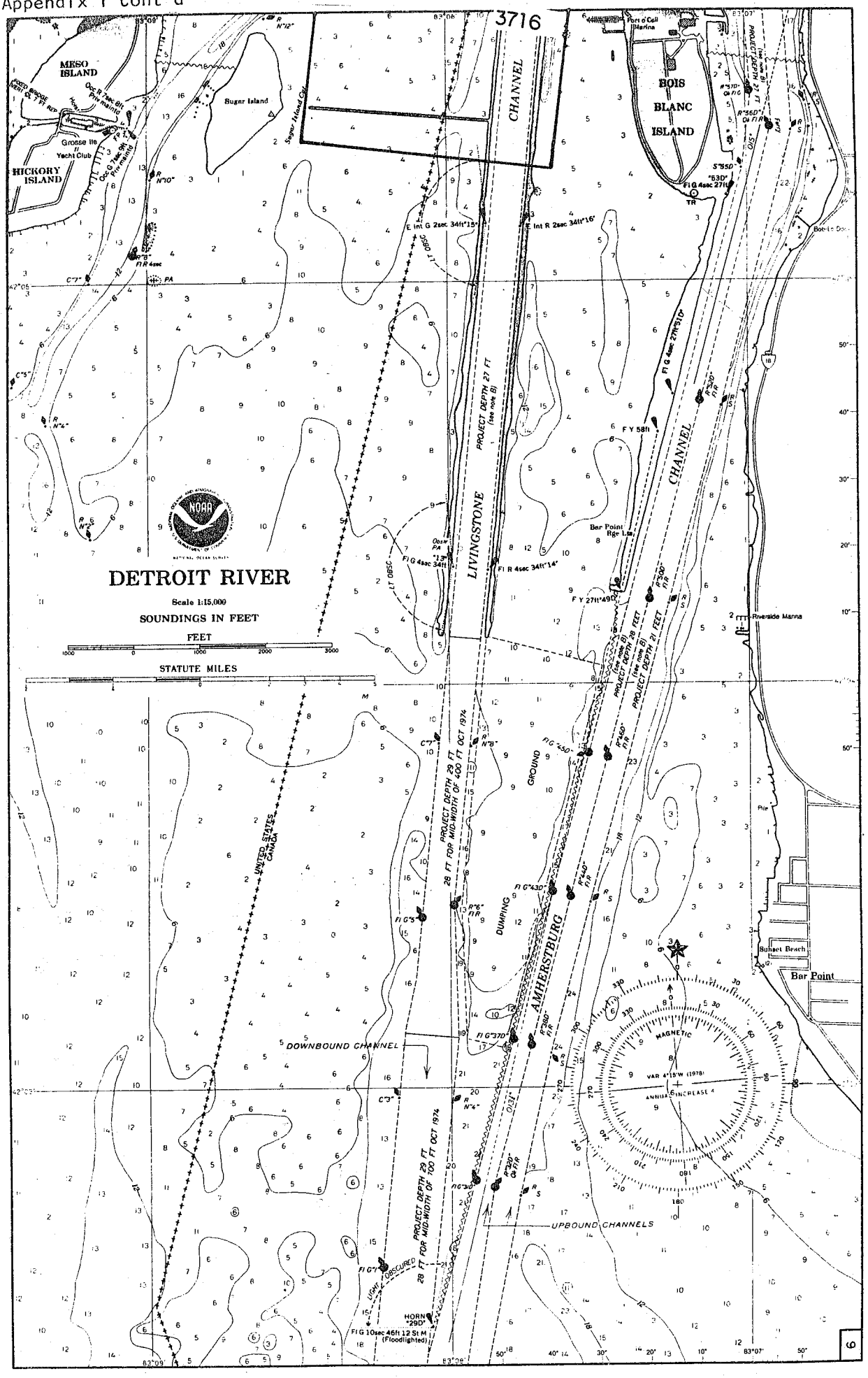
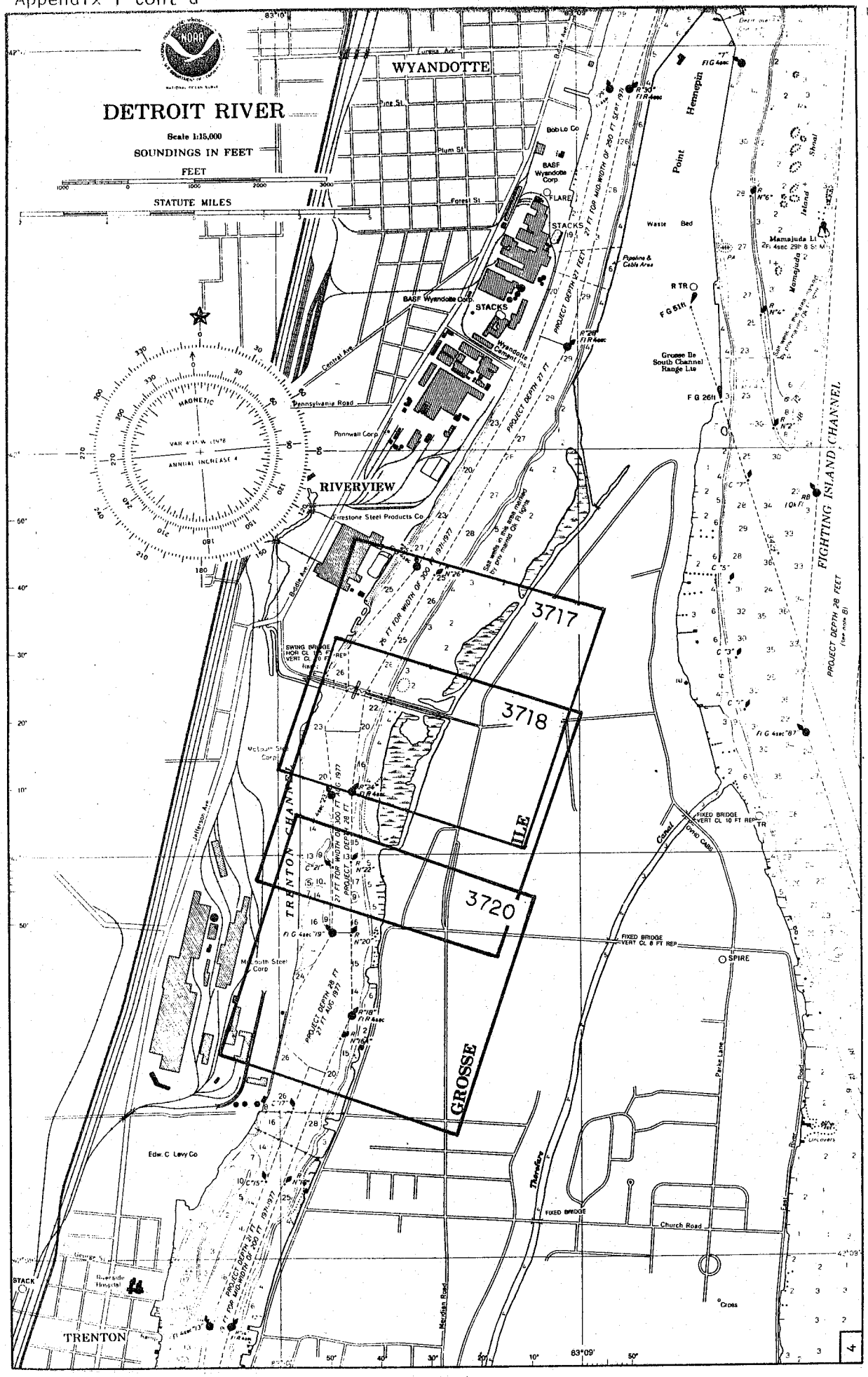


Figure 1. Approximate locations of 10 sites where aerial color transparencies and collateral ground survey information were obtained in the St. Clair-Detroit River system in September 1978.

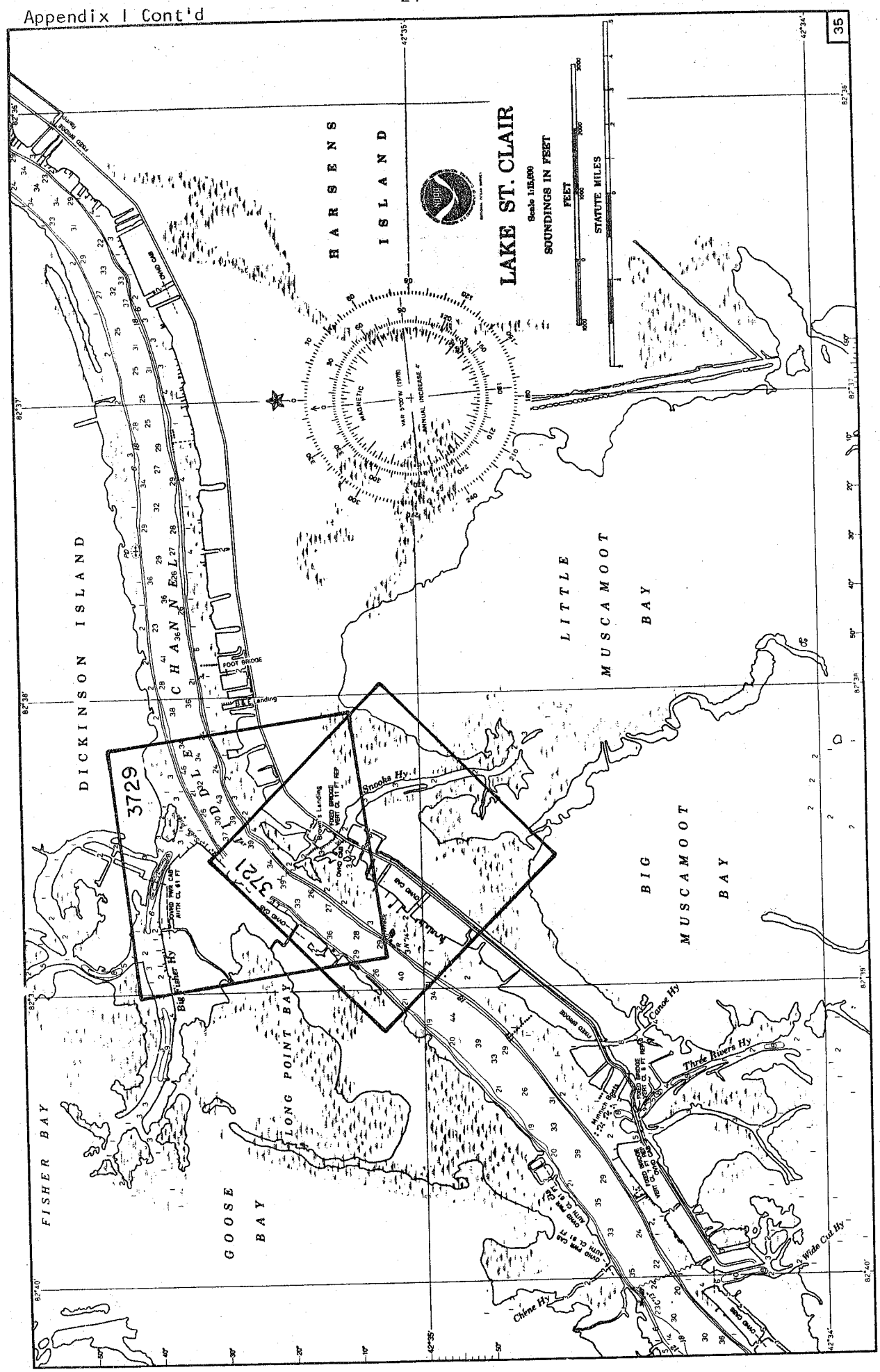
Appendix I. Locations of 17 aerial transparencies (indexed on NOAA charts) of 10 sites in the St. Clair-Detroit River system taken September 26, 1978. The number on each indexed frame (i.e., transparency number) corresponds to the number of that transparency on file at the Great Lakes Fishery Laboratory. (The sites are not numbered consecutively; they are 3716, 3717, 3718, 3720, 3721, 3729, 3733, 3737, 3740, 3743, 3745, 3748, 3749, 3753, 3758, 3759, and 3765).


3716
MESO ISLAND
HICKORY ISLAND
Grosse Ile Yacht Club
Sugar Island
CHANNEL
BOIS BLANC ISLAND
Port o'Call Marina
LIVINGSTONE CHANNEL
PROJECT DEPTH 27 FT
(see note B)
Bar Point Rge L.B.
Riverside Marina
DETROIT RIVER
Scale 1:15,000
SOUNDINGS IN FEET
FEET
STATUTE MILES
UNITED STATES CANADA
PROJECT DEPTH 29 FT FOR MID-WIDTH OF 400 FT OCT 1974
GROUND
DUMPING
AMHERSTBURG
Sunset Beach
Bar Point
DOWNBOUND CHANNEL
UPBOUND CHANNELS
MAGNETIC
VAR 4°15'W (1978)
ANNUAL INCREASE 4'
PROJECT DEPTH 29 FT FOR MID-WIDTH OF 700 FT OCT 1974
OBSCURED
HORN
Fl G 10sec 46ft 12 St M
(Floodlighted)
6
14853 Bin Fd. Apr 14/79

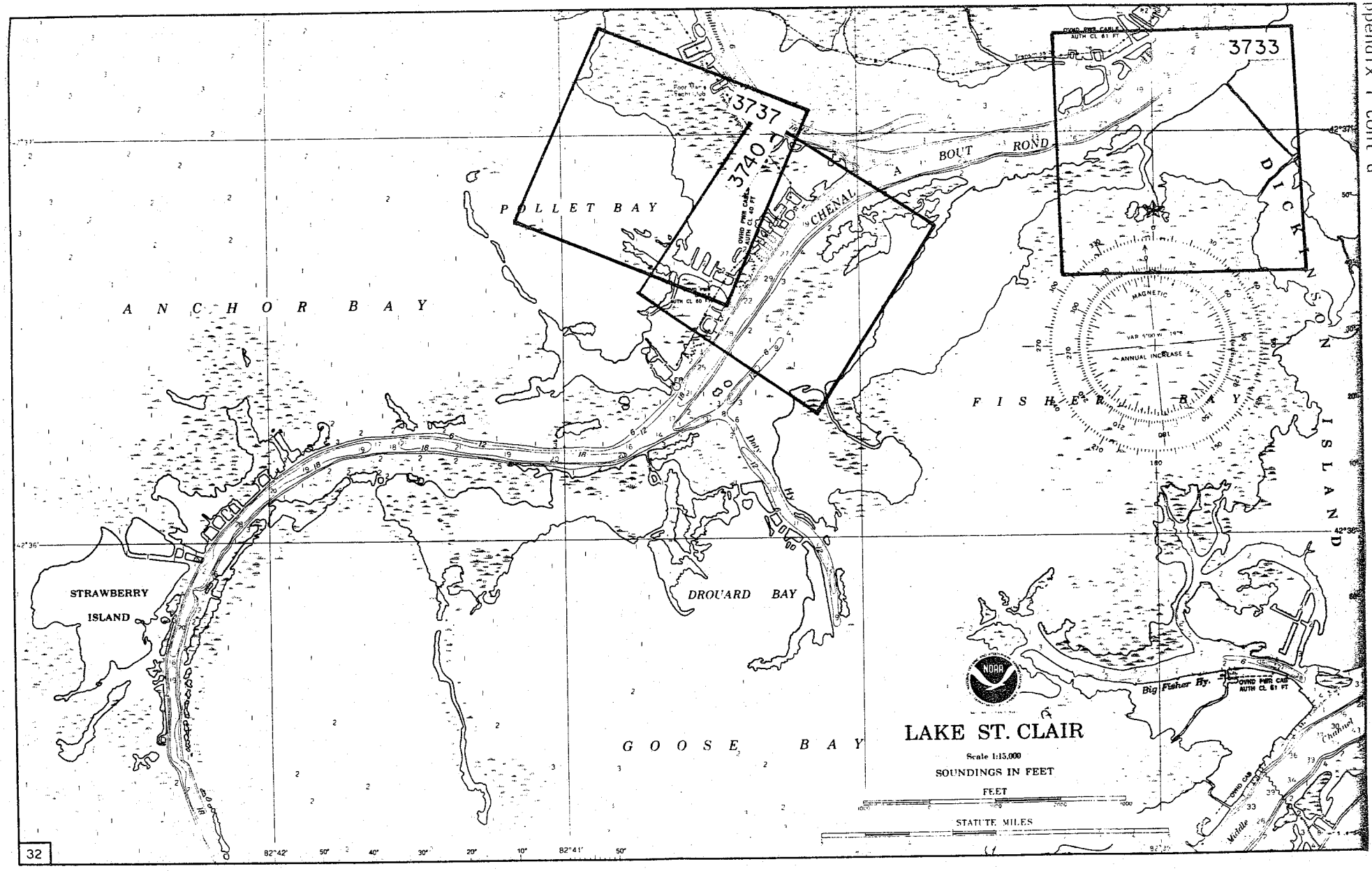


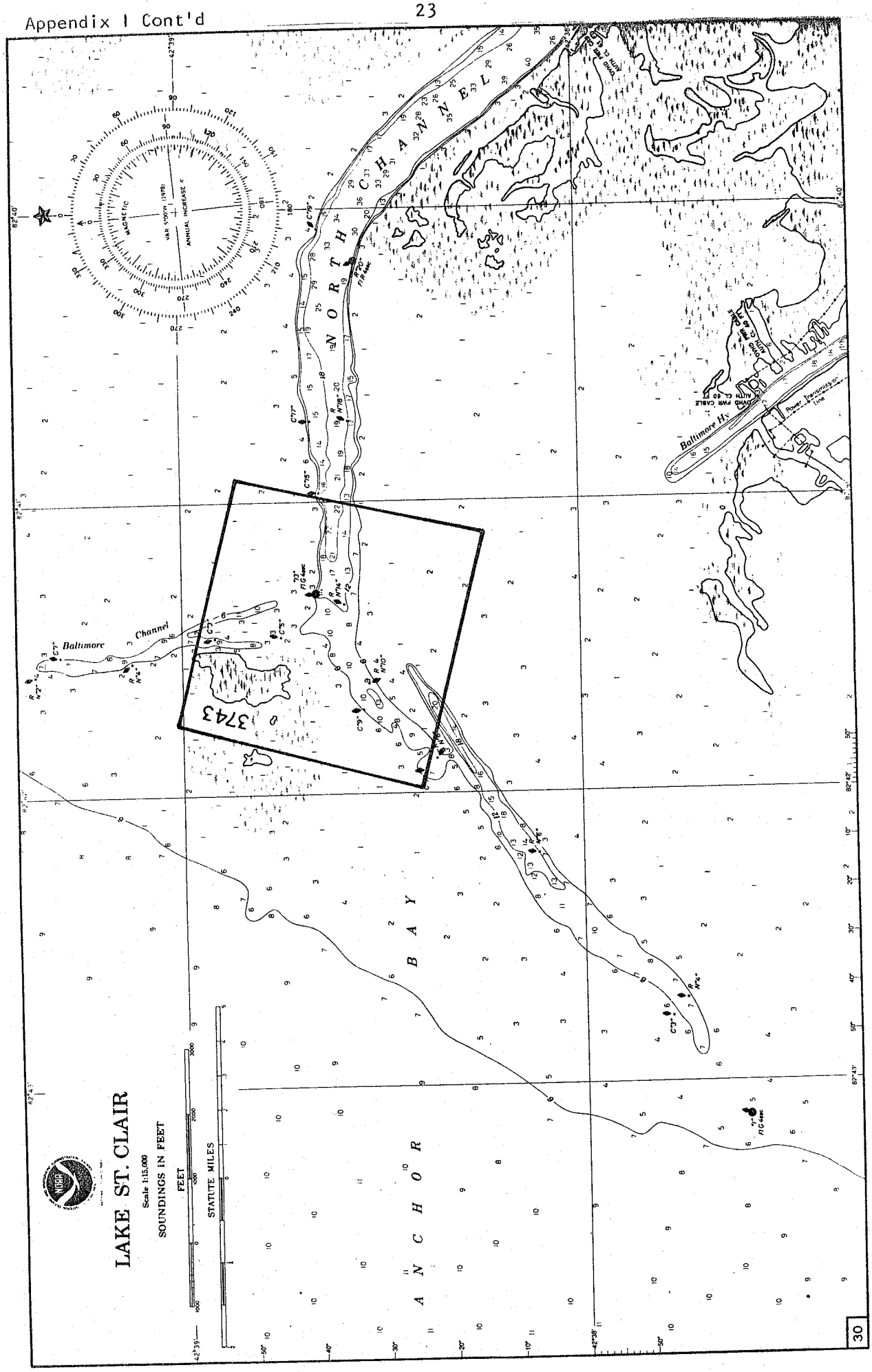
14853 8th Ed., Apr 14/79

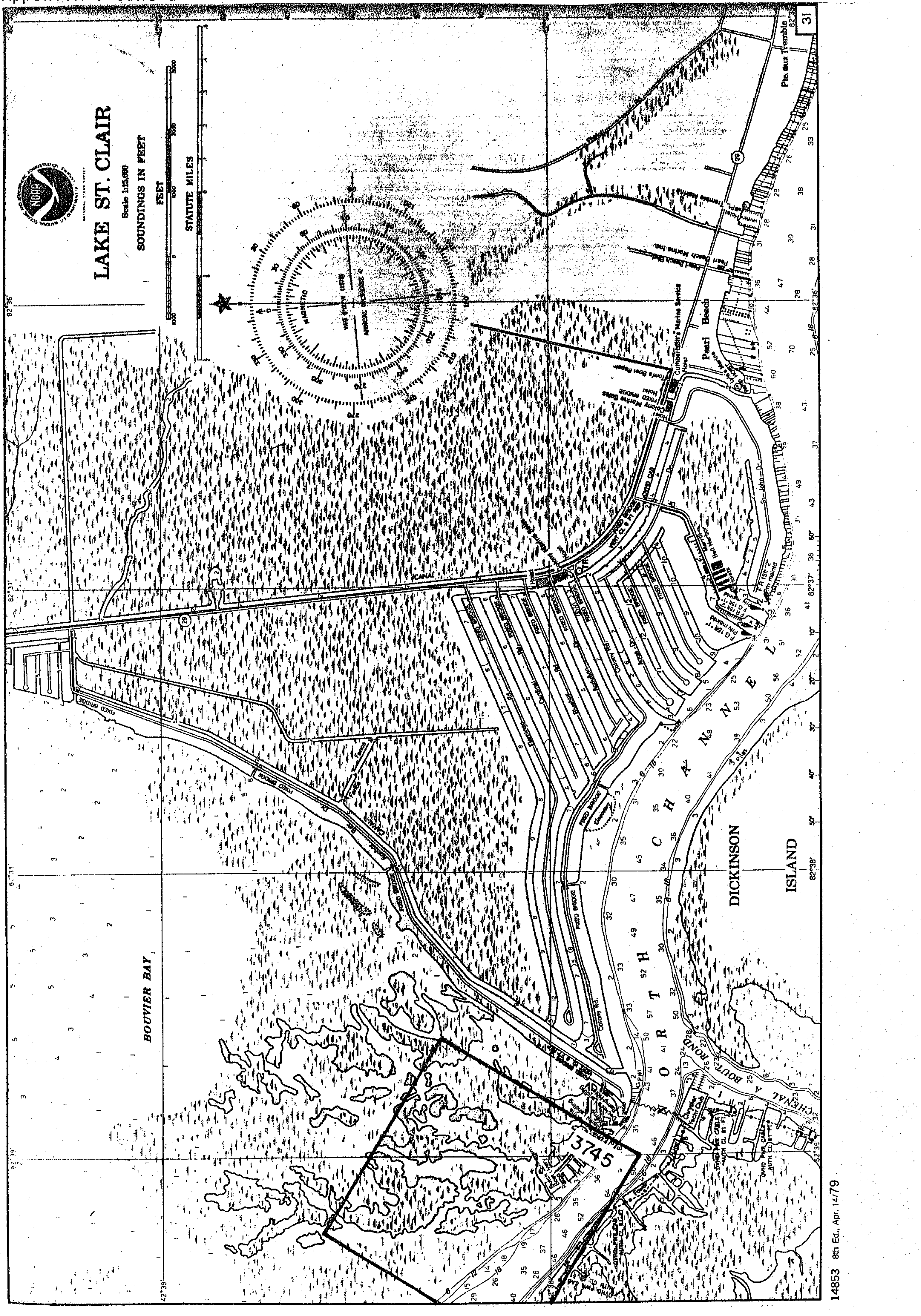
Appendix I Cont'd

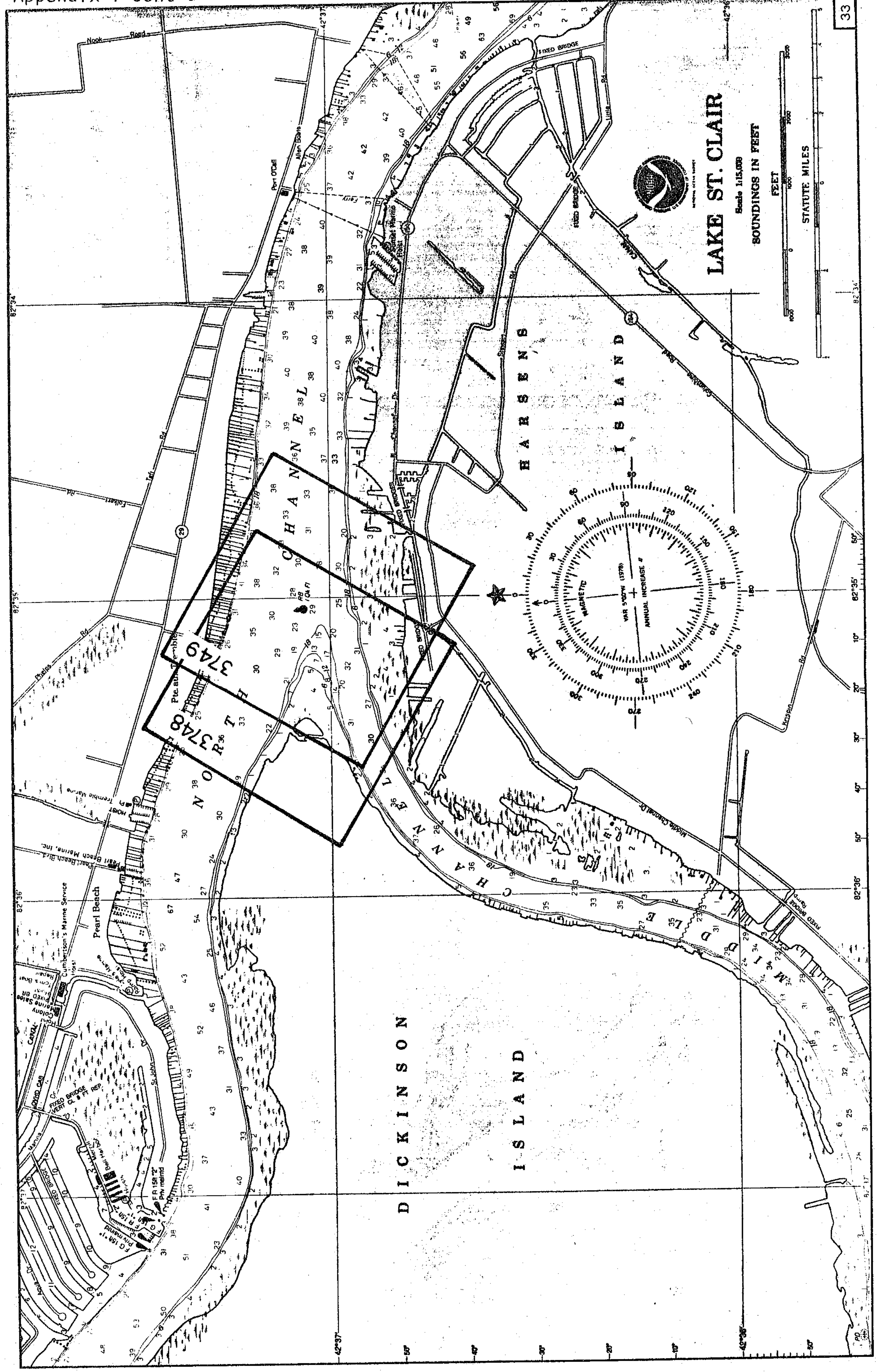


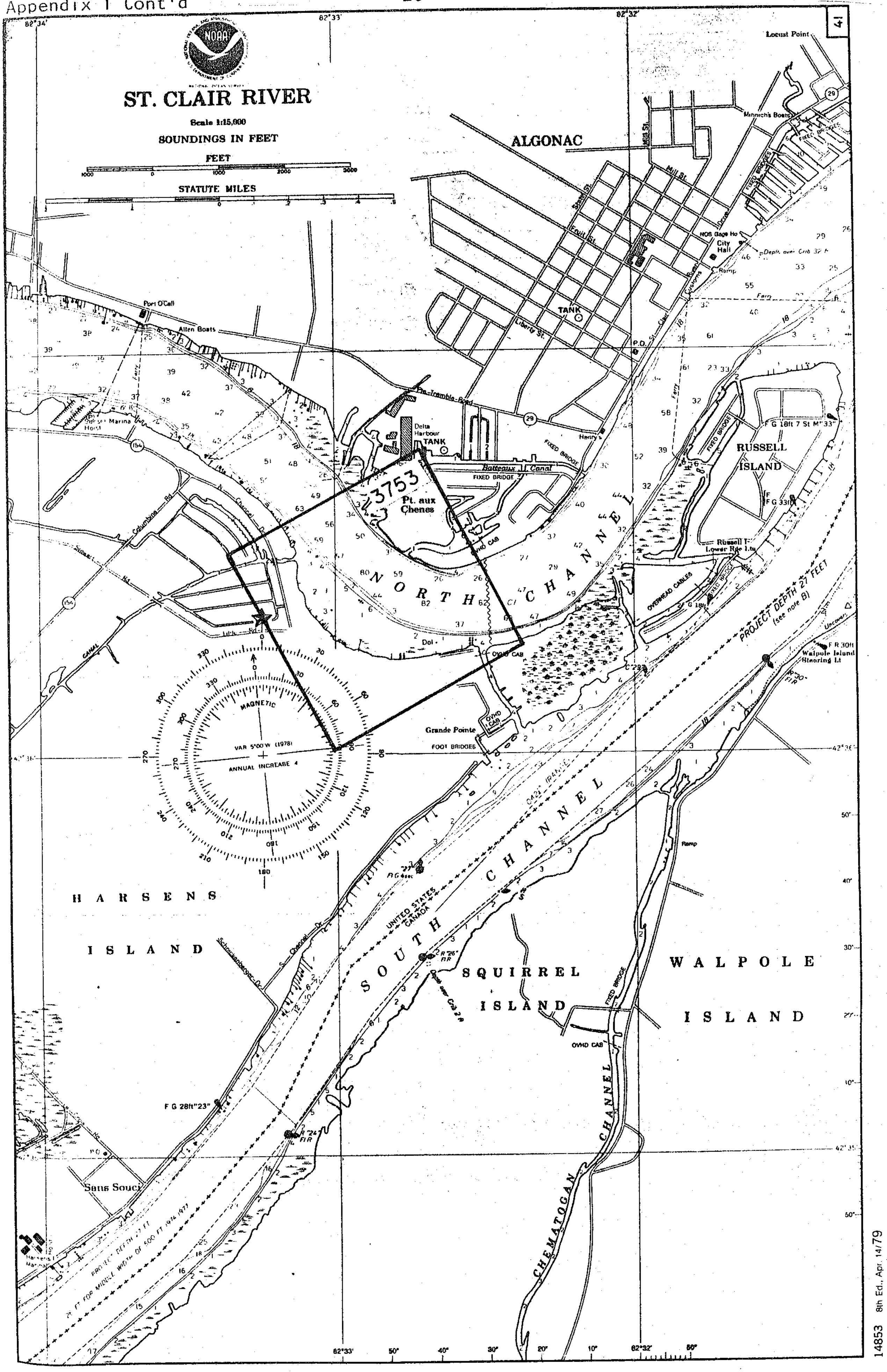
14853 Amd Ent Apr 14/79


3737
3740
3733
POLLET BAY
ANCHOR BAY
CHENAL
A BOUT ROND
DICKINSON ISLAND
FISHER BAY
STRAWBERRY ISLAND
DROUARD BAY
GOOSE BAY
Big Fisher By.
Middle Channel
LAKE ST. CLAIR
Scale 1:15,000
SOUNDINGS IN FEET
FEET
STATUTE MILES
82°42'
82°41'
42°36'
42°37'
32

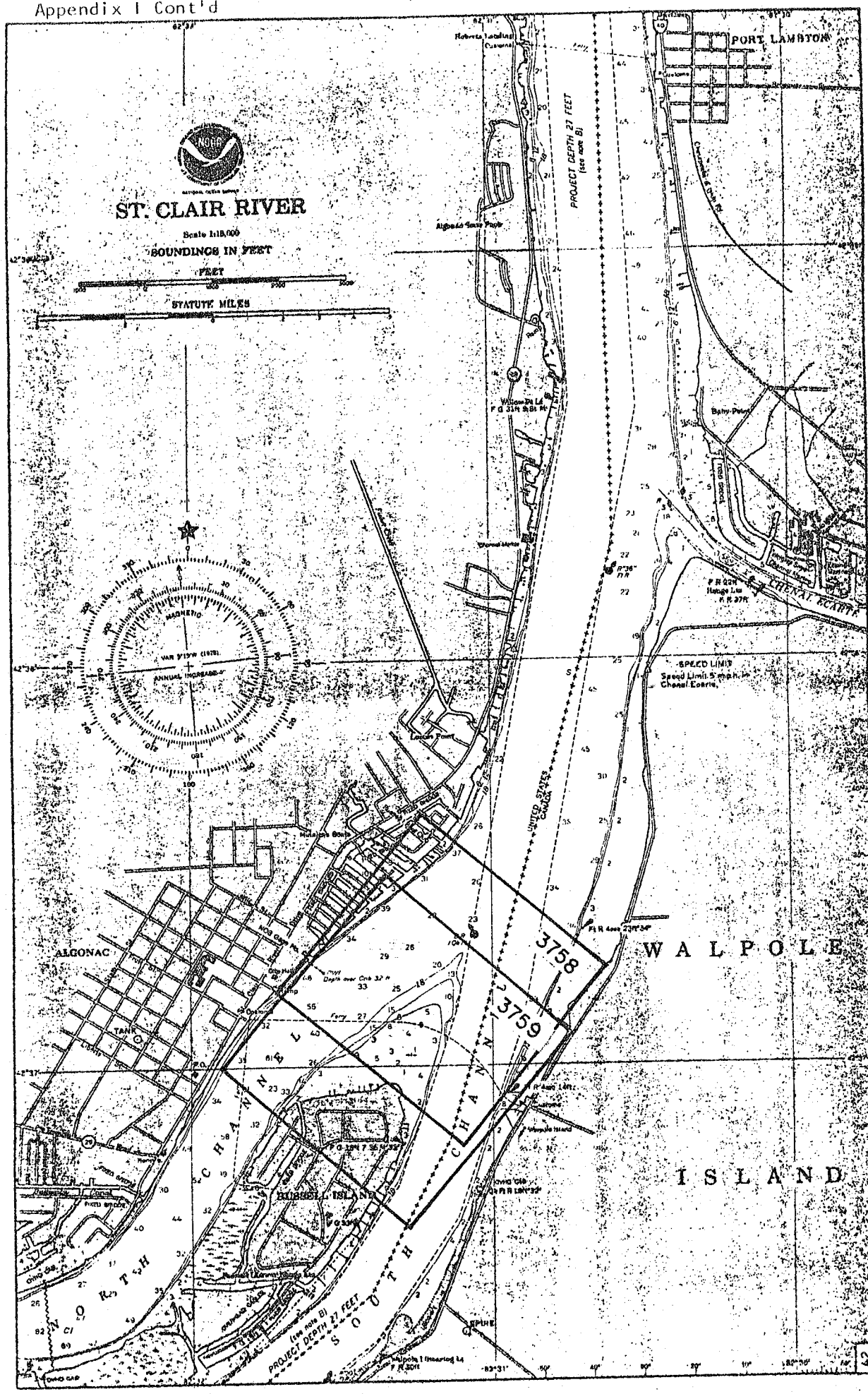

LAKE ST. CLAIR
Scale 1:15,000
SOUNDINGS IN FEET
FEET
STATUTE MILES
NORTH CHANNEL
ANCHOR BAY
Baltimore Channel
Baltimore
Baltimore Hy
Power Transmission Line
3743
MAGNETIC
VAR 5°00'W (1978)
ANNUAL INCREASE 4'
GRID
30


LAKE ST. CLAIR
SOUNDINGS IN FEET
FEET
STATUTE MILES
BOUVIER BAY
DICKINSON
ISLAND
NORTH CHANNEL
Pearl Beach
FIXED BRIDGE
CANAL
3745
31
14853 8th Ed., Apr. 14/79

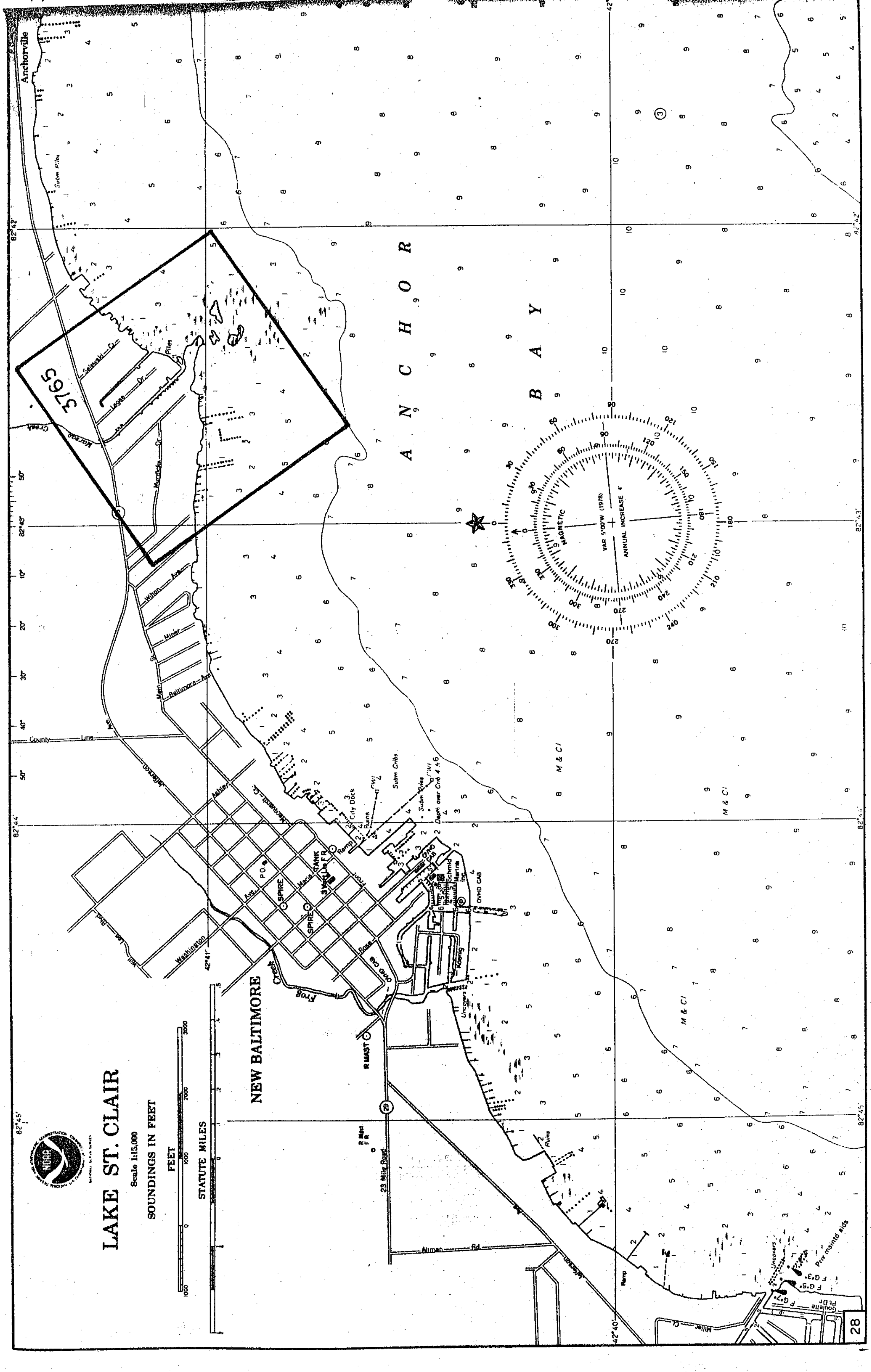

LAKE ST. CLAIR
Scale 1:15,000
SOUNDINGS IN FEET
STATUTE MILES
33
NORTH CHANNEL
HARSENS ISLAND
DICKINSON ISLAND
MIDDLE CHANNEL
3749
3748
Pearl Beach
14853 8th Ed., Apr. 14/79


ST. CLAIR RIVER
Scale 1:15,000
SOUNDINGS IN FEET
FEET
STATUTE MILES
ALGONAC
NORTH CHANNEL
SOUTH CHANNEL
RUSSELL ISLAND
HARSENS ISLAND
SQUIRREL ISLAND
WALPOLE ISLAND
CHEMATOGAN CHANNEL
Pt. aux Chenes
3753
Grande Pointe
Sans Souci
Port O'Call
Allen Boats
Delta Harbour
TANK
Batteaux Canal
FIXED BRIDGE
Locust Point
City Hall
PROJECT DEPTH 27 FEET (see note B)
UNITED STATES
CANADA
MAGNETIC
VAR 5°00'W (1978)
ANNUAL INCREASE 4'
41
14853 8th Ed., Apr. 14/79

Appendix I Cont'd



14853 3m Ed_Apr 1979


LAKE ST. CLAIR
Scale 1:15,000
SOUNDINGS IN FEET
FEET
STATUTE MILES
NEW BALTIMORE
ANCHOR
BAY
3765
Anchorville
Washington
Baltimore Ave
Wilton Ave
County Line
23 Mile Road
Ramp
City Dock
Subm Cribs
28
14853 8th Ed., Apr. 14/79

Appendix II. Instructions, dichotomous key, and answer sheet provided to three pairs of test subjects to identify 20 submersed macrophyte beds delineated on 17 aerial transparencies of 10 sites in the St. Clair-Detroit River system taken on September 26, 1978.

AERIAL PHOTOGRAPH INTERPRETATION TEST: IDENTIFICATION OF TAXA OF SUBMERSED MACROPHYTES

Instructions

The purpose of this test is to determine your ability to identify submersed macrophytes delineated on aerial transparencies (approximate scale 1:5000) with the aid of a simple dichotomous key. The test will determine your ability to identify submersed macrophyte beds, but the subjects to be identified are not necessarily restricted to submersed macrophytes (i.e., one or more delineated areas have no plants). The dichotomous key is arranged to allow you to make one of two choices on the basis of characteristics of submersed macrophytes on the aerial photographs provided; follow along from one couplet to the succeeding one until you reach an answer. Once you have made your determination, place your answer on the attached answer sheet adjacent to the appropriate transparency number (note that three transparencies have two delineated areas each).

Note: To be sure that the delineated are on the plastic cover aligns with the intended area on the transparency, please align the upper left and lower right corners of the transparency with the lines marked on the plastic cover; the transparency may be moved by grasping the edge through the opening at the left side of the plastic cover.

Key to the Identification of Submersed Macrophyte Beds Delineated on Aerial Transparencies of the St. Clair-Detroit River System

1A. Vegetation floating in mats on water surface; floating vegetation either much darker and rougher in texture than adjacent submersed vegetation, giving spotty or clumped appearance, or very light green against a darker background of underlying plant beds with little or no detectable texture; depth of field visible between floating and submersed vegetation..... 7A

1B. Vegetation not floating on surface (for example, see transparencies #3737-1, 3740-1, and 3743-1)..... 2A

2A.(1B) Color of designated area uniform throughout; showing no lines or texture..... 3A

2B. Color of designated area non-uniform throughout; having a textured appearance..... 4A

3A.(2A) Color light olive green to tan..... Sand substrate

3B. Color green to light brown..... Myriophyllum

4A.(2B) Textured area light green, tan, or light brown..... 5A

4B. Textured area dark green to brownish black..... 6A

5A.(4A) Area light green to tan showing a faint mosaic pattern or white to tan lines..... Chara

5B. Area light brown showing a faint mosaic pattern or patchy texture..... Vallisneria

6A.(4B) Textured area brown to brownish black..... Myriophyllum

6B. Textured area dark green..... Potamogeton

7A.(1A) Floating vegetation brown to brownish black in color; in irregularly shaped mats..... Myriophyllum

7B. Floating vegetation dark green to black; appearing as discrete spots or clumps of uniform size against lighter green or tan background (i.e., speckled appearance)..... Heteranthera

TEST ANSWER SHEET

Transparencies (about 1:5000 scale) and corresponding test identifications made by a test subject using a dichotomous key.

NAME OF TEST SUBJECT:_____ DATE: _____

Transparency Number [1] delineated area number	Site[2]	Identification
3716-1	1.....	_____
3717-1	2.....	_____
3718-1	2.....	_____
3720-1	2.....	_____
3721-1	3.....	_____
3729-1	3.....	_____
3729-2	3.....	_____
3733-1	4.....	_____
3733-2	4.....	_____
3737-1	4.....	_____
3740-1	4.....	_____
3743-1	6.....	_____
3743-2	6.....	_____
3745-1	7.....	_____
3748-1	8.....	_____
3749-1	8.....	_____
3753-1	9.....	_____
3758-1	10.....	_____
3759-1	10.....	_____
3765-1	5.....	_____

[1] Location of each transparency is shown in Appendix I.

[2] Approximate location of each site is shown in Figure 1.

TEST ANSWER SHEET

Transparencies (about 1:5000 scale) and corresponding test identifications made by a test subject using a dichotomous key.

NAME OF TEST SUBJECT:_____ DATE: _____

Transparency Number [1] delineated area number	Site[2]	Identification
3716-1	1	_____
3717-1	2	_____
3718-1	2	_____
3720-1	2	_____
3721-1	3	_____
3729-1	3	_____
3729-2	3	_____
3733-1	4	_____
3733-2	4	_____
3737-1	4	_____
3740-1	4	_____
3743-1	6	_____
3743-2	6	_____
3745-1	7	_____
3748-1	8	_____
3749-1	8	_____
3753-1	9	_____
3758-1	10	_____
3759-1	10	_____
3765-1	5	_____

1/ Location of each transparency is shown in Appendix I.

2/ Approximate location of each site is shown in Figure 1.

TEST ANSWER SHEET

Transparencies (about 1:5000 scale) and corresponding test identifications made by a test subject using a dichotomous key.

NAME OF TEST SUBJECT:_____ DATE: _____

Transparency Number [1] delineated area number	Site [2]	Identification
3716-1	1.....	_____
3717-1	2.....	_____
3718-1	2.....	_____
3720-1	2.....	_____
3721-1	3.....	_____
3729-1	3.....	_____
3729-2	3.....	_____
3733-1	4.....	_____
3733-2	4.....	_____
3737-1	4.....	_____
3740-1	4.....	_____
3743-1	6.....	_____
3743-2	6.....	_____
3745-1	7.....	_____
3748-1	8.....	_____
3749-1	8.....	_____
3753-1	9.....	_____
3758-1	10.....	_____
3759-1	10.....	_____
3765-1	5.....	_____

[1] Location of each transparency is shown in Appendix I.

[2] Approximate location of each site is shown in Figure 1.

Figure 2. Example photocopy of a color transparency (number 3759, Appendix I) showing submersed macrophytes at site 10 (Figure 1) in the St. Clair-Detroit River system on September 26, 1978.