HRBMP
Hudson River Biological Monitoring Program

Description of the Water Quality Survey: A Component of the Historical Hudson River Biological Monitoring Program

1. The Water Quality Survey

1.1 General Survey Design and Implementation

The Hudson River Biological Monitoring Program (HRBMP) is a large-scale comprehensive long-term survey program covering the Hudson River Estuary (HRE) from Battery Park (river mile [RM] 0) to Albany (RM 152), NY (Figure 1). The initial purpose of the HRBMP was to quantify HRE fish distribution, relative and absolute abundance, and species population and community health, to understand the potential effects of Indian Point and other power generation facilities and anthropogenic activities. The historical HRBMP, gifted to and curated by the Chen Lab at Stony Brook University, includes the six core surveys conducted from 1974 through 2018. The Water Quality Survey (WQS), a component of the HRBMP, is an extensive time series of water quality observations over more than 40 years covering the tidal portion of the HRE from NYC to Albany.

The primary objective of the WQS was to determine the spatial and temporal distribution of water temperature, dissolved oxygen (DO), and conductivity measured along the 152 miles of the HRE (Figures 2-7). The WQS began in 1973 and continued annually through 2018. Prior to 1982, water quality measurements were taken at depths associated with each Long River Survey (LRS), Fall Juvenile Survey (FJS), and Beach Seine Survey (BSS) sample. This resulted in measurements taken at approximately 100 to 200 stations and depth combinations during each week of sampling.

Beginning in 1982, and continuing through 2018, water quality measurements were dissociated from the sample collections of the LRS and FJS and instead were collected at 65 fixed stations at approximately three-mile intervals along the length of the HRE, resulting in measurements taken at 182 stations over different depth categories (Table 1). Water quality measurements from 1974 through 2018 total approximately 232,000 samples, with an additional 60,000 water quality measurements from the BSS during the period.

Starting in 1977, Yellow Spring Instruments (YSI) were used at depth to collect in situ samples instead of using the Van Dorn sampler. At each fixed station, water quality measurements were taken and recorded at near-surface, mid-depth, and near-bottom, except in shallow areas (depths $\leq$ 6.1 meters) where only near-surface and near-bottom measurements were considered sufficiently representative. The water quality parameters measured depended on which biological sampling program they were taken concurrently with. Temperature, DO, and conductivity were recorded for all programs, but for some biological sampling programs pH and turbidity were also collected. At each location and depth, water temperature was measured to the nearest 0.1 degrees Celsius (°C), DO was measured to the nearest 0.1 milligrams per liter (mg/l), and conductivity

was measured in microsiemens per centimeter (µS/cm) to the nearest scaling factor and then adjusted to water at 25°C. Water quality instrumentation was subjected to daily calibration and quality control (QC) against known laboratory standards. After 1981, turbidity and pH were no longer measured.

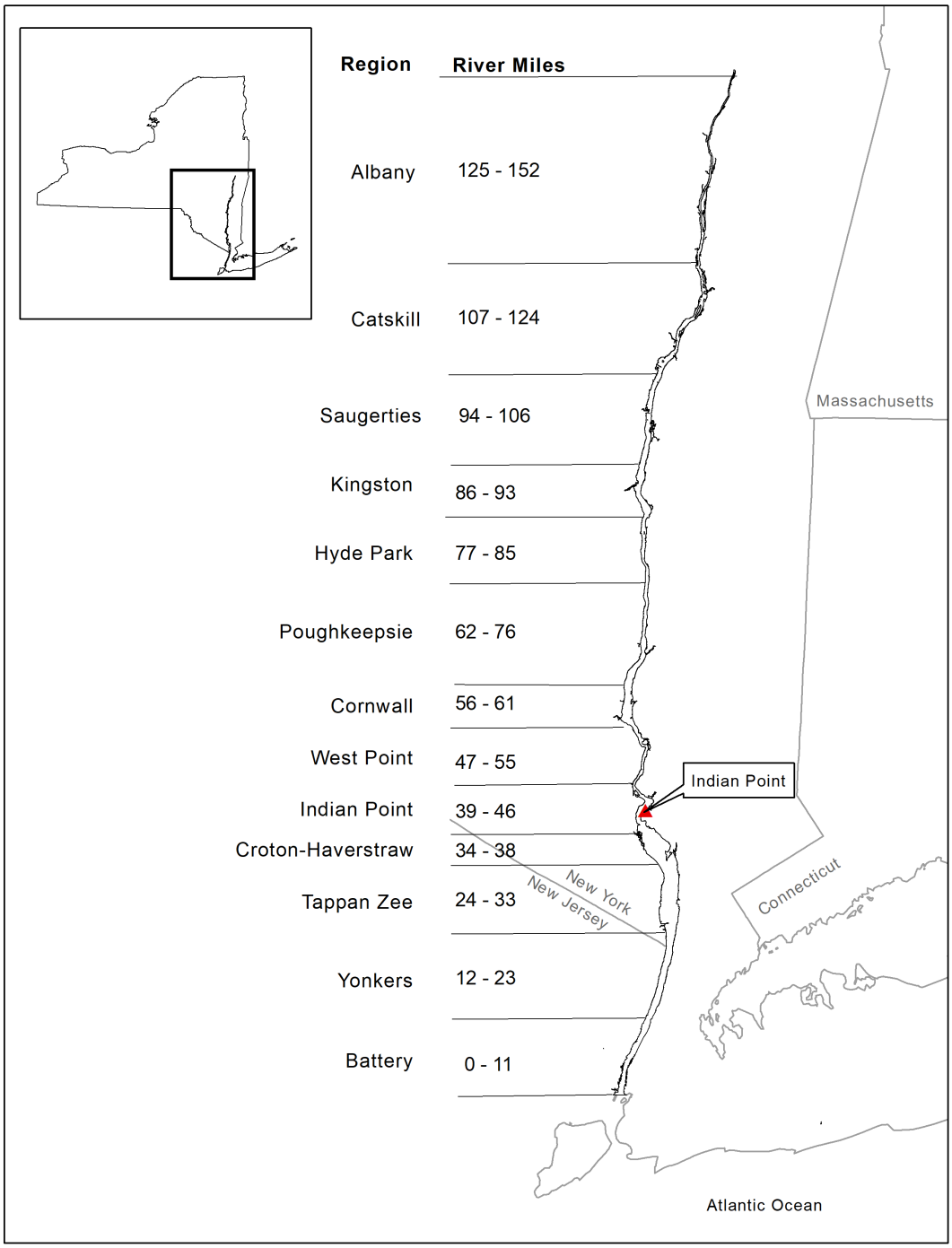

Figure 1. Map depicting the 13 geographic river regions of the HRE sampled by the WQS.

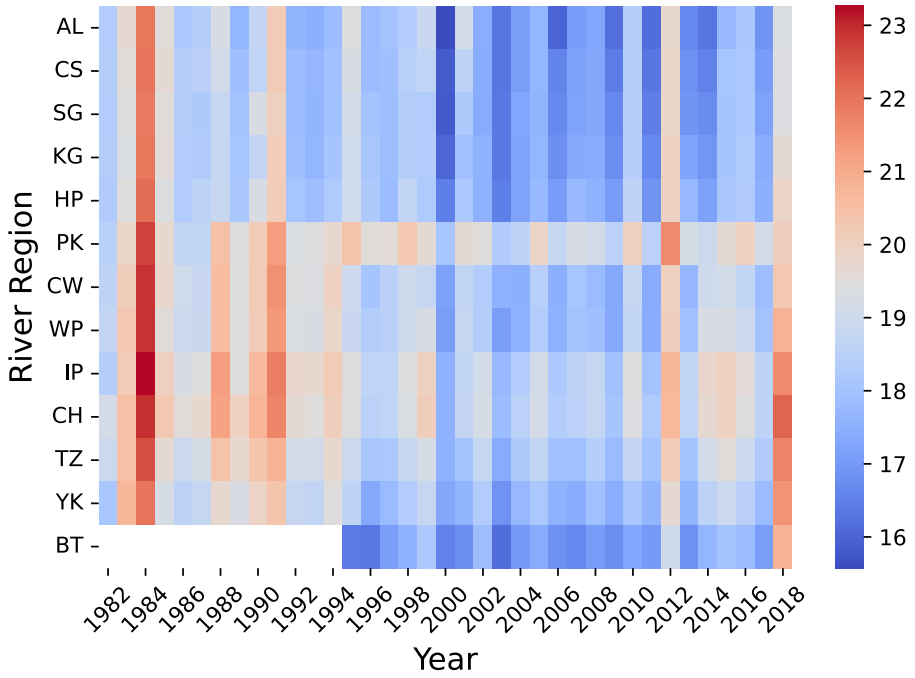

Figure 2. The heat map shows the variation in mean water temperature (°C) of the 13 Hudson River Estuary regions (y-axis) from 1974 through 2018 based on a standardized subset of data from the LRS and FJS sampled at the fixed water quality stations (Task Code = 98 only).

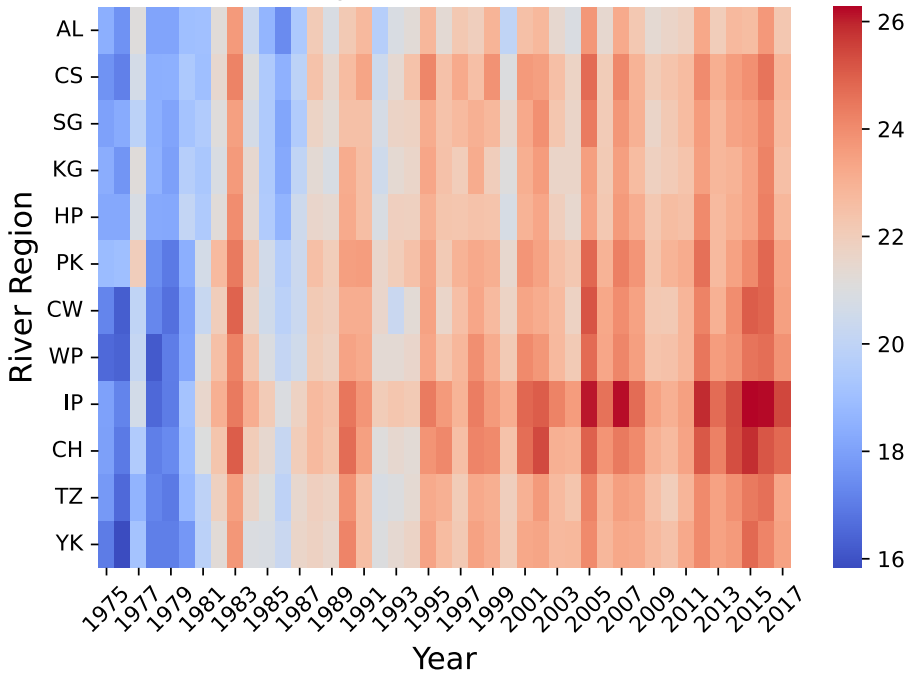

Figure 3. The heat map shows the variation in mean water temperature (°C) in the shore zone of 12 Hudson River Estuary regions (y-axis) from 1974 through 2017 sampled by the BSS (Task Code = 23 only).

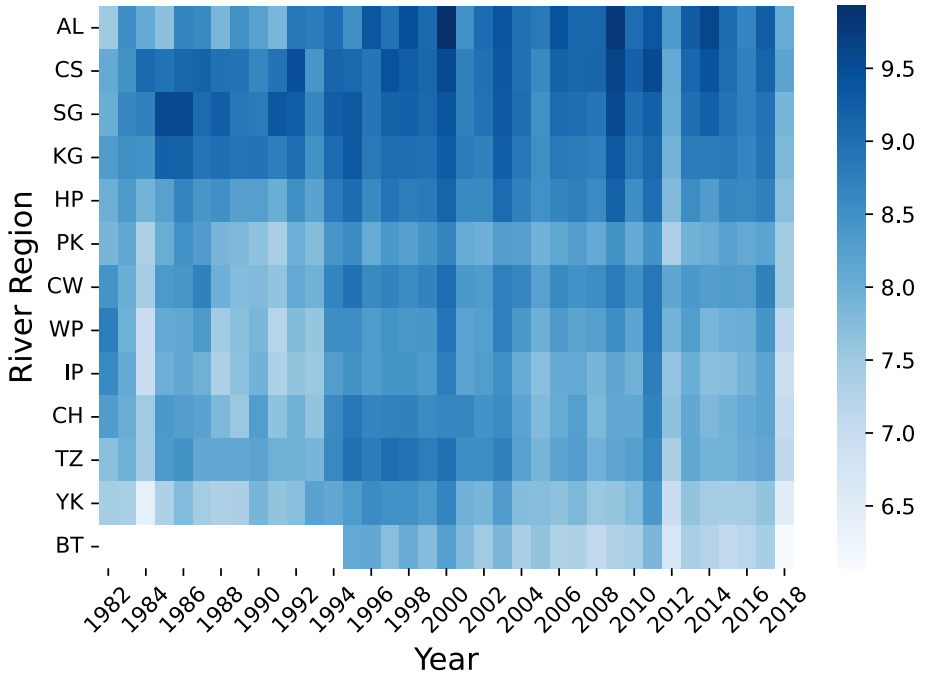

Figure 4. The heat map shows the variation in mean dissolved oxygen (mg/L) of the 13 Hudson River Estuary regions (y-axis) from 1974 through 2018 based on a standardized subset of data from the LRS and FJS sampled at the fixed water quality stations (Task Code = 98 only).

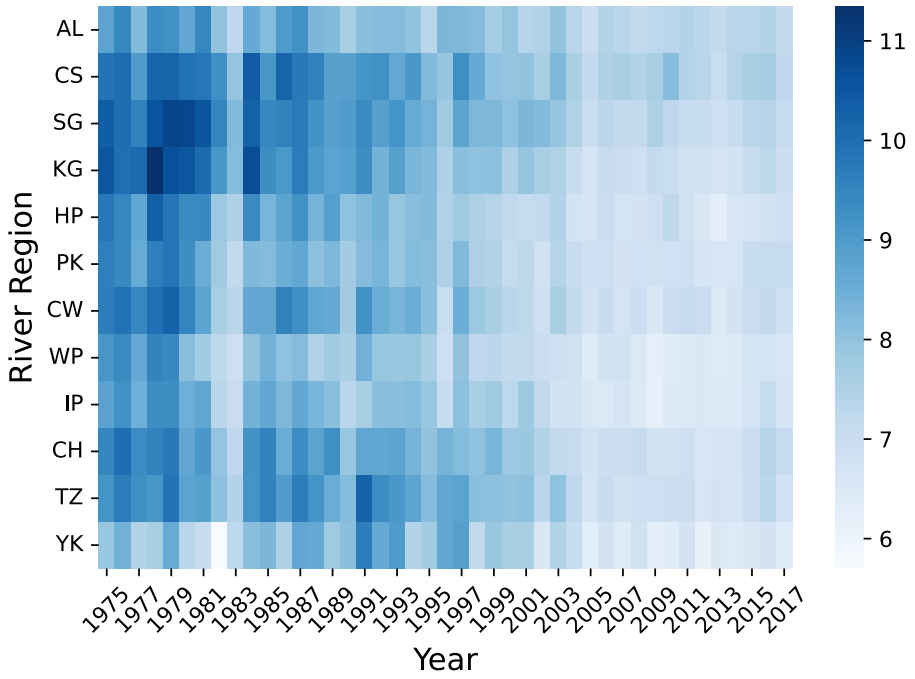

Figure 5. The heat map shows the variation in mean dissolved oxygen (mg/L) in the shore zone of 12 Hudson River Estuary regions (y-axis) from 1974 through 2017 sampled by the BSS (Task Code = 23 only).

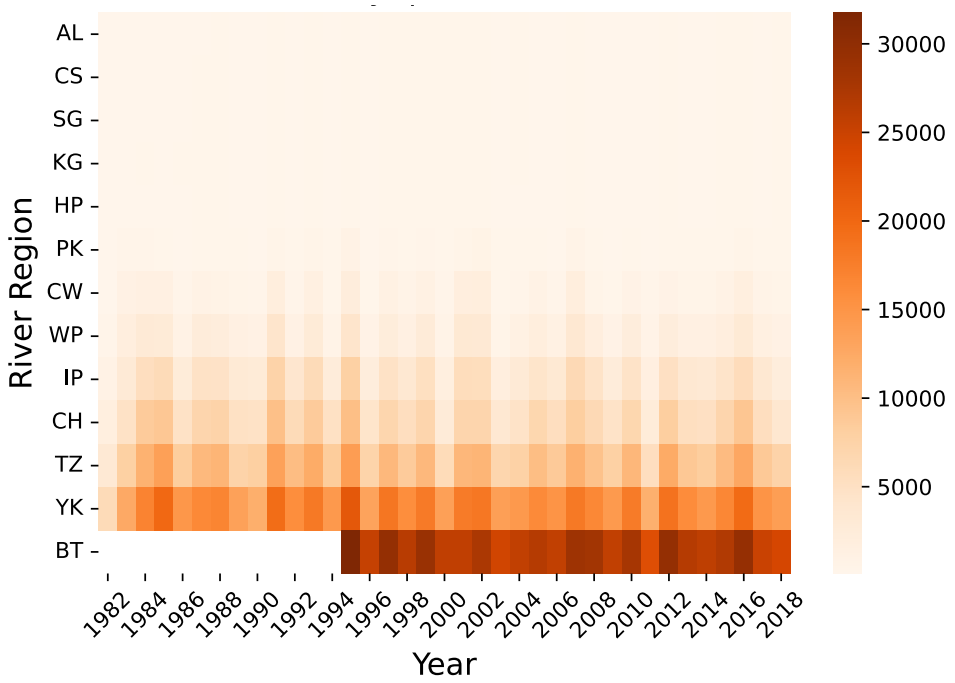

Figure 6. The heat map shows the variation in mean conductivity (µS/cm) of the 13 Hudson River Estuary regions (y-axis) from 1974 through 2018 based on a standardized subset of data from the LRS and FJS sampled at the fixed water quality stations (Task Code = 98 only).

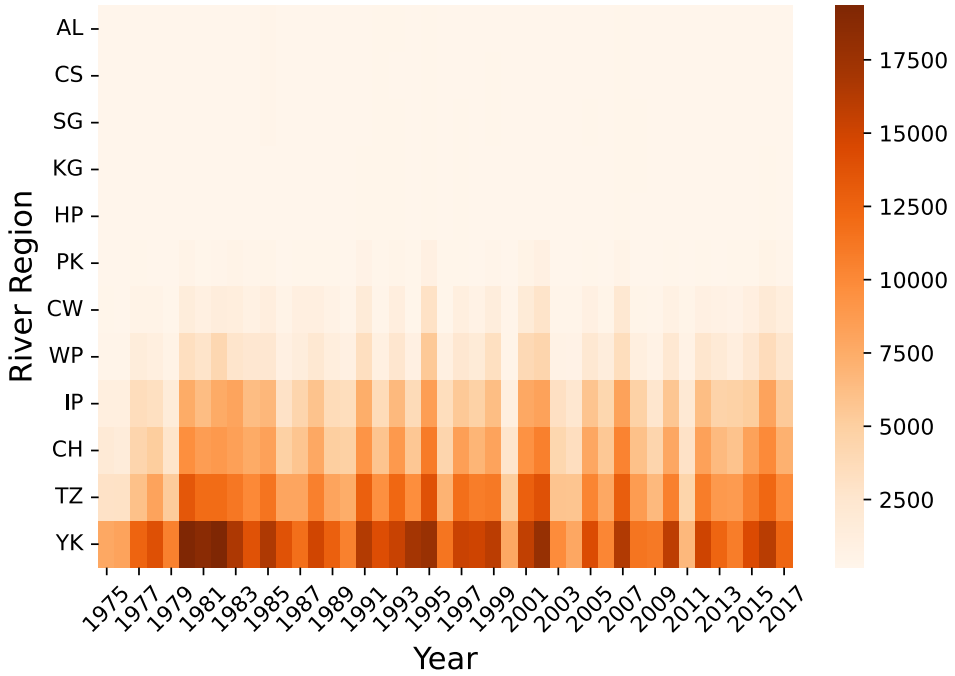

Figure 7. The heat map shows the variation in mean conductivity (µS/cm) in the shore zone of 12 Hudson River Estuary regions (y-axis) from 1974 through 2017 sampled by the BSS (Task Code = 23 only).

Table 1. WQS sampling locations for the LRS and FJS. Dashes (--) indicate no sampling schedules. Shoal samples were collected from east and west shoals at designated river mile.

	Scheduled sampling locations (River Mile)		Number of Water Quality Samples Scheduled Per Region Per Week			
River Region	Shoals	Channel	LRS Weeks 1-3	LRS Weeks 4-16	LRS Weeks 17-23	FJS Weeks 1-11
Battery	--	1, 3, 6, 9	12	12	12	12
Yonkers	19	12, 14, 17, 19, 22	19	19	19	19
Tappan Zee	29	25, 27, 29, 32	16	16	16	16
Croton-Haverstraw	36	35, 36, 37, 38	16	16	16	16
Indian Point	43	40, 42, 43, 46	16	16	16	16
West Point	--	49, 51, 53, 55	12	12	12	12
Cornwall	59	56, 57, 59, 61	16	16	16	16
Poughkeepsie	--	63, 67, 71, 75	--	12	12	12
Hyde Park	--	78, 80, 82, 84	--	12	--	12
Kingston	--	87, 89, 91, 93	--	12	--	12
Saugerties	--	96, 99, 102, 105	--	12	--	12
Catskill	--	109, 114, 118, 122	--	12	--	12
Albany	--	126, 131, 135, 138, 142	--	15	--	15
Weekly Total			**107**	**182**	**119**	**182**

1.2 Survey Design and Implementation by Task Code

Varying water quality parameters were collected by the different HRBMP components (Table 2). The BSS collected water temperature, DO, and conductivity 1-ft below the surface, and approximately 50-ft from shore, at each beach seine sample location. The Atlantic Tomcod Stock Assessment measured conductivity and water temperature in situ, with measurements corresponding to each box trap or trawl sample collection. Water quality readings were made 1-ft below the surface and at sampling depth at box trap sites, and 1-ft below the surface and sampling depth immediately after the completion of each 9-m trawl tow. A YSI salinity-conductivity-temperature meter was used to measure surface and bottom water temperature and conductivity at the end of each tow. All conductivity measurements were adjusted to 25 °C (specific conductance). The Adult Striped Bass Stock Assessment collected water quality parameters with each gill net sampling. Unfortunately, there is limited documentation on how water quality measurements were taken by the ancillary HRBMP surveys, such as the Try Trawl Survey of the Mark-Recapture survey (Table 2).

Table 2. Water quality parameters collected by different HRBMP surveys.

Task Code	Survey Name	Time Period	Water Quality Parameters Collected
3	Standard Stations	1975	Water temperature, pH, DO, conductivity, and turbidity
13	Interregional Trawl Survey	1975-1980	Water temperature, pH, DO, conductivity, and turbidity

23	Beach Seine Survey	1974-2017	Water temperature, pH, DO, conductivity, and turbidity
24	Beach Seine Efficiency	1977-1978	Water temperature, pH, DO, conductivity, and turbidity
33	Mark-Recapture	1975-1980	Water temperature, pH, DO, conductivity, and turbidity
39	Try Trawl Survey	1979-1980	Water temperature
43	Atlantic Tomcod Stock Assessment	1975-1981	Water temperature and conductivity
53	Adult Striped Bass Stock Assessment	1976-1980	Water temperature, pH, DO, conductivity, and turbidity
88	Long River Ichthyoplankton Survey	1974-1984	Water temperature, pH, DO, conductivity, and turbidity
89	Long River Ichthyoplankton Survey and Fall Shoals Water Quality	1982-2018	Water temperature, DO, and conductivity
98	Fall Shoals Survey	1974-1982	Water temperature, pH, DO, conductivity, and turbidity

1.2 Potential Data Quality Issues

Some variables in the original data set, such as WS, WD, and ND, have too few records, whereas variables such as DATE have complete data after 1981 (Table 3). Other variables like NET_MESH only have records before 1981. There are 20404 rows with only year data and no specific date. Five columns include mixed data types, such as string data found in numeric columns. Additionally, outliers were identified in various water quality parameters; dissolved oxygen has extreme values of 0 and 29.9, pH has extreme values less than four, and conductivity has extreme values greater than 90,000.

Table 3. Data availability for each variable collected by the WQS.

Variable	Years Available
AIR.TEMPERATURE	1975–1978, 1988–2017
BEACH.NUMBER	1980–2017
BOTTOM.TYPE	1975–2017
CATCH_CD	1974–1981
CLOUD.COVER	1975–1978, 1980
COMMENTS	1980, 1984–1995, 1997, 199–2000, 2002–2017
CONDUCTIVITY	1974–2018
DATE	1974–2018
DISSOLVED.OXYGEN	1974–2018

DURATION	1974–1981
FLOWMETER.DIFFERENCE	1974–1981
FLOWMETER.END	1974–1981
FLOWMETER.NUMBER	1974–1981
FLOWMETER.START	1974–1981
GEAR.CODE	1974–2017
GEAR.NARRATIVE	1975–1979, 1981
LAT.DEGREE	2003–2017
LAT.MINUTE	2003–2017
LONG.DEGREE	2003–2017
LON.MINUTE	2003–2017
ND	2004–2016
NET.LENGTH.OPENING.WIDTH.RATIO	1974–1981
NET.MESH	1974–1981
NM	2004–2015
NS	2004–2015
NUMBER.OF.GEARS.USED	1975–1980, 1983, 1985–2017
PH	1974–1981
PROCESSING.DATE	1980–1982, 1985–2017
PROJECT	1983
RELATIVE.DEPTH	1982
RIVER.DEPTH	1974–1981
RIVER.MILE	1974–2018
RIVER.RUN	1974–2018
SAM_NARR	1975–1983, 1985–2017
SAMPLE.NUMBER	1974–2018
SITE	1974–2018
SPLIT_CD	1980–1981
STATION	2007–2018
STRATA.CODE	1974–1981

TASK_CODE	1974–2018
TIDAL.METHOD	1975–1978
TIDE.STAGE	1974–1978, 1988–2017
TIME	1974–2018
TOW.DIRECTION	1980–1981
TOW.SPEED	1974–1981
TURBIDITY	1974–1979
USE.CODE	1975–2017
VESSEL.CODE	1974–1981
VOLUME.OF.WATER.SAMPLED.IN.CUBIC.METERS	1974–1981
WATER.QUALITY.SAMPLE.DEPTH.m	1974–2018
WATER.TEMPERATURE	1974–2018
WAVE.HEIGHT	1974–2017
WD	2004–2015
WIND.DIRECTION	1975–1978
WIND.SPEED	1975–1978
WM	2004–2015
WS	2004–2015
YEAR.OF.DATA.COLLECTION	1974–2018