A Pale View of Shizuo Ishiguro's Research —*Abiki*, the 1953 North Sea Flood, and Beyond—

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Shizuo Ishiguro, the father of Nobel Prize-winning British novelist Kazuo Ishiguro, studied various sea-level changes, such as seiche, also known as *abiki* in the Nagasaki dialect, and the 1953 North Sea Flood, with his pioneering use of an analog computer in the 50s and 60s. Note that pioneering studies by Lorenz and Ueda using digital and analog computers were also performed in the 60s. Based on a retrospective review, it is discussed whether nonlinear phenomena, such as chaos, can be observed in line with his pioneering studies. His studies are also reconsidered in the context of advanced education for high-school students.
Key words: Abiki, Seiche, Secondary Undulation, 1953 North Sea Flood, Shizuo Ishiguro, Kazuo Ishiguro, Nagasaki Marine Observatory

I had a rather precarious feeling, perched on the edge of that mountain looking out over such a view; a long way below us, we could see the harbor looking like a dense piece of machinery left in the water. Across the water, on the opposite bank, rose the series of hills led into Nagasaki. The land at the foot of the hills was busy with houses and buildings. Far over to our right, the harbor opened out on to the sea. So Nagasaki Bay is described in the seventh chapter of Kazuo Ishiguro's first novel: *A Pale View of Hills* (Ishiguro, 2010). This scenery from the hilltop of *Inasa*, located 333 meters above sea level, is also shown in the photo in Fig. 1.

Fig. 1. Nagasaki Bay, viewed from the hilltop of *Inasa*, suffers occasionally from *abiki*.

Shizuo Ishiguro, whose son, Kazuo Ishiguro, received the Nobel prize in Literature in 2017, wrote a dissertation on modeling ocean wave dynamics with an analog computer, and received a Doctorate of Science from the University of Tokyo in 1958. As an oceanographer, he was in 1948 assigned to the Nagasaki Marine Observatory (present: Nagasaki Meteorological Office), which is located *on the opposite bank* in the previous quote, after serving at the Meteorological Research Institute. He lived until 1960 in Nagasaki, which was a venue of the *Symposium on Form*, where the present topic was contributed in the *Forum* category.

Large oscillations in the water level in Nagasaki Bay which occur not very regularly, but may put human lives at risk in some situations, are called *abiki* in the Nagasaki area. Quite recently, on March 21, 2019, the city center of Nagasaki suffered damage from a flood despite fine weather, caused by *abiki*, which was analyzed and reported promptly by the Nagasaki Meteorological Office (Nagasaki Meteorological Office, March 2019). The Nagasaki Meteorological Office has always been keenly interested in *abiki* and illustrates this phenomenon on its Japanese website (Nagasaki Meteorological Office, May 2019).

At the Nagasaki Marine Observatory, Shizuo Ishiguro started to study *abiki*, also known as secondary undulation, using analog computer simulation as early as in 1949 (Ishiguro, 1950, 1959). A similar phenomenon called *seiche* occurs in Lake Geneva, Switzerland. This study received recognition and brought him to England. A similar analog computer simulation was performed for the North Sea flood of 1953 by him (Kennard, 2016; Science Museum, 2018). The natural voice of Shizuo Ishiguro was recorded during a lecture under the title of *Storm Surges in the North Sea* (Ishiguro, 1968). Later he was also engaged in research on North Sea oil fields. This time of his studies on *abiki* and the North Sea flood coincided with pioneering works on chaos using analog and digital computers by Lorenz (Lorenz, 1963, 1993) and Ueda. Around this time

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the *broken egg* in analog computer simulation was discovered by Ueda (Grebogi-Yorke, 1997; Ueda, 2012). Due to this timing coincidence, it is tempting to think of Shizuo Ishiguro as a pioneer in the research field of nonlinear dynamics and chaos.

Fig. 2. A soliton-like or tsunami-like wave due to *abiki* moved upstream along the Urakami River flowing into Nagasaki Bay on March 16, 1988 (Courtesy of Nagasaki Meteorological Office). Original: http://www.jma-net.go.jp/nagasaki-c/kaiyo/knowledge/abiki/urakami.gif

Let us examine the abstract of a paper published in 1959 (Ishiguro, 1959): *A method of analysis for long-wave phenomena in the ocean and examples of its applications are described. A phenomenon to be analyzed is assumed to be 'response' resulting from an 'excitation' on the 'system' , and the relations between these are analyzed. The original hydraulic system is divided into a number of cells of finite size. Each cell is assumed to have a constant depth within itself, and is represented by a two-dimensional electric network consisting of many capacitors, which are proportional to the area of the mesh, variable inductors, inversely proportional to the depth of each mesh and variable resistors, proportional to the total energy loss in each mesh. The excitation and its response are represented either by a voltage which represents the water elevation of each mesh or electric current which corresponds to the total flow across each mesh. Complicated cases, like that where the excitation is changing irregularly with both time and two-dimensional space, can be treated by simple and small-scale equipment by applying the reciprocity theorem and the pulse-superposition method.* Such an approach was explained by Shizuo Ishiguro himself in his lecture (Ishiguro, 1968). Note that we can find the term *reciprocity theorem* in the last sentence of the abstract, which implies that the equations of motion in his simulation are assumed by himself to be linear, so that various nonlinear phenomena, such as chaos or soliton, turn out to be unfortunately absent.

Shizuo Ishiguro greatly contributed to *Oceanography and Meteorology*, published by the Nagasaki Marine Observatory from 1947 to 2000. Some publication data are found at the cited URL of the National Institute of Informatics (NII, 2019), and are archived as one of the National Diet Library Digital Collections (NLD, 2019). In the fifth issue of the second volume published in 1948, just three years after the atomic bombing of Nagasaki, he wrote two handwritten, mimeographed articles on automatic recording of aeolian dust and wave pressure. In the latter, electromagnetic induction between two coils is applied. He made by hand, not only analog computers, but also various measuring machines and experimental equipment, and took full advantage of these during research and observation. Although such instrument-making was thought to begin out of necessity during the postwar disorder, it can be considered an important study topic even now for advanced high-school students such as those of super science high schools, often abbreviated as SSH, which are supported by the Education, Science and Technology Ministry of Japan. His early works on instrument-making are believed to be extremely useful, since instrument-making taxes high-school students' ingenuity.

There have long been advanced educational institutions in Nagasaki. Let us recall two historical examples: one is the *Arima seminário* founded in 1580 by Arima Harunobu, who was known as a Christian daimyo (Christian feudal lord) who cooperated with the Jesuit inspector Alessandro Valignano, and another is the *Narutaki-juku* founded in 1824 by Philipp Franz von Siebold. In the *Arima seminário*, a Renaissance education consisting of Latin, Portuguese, Japanese, classic Japanese, fine arts, geography, and gymnastics is offered. Four young Japanese boys from the seminário at the tender age of thirteen or fourteen went to Europe as the Tensho embassy (Cooper, 2005). In the *Narutaki-juku*, von Siebold and as many as over fifty educated Japanese from across the country, some of whom were barely out of their teens, exchanged their knowledge of Western science, including Western medicine and Japanese fauna and flora and other Japanese things. Siebold himself described the *Narutaki-juku* in his own writing *Reise nach dem Hofe des Sjogun im Jahre 1826* (Siebold, 1897): *... ward Narutaki der Sammelplatz japanischer Freunde europäischer Wissenschaft, ... Von diesem kleinen Punkte breitete sich allmählich ein neuer Lichtstrahl wissenschaftlicher Bildung und mit ihm unsere Verbindung über das japanische Reich aus. Die wir von nun an unsere Schüler nennen dürfen, haben hier den ersten Grundstein zu ihrer europäischen Bildung gelegt und vieles zu unsern Forschungen beigetragen...* (... Narutaki became a designated place of Japanese friends learning European knowledge, ... From this small point onward, a new ray of scientific education and our connection spread out gradually all over the Empire of Japan. Those whom we may call our students from now on, have here laid the first foundation stone to European education, and contributed greatly to our research...) In both, the smartest younger students in Japan were taught the latest technologies and knowledge from Europe.

The do-it-yourself approach of Shizuo Ishiguro is believed to serve as a model of SSH-like advanced studies for high-school students and to preserve the traditions of historical advanced educational opportunities even in very small quantities. As for *Science on Form*, we can recall his studies such as spatial dependences and dynamics of sea-level changes or sea surface waves. He built in these studies an automatic wave recorder on his own based on mathematical and physical foundations rather easily understood by high-school students such as electromagnetic induction. It may be a good exercise for SSH students to build an automatic wave recorder consisting of two coils as shown in Fig. 3 in order to gain a better understanding of the theoretical basis.

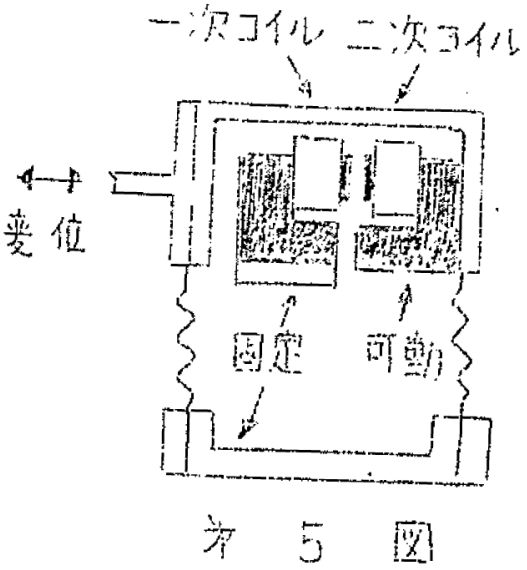

Fig. 3. Main parts of Ishiguro's automatic wave recorder consisting of a fixed coil and a movable coil as shown in Fig. 5 of the reference (Ishiguro, 1948). (Courtesy of Nagasaki Meteorological Office).

Shizuo Ishiguro's persistence with analog not digital computing, which was recited by himself in his lecture (Ishiguro, 1968), in addition to his not nonlinear but linear treatment of his simulations may be a *pale view*, judged by current academic standards. Nonetheless, his do-it-yourself approach is believed to be clearly suggestive in SSH-like advanced studies for high-school students. There is a monument erected in Dejima, which was a Dutch trading post located in Nagasaki from 1641 to 1854 and the only window open to foreign countries, by Siebold to honor Kaempfer and Thunberg: *E. KAEMPFER C. P. THUNBERG ECCE! VIRENT VESTRAE HIC PLANTAE FLORENTQUE QUOTANIS CULTORUM MEMORES SERTA FERUNTQUE PIA!* (Look! Your plants flourish every time we visit, and the blossoms reach full bloom in memory of the planters!) We hope that younger Japanese students will learn about *Arima Seminário*, *Narutaki-juku*, and *Shizuo Ishiguro*. Let them blossom.

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