Identifying Submarines and Missiles by Using a Dichotomous Key

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Introduction:

In this unit of study students will learn how to read, use, and construct dichotomous keys. Students will begin the unit by identifying the need for dichotomous keys in science. Students will begin the unit by discussing some background information on the variety of submarines utilized by the world's navies during the Cold War. Student will be instructed on reading a dichotomous key and will be given data on Cold War submarines (US and Soviet) and will be asked to utilize provided keys to identify the classification (type) of submarine shown in the pictures. Students will then practice using a dichotomous key to classify various missiles developed and deployed during the Cold War. Finally, students will demonstrate mastery by constructing their own dichotomous key in the classroom.

Dichotomous keys fall under the following North Carolina Biology Standard:

Competency Goal 4: The learner will develop an understanding of the unity and diversity of life

Objective 4.01 Analyze the classification of organisms according to their evolutionary relationships.

- *The historical development and changing nature of classification systems.*
- *Classify organisms using keys.*

Background on Cold War Era Submarines:

During the Cold War (post WW II – 1991) many nations utilized the submarine as a key weapon. While the United States and the Soviet Union developed the largest and most diverse fleet of submarines, other nations such as France and the United Kingdom also utilized the awesome power of the submarine. Submarines are often classified both by their form of propulsion and their strategic purpose. At the start of the Cold War submarines ran on diesel powered engines. In 1954, the US launched the USS Nautilus, the first nuclear powered submarine. Nuclear submarines come in two types; SSNs and SSBNs. The SSN is a nuclear (hence the N in SSN, the SS is for "submersible ship") fast attack sub. SSNs are used to attack other submarines, surface targets, and to support the fleet in other capacities. SSBNs, also called boomers, are nuclear (N) submarines that carry ballistic (B) missiles. The ballistic missiles carried by SSBN submarines act as a deterrent to war by having the ability to launch a large number of missiles each carrying multiple nuclear warheads.

Soviet Attack Submarines

Soviet/US Nuclear-Powered Ballistic Missile Submarines

TRIDENT I (C4) MISSILE   TRIDENT II (D5) MISSILE

Activity #1 - Hook Activity: Friend or Foe?

Objectives:

➢ *Identify the need to correctly classify objects based on physical characteristics.*

➢ *Introduce the diversity of life and the importance of classification systems in science.*

Materials:

✓ Pictures of various Cold War submarines

Procedure:

1. *Show students the pictures of the submarines (the images can be found on the museum website)*

2. *Ask students what kind of submarine each one is.   Is it American or Russian? Friend or foe?*

Realistically, students and adults alike will have no idea what type of subs these are. That's the point. Discuss with students differences and similarities between the pictured subs. Allow students to point out any distinguishing characteristics unique to that particular sub.

3. *Allow students to offer suggestions on telling the submarines apart. Reinforce the idea that submarines are very similar in appearance but telling them apart is critical.*

4. *Relate to students that the same problems exist for biologists when they attempt to study or classify all kinds of living things (birds, fish, insects, trees, etc.)*

Hint: Upon completion of this hook activity, the teacher may wish to show actual biology dichotomous keys and/or demo how to use the key itself. The two biggest problems students usually have in using dichotomous keys are that 1) they read them top to bottom (and not read the number choices in pairs) or 2) they skip ahead and try to start in the middle of the key. Both errors usually result in mistakes being made.

Hint: Remind students that the prefix (di-) in dichotomous means "two" and they must start with number one and read *both* choices (1A and 1B). An accurate key (if followed properly) always provides the user with one correct and one incorrect choice for every number on the key. The student should never arrive at a situation where neither choice (A or B) is correct.

Friend or Foe?

Answer – Foe!

The sub pictured above is a Soviet Oscar Class SSGN (a foe during the Cold War)

Friend or Foe?

Answer – Friend!

The sub pictured above is the *USS Skipjack SSN 585* (a US Cold War submarine)

http://www.usnavymuseum.org/images/Slides/Ex9-Submarines/Exp-Sub_Skipjack.jpg

Answer – Foe!

The sub pictured above is a Soviet Victor III Class SSN (a foe during the Cold War)

Activity #2 – Dichotomous Key for Soviet Subs

Objectives:

➢ Use the provided **Dichotomous Key of Soviet Attack Submarines** to identify the names of each of the represented classes of Soviet Cold War era submarines.

➢ Familiarize students with the assessment process in working with dichotomous keys.

Materials:

✓ Dichotomous Key of Soviet Attack Submarines

✓ One version of the worksheet (A or B) showing 5 subs to classify.

Procedure:

1. Students may be grouped or work individually on this assignment.

2. Give each student or group the hand out **Dichotomous Key of Soviet Attack Submarines.**

3. Give each student or group one or both versions of the worksheet showing the (5) subs to be classified.

4. Have students identify the (5) unknown submarines on their version of the worksheet (a, b or both).

5. Since there are two versions for this activity (a and b) the teacher may wish to give different sheets to different students or groups, different periods, or both to everyone. The second version may also be used as an exit activity, check for understanding, or homework.

Dichotomous Key of Soviet Attack Submarines

1A) The sub uses diesel power for propulsion…………………………………………………………Go to 2

1B) The sub uses nuclear power for propulsion………………………………………………………….Go to 3

2A) If the sub is 70 m in length……………………………………………………………..KILO-Class SS

2B) If the sub is 92 m in length……………………………………………………………...TANGO-Class SS

3A) If the submerged displacement of the sub is 10,000 MT or more………………………………Go to 4

3B) If the submerged displacement of the sub is less than 10,000 MT…………………………….Go to 6

4A) If the subs armament consists of torpedoes only…………………………………...YANKEE-Class SSN

4B) If the subs armament includes more than just torpedoes…………………………………….......Go to 5

5A) If the sub carries SS-N-19 antiship cruise missiles………………………………OSCAR-Class SSGN

5B) If the sub carries ASW missiles and SS-N-21 missiles…………………………......AKULA-Class SSN

6A) If the sub is less than 110 m in length………………………………………………………..Go to 7

6B) If the sub is 110 m in length……………………………………………………………………Go to 9

7A) If the sub reached initial operational capability in 1974……………………CHARLIE II-Class SSGN

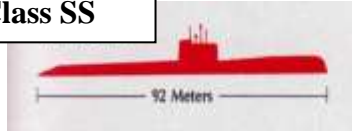7B) If the sub reached initial operational capability after 1974………………………………..Go to 8

8A) If the sub is over 100 m in length………………………………………………...VICTOR III-Class SSN

8B) If the sub is less than 100 m in length……………………………………………...ALFA-Class SSN

9A) If the sub has a submerged displacement of 6,400 MT……………………………….MIKE-Class SSN

9B) If the sub has a submerged displacement of 7,600 MT………………………………SIERRA-Class SSN
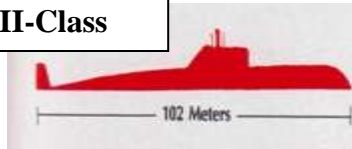
Name_____Period_____Date_____

Directions: Using the Dichotomous Key of Soviet Attack Submarines identify each of the following Cold War era Soviet submarines. Write the class of the sub in the space provided.
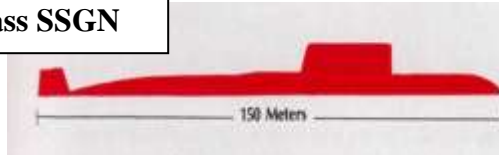
Sub #1:   TANGO-Class SS

92 Meters

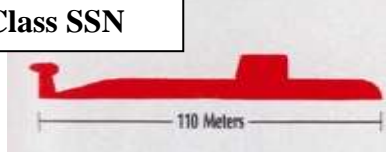| Armament: | Torpedoes |
Propulsion:	Diesel
Submerged Displacement:	3,900 MT
Initial Operational Capability:	1973

Sub #2: CHARLIE II-Class

102 Meters

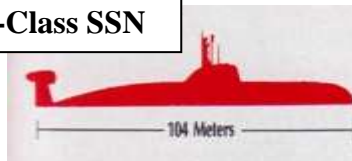| Armament: | Torpedoes, SS-N-9 antiship cruise missile |
Propulsion:	Nuclear
Submerged Displacement:	5,400 MT
Initial Operational Capability:	1974

Sub #3: OSCAR-Class SSGN

150 Meters

Armament:	Torpedoes, SS-N-19 antiship cruise missile
Propulsion:	Nuclear
Submerged Displacement:	16,000 MT
Initial Operational Capability:	1981

Sub #4: SIERRA-Class SSN

110 Meters

Armament:	Torpedoes, ASW missile
Propulsion:	Nuclear
Submerged Displacement:	7,600 MT
Initial Operational Capability:	1984

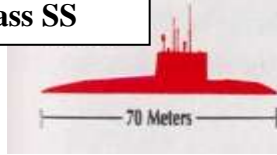**Sub #5: VICTOR III-Class SSN**

104 Meters

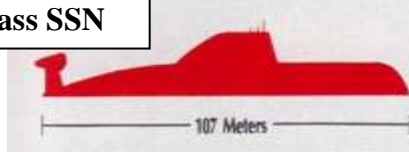| Armament: | Torpedoes, ASW missile |
Propulsion:	Nuclear
Submerged Displacement:	6,300 MT
Initial Operational Capability:	1979

Name_____Period_____Date_____

Directions: Using the Dichotomous Key of Soviet Attack Submarines identify each of the following Cold War era Soviet submarines. Write the class of the sub in the space provided.
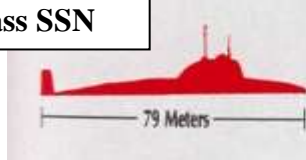
Sub #1:   KILO-Class SS

Armament:	Torpedoes
Propulsion:	Diesel
Submerged Displacement:	3,000 MT
Initial Operational Capability:	1980

70 Meters
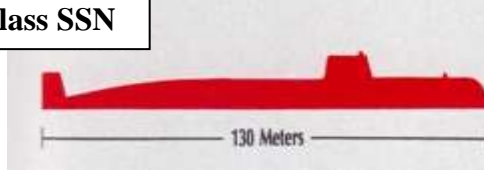
Sub #2:   AKULA-Class SSN

Armament:	Torpedoes, ASW missile, SS-N-21
Propulsion:	Nuclear
Submerged Displacement:	10,000 MT
Initial Operational Capability:	1988

107 Meters

Sub #3:   ALFA-Class SSN

Armament:	Torpedoes, SS-N-15 ASW missile
Propulsion:	Nuclear
Submerged Displacement:	3,700 MT
Initial Operational Capability:	1978

79 Meters

Sub #4:   YANKEE-Class SSN

Armament:	Torpedoes
Propulsion:	Nuclear
Submerged Displacement:	10,000 MT
Initial Operational Capability:	1988

130 Meters

Sub #5:   MIKE-Class SSN

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Armament:	Torpedoes, ASW missile
Propulsion:	Nuclear
Submerged Displacement:	6,400 MT
Initial Operational Capability:	1986

110 Meters

Activity #3 -Dichotomous Key of Cold War Missiles

Objectives:

➢ *Use the provided* **Soviet/US Nuclear Submarine-Launched Ballistic Missile Dichotomous Key** *to identify the names of each of the represented classes of Cold War era ballistic missiles.*

➢ *Familiarize students with the assessment process in working with dichotomous keys.*

Materials:

✓ *Soviet/US Nuclear Submarine-Launched Ballistic Missile Dichotomous Key*

✓ *Student copies of the worksheet containing the (9) missiles to identify.*
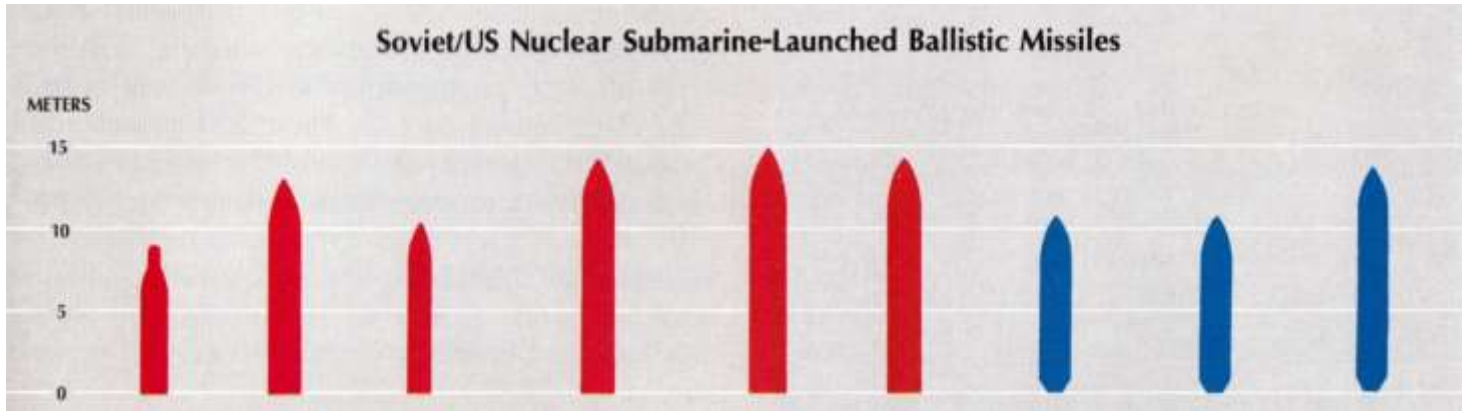
Procedure:

1. *Students may be grouped or work individually on this assignment.*

2. *Give each student or group the hand out* **Soviet/US Nuclear Submarine-Launched Ballistic Missile Dichotomous Key.**

3. *Give each student or group the worksheet with the (9) missiles to identify.*

4. *Have students identify the (9) unknown missiles on the worksheet.*

Note: This activity can be done in class or as a homework assignment. This activity can follow the earlier **Dichotomous Key for Soviet Submarines** activity or as a replacement for it. It can also be used as a replacement activity for students who were absent or may need extra help or reinforcement.

Soviet/US Nuclear Submarine-Launched Ballistic Missile Dichotomous Key

1A) If it is a US missile (Blue) …………………………………………….. Go to 2

1B) If it is a Soviet missile (Red) ………………………………………….. Go to 4

2A) If it has 10 MIRVs ………………………………....................Poseidon SLBM C-3

2B) If it has 8 MIRVs ……………………………………………….............. Go to 3

3A) If the missile is 10.4 m tall………………………………………… Trident SLBM C-4

3B) If the missile is 13.4 m tall……………………………………………Trident II SLBM D-5

4A) If the missile has 1 reentry vehicle (RV)……………………………………. Go to 5

4B) If the missile has multiple independent reentry vehicles (MIRVs)…………. Go to 7

5A) If the missile is less than 10 m in length …………………………………… SS-N-6

5B) If the missile is more than 10 m in length ………………………………….. Go to 6

6A) If the missile has a range of 9,100 km …………………………………… SS-N-8

6B) If the missile has a range of 3,900 km …………………………………… SS-N-17

7A) If the missile has a range less than 8,000 km ……………………………… SS-N-18

7B) If the missile has a range greater than 8,000 km …………………………… Go to 8

8A) If the missile is 15 m tall ………………………………………………… SS-N-20

8B) If the missile is less than 15 m tall ……………………………………… SS-N-23

Name_____Period_____Date_____

Soviet/US Nuclear Submarine-Launched Ballistic Missiles

METERS

	MOD		MOD		MOD				SLBM C-3	SLBM C-4	SLBM D-5
	1	2	2		1	3					
RVs	1	1	1	1	3 MIRVs	7 MIRVs	10 MIRVs	Up to 10 MIRVs	10 MIRVs	8 MIRVs	8 MIRVs
RANGE (KM)	2,400	3,000	9,100	3,900	6,500	6,500	8,300	9,000	4,000	7,400	7,400

#1   #2   #3   #4   #5   #6   #7   #8   #9

Using the data above and the *Soviet/US Nuclear Submarine-Launched Ballistic Missile Dichotomous Key* provided, identify the names of each missile (#1 - #9). Write your answer in the space provided.

1)   SS-N-6

2)   SS-N-8

3)   SS-N-17

4)   SS-N-18

5)   SS-N-20

6)   SS-N-23

7)   Poseidon SLBM C-3

8)   Trident SLBM C-4

9)   Trident II SLBM D-5

Activity #4 - Advanced Key of Soviet Submarines and Questions for Understanding

Objectives:

➢ Use the provided **Dichotomous Key of Soviet Attack Submarines** *to identify the names of each of the represented classes of Soviet Cold War era submarines.*

➢ *Familiarize students with the assessment process in working with dichotomous keys.*

Materials:

✓ *Dichotomous Key of Soviet Attack Submarines*

✓ *Packet including the (10) submarines to be identified along with the follow-up questions sheet.*

Procedure:

1. *Students may be grouped or work individually on this assignment.*

2. *Give each student or group the hand out* **Dichotomous Key of Soviet Attack Submarines.**

3. *Give each student or group the packet showing the (10) submarines to be classified along with the follow up questions.*

4. *Have students identify the (10) unknown submarines and answer the follow up questions.*

Note: This activity can be done in class or as a homework assignment. This activity can follow the earlier **Dichotomous Key for Soviet Submarines** activity or the **Soviet/US Nuclear Submarine-Launched Ballistic Missile Dichotomous Key activity** or as a replacement for either or both. It can also be used as a replacement activity for students who were absent or may need extra help or reinforcement. This activity can also be used for advanced classes while the earlier activities may be used for academic or standard classes.

Fast Facts for this activity:

- "Akula" which is the name of one of the Soviet classes of submarine, is the Russian word for "shark".
- The submarine classes also include the letters SS, SSN, SSBN, or SSGN. The "SS" stands for *submersible ship*, the "N" stands for *nuclear* (pertaining to the subs propulsion, not weapons), the "B" stands for *ballistic* (indicating that this submarine carried ballistic nuclear missiles), and "G" stands for *guided* (indicating that this submarine carried guided missiles used to attack ships or land targets).

Dichotomous Key of Soviet Attack Submarines

1A) The sub uses diesel power for propulsion……………………………………………………Go to 2

1B) The sub uses nuclear power for propulsion…………………………………………………….Go to 3

2A) If the sub is 70 m in length………………………………………………………..KILO-Class SS

2B) If the sub is 92 m in length………………………………………………………..TANGO-Class SS

3A) If the submerged displacement of the sub is 10,000 MT or more………………………………Go to 4

3B) If the submerged displacement of the sub is less than 10,000 MT……………………………..Go to 6

4A) If the subs armament consists of torpedoes only………………………………...YANKEE-Class SSN

4B) If the subs armament includes more than just torpedoes……………………………………......Go to 5

5A) If the sub carries SS-N-19 antiship cruise missiles…………………………………OSCAR-Class SSGN

5B) If the sub carries ASW missiles and SS-N-21 missiles…………………………......AKULA-Class SSN

6A) If the sub is less than 110 m in length……………………………………………………..Go to 7

6B) If the sub is 110 m in length……………………………………………………………….Go to 9

7A) If the sub reached initial operational capability in 1974……………………CHARLIE II-Class SSGN

7B) If the sub reached initial operational capability after 1974………………………………….Go to 8

8A) If the sub is over 100 m in length………………………………………………...VICTOR III-Class SSN

8B) If the sub is less than 100 m in length………………………………………………..ALFA-Class SSN

9A) If the sub has a submerged displacement of 6,400 MT……………………………….MIKE-Class SSN

9B) If the sub has a submerged displacement of 7,600 MT…………………………….SIERRA-Class SSN

Name_____Period_____Date_____

Directions: Using the *Dichotomous Key of Soviet Attack Submarines* identify each of the
following Cold War era Soviet submarines. Write the class of the sub in the space provided.

Submarine #1

Armament:	Torpedoes
Propulsion:	Diesel
Submerged Displacement:	3,900 MT
Initial Operational Capability:	1973

92 Meters

Submarine #2

Armament:	Torpedoes, SS-N-9 antiship cruise missile
Propulsion:	Nuclear
Submerged Displacement:	5,400 MT
Initial Operational Capability:	1974

102 Meters

Submarine #3

Armament:	Torpedoes, ASW missile
Propulsion:	Nuclear
Submerged Displacement:	6,300 MT
Initial Operational Capability:	1979

104 Meters

Submarine #4

Armament:	Torpedoes, SS-N-15 ASW missile
Propulsion:	Nuclear
Submerged Displacement:	3,700 MT
Initial Operational Capability:	1978

79 Meters

Submarine #5

Armament:	Torpedoes, SS-N-19 antiship cruise missile
Propulsion:	Nuclear
Submerged Displacement:	16,000 MT
Initial Operational Capability:	1981

150 Meters

Submarine #6

Armament:	Torpedoes
Propulsion:	Diesel
Submerged Displacement:	3,000 MT
Initial Operational Capability:	1980

70 Meters

Submarine #7

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Armament:	Torpedoes, ASW missile
Propulsion:	Nuclear
Submerged Displacement:	6,400 MT
Initial Operational Capability:	1986

110 Meters

Submarine #8

Armament:	Torpedoes, ASW missile
Propulsion:	Nuclear
Submerged Displacement:	7,600 MT
Initial Operational Capability:	1984

110 Meters

Submarine #9

Armament:	Torpedoes
Propulsion:	Nuclear
Submerged Displacement:	10,000 MT
Initial Operational Capability:	1988

130 Meters

Submarine #10

Armament:	Torpedoes, ASW missile, SS-N-21
Propulsion:	Nuclear
Submerged Displacement:	10,000 MT
Initial Operational Capability:	1988

107 Meters

Submarine #1: **TANGO-Class SS**

Submarine #2: **CHARLIE II-Class SSGN**

Submarine #3: **VICTOR III-Class SSN**

Submarine #4: **ALFA-Class SSN**

Submarine #5: **OSCAR-Class SSGN**

Submarine #6: **KILO-Class SS**

Submarine #7: **MIKE-Class SSN**

Submarine #8: **SIERRA-Class SSN**

Submarine #9: **YANKEE-Class SSN**

Submarine #10: **AKULA-Class SSN**

Reflection Short Answer/Essay: Answering the following questions about using a dichotomous key. Answer in complete sentences.

1) **What was the most challenging part of using a dichotomous key?**

Answers will vary for each student. Most students will mention that the decision making process was sometimes challenging or mistakes are often made by moving to the wrong number.

2) **The prefix (di-) means two. Why do you think the term dichotomous is used to describe the key used in this activity?**

The (di-) in the case of dichotomous keys refers to the fact that objects or species classified in a dichotomous key are always broken down at every level into two choices. The first series of statements (1A and 1B) include every possible item to be identified. As you get deeper into the key itself, you get more and more specific as you go, eventually arriving at the exact item to be classified.

3) **How would a biologist use a dichotomous key in classifying various forms of life? Give some examples of plants and animals that could be classified this way.**

Answers will vary by student. Keys exist for virtually every group of similar plants and animals found in nature. There are keys for fish, birds, snakes, trees (usually based on leaves), insects, rodents, etc. Keys are vital tool of the field biologist.

4) **Other than a biologist or the military, who else may benefit from using a dichotomous key? What kind of key would you be interested in making or using?**

Answers will vary by student.

Objectives:

➢ Use the provided **US Submarines of the Cold War Dichotomous Key** to identify the names of each of the represented classes of US Cold War era submarines.

➢ Familiarize students with the assessment process in working with dichotomous keys.

Materials:

✓ US Submarines of the Cold War Dichotomous Key.

✓ Handout of the (5) submarines to be identified.

Procedure:

1. Students may be grouped or work individually on this assignment.

2. Give each student or group the hand out **US Submarines of the Cold War Dichotomous Key.**

3. Give each student or group the handout showing the (5) submarines to be classified.

4. Have students identify the (5) unknown submarines.

Note: This activity is provided simply as an extra or supplement. It can be done in class or as a homework assignment. This activity can follow the earlier **Dichotomous Key for Soviet Submarines** activities or the **Soviet/US Nuclear Submarine-Launched Ballistic Missile Dichotomous Key activity** or as a replacement for any of the other activities in this unit. It can also be used as a replacement activity for students who were absent or may need extra help or reinforcement. This activity can also be used as a review before a quiz or test.

Fast Facts for this activity:

• The submarine classes also include the letters SS, SSN, SSBN, or SSGN. The "SS" stands for *submersible ship*, the "N" stands for *nuclear* (pertaining to the subs propulsion, not weapons), the "B" stands for *ballistic* (indicating that this submarine carried ballistic nuclear missiles), and "G" stands for *guided* (indicating that this submarine carried guided missiles used to attack ships or land targets).
• For many years US submarine classes were named after types of fish or sea life (nautilus, skipjack, sturgeon, etc.). Later in the Cold War they were named for US cities (Los Angeles) and states (Ohio). Four-star admiral Hyman G. Rickover, known as the "Father of the Nuclear Navy" explains the change from fish names to places with the famous quote "Fish Don't Vote!" indicating the importance of funding in building and maintaining nuclear submarines.

US Submarines of the Cold War Dichotomous Key

1A) The sub has two propellers…………………………..*USS Clamagore, BALAO-Class Diesel*

1B) The sub has only one propeller……………………………………………………………Go to 2

2A) The sub has hatches behind the sail for vertically launching missiles………………Go to 3

2B) The sub does not have hatches behind the sail for vertically launching missiles……Go to 4

3A) The sub has 12 pairs of hatches located behind the sail……...*USS Ohio, OHIO-Class SSBN*

3B) The sub has 8 pairs of hatches located behind the sail…………...*USS James K. Polk SSBN**

4A) From a top view, the towed sonar array is on the left side of the sail. Vertical stabilizers can be seen on the stern dive planes……………………...*USS Sturgeon, STURGEON-Class SSN*

4B) From a top view, the towed sonar array is on the right side of the sail. Stern dive planes do not have vertical stabilizers………………………*USS Los Angeles, LOS ANGELES-Class SSN*

*During the Cold War, the *USS James K. Polk* was built as a BEN FRANKLIN-Class SSBN but was later converted to an SSN after the Cold War.

Helpful hints for using the key: Bow = front of the sub   Stern = back of the sub

The "towed sonar array" referenced in the key is housed on the top side of the sub and when deployed extends behind the submarine. The housing can be seen as a horizontal line running the length of the submarine.

Vertical Stabilizers Present   Vertical Stabilizers Absent

Using the *US Submarines of the Cold War Dichotomous Key* indentify the name of each of the submarines pictured. (The pictures of these subs are not to scale)

#1

#2

#3

#4

#5

Write the name of each submarine in the space provided:

Submarine #1 = *USS James K. Polk*

Submarine #2 = *USS Los Angeles*

Submarine #3 = *USS Clamagore*

Submarine #4 = *USS Ohio*

Submarine #5 = *USS Sturgeon*

Fun Facts/Topics for further discussion:

Who was James K. Polk and what is his connection to the Navy?

Answer: *11ᵗʰ President of the United States, the United States Naval Academy in Annapolis was established during his term.*

Who or what is a clamagore?

Answer: *A blue parrot-fish found in the West Indies and Chesapeake Bay.*

Based on the names and classes of submarines shown on the dichotomous key, can you guess how the names and classes are related?

Answer: Whatever the first name of the submarine is in a new class, becomes the name of that class. For example, the *USS Los Angeles* was the first submarine built in a new class that first went into service in the 1970's (built starting in 1972, first commissioned in 1976). Since the *USS Los Angeles* was the first named submarine of the new type, the class became known as the Los Angeles Class. Later boats of the Los Angeles Class (at one time there were 62) include the *USS Dallas* (seen in *The Hunt for Red October*), *USS Boise*, *USS Pittsburgh*, etc. (all named after US cities.

The Ohio Class shows the same sequence regarding names. The *USS Ohio* was the first submarine of a new class that was built starting in 1976 and was first commissioned in 1981. Thus was born the Ohio Class. Later submarines in the class include USS Alabama (seen in *Crimson Tide*), USS Pennsylvania, USS Louisiana, etc. (all named after US states).

Fun Fact: The video game *Call of Duty 2: Modern Warfare* shows two different Los Angeles class nuclear submarines during cut sequences in the game (*USS Chicago* and *USS Dallas*).

Fun Fact: The movie *Terminator Salvation* shows a Los Angeles Class submarine (*USS Wilmington*) being used as the resistance headquarters.

Fun Fact: James Cameron's *The Abyss*, has divers recovering a nuclear weapon from the *USS Montana*, a fictional Ohio Class submarine that had sunk.

Activity #6 - Mastery Exercise: Shoe Dichotomous Key

Objectives:

➢ *Students will generate their own dichotomous key in the classroom.*

Materials:

✓ *Pencil or Pen*
✓ *Paper (lined notebook paper works the best)*
✓ *Optional – Computer with Printer (not required)*

Procedure:

1. *Students work in one giant group as an entire class.*

   Note: In very large classes (30-40), students can be divided into two groups (15-20). Even large classes can work as one large group, but the teacher may opt for smaller groups based on behavior of the class, ability levels, or time constraints (smaller groups = less time needed).

2. *Have each student remove one shoe (not both), and place it in a pile.*

   Note: It doesn't matter if it is the left or right shoe (it is actually better if it is a random mixture of left and right shoes). Students may wish to remove both shoes to be able to walk around more comfortably. Make sure the shoe in the pile is not mixed in with the other removed shoe (as left and right may become a criterion in the student's dichotomous key).

3. *Have students generate a dichotomous key classifying each person's shoe. Once completed the key should indicate the owner of the shoe.*

   Hint: For students needing more guidance, roles can be assigned for this activity. Designate students to be *leaders*, *recorders* (who write or type the key), *movers* (who move the shoes around in piles), *testers* (who key out shoes and test the key at the end), etc.

4. *Key out random shoes once students have finished and check for correctness.*

   Hint: This activity should be completed in one class period (since students may wear different shoes the next day). The teacher may also contribute a shoe to the pile to be included in the key.

Activity #7 – Biology Exercise

Subject: High School Biology (grades 9-12) Middle School Science (grades 6-8)

A dichotomous key is a valuable tool used by biologists to quickly and accurately identify a species. Imagine that you catch a fish or see a bird in the woods. What kind of fish or bird is it? What is the scientific name of the species? That's where a dichotomous key comes in.

In a dichotomous key, there are a series of choices based on the physical descriptions of the specimen being looked at. The biologist (or student) looks at the specimen and reads the key. The first two statements on the top of the key (1A and 1B) would present two choices to be assessed. Whichever statement proves to accurately describe the specimen will direct the user to move to the next series of statements. The eventual result of the key provides the name of the species of that particular organism. There are biological dichotomous keys for many plants and animals including leaves of trees, fish, birds, snakes, insects, rodents, etc.
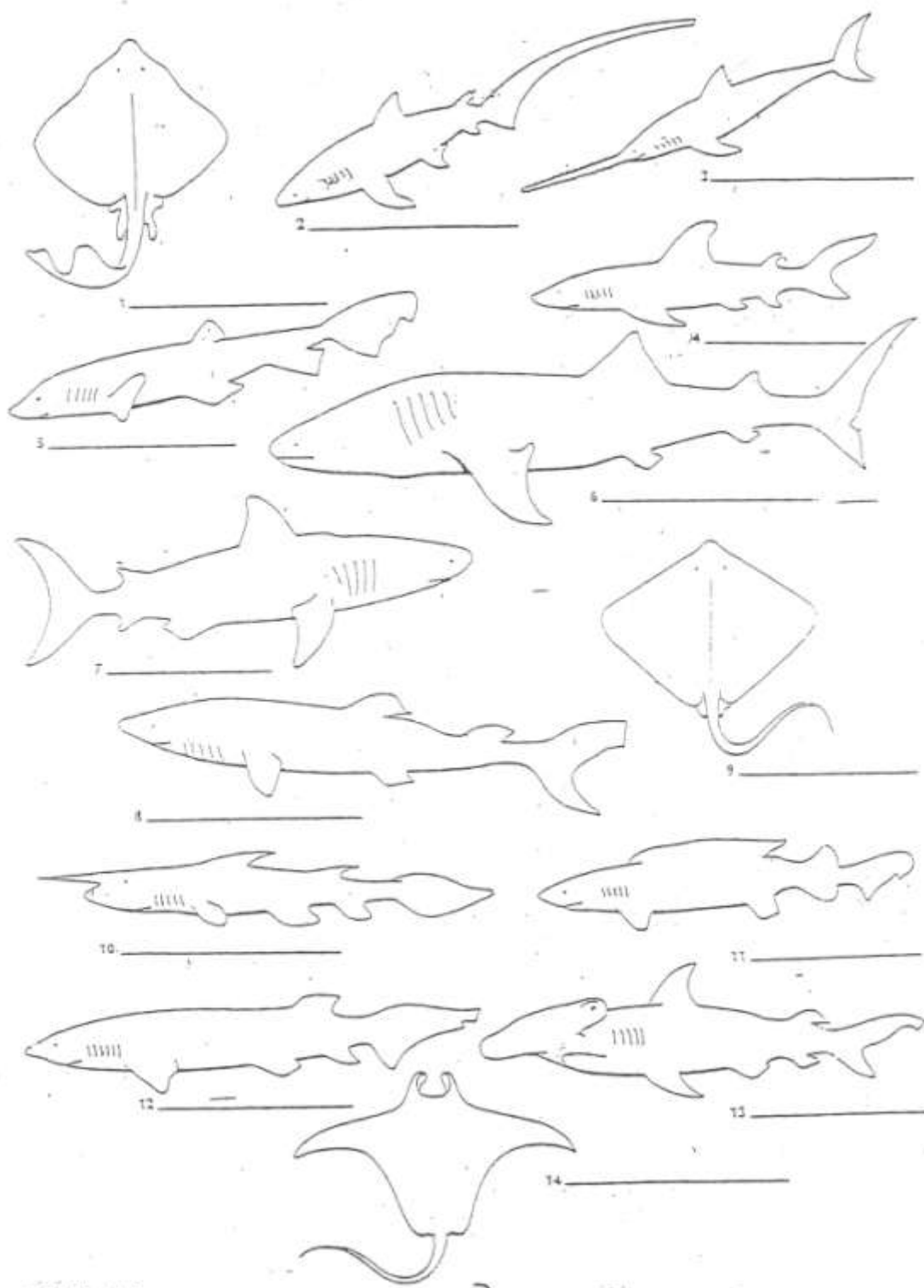
1 _____

2 _____

3 _____

4 _____

5 _____

6 _____

7 _____

8 _____

9 _____

10 _____

11 _____

12 _____

13 _____

14 _____

FIGURE 44-2

2

Shark Dichotomous Key

1. A. Body kitelike in shape (if view from above)…………… …………………….Go to statement 12

    B. Body not kitelike in shape (if view fro above) …………………………………..... Go to statement 2

2. A. Pelvic fin absent and nose sawlike ……………………………........................... Family Pristophoridae

    B. Pelvic fin present……………………………………………………………….....Go to statement 3

3. A. Six gill slits present……………………………………………………….…Family Hexanchidae

    B. Five gills present…………………………………………………………….....Go to statement 4

4. A. Only one dorsal fin present…………………………………………………......Family Scyliorhinidae

    B. Two dorsal fins present………………………………………………….……….Go to statement 5

5. A. Mouth at the front of the head rather than back along underside of head……..Family Rhinocodontidae

    B. Mouth back along underside of head……………………… ………………….….Go to statement 6

6. A. Head expanded on the side with eyes at the end of expansion………………...….Family Sphyrnidae

    B. Head not expanded……………………………………………………………......Go to statement 7

7. A. Top half of caudal fin exactly same size and shape as bottom half…………………….Family Isuridae

    B. Top half of caudal different in size and shape from the bottom half………………Go to statement 8

8. A. First dorsal fin very long, almost half the length of the total body……………Family Pseudotriakidae

    B. first dorsal fin length much less than the half the total length of body……………Go to statement 9

9. A. Caudal fin very long, almost as long as the entire body……………………………...Family Aloplidae

    B. Caudal fin length much less than length of entire body……………………………Go to statement 10

10. A. Nose with long needlelike point on end……………………………………........Family Scapanorhynchidae

    B. Nose without needlelike point………………………………………………………Go to statement 11

11. A. Anal fin absent…………………………………………………………………......Family Squalidae

    B. Anal fin present……………………………………………………………….…Family Carcharhinidae

12. A. Small dorsal fin present near tip of tail…………………………………………….....Family Rajidae

    B. Small dorsal fin absent near tip of tail……………………………………………….Go to statement 13

13. A. Hornlike appendages at front of shark...…......Family Mobulidae

    B. Hornlike appendages not present at front of shark………………………………......Family Dasyatidae